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Comment On: DOE-HQ-2010-0002-0014
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Comment on FR Doc # 2010-32316

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General Comment

Please do not include "Wind Turbines" and "Solar Potovoltaic" systems among categorical exclusions. Such projects are far too big and consume far too much land to be build without following the EIS process. Wind Turbines kill birds in violation of the Migratory Bird Treaty Act. Without mandatory compliance with EIS no mechanism to assurme BMPs for minimizing bird kills will be in place. Solar Potovoltaic systems have the potential to condemn vast amounts of federal land simultaneously negatively affecting ecosystems of other species, such as sage grouse and economic interests of local communities who might be shut off from existing economic uses of federal lands. One advantage of the EIS processs is considering multiple options for decisions. The use of far too much land is at stake for including both uses as categorical exclusions.

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General Comment

RIN 1990-AA34 - I DO NOT WANT THESE CHANGES TO NEPA IN ANY WAY, SHAPE OR FORM. I THINK THIS IS A POWER GRAB BY A POWER MAD DOE. I THNK THE BUSH CHENEY OIL GUYS WHO DESTROY ENVIRONMENT ARE STILL THERE IN PROFUSION AND THEY ARE SEEKING TO DESTROY, DESTROY, DESTROY GOD'S WORK. I THINK THIS CHANGE WILL LEAD TO ANOTHER DEBACLE LIKE THE GULF OIL MESS. I DO NOT BELIEVE DOE SHULD EVER BLINDLY ACCEPT WHAT USDA DOES, BECAUSE USDA IS A CORRUPT AGENCY THAT WORKS FOR AGRIBUSINESS AND CONSIDERS NOT THE GENERAL EFFECTON AMERICANS FROM THEIR FRANKENFOOD CORRUPTION. I DO NOT LIKE THE SECTION ON PIPELINES. WE HAVE HAD MAJOR PIPELINES BLOW UP. THIS AGENCY HAS ALSO ALLOWED MAJOR OIL FIRMS TO FAIL TO MAINTAIN PIIPELINES FOR 17 YEARS. THIS AGENCY HAS ALLOWED THOUSANDS OF OIL SPILLS WITH LITTLE PUNISHMENT. THIS AGENCY NEEDS BRAKES ON IT. I THINK THIS AGENCY IS TRYING TO GUT NEPA. I DO NOT APPRECIATE THAT AND BELIEVE IF YOU DESTROY THE ENVIRONMENT, YOU DESTROY US ALL.

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Comment On: DOE-HQ-2010-0002-0014
National Environmental Policy Act Implementing Procedures

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Comment on FR Doc # 2010-32316

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General Comment

With the resources we have today we are able to understand the importance of proper containment of coal combustion residue. As the accident in the Tennessee Valley Area proved, our facilities are not invincible. The estimated cost of cleaning up the disaster was $1.2 billion. That facility failed, leaving me wondering about all of the other ones scattered across the United States. Incidents like that prove that CCR must be included instead of excluded in the Resource Conservation and Recovery Act. The question is which subtitle to add it to?
Out of the two options I believe that adding coal combustion residue should be added to RCRA Subtitle C for four reasons; they are:
1. Continuation of evolution. To ultimately succeed we need to put more than a band-aid upon the wound CCR has on our environment, we need to pass regulation that controls CCR by balancing resource consumption and environmental impact. The mandatory containment liner thickness is definitely a must to prevent as much leaching as possible.
2. Plenty of time granted. Subtitle C grants CCR containment facilities five years to meet the regulation along with two more years for facilities that plan on closing. That is plenty of time allotted to meet the requirements of subtitle C.
3. Costs. The difference in estimated costs of regulating CCR for 50 years in each subtitle is large; c

is $20 billion, d is $8 billion; approximately the cost of 14 TVA accidents. But the difference between the two options goes much further than the cost.
4. Our future. We can “clean up” the area where a CCR release has occurred, but it doesn’t remove everything. Leaching can also cause contamination in waterways, ultimately making its way into our drinking water. With such importance riding on this decision I know that higher regulation of CCR disposition will pay off.

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General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0022.1: Comment on FR Doc # 2010-32316

T r i – V a l l e y   C A R E s

Communities **A**gainst a **R**adioactive **E**nvironment

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NEPA Rulemaking Comments
Office of NEPA Policy and Compliance (GC–54)
U.S. Department of Energy
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Washington, DC 20585

February 3, 2011

Re: Docket ID: DOE–HQ–2010–0002: Comment on DOE Rulemaking Change Regarding Regulations Governing Compliance with the National Environmental Policy Act

To the U.S. Deparment of Energy's Office of NEPA Policy and Compliance,

Tri-Valley CAREs (TVC) is a non-profit organization founded in 1983 by Livermore, California area residents to research and conduct public education and advocacy regarding the potential environmental, health and proliferation impacts of the Department of Energy (DOE) nuclear weapons complex, including the nearby Lawrence Livermore National Laboratory.

Since its inception, TVC has participated in numerous National Environmental Policy Act (NEPA) administrative review processes being done by DOE. We comment during scoping for DOE NEPA documents and on drafts of its Environmental Assessments and Environmental Impact Statements. The group has also participated in federal litigation to uphold NEPA when the DOE violated statutory requirements or ignored concerns expressed in comments.

The proposed rule change to 10 CFR 1021 contains some alterations to the statute that we believe could expand the use of categorical exclusions in a manner that could result in violations of NEPA and other statutes. Our concerns include the following;

1) Generally, the decision to add "headings" to each section is a good one. However, it is unclear as to why the addition of headings to the sections negates the need for a table of contents. The table of contents for these sections is extremely useful for non-agency users and for lawyers conducting legal research. We urge the Agency to add revised tables of contents to these regulations rather than removing them entirely. Can the Agency explain why it can not continue to provide a table of contents for these sections and also provide section headings?

2) § 1021.410 (e) – This new section provides that "Categorical exclusion determinations for actions listed in appendix B shall be documented and made available to the public by

posting online." It is a welcome development that the Department is taking steps towards increased transparency. However, because these postings will withhold "information that DOE would not disclose pursuant to the Freedom of Information Act (FOIA)," we are concerned that the public will be deprived of a right to challenge these withholdings that it would have if it the information was requested using FOIA and there were withholdings. Can the Agency please explain the process by which the public can challenge potentially improper withholdings in an online posting of a categorical exclusion determination under this rule change?

3) Appendix B to Subpart D of part 1021. B (4) - This section defines the conditions that must not be "integral elements of the classes of action," for a proposal to be categorically excluded. Part (4) was changed from "*a proposal must be one that would not: (4) Adversely affect environmentally sensitive resources*," to "*a proposal must be one that would not: (4) Have the potential to cause significant impacts on environmentally sensitive resources*." The Agency explains that its reasoning for making this type of change is to ensure the regulations are "*clearly aligned with the regulatory standard in NEPA,*" and points to, 40 CFR 1508.4[1]. Additionally, by this proposed change, DOE seeks to clarify the affected provisions and to facilitate consistent application. However, we are concerned that this specific change will allow for an expansion of the categorical exclusion without providing an analysis of whether there was actually a potential for significant environmental impact. For example, under the older language, if an action had any adverse affect on the environment, the agency would have to perform a more extensive study as to whether that adverse affect would be "significant" under NEPA. Under the new rule change even if there is an adverse effect on the environment, if the agency makes the determination (without doing any in depth study) that that "adverse" impact could never "potentially" become a "significant impact" on the environment, the agency could exempt the project under this categorical exclusion. Can the Agency explain how this change will prevent a violation of NEPA? Additionally, 40 CFR 1508.4 requires the Agency to provide for extraordinary circumstances in which a normally excluded action may have a significant environmental effect. Can the agency explain how this requirement is met? Will the Agency explain whether this change will, in its opinion, expand the use of this categorical exclusion, and if so, how much?

4) Appendix B to Subpart D of part 1021. B1.11- This section defines the "Facility Operations" that can be categorically excluded from NEPA. B1.11 explains that "Fencing" can be excluded. It was changed from excluding "Fencing" that "*will not adversely affect wildlife…*," to excluding "Fencing" that "*would not have the potential to cause significant impacts on wildlife*." The Agency explains that its reasoning for making this type of change is to ensure the regulations are "*clearly aligned with the regulatory standard in NEPA,*" and points to, 40 CFR 1508.4. Additionally, by this proposed change, DOE seeks to clarify the affected provisions and to facilitate consistent application. However, we are concerned that this specific change will allow for an expansion of the categorical exclusion without providing an analysis of whether there was actually a potential for significant environmental impact. For example, under the

[1] 40 CFR 1508.4 reads: "Categorical exclusion" means a category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a Federal agency in implementation of these regulations (Sec. 1507.3) and for which, therefore, neither an environmental assessment nor an environmental impact statement is required. An agency may decide in its procedures or otherwise, to prepare environmental assessments for the reasons stated in Sec. 1508.9 even though it is not required to do so. Any procedures under this section shall provide for extraordinary circumstances in which a normally excluded action may have a significant environmental effect.

older language, if an action had any adverse affect on the wildlife or surface water flow, the agency would have to perform a more extensive study as to whether that adverse affect would be "significant" under NEPA. Under the new rule change even if there is an adverse effect on wildlife or surface water flow, if the agency makes the determination (without doing any in depth study) that that "adverse" impact could never "potentially" become a "significant impact" on the environment, the agency could exempt the project under this categorical exclusion. Can the Agency explain how this change will prevent a violation of NEPA? Additionally, 40 CFR 1508.4 requires the Agency to provide for extraordinary circumstances in which a normally excluded action may have a significant environmental effect. Can the agency explain how this requirement is met? Will the Agency explain whether this change will, in its opinion, expand the use of this categorical exclusion, and if so, how much?

5) Appendix B to Subpart D of part 1021. B1.18- This section defines the "Facility Operations" that can be categorically excluded from NEPA. B1.18 explains that "Water Supply Wells" can be excluded. It was changed from excluding "Water Supply Wells" that "*will have no resulting long-term decline of the water table, and no degradation of the aquifer*" to excluding "Water Supply Wells" that "*would not have the potential to cause significant long-term decline of the water table and would not have the potential to cause significant degradation of the aquifer* ." The Agency explains that its reasoning for making this type of change is to ensure the regulations are "*clearly aligned with the regulatory standard in NEPA,*" and points to, 40 CFR 1508.4. Additionally, by this proposed change, DOE seeks to clarify the affected provisions and to facilitate consistent application. However, we are concerned that this specific change will allow for an expansion of the categorical exclusion without providing an analysis of whether there was actually a potential for significant environmental impact. For example, under the older language, if a water supply well caused any long term decline of the water table or degradation of the aquifer, the agency would have to perform a more extensive study as to whether that adverse affect would be "significant" under NEPA. Under the new rule change even if there is long term decline of the water table or degradation of the aquifer, if the agency makes the determination (without doing any in depth study) that that "adverse" impact could never "potentially" become a "significant impact" on the environment, the agency could exempt the project under this categorical exclusion. Can the Agency explain how this change will prevent a violation of NEPA? Additionally, 40 CFR 1508.4 requires the Agency to provide for extraordinary circumstances in which a normally excluded action may have a significant environmental effect. Can the agency explain how this requirement is met? Will the Agency explain whether this change will, in its opinion, expand the use of this categorical exclusion, and if so, how much?

6) Appendix B to Subpart D of part 1021. B2.3- This section defines the "Categorical Exclusions Applicable to Safety and Health." B2.3 explains that certain installation of, and improvements to "Personal safety and health equipment" can be excluded. It was changed from allowing exclusion of these items "*provided that emissions would not increase*" to excluding them "*provided that the covered actions would not have the potential to cause significant increase in emissions*." The Agency explains that its reasoning for making this type of change is to ensure the regulations are "*clearly aligned with the regulatory standard in NEPA,*" and points to, 40 CFR 1508.4. Additionally, by this proposed change, DOE seeks to clarify the affected provisions and to facilitate consistent application. However, we are concerned that this specific change will allow for an expansion of the categorical exclusion without providing an analysis of whether there was actually a potential for significant environmental impact. For example, under the

older language, if the installation or improvement caused any increase in emissions, the agency would have to perform a more extensive study as to whether that increase would be "significant" under NEPA. Under the new rule change even if there is an increase in emissions, if the agency makes the determination (without doing any in depth study) that that new emissions could never "potentially" become a "significant impact" on the environment, the agency could exempt the project under this categorical exclusion. Can the Agency explain how this change will prevent a violation of NEPA? Additionally, 40 CFR 1508.4 requires the Agency to provide for extraordinary circumstances in which a normally excluded action may have a significant environmental effect. Can the agency explain how this requirement is met? Will the Agency explain whether this change will, in its opinion, expand the use of this categorical exclusion, and if so, how much?

7) Appendix B to Subpart D of part 1021. B3.11- This section establishes categorical exclusions for certain outdoor tests and experiments on materials and equipment components. While the section maintains that "covered actions would not involve source, special nuclear, or byproduct materials," it is changed to include an exception for "encapsulated sources that contain source, special nuclear or byproduct materials" stating that they "may be used for nondestructive actions such as detector/sensor development and testing and first responder field training." We are concerned that this exemption could allow for potentially "nondestructive actions" involving encapsulated source, special nuclear or byproduct materials in outdoor tests and experiments on materials and equipment components where those materials could get accidentally "destroyed" or somehow spread into the environment during the tests or experiments. We are also concerned that there is no mention of a limit on how much encapsulated source, special nuclear or byproduct materials can be used in these tests and experiments. Can the Agency explain how this exemption will not result in potentially significant impacts to the environment?

8) Appendix B to Subpart D of part 1021. B6.1 - This section establishes categorical exclusions for certain cleanup actions. The change expands the clean up actions that can be exempt from those that cost less then "approximately 5 million dollars" and last "5 years" in duration, to exempting those that cost less then "approximately 10 million dollars" without any time restriction. This has the potential to expand the types of clean up actions that DOE believes are exempt from NEPA greatly. For example, a clean up action that involves 10 years of container removal could potentially be exempt. Can the Agency explain how this increased exemption will not result in potentially significant impacts to the environment?

Thank you for your consideration.

Sincerely,

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General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0023.1: Comment on FR Doc # 2010-32316

CHESAPEAKE BAY FOUNDATION
Saving a National Treasure

February 8, 2010

NEPA Rulemaking Comments
Office of NEPA Policy and Compliance (GC-54)
U.S. Department of Energy
1000 Independence Ave, SW
Washington, D.C. 20585

RE: DOE NEPA Implementing Procedures, RIN 1990-AA34, Docket ID: DOE-HQ-2010-0002

To whom it may concern:

Introduction

On behalf of the Chesapeake Bay Foundation, Inc. ("CBF"), thank you for the opportunity to provide written comments on the Department of Energy's ("DOE") proposed rulemaking to amend existing categorical exclusions under the National Environmental Policy Act ("NEPA"). CBF is the largest non-profit organization dedicated to restoring the Chesapeake Bay, and represents approximately 206,000 members and e-subscribers. We are active in federal, state and local legislative and regulatory arenas, and employ scientists, land planners, attorneys, educators, policy and technical experts to advocate on behalf of the nation's largest estuary and a vital economic and ecological region.

The Chesapeake Bay watershed incorporates more than 64,000 square miles, including over 100,000 rivers and streams, stretching from New York to Virginia. The Bay watershed is truly a unique and critical resource, and the Chesapeake Bay itself, the nation's largest estuary, is valued at over $1 trillion.[1] Indeed, Congress has recognized that the Chesapeake Bay is a "national treasure and resource of worldwide significance."[2]

In May 2009, President Obama declared the Chesapeake Bay "one of the largest and most biologically productive estuaries in the world" and issued Executive Order 13508 aimed at renewed efforts to protect and restore the Bay's health, heritage, natural resources, and social and economic value.[3] The subsequent Executive Order Strategy

[1] Chesapeake Bay Watershed Blue Ribbon Finance Panel Report, *Saving a National Treasure: Financing the Cleanup of the Chesapeake Bay* (2004).
[2] Chesapeake Bay Restoration Act of 2000, P.L. 106-457, Title II, § 202, 114 Stat. 1967 (November 7, 2000).
[3] Executive Order 13508, Chesapeake Bay Protection and Restoration, 74 Fed. Reg. 23099 (May 15, 2009), available at: http://www.whitehouse.gov/the-press-office/executive-order-chesapeake-bay-protection-and-restoration.

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released in May 2010 established a Federal Leadership Committee ("FLC") composed of representatives from several federal departments who are charged with developing an ongoing, coordinated strategy to "protect and restore the health, heritage, natural resources and social and economic value of the nation's largest estuarine ecosystem and the natural sustainability of its watershed"[4] and to consult with other stakeholders to achieve this major goal.

While DOE's presence and footprint in the Chesapeake Bay watershed is not extensive, it does have substantial administrative and some research facilities in six-state region and the District of Columbia, and it does undertake research activities here which may or may not expand in the future. Additionally, DOE has some authority over nuclear energy activity, liquefied natural gas facilities, natural gas transmission, power transmission, and certain energy resource import and export activities, all of which occur within our region. Both because of DOE's physical presence and its functional authority, we believe some existing, and some of the proposed categorical exclusions should be modified in order to be fully protective of the Chesapeake Bay and its freshwater tributaries across its watershed.

Discussion and Recommendations

The purpose of NEPA is plain and clear: federal agencies must consider environmental effects in its decision making process. To do so, federal agencies are required to prepare environmental assessments ("EA") and environmental impact statements ("EIS") that analyze the environmental effects of proposed federal agency actions. While categorical exemptions ("CEs") are permitted for categories of actions that an agency has determined do not individually or cumulatively have a significant effect on the quality of the environment,[5] an agency must still check to make sure that no extraordinary circumstances exist that may cause the proposed action to have a significant effect, and the agency must prepare an EA or EIS in the event of an extraordinary circumstance.

Generally speaking, the notion of categorical exemptions undermines the very intent of NEPA review and should be limited to the extent possible rather than routinely expanded. In accordance with the Council on Environmental Quality's ("CEQ") issuance of final technical guidance on categorical exclusions[6] in November 2010, we recommend that DOE provide a clear explanation and evidential support rather than unverified and blanket forecasts when proposing categorical exclusions. We also support CEQ's recommendation that agencies such as DOE develop a schedule for periodic review at least every seven years to determine whether these numerous CEs can be continually

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[4] Id.
[5] 40 C.F.R. §1508.4
[6] Council on Environmental Quality, "Final Guidance for Federal Departments and Agencies on Establishing, Applying, and Revising Categorical Exclusions under the National Environmental Policy Act," 75 Fed Reg 75628 (December 6, 2010), available at: http://www.gpo.gov/fdsys/pkg/FR-2010-12-06/pdf/2010-30017.pdf.

justified. CEQ's new guidance is intended to increase transparency and ensure that categorical exclusions are used only where appropriate.

Prior to our category-specific comments, we wish to comment on three of the Department's more generally-described changes. First, Part IV B of the Notice, at B.7, describes the issue of "how small is small." DOE correctly notes that all the related adjectives it uses to describe a "minor" or "negligible" impact in the following specific categorical exclusions require a consideration of "context and intensity." A project that will affect only five acres of land on a DOE site that is 500 acres in size *may* in fact be minor or negligible. However, more specificity is needed before such a conclusion can be determined that would warrant a flat categorically exemption.

The project's location on the landscape is an important factor: if the five acre project is on the DOE property's edge, adjacent to homes, a school, or a sensitive stream, for example, its impact might be considered differently. Similarly, the full landscape setting and full set of resources present are important: if the setting is largely rural with few neighbors and non-valuable habitat, that is one thing; if, however, the setting is suburban or urban (as noted), or if the land exhibits other ecological values, more consideration is required. The regulation needs to specify that these considerations will be made prior to a declaration that a project's size is so small as to have minimum impact and thus be categorically excluded from NEPA analysis.

Second, we wish to comment on certain proposed changes to Appendix B, described at Part IV E of the Notice. Specifically, in Appendix B(4), "DOE proposes to clarify its use of „environmentally sensitive resource.'" We find the proposed clarification too cramped and limiting. It would not, for example:

a) Include riparian stream buffers in places where such high environmental value lands are clearly recognized (e.g., local land use plans or guidance) but whose protection is not assured through regulation, ordinance, or statute;
b) Recognize large forest or contiguous woodland assemblages, locally specified high value farmland that is not considered "prime" farmland, or "candidate" state or federal threatened or endangered species or their habitat;
c) Include certain water resources (e.g. drinking water supply streams or reservoirs) whose immediately surrounding lands are not controlled by regulation; or
d) Include headwater streams – again, perhaps recognized as ecologically valuable in policy documents such as local land use plans, but not protected by a regulation, such as zoning.

A more expansive definition is required in order to recognize and protect these and similar resources of high local, state, or federal value and concern that may not enjoy, or may not yet have received, specific regulatory or statutory protection.

Third, the words “previously disturbed or developed area” are used extensively throughout these categorical exclusions as a way to distinguish between: (1) areas where additional development activity by many of the facilities discussed in these exclusions (such as natural gas pipelines and electrical transmission facilities, or thermal or photovoltaic solar facilities) may proceed with little environmental analysis because they would have substantially less impact on the environment; and (2) currently undeveloped areas where impacts are more likely to occur because natural conditions are still extant. For the most part, the principle is sound, but without an adequate definition of “previously disturbed or developed,” interpretation is left to chance or unstated circumstances.

“Previously disturbed” should refer to land that has largely been transformed from natural cover to a managed state and which has remained in that managed state (rather than reverted back to largely natural cover). A “developed area” is land that is largely covered by man-made land uses and activities – residential, commercial, institutional, industrial, and transportation. Such are the conditions that should prevail before areas can be said to be “previously disturbed or developed.”

Finally in this regard, while natural resource impacts are usually more likely to occur in rural and undisturbed areas, in some instances in more developed areas other adverse effects can be found -- sometimes the placement or expansion of a facility in an already disturbed or developed area, while avoiding natural resource or environmental impacts, can have significant effects on the human environment – depending upon proximity to residential and commercial land uses. The larger the facility (and ten acres may well be too large in this more urban context), the higher the possibility of such adverse interactions.

Comments on specific categorical exclusions

Categorical Exclusions Applicable to Facility Operation (B1)

B1.26 Small Water Treatment Facilities. The existing categorical exclusion allows construction or expansion of small wastewater and surface water treatment facilities without NEPA review. Small is noted as “having a total capacity less than approximately 250,000 gallons per day” [GPD]. We do not consider such facilities necessarily small, however. At 250,000 GPD, a wastewater treatment plant can serve some 1,000 homes or more than 2,500 people – the equivalent of half a small town. We believe that such a plant is at a scale that NEPA review might be appropriate – or at least that a full NEPA process should be followed, allowing a “finding of no significant impact” (FONSI) to be made if the context of such a facility so warrants.

B1.29 Disposal Facilities for Construction and Demolition Waste. DOE proposes to add "expansion" and "modification" to the existing categorical exclusion. We recommend, however, that the existing exclusion be modified still further to use "less than approximately five acres" to describe "small" in the context of this land use, instead of the current 10 acres, and to further refer to the full context issues we have noted previously.

Categorical Exclusions Applicable to Site Characterization and Environmental Monitoring (B3)
B3.14 Small-Scale Educational Facilities.
B3.15 Small-Scale Indoor Research and Development Projects Using Nanoscale Materials. The facilities parenthetically mentioned in these two proposed exclusions can be sizable and in those circumstances would not be considered "small-scale" by most measures. "Conventional teaching facilities, libraries, laboratories, auditoriums, museums, visitor centers, exhibits, and associated offices" can individually or collectively as a campus have a substantial footprint that, depending upon actual size and location, could impose significant impacts on the environment. This is the case regardless of whether that location is in a "developed area," or where such new or expanded facilities may be "contiguous to" a developed area. The same can be said for nano-materials research and development facilities. Either a specific small size (e.g., five acres or smaller) in a developed area (with specific location and context taken into account), should be the required size/location set of parameters for excludable facilities, or this categorical exclusion should be eliminated.

Categorical Exclusions Applicable to Power Resources (B4)
B4.11 Electric Power Substations and Interconnection Facilities. The proposal would categorically exclude the construction or modification of these facilities, including switching stations and support facilities. Context and size, however, should be important considerations, and a categorical exclusion without any limitations or conditions on what can be fairly substantial development is inappropriate.

With pad and clearing requirements, major electric power substations can occupy 10-20 acres of land, and depending upon location, construction, and operation, can have significant adverse impacts upon environmental resources and resource lands. While small (five acres or less) facilities may qualify for a categorical exclusion, larger facilities should be required to go through at least the minimal NEPA analyses of an environmental assessment, in order to reach the possible conclusion of a FONSI. Modifications or upgrades of existing facilities might qualify for such exclusion, to the extent they do not substantially increase the disturbed areas associated with an existing substation.

Second in this regard, permitting the categorical exclusion of such substation and interconnection/switching facilities as those that will serve new generation resources of up to 50 megawatts also means they can be of notable size – capable of serving a city of about 120,000 (40,000 households) – in our watershed, about the combined size of the cities of Wilkes-Barre and Scranton, Pennsylvania. Again, the size of the facilities (smaller or larger than five acres) should help determine whether a categorical exclusion is appropriate.

B4.12 Construction of Transmission Lines. The proposed exclusion for transmission line construction or rebuilding activities in corridors outside previously disturbed rights-of-way is too extensive. A 10-mile line can directly impact some 200 acres of land, depending upon the exact width of the corridor. In a previously undisturbed location, the impacts of the clearing of, and construction on 200 acres, and then maintaining such clearance over time, can be significant depending upon the nature of the land resources affected, the location or proximity of streams and water-bodies, and related land use/land cover/environmental issues. We do not believe a categorical exclusion is appropriate for corridors that long outside previously developed rights-of-way.

<u>Categorical Exclusions Applicable to Conservation, Fossil, and Renewable Energy Activities (B5)</u>
B5.3 Modification or Abandonment of Wells. While the limitations that DOE proposes to add help circumscribe the use of this categorical exclusion to some extent, one problem with well abandonment is that the land use impacts that occurred with the construction and operation of the well – removal of trees and other woody vegetation to construct a pad, parking areas, and access-ways -- will remain a long-standing impact unless the abandonment is accompanied by re-vegetation and rehabilitation of the land. Because such impacts continue into the future, unless that restoration practice is specified in DOE protocols and referred to here, it is inappropriate to categorically exclude abandonment as having minimal environmental impact.

<u>Appendix C to Subpart D of Part 1021 – Classes of Actions That Normally Require EAs But Not Necessarily EISs</u>
C12 Energy System Demonstration Actions. Scale is central to the consideration of demonstration projects and the extent to which they should undergo EA/EIS analyses. Demonstration actions "(including, but not limited to, wind resource, hydropower, geothermal, fossil fuel, biomass, and solar energy…)" are intended to scale-up facilities following research and development (R&D) after pilot projects, and are generally "directed at establishing proof of concept." The extent to which scale must be considered is not at all covered or clear in the language of this limited exclusion, but must be made so. It is one thing for small-scale R&D and pilot projects to move forward without extensive environmental review, in accordance with proposed section B3.6; it is quite another for an experimental energy production facility of some scale and intensity to do so with only modest environmental consideration, as may occur under this proposed language.

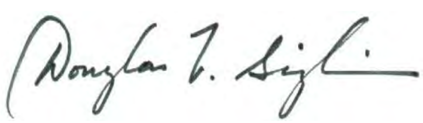
Conclusions

NEPA review is the optimal method for determining whether a proposed project presents an environmental impact. Loosening NEPA requirements by expanding categorical exemptions as currently proposed may have an unintended adverse impact on in the impaired Chesapeake Bay watershed. Because of this, we advocate against certain categorical exclusions and for further clarity with terms used to justify the need for categorical exclusions for the reasons stated above.

Thank you again for the opportunity to present our views. We look forward to working with DOE and other stakeholders to help revise the proposed rule to ensure that adequate NEPA review is rigorously applied as appropriate so that agencies and the public understand the environmental consequences of federal actions.

Respectfully submitted,

Lee R. Epstein
Director, Lands Program



Douglas V. Siglin
Federal Affairs Director

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Comment On: DOE-HQ-2010-0002-0014
National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0024
Comment on FR Doc # 2010-32316

Submitter Information

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Submitter's Representative: Regan Weeks
Organization: Pacific Northwest National Laboratory

General Comment

Please see attached.

Attachments

DOE-HQ-2010-0002-0024.1: Comment on FR Doc # 2010-32316

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** *Since 1965*

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OUT-0079-2011

February 11, 2011

NEPA Rulemaking Comments
Office of NEPA Policy and Compliance (GC-54)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington DC, 20585

RE: DOE NEPA IMPLEMENTING PROCEDURES, RIN 1990-AA34

Pacific Northwest National Laboratory (PNNL) appreciates and supports the proposed rule amending the DOE NEPA Implementing Procedures as set forth in the Federal Register on February 3, 2011 (76 FR 214). In particular, we support the development of new categorical exclusion (CX) numbers B3.16 and B5.13 through B5.25 for research and alternative energy activities. PNNL has conducted several projects of these types that have had minimal impacts on human health and the environment. The ability to conduct similar projects without the requirement to perform more detailed assessment activities will make those projects more timely and cost-efficient in the future.

We offer the following comments:

Specific Comments on Proposed Rule

1. Appendix B, "Conditions That Are Integral Elements…, B(4)(ii): Minor correction: citation should be to "Marine Mammal Protection Act", not "Mammals". See 16 USC 1361.

2. Appendix B, "Conditions That Are Integral Elements…" , B(4)(ii): consider whether the Bald and Golden Eagle Protection Act (BGEPA) should be included, since neither of those highly visible species are currently listed under the Endangered Species Act (ESA), but the "take" prohibition for these birds is the same under the BGEPA as under the ESA.

3. CX B3.16: We suggest that the second half of the CX be revised to read "None of the above activities would be conducted within the boundary of an established marine sanctuary or wildlife refuge ***in a manner that is inconsistent with the sanctuary goals and objectives*****…..**" Most of the activities under this CX (a) through (h) are essentially non-intrusive. PNNL's Marine Sciences Laboratory, on the Olympic Peninsula of Washington State, is located directly outside of the Protection Island Aquatic Reserve, which was established late last year by the State of Washington with the enthusiastic support of PNNL. PNNL occasionally supports the State by collecting biological samples, installing monitoring devices, and conducting ecological and environmental research within the boundary of the Aquatic Reserve. With no revision to the CX, our continuing support will become quite difficult and expensive to perform, with no corresponding environmental benefit.

4. CX B5.18: Include appropriate exclusionary wording regarding wind turbine installations in sensitive environments – "(6) are not sited within the boundary of an established marine sanctuary or wildlife refuge…"

5. CX B5.24: Reword this CX to read: "…(2) not have the potential to cause impacts to threatened or endangered species, or significant impacts on water quality, temperature, flow, volume, fish or wildlife" and delete the entire following sentence in the proposed rule "Covered systems would be…" . We believe protection of fish and wildlife from drop-in hydroelectric systems should be added here. Further, the limitation of the CX to "natural" fish barriers is unduly restrictive. As written, this CX could not be used for a small-scale hydro system in an irrigation canal that uses existing fish screens, or in the extensive Columbia River system above the Grand Coulee Dam. Perhaps what is intended is not to allow projects that must install additional barriers in order to protect anadromous fish; if so, that should be made clear.

6. B5.25 (and consider for B5.18): To the list of caveats add (4) "if a structure interferes with shipping navigation, or requires significant dredging for placement of a small-scale renewable energy R&D or pilot project device". These activities should be further assessed and not categorically exempt.

General Comment

Reconsider the placement of the division between appendix A and appendix B CXs. The current system allows for no prioritization; DOE NEPA implementing procedures require essentially the same level of staff time, attention, and cost for very minor activities as for more extensive activities. This is an inefficient allocation of time and money within the DOE facility complex. We suggest that DOE evaluate moving several appendix B CXs to appendix A to make them self-implementing. For instance, CX B1.3, Routine Maintenance is used to evaluate activities performed hundreds of times daily at every DOE site in a safe and largely impact-free manner. Requiring full NEPA CX documentation for these minor types of activities:

a. Requires staff time that is better spent focusing on activities with a potential for environmental impacts.
b. Results in a potential compliance gap during audits and self-assessments; it is obvious when reviewing the publicly available CX determinations that no DOE site is documenting these minor maintenance activities in the same manner that other appendix B CX activities are documented.

Thank you for the opportunity to provide comments. Should you have any questions or require additional information, please contact Regan Weeks at (509) 372-6531.

Sincerely,

Cameron M. Andersen

Cameron M. Andersen, Director
Environment, Health, Safety & Security

CMA/RSW/jek

cc: Theresa Aldridge, PNSO
Ted Pietrok, PNSO

PUBLIC SUBMISSION

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Comment On: DOE-HQ-2010-0002-0014
National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0025
Comment on FR Doc # 2010-32316

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Submitter's Representative: Jim Creevy
Organization: National Electrical Manufacturers Association (NEMA)

General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0025.1: Comment on FR Doc # 2010-32316

Setting Standards for Excellence

KYLE PITSOR
Vice President, Government Relations

February 15, 2011

Ms. Carol Borgstrom
Director
Office of NEPA Policy and Compliance
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

SUBJECT: DOE NEPA Implementing Procedures
Docket No. DOE-HQ-2010-0002
RIN 1990–AA34

Dear Ms. Borgstrom:

The National Electrical Manufacturers Association (NEMA) thanks you for the opportunity to provide the following comments on the Department of Energy's proposed rule governing compliance with the National Environmental Policy Act, released on January 3, 2011 for public comment.

As you may know, NEMA is the trade association of choice for the electrical manufacturing industry. Founded in 1926 and headquartered near Washington, D.C., its approximately 450 member companies manufacture products used in the generation, transmission and distribution, control and end-use of electricity. These comments are submitted on behalf of the member companies of the NEMA Electric Vehicle Supply Equipment and Systems Section.

We write in support of the establishment of a new class of actions in Categorical Exclusions Applicable to Conservation, Fossil, and Renewable Energy Activities (B5), namely Electric Vehicle Charging Stations (B5.23).

NEMA shares the view that, absent extraordinary circumstances, the installation, modification, operation, and removal of electric vehicle charging stations within a previously disturbed or developed area would not have the potential to cause significant environmental impacts.

National Electrical
Manufacturers Association

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Rosslyn, VA 22209
(703) 841-3274
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kyl_pitsor@nema.org

Electric vehicle charging stations, themselves with a small footprint, are generally installed within the footprint of a building or other developed property. As with many other devices that might be installed as part of a building, electric vehicle charging stations do not fundamentally alter the facility.

Such a determination would negate the requirement of completion of an Environmental Impact Statement (EIS) or an Environmental Assessment (EA). NEMA believes this exclusion would encourage the adoption of electric vehicle charging technologies. Further, rapid proliferation of charging infrastructure would accelerate the adoption of electric vehicles which would have a positive impact on the quality of the air due to decreased emissions.

Thank you again for the opportunity to provide these comments. If you have any questions, please contact Jim Creevy at jim.creevy@nema.org or 703.841.3265.

Sincerely,

Kyle Pitsor

Kyle Pitsor
Vice President,
Government Relations

As of: February 18, 2011 **Received:** February 16, 2011 **Status:** Posted **Posted:** February 16, 2011 **Tracking No.** 80bf0a92 **Comments Due:** March 07, 2011 **Submission Type:** E-mail

PUBLIC SUBMISSION

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Rulemaking to Amend 10 CFR Part 1021: National Environmental Policy Act Implementing Procedures

Comment On: DOE-HQ-2010-0002-0014
National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0026
National Environmental Policy Act Implementing Procedures

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General Comment

Please see the attachments

Attachments

DOE-HQ-2010-0002-0026: National Environmental Policy Act Implementing Procedures

From:	Julie Sibbing
To:	askNEPA
Subject:	Extension request
Date:	Wednesday, February 16, 2011 12:19:24 PM

Ms. Yardena Mansoor
Office of NEPA Policy and Compliance
Office of General Counsel
U.S. Department of Energy
askNEPA@hq.doe.go

Dear Ms. Mansoor:

On behalf of the undersigned organizations, I would like to request an extension until March 7, 2011 to the public comment period for Department of Energy notice: Docket ID: DOE–HQ–2010–0002, 10 CFR Part 102, RIN 1990–AA34, National Environmental Policy Act Implementing Procedures. We did not become aware of this Federal Register notice until yesterday and thus will not have time to prepare substantive comments prior to tomorrow's deadline.

Our organizations work extensively on solar, wind and bioenergy issues and believe that we have valuable insight to contribute to this rulemaking. We hope that your office will seriously consider this extension request in the interest of gaining the broadest possible input on this action.

We thank you in advance for your consideration of this matter.

Sincerely,

National Wildlife Federation

Friends of the Earth

International Center for Technology Assessment

Center for Food Safety

Greenpeace USA

Natural Resources Defense Council

Clean Air Task Force

Environmental Working Group

Union of Concerned Scientists

The Wilderness Society
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Rulemaking to Amend 10 CFR Part 1021: National Environmental Policy Act Implementing Procedures

Comment On: DOE-HQ-2010-0002-0014
National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0027
Comment on FR Doc # 2010-32316

Submitter Information

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Organization: Granite Construction Company

General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0027.1: Comment on FR Doc # 2010-32316

February 17, 2011

Submitted electronically: www.regulations.gov

NEPA Rule Making Comments
Office of NEPA Policy and Compliance (GC-54)
US Department of Energy
1000 Independence Avenue, SW
Washington DC, 20585

RE: DOE NEPA Implementing Procedures, RIN 1990-AA34. Docket ID: DOE-HQ-2010-0002. Comments specific to proposed categorical exclusions B5.16 and B5.18

Dear Sir:

Granite Construction Company (Granite) is one of the nation's largest diversified heavy civil contractors and construction materials producers. Granite serves public- and private-sector clients through its offices and subsidiaries nationwide. Granite fully supports renewable energy technology projects. We have reviewed the proposed rule changes outlined in the Federal Register, Volume 76, Number 1 dated January 3, 2011. The following comments and recommendations are provided in response to the January 3, 2011 notice of proposed rulemaking specific to proposed exemptions B5.16 and B5.18.

Proposed Exemption B5.16

The DOE has determined that photovoltaic systems activities would not have the potential to cause significant impacts on lands located on previously developed or disturbed lands. However, the proposed 10 acre footprint limit in the proposed exemption B5.16 does not provide adequate flexibility for commercially viable photovoltaic systems located on mine and quarry operations.

Mine and quarry operations typically have large footprints in excess of 10 acres and operate for many years following an extensive entitlement process. Mine and quarry sites are ideal for renewable energy projects as a secondary land use. These locations have previously under gone extensive environmental analyses including public review prior to receipt of operating permits. These analyses resulted in the identification and implementation by the operator of mitigation measures designed to address impacts typically identified during the NEPA process. Locating photovoltaic systems on previously entitled mine and quarry lands would not have the potential to cause significant new impacts.

Locating photovoltaic systems on currently entitled existing mine and quarry properties has the added positive impact of producing power at, or adjacent to, a significant power consumption point. Granite's experience with commercially available solar photovoltaic systems shows that the currently proposed B5.16 ten-acre footprint limitation prohibits the installation of a viable photovoltaic system sized to power mine and quarry operations or provide electricity for commercial operations. It is necessary to increase the allowable footprint in previously entitled mine and quarry properties to accommodate the space requirements for a photovoltaic system sized to power an existing mine or quarry operation or to provide commercial power.

In order to support the development of solar photovoltaic systems on mine and quarry sites Granite urges the DOE to modify categorical exemption B5.16 to read as follows:

> *The installation, modification, operation, and removal of commercially available solar photovoltaic systems located on a building or other structure (such as rooftop, parking lot or facility, and mounted to signage, lighting, gates, or fences), or if located on land, generally comprising less than or equal to 100 acres within a previously entitled, disturbed or developed area. Covered actions would be in accordance with applicable requirements (such as local land use and zoning requirements) in the proposed project area and would incorporate appropriate control technologies and best management practices.*

Granite believes that that the solar photovoltaic system activities under this modified categorical exclusion, when subject to proposed limitations, would not have the potential to cause significant impacts because:

(1) These are systems would be located on previously entitled, developed or disturbed land; and thus have already undergone environmental analyses, which in some cases are more stringent than the NEPA process. Additionally, the installation of facilities within previously entitled, developed or disturbed land would generally involve no more than minor changes to facility footprints and would not involve major new construction; and

(2) These systems generally would support all or a portion of the operation of an existing facility. Such activities also will serve to lessen potential air emissions impacts compared to electricity generated by fossil fuel or natural gas sources.

Granite urges the DOE to include the above recommended change in categorical exemption B5.16.

<u>Proposed Exemption B5.18</u>

The Department of Energy (DOE) has determined that wind turbines subject to the proposed exemption B5.18 would not have the potential to cause significant impacts on lands located on previously developed or disturbed lands. Granite supports the exemption for wind turbines as written and urges approval of proposed exemption B5.18.

Sincerely,
Granite Construction Company

Jayne Powell

Jayne Powell
Environmental Manager
Southern California Region

Southern California Region
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Indio, CA 92203
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Comment On: DOE-HQ-2010-0002-0014
National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0028
Comment on FR Doc # 2010-32316

Submitter Information

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Organization: Ocean Renewable Power Company
Government Agency Type: Federal
Government Agency: DOE

General Comment

Signed Letter.
See attached file(s)

Attachments

DOE-HQ-2010-0002-0028.1: Comment on FR Doc # 2010-32316

ORPC
OCEAN RENEWABLE POWER COMPANY

John Ferland
VICE PRESIDENT, PROJECT DEVELOPMENT

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February 17, 2011

NEPA Rulemaking Comments
Office of NEPA Policy and Compliance (GC-54)
U.S. Department of Energy
1000 Independence Ave, SW
Washington, DC, 20585

RE: DOE NEPA Implementing Procedures, RIN 1990-AA34

To Whom It May Concern:

We are writing in support of the U.S. Department of Energy's (DOE) proposal to amend its existing regulations governing compliance with the National Environmental Policy Act (NEPA). Specifically, we support the proposal identified in the Proposed Rule as B5.25 "Small-scale Renewable Energy Research and Development and Pilot Projects in Salt Water and Fresh Water Environments."

Ocean Renewable Power Company, LLC (ORPC) is headquartered in Portland, Maine with an operations center in Eastport, Maine and a project office in Anchorage, Alaska. ORPC is a developer of hydrokinetic energy technology and projects that harness the power of tidal and river currents to generate emission-free, predictable, and cost-competitive electricity. In 2008 ORPC became the first tidal energy company to generate electricity with a hydrokinetic device in the waters in the Bay of Fundy area (United States and Canada). In 2010 we built, launched and successfully tested the largest ocean energy device ever deployed in the U.S. at our permitted site in Cobscook Bay, Maine at the entrance to the Bay of Fundy.

Over the next three years, ORPC plans to commercialize its technology by installing a series of grid-connected tidal power systems off the coast of Maine and Alaska at sites where we have already received preliminary permits and plan to receive pilot project licenses from the Federal Energy Regulatory Commission (FERC).

Federal funding from DOE has been critical for helping ORPC advance its technology. We are currently managing approximately $13 million DOE marine hydrokinetic industry funded projects, with three of the projects requiring NEPA review. ORPC has initiated the state, federal and local approval processes for two of these projects.

For one project in particular, the TidGen™ Power System Commercialization Project (DE-EE0003647) — a project which provides for $10 million of DOE funding over three years, ORPC is proceeding through the FERC pilot project licensing application system and is making substantive progress with review agencies as we plan to file our final license application at the end of March 2011. ORPC, however, is also required to submit this DOE-funded project

ORPC
OCEAN RENEWABLE POWER COMPANY

separately through the existing NEPA process, a review which is already done through consultation with the same agencies that ORPC is in consultation with for permits and study plan approvals.

As you see from this example, the NEPA process creates a duplicative and unnecessary review by the existing agencies. We find the current NEPA approach to be cumbersome because 1) it adds to the cost of the regulatory process, 2) creates duplicity of agencies' reviews, 3) causes lost time internal to DOE, and 4) creates unnecessary delays for the developer. Ultimately, it raises the potential for projects to not occur because of added costs or missed schedules, which affects the ability of companies such as ORPC to acquire private financing. In point of fact, ORPC is about to lose a sampling date because DOE funds are on hold for a NEPA review, while our regulators have all ready given us approval to do the DOE-funded project.

We support the categorical exclusion process because it is consistent with the FERC Pilot Project Process, which promotes advancement of U.S. marine hydrokinetic technology. FERC developed the hydrokinetic pilot project license process to advance testing of new technology while minimizing the potential for environmental impacts. The goal of the process is to allow developers to test and evaluate new, small-scale, short-term hydrokinetic technologies and determine environmental effects of the technologies, while maintaining FERC oversight and agency input. The FERC pilot project license is an example of regulatory innovation that provides an excellent opportunity for advancing new technology in a disciplined and measured manner that is fully protective of the environment. Recognizing this opportunity, in 2009 the State of Maine signed a Memorandum of Understanding with FERC pledging alignment of state and federal approaches to regulating tidal energy pilot projects. We feel this collaborative approach sets a standard for how other agencies should streamline their tidal energy regulations. We applaud the DOE for examining its procedures and proposing the categorical exclusion.

Sincerely,

John Ferland
Vice President, Project Development

PUBLIC SUBMISSION

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Comment On: DOE-HQ-2010-0002-0014
National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0029
Comment on FR Doc # 2010-32316

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Organization: Columbia Riverkeeper

General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0029.1: Comment on FR Doc # 2010-32316

COLUMBIA RIVERKEEPER®

Clean Water ~ Healthy Rivers ~ Our Future

Columbia Riverkeeper
724 Oak Street
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Phone: (541) 387-3030
www.columbiariverkeeper.org

February 17, 2011

NEPA Rulemaking Comments
Office of NEPA Policy & Compliance (GC-54)
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

Submitted via electronic docket filing

RE: DOE NEPA Implementing Procedures, RIN-1990-AA34; Docket ID: DOE-HQ-2010-0002

Dear U.S. Department of Energy:

On behalf of Columbia Riverkeeper, please accept the following public comments on the proposed DOE NEPA Implementing Procedures, RIN-1990-AA34; Docket ID: DOE-HQ-2010-0002. For over twenty years, Columbia Riverkeeper ("Riverkeeper") and our predecessor organization, Columbia River United, have advocated for effective, prompt cleanup of the Hanford Nuclear Reservation, located along the Columbia River's shores in eastern Washington State. The Department of Energy's ("DOE") proposed changes to its National Environmental Policy Act of 1969 ("NEPA"), 42 U.S.C. § 4321 *et seq.*, implementing regulations will directly impact DOE actions at the Hanford site. We therefore urge DOE to carefully assess public comments submitted by Tri-Valley CAREs, which are herein incorporated by this reference, and the comments submitted below.

I. COLUMBIA RIVERKEEPER'S COMMITMENT TO PROMPT, EFFECTIVE CLEANUP AT HANFORD

Columbia Riverkeeper is a 501(c)(3) nonprofit organization with thousands of members in Washington and Oregon. Our mission is to protect and restore the Columbia River, from its headwaters to the Pacific Ocean. Since 1989, Columbia Riverkeeper has played an active role in monitoring and improving cleanup activities at the Hanford Nuclear Reservation ("Hanford"). A legacy of World War II and the Cold War, the Hanford site continues to leach radioactive pollution into the Columbia River. Hanford's legacy is not a local issue. Nuclear contamination from Hanford threatens the Pacific Northwest's people, a world-renowned salmon fishery, and countless other cultural and natural resources.

Columbia Riverkeeper's staff and members are dedicated to a long-term solution for Hanford cleanup. Simply put, Hanford is one of the world's most contaminated sites. Despite this status, the public and Columbia Riverkeeper's members continue to catch and consume fish from the Columbia River and recreate near and downstream of Hanford.

Each summer Columbia Riverkeeper leads a series of kayak trips on the Hanford Reach of the Columbia River. During these trips, Columbia Riverkeeper's staff and members tour areas of the Hanford Reach that are currently being polluted by excessive levels of radioactive and toxic pollution – all areas that would be affected by DOE's NEPA rulemaking proposals. The Hanford Reach is particularly unique because it is the last free-flowing stretch of the Columbia River. For example, during a trip on July 17, 2010, Riverkeeper's staff and members observed over a dozen salmonids while kayaking past the Hanford site. On these educational tours, our members learn about the Endangered Species Act-listed salmon and steelhead that spawn, rear, and migrate in the Hanford Reach.

Among the forty-three species of fish present in the Hanford Reach are several endangered species, including the Upper Columbia River spring-run Chinook salmon and steelhead ESUs. For thousands of years, the Columbia River supported the most abundant salmon runs on Earth.[i] Beginning in the late 1990s, the National Marine Fisheries Services listed thirteen stocks of migratory salmonids as threatened or endangered under the Endangered Species Act. These fish spend part of their life-cycle in the Columbia River and its tributaries and part of their life in the Pacific Ocean, eventually returning to the Columbia and its tributaries to reproduce and die.

The Hanford Reach is well documented as the only remaining significant spawning ground for the fall run Chinook salmon on the mainstem of the Columbia River.[ii] According to the U.S. Fish and Wildlife Service, "[t]he [Hanford] Reach contains islands, riffles, gravel bars, oxbow ponds, and backwater sloughs that support some of the most productive spawning areas in the Northwest, including the largest remaining stock of wild fall Chinook salmon in the Columbia River."[iii] The fall Chinook salmon that spawn and rear throughout the Hanford Reach support in-river commercial and tribal fisheries, commercial fisheries in the North Pacific Ocean, and sport fisheries.[iv]

In addition to fall run Chinook salmon, the Hanford Reach also supports over forty other species of fish, including sturgeon, steelhead, and bull trout. The prevalence of endangered and threatened fish, as well as many other species, in the Hanford Reach raises serious questions about the current and future impacts of Hanford's pollution legacy and the integrity of DOE compliance with NEPA.

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II. DOE's DUTY TO COMPLY WITH NEPA.

NEPA plays a critical role in ensuring effective cleanup and management of the Hanford site. NEPA is "our basic national charter for protection of the environment." 40 C.F.R. § 1500.1(a). By design, NEPA "is a procedural statute that requires the Federal agencies to assess the environmental consequences of their actions before those actions are undertaken." *Klamath-Siskyou Wildlands Ctr. v. Bureau of Land Mgmt.*, 387 F.3d 989, 993 (9th Cir. 2004). It "contains 'action forcing' provisions to make sure that federal agencies act according to the letter and spirit of the Act." 40 C.F.R. § 1500.1.

Congress enacted NEPA for two central purposes. First, Congress sought to ensure that all federal agencies take a "hard look" at the environmental impacts of their actions before acting. 42 U.S.C. § 4331. Second, Congress intended that NEPA provide a mechanism for the public to learn about and comment on the environmental impacts of proposed agency action. *Marsh v. Or. Natural Res. Council*, 490 U.S. 360, 371 (1989). To achieve these purposes, the Act created the Council on Environmental Quality ("CEQ") to promulgate regulations "to tell federal agencies what they must do to comply with the procedures and achieve the goals" of NEPA. 40 C.F.R. § 1500 *et seq*.

NEPA requires federal agencies "to prepare a detailed EIS [Environmental Impact Statement] for all 'major Federal actions significantly affecting the quality of the human environment.' " *Blue Mountains Biodiversity Project v. Blackwood*, 161 F.3d 1208, 1211-12 (9th Cir. 1998) (citing 42 U.S.C. § 4332(2)(C)). An Environmental Impact Statement "ensures that the agency, in reaching its decision, will have available, and will carefully consider, detailed information concerning significant environmental impacts; it also guarantees that the relevant information will be made available to the larger [public] audience that may also play a role in both the decisionmaking process and implementation of that decision." *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 349 (1989).

In particular, NEPA ensures that federal agencies make informed decisions about the potential environmental impact of an action before it is too late. *Klamath-Siskyou Wildlands Ctr. v. Bureau of Land Mgmt.*, 387 F.3d at 993. NEPA's implementing rules expressly provide that, "[u]ntil an agency issues a record of decision . . . no action concerning the proposal shall be taken which would: (1) Have an adverse environmental impact; or (2) Limit the choice of reasonable alternatives." 40 C.F.R. § 1506.1(a); see also 40 C.F.R. 1500.1(c) (one of act's fundamental purposes is to "help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment."). NEPA, therefore, promotes informed and transparent government decisionmaking.

To determine whether an EIS is required, agencies may prepare an environmental assessment ("EA"). 40 C.F.R. § 1508.9. "The purpose of an EA is to provide the agency with sufficient evidence and analysis for determining whether to prepare an EIS or to issue a FONSI." *Metcalf v. Daley*, 214 F.3d 1135, 1143 (9th Cir. 2000) (citing 40 C.F.R. § 1508.9).

In certain circumstances, federal agencies may exempt categories of actions from NEPA review via a "categorical exclusion." Specifically, 40 C.F.R. § 1508.4 states:

> *Categorical exclusion* means a category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a Federal agency in implementation of these regulations (§1507.3) and for which, therefore, neither an environmental assessment nor an environmental impact statement is required. An agency may decide in its procedures or otherwise, to prepare environmental assessments for the reasons stated in §1508.9 even though it is not required to do so. Any procedures under this section shall provide for extraordinary circumstances in which a normally excluded action may have a significant environmental effect.

(emphasis in original). According to the Council on Environmental Quality ("CEQ"), the majority of agency NEPA reviews are currently conducted under categorical exclusions.[1]

On November 23, 2010, the CEQ released a new guidance document on establishing, revising, and applying categorical exclusions under NEPA. Like the CEQ's prior guidance on categorical exclusions, the CEQ's new guidance "urges agencies to consider whether the cumulative effects of multiple small actions 'would cause sufficient environmental impact to take the actions out the categorically-excluded class.' " CEQ Memo at 5. The CEQ's new guidance goes further and advises agencies "that the text of a proposed new or revised categorical exclusion should clearly define the eligible category of actions, as well as any physical, temporal, or environmental factors that would constrain its use." *Id.*

Even if an action falls within a categorical exclusion, it may nonetheless require an EA or EIS if "extraordinary circumstances" exist. The CEQ's November 2010 guidance document states:

> When proposing new or revised categorical exclusions, Federal agencies should consider the extraordinary circumstances described in their NEPA procedures to ensure that they adequate account for those situations and settings in which a proposed categorical exclusion should not be applied.

[1]CEQ Memo from Nancy H. Sutley to the Heads of Federal Departments and Agencies, "Establishing, Applying, and Revising Categorical Exclusions under the National Environmental Policy Act" (Nov. 23, 2010) (hereinafter "CEQ Memo")

CEQ Memo at 6. The CEQ goes on to identify examples of "extraordinary circumstances." For example, the presence of an endangered or threatened species or a historic resource could be an "extraordinary circumstance."

III. SPECIFIC COMMENTS ON DOE'S DRAFT RULEMAKING PROPOSALS.

1. DOE's Description of "Extraordinary Circumstances" does not Square with CEQ Guidance.

In Appendix B to Subpart D, § 1021.410(b)(3), DOE describes "extraordinary circumstances" as "situations presented by specific proposals, including, but not limited to, scientific controversy about the environmental effects of the proposal; uncertain effects or effects involving unique or unknown risks; and unresolved conflicts concerning alternative uses of available resources."

Compared to the CEQ's examples, DOE's sets a significantly higher bar. As noted above the CEQ's November guidance document, provides examples of "extraordinary circumstances" as "presence of an endangered or threatened species or a historic resource." DOE's examples in § 1021.410(b)(3) require a more rigorous showing of "extraordinary circumstances." In practice, DOE's rules will have the effect of excluding actions from consideration under a categorical exclusion. Columbia Riverkeeper recommends that DOE revise its implementing rules to ensure consistency with CEQ guidance.

2. Property Transfers of Contaminated Property do not Warrant Categorical Exclusions pursuant to B1.24.

Categorical exclusions for transfer, lease, or disposition of contaminated are not warranted under DOE's proposed B1.24 category.

DOE proposed revision to B1.24 is not appropriate under 40 C.FR. 1508.4. Under DOE's current rules, B1.24 states:

> Transfer, lease, disposition or acquisition of interests in *uncontaminated* permanent or temporary structures, equipment therein, and only land that is necessary for use of the transferred structures and equipment, for residential, commercial, or industrial uses (including, but not limited to, office space, warehouses, equipment storage facilities) where, under reasonably foreseeable uses, there would not be any lessening in quality, or increases in volumes, concentrations, or discharge rates, of wastes, air emissions, or water effluents, and environmental impacts would generally be similar to those before the transfer, lease, disposition, or acquisition of interests. *Uncontaminated means that there would be no potential for release of substances at a level, or in a form, that would pose a threat to public health or the environment.*

(emphasis added). In the Federal Register notice for this proposed rulemaking, DOE explains proposed revisions to B1.24, stating:

> In DOE's experience, the potential for certain types of actions to have significant impacts on the human environment is generally avoided when that action takes places within a previously disturbed or developed area, *i.e,* land that has been changed such that the former state of the area and its functioning ecological processes have been altered.

Unfortunately, DOE's rationale fails to account for the environmental impacts of the proposed land transfer. For example, DOE's categorical exclusion fails to consider the environmental impacts of a land transfer post-transfer, *i.e.*, the operational impacts. Regardless of whether DOE property is "contaminated," transfer, lease, disposition or acquisition of interests in real property may have a significant impact on the environment.

Absent an EA or EIS, it is entirely unclear how DOE will transparently assess if a categorical exclusion is warranted under B1.24. DOE's proposed revisions to B1.24 states:

> Transfer, lease, disposition, or acquisition of interests in personal property (including, but not limited to, equipment and materials) or real property (including, but not limited to, permanent structures and land), provided that under reasonably foreseeable uses (1) there would be no potential for release of substances at a level, or in a form, that could pose a threat to public health or the environment and (2) the covered actions would not have the potential to cause a significant change in impacts from before the transfer, lease, disposition, or acquisition of interests.

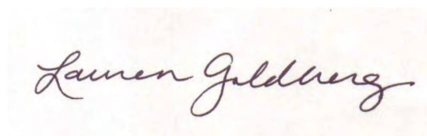
The qualifying criteria in B1.24 demonstrate that DOE's actions in transferring, leasing, disposing, and acquiring property require review under an EA or EIS. How will DOE assess if "there would be no potential for release of substances at a level, or in a form that could pose a threat to public health or the environment"? What risk levels with DOE adopt when making this assessment? How will DOE determine if "the covered actions would not have the potential to cause a significant change in impacts from before the transfer, lease, disposition, or acquisition of interests"? Based on the fact that DOE intends to use a categorical exclusion, there is no pathway for public involvement or comment on DOE's review under B1.24.

By definition, a categorical exclusion is a "category of actions which do not individually or cumulatively have a significant effect on the human environment." 40 C.F.R. § 1508.4. DOE's treatment of property transfers under B1.24 puts the cart before the horse. That is, DOE presumes no "significant effect" by placing property transfers under a categorical exclusion, and then proceeds to require an analysis of significance as part of meeting the B1.24 requirements. The proper place to assess significance is in an EA.
//

IV. CONCLUSION.

As noted above, Hanford is the most contaminated place in the western hemisphere. The proposed revisions to DOE's implementing regulations will have real consequences in DOE's management of Hanford and other DOE sites. We urge DOE to revise its regulations to ensure compliance with the plain language and intent of NEPA. Thank you in advance for considering and responding to Columbia Riverkeeper's comments. If you would like to discuss any of the issues raised in this comment, please contact me at 541-965-0985 or lauren@columbiariverkeeper.org.

Sincerely,



Lauren Goldberg
Staff Attorney, Columbia Riverkeeper

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[i] National Resource Council, *Managing the Columbia River: Instream Flows, Water Withdrawals, and Salmon Survival* (2004).
[ii] "The Hanford Reach of the Columbia River provides the only major spawning habitat for the upriver bright race of fall Chinook salmon in the mainstem Columbia River." USDOE-PNNL, PNL-7289; USDOE OSTI ID: 7051730. "Today, however, the 51-mile Hanford Reach is the only significant spawning habitat that remains for the upriver bright race of fall Chinook salmon in the main stem Columbia River." USDOE-PNNL at: http://science-ed.pnl.gov/pals/resource/cards/Chinooksalmon.stm (2009).
[ii] U.S. Fish and Wildlife Service Website, http://www.fws.gov/hanfordreach/salmon.html.
[iii] *Id.*
[iv] *Id.*

PUBLIC SUBMISSION

As of: February 18, 2011
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Docket: DOE-HQ-2010-0002
Rulemaking to Amend 10 CFR Part 1021: National Environmental Policy Act Implementing Procedures

Comment On: DOE-HQ-2010-0002-0014
National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0030
Comment on FR Doc # 2010-32316

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General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0030.1: Comment on FR Doc # 2010-32316

Amonix, Inc.
1709 Apollo Ct
Seal Beach, California 90740
Tel: (562) 200-7700
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Thursday, February 17, 2011

NEPA Rule Making Comments
Office of NEPA Policy and Compliance (GC-54)
US Department of Energy
1000 Independence Avenue, SW
Washington DC, 20585

To Whom It May Concern:

Amonix is the leading designer and manufacturer of concentrated photovoltaic (CPV) solar systems. With 21 years in business, 16 years of CPV field experience, and seven generations of system evolution, Amonix is the proven choice for utility-scale solar energy production in climates that are sunny and dry. Amonix recently used a $5.9 million manufacturing investment tax credit from the American Reinvestment and Recovery Act to build a new manufacturing facility, adding 278 new clean energy jobs, and has multiple projects in active development throughout the U.S. Southwest, primarily located on degraded sites with little to no habitat value.

Amonix has reviewed the Proposed Rule change in the National Environmental Policy Act Implementing Procedures, (as published in the Federal Register Volume 76, Number 1 on Monday, January 3, 2011), and appreciates the opportunity to comment. In particular, Amonix wishes to comment on section B5.16, which proposes a categorical exclusion for solar photovoltaic systems. We support the intent of this measure to expedite review of distributed solar energy resources with certain attributes. However, the proposed categorical exclusion is limited to projects installed on a maximum of 10 acres. This limitation is too low, as it would only advantage very small scale solar PV projects, of no more than one to two megawatts (MWs) in total capacity, and ignores the benefits of larger distributed solar projects on severely disturbed lands. Amonix can currently install one MW of solar generation per every five acres, and many other solar companies are also approaching that land-use threshold.

Amonix proposes that the categorical exclusion acreage limitation be increased to 100 acres, enabling solar energy projects of up to 20 MWs, when those projects are located on classes of land previously entitled and used for activities causing heavily land disturbance, particularly mines and quarries. Through their use, these lands have undergone extensive environmental analyses, permitting and public review that have previously confirmed the land to have no habitat or environmental value that would prohibit such uses, all of which are more impactful than the development of clean solar energy. We believe that our proposal is consistent with the Proposed Rule.

The Proposed Rule is rooted in three relevant concepts:

(1) Supporting the operation of an existing facility by providing on-site renewable energy,
(2) Compatibility with existing land use, and
(3) Minimal to no expansion of the footprint of an existing facility.

Amonix is confident that our proposal to expand the categorical exclusion to include previously disturbed lands of at least 100 acres in size fits within this paradigm.

(1) First, mines and mining facilities use a significant amount of energy, and have traditionally produced power on-site with significantly greater emissions, which could be avoided under our proposal. The 10 acre limitation in the proposed rule would artificially limit the environmental benefits that could be achieved by allowing for larger solar photovoltaic installations on-site.
(2) Second, solar installations are compatible with existing land use. Mined out lands sites offer relatively large, flat, and previously disturbed areas to install solar facilities. Importantly, solar projects can be installed in a manner that allows for mining activities to continue unimpeded.
(3) Third, even with a larger footprint than in the proposed rule, these types of solar installations would require minimal to no expansion of the footprint of disturbed areas due to their ability to make use of the pre-existing footprint of mined areas. Additionally, since these are active mines, any vegetation or animal life would be subject to the ongoing mining activities, precluding any protection. Further, a quarry or mine has clearly disturbed the natural state of the land as significantly as is possible, since the land has literally been removed from its natural state. For these reasons we believe that DOE should slightly modify its proposed rule and should enhance the categorical exclusion so as to include previously disturbed areas up to at least 100 acres, such as the mined out areas of active mines and quarries.

Finally, we believe that 100 acres is a reasonable limitation in that it would align with both existing policy priorities and industry capabilities. For example, several recent policies and regulations have been created that would spur solar distributed generation projects of up to approximately 20 MWs. For example, the Federal Energy Regulatory Commission adopted a streamlined study and interconnection process for small generation projects, up to a maximum of 20 MWs. That process is the SGIP (Small Generator Interconnection Procedures). The state of California has created new incentives for solar energy distributed generation of up to 20 megawatts in capacity, and Governor Jerry Brown has announced a statewide goal of 12 gigawatts (GWs) of renewable energy projects of up to 20 MWs in capacity, by 2020.

Thank you for your consideration of our views on this proposal, and please do not hesitate to contact us with any questions.

Best Regards,

Brian Robertson
Chief Executive Officer

As of: March 01, 2011
Received: February 18, 2011
Status: Posted
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Tracking No. 80bf2472
Comments Due: March 07, 2011
Submission Type: Web

PUBLIC SUBMISSION

Docket: DOE-HQ-2010-0002
Rulemaking to Amend 10 CFR Part 1021: National Environmental Policy Act Implementing Procedures

Comment On: DOE-HQ-2010-0002-0014
National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0031
Comment on FR Doc # 2010-32316

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General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0031.1: Comment on FR Doc # 2010-32316

OCEAN RENEWABLE ENERGY COALITION

The National Trade Association for Hydrokinetic and Marine Renewables

OREC COMMENTS ON NATIONAL ENVIRONMENTAL POLICY ACT IMPLEMENTING PROCEDURES AND DEPARTMENT OF ENERGY PROPOSED CATEGORICAL EXCLUSIONS

The Ocean Renewable Energy Coalition (OREC) hereby submits comments on the United States Department of Energy (DOE) proposed rulemaking to amend its existing regulations governing compliance with the National Environmental Policy Act (NEPA). As the national trade association for the marine and hydrokinetic (MHK) industry in the United States, OREC's comments will focus on DOE's proposed Categorical Exclusion B5.25, which would create an exclusion from NEPA for small scale, pilot projects. As discussed herein, OREC believes that the 600 pages of environmental reports and opinions from industry experts demonstrates that small scale pilot projects are not actions which would have a major effect on the environment and as such, do not trigger NEPA review. OREC applauds DOE's efforts to aid in removing barriers to development of the marine and hydrokinetic industry in the

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United States. OREC hopes that other federal agencies with jurisdiction over pilot projects will follow DOE's lead and identify ways to streamline the permitting process. OREC seeks clarification on certain aspects of the proposed rule, such as whether the categorical exclusion will apply to project transmission lines and how a "small" project would be defined.

I. OREC's Interest in the Proceeding and Background

OREC is the national trade association for the MHK industry in the United States, which encompasses wave, tidal, current, ocean thermal energy conversion (OTEC) and offshore wind. Founded in April 2005, OREC now has 45 members, including MHK industry leaders, law firms, environmental consultants and academic institutions. Since its inception, OREC has successfully lobbied Congress to appropriate money to support the development and advancement of the MHK industry in the United States. OREC has also worked closely with the Federal Energy Regulatory Commission (FERC), the Bureau of Ocean Energy Management (BOEM) and other federal and state agencies with jurisdiction over MHK projects to ensure cost effective and environmentally responsible deployment of MHK projects.

While OREC has succeeded in obtaining funding for the MHK industry and securing favorable policies (such as the ARRE Section 1603 PTC/ITC cash swap) for development, unfortunately, MHK developers have not been able to fully avail themselves of the fruits of OREC's success. The regulatory process for siting just a handful of buoys is so onerous and protracted that most MHK members will not have projects in the water in time to take advantage of the ARRE stimulus funding programs. Likewise, even the generous awards that DOE has made to project developers do not go very far because developers must spend that money on endless stakeholder meetings and pre-deployment environmental studies – rather than on technology development and post-deployment monitoring which would generate real-world data to inform the licensing process.

OREC has long recognized that defining a more efficient deployment process will help break the Catch-22 cycle – lack of data to assist with decisions on one hand but inability to get projects in the water to obtain that data on the other. Thus, OREC is gratified to see that DOE has taken substantial steps forward towards that goal.

II. DOE Proposal

A. Description of Proposal

DOE's proposed categorical exclusions apply to activities currently subject to DOE jurisdiction and requiring DOE approval. Under B5.25, DOE proposes to create a new categorical exclusion for small-scale renewable energy research and development and pilot projects in salt and freshwater environments. The exclusion would apply to projects located in areas where there is no potential for significant impact. These "off limits" locations include areas with hazardous natural bottom conditions, within the boundary of a marine sanctuary or recognized area of high biological sensitivity. Further, construction or installation of permanent devices would not be covered by the exclusion.

B. Comments

DOE's proposal is a good start towards streamlining the process. Moreover, the 600 page record amply supports DOE's conclusion that small scale pilot projects will not have significant impacts. Finally, the report's discussion of other projects are useful in understanding the types of projects that qualify for the DOE categorical exclusion.

Certain aspects of the proposed rule require more explanation. Is a "small" project measured by its footprint? Megawatt capacity? Number of units? Would a 1 MW project comprised of 40 units be considered small? Likewise, would a one unit, 10 MW project fall within the categorical exclusion. Additional information is required – though using the rough guidelines set by FERC for size qualifications for a FERC pilot license (5 MW) seems reasonable. It may be sensible to provide a range for single devices and a separate range for arrays.

Second, if a pilot project includes a transmission line, will it still qualify for an exclusion. It is vital that pilot projects have an opportunity to tie into the grid to understand operational efficiencies in real world conditions. Moreover, transmission

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lines can be deployed temporarily so inclusion of transmission lines would not conflict with DOE's basis for categorical exclusions.

Finally, additional guidance is needed on how "biologically sensitive" areas will be defined. OREC notes that one of the projects identified in the DOE Report, the Makah Pilot Project, was located in a marine sanctuary yet was still deemed to have minimal impacts. OREC does not suggest that DOE alter these requirements, but rather, that some type of guidance be put in place to help parties understand what constitutes a recognized area of biological sensitivity.

Of course, DOE's categorical exclusions only apply to DOE actions – such as release of funds for research projects or DOE-sponsored research. Many OREC members have gone past this stage and are now grappling with onerous permitting requirements for FERC licenses – a process which was intended to take one year, but is already taking twice that amount of time. FERC should review DOE's proposed exclusions and consider adopting some of the same. BOEM should also do the same.

III. CONCLUSION

Keeping projects out of the water while developers are required to perform years of studies on hypothetical impacts does not help anyone. Developers cannot get projects in the water or retain the resources to improve their technology. Without projects in the water, developers cannot gather the type of real-world data that will help resource agencies and environmental stakeholder groups evaluate the real effects of the project. For these reasons, not only does OREC support this proposed initiative, but also urges other agencies to follow suit.

Respectfully submitted,

____

Carolyn Elefant; Counsel to OREC
Ocean Renewable Energy Coalition

Paperwork Reduction Act

This proposed rule contains no new information collection or recordkeeping requirements under the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 *et seq.*).

List of Subjects

7 CFR Part 318

Cotton, Cottonseeds, Fruits, Guam, Hawaii, Plant diseases and pests, Puerto Rico, Quarantine, Transportation, Vegetables, Virgin Islands.

7 CFR Part 319

Coffee, Cotton, Fruits, Imports, Logs, Nursery stock, Plant diseases and pests, Quarantine, Reporting and recordkeeping requirements, Rice, Vegetables.

Accordingly, we are proposing to amend 7 CFR parts 318 and 319 as follows:

PART 318—STATE OF HAWAII AND TERRITORIES QUARANTINE NOTICES

1. The authority citation for part 318 continues to read as follows:

Authority: 7 U.S.C. 7701–7772 and 7781–7786; 7 CFR 2.22, 2.80, and 371.3.

§ 318.13–6 [Amended]

2. In § 318.13–16, the table in paragraph (a) is amended under Puerto Rico and U.S. Virgin Islands by removing the entries for "Cactus".

PART 319—FOREIGN QUARANTINE NOTICES

3. The authority citation for part 319 continues to read as follows:

Authority: 7 U.S.C. 450, 7701–7772, and 7781–7786; 21 U.S.C. 136 and 136a; 7 CFR 2.22, 2.80, and 371.3.

4. In § 319.37–2, paragraph (a), the table is amended by adding, in alphabetical order, new entries for *Consolea* spp., *Cylindropuntia* spp., *Nopalea* spp., and *Opuntia* spp. to read as follows:

§ 319.37–2 Prohibited articles.

(a) * * *

Prohibited article (includes seeds only if specifically mentioned)	Foreign places from which prohibited	Plant pests existing in the places named and capable of being transported with the prohibited article
* * *	* * *	*
Consolea spp.	Antigua, Argentina, Ascension Island, Australia, Bahamas, Botswana, Brazil, Cayman Islands, Cuba, Dominican Republic, Dominica, Guadeloupe, Haiti, Jamaica, Lesotho, Mauritius, Montserrat, Namibia, Nevis, New Caledonia, Paraguay, South Africa, St. Helena, St. Lucia, St. Vincent, St. Kitts, Tanzania, Uruguay, Republic of Zimbabwe.	*Cactoblastis cactorum* (South American cactus moth).
* * *	* * *	*
Cylindropuntia spp.	Antigua, Argentina, Ascension Island, Australia, Bahamas, Botswana, Brazil, Cayman Islands, Cuba, Dominican Republic, Dominica, Guadeloupe, Haiti, Jamaica, Lesotho, Mauritius, Montserrat, Namibia, Nevis, New Caledonia, Paraguay, South Africa, St. Helena, St. Lucia, St. Vincent, St. Kitts, Tanzania, Uruguay, Republic of Zimbabwe.	*Cactoblastis cactorum* (South American cactus moth).
* * *	* * *	*
Nopalea spp.	Antigua, Argentina, Ascension Island, Australia, Bahamas, Botswana, Brazil, Cayman Islands, Cuba, Dominican Republic, Dominica, Guadeloupe, Haiti, Jamaica, Lesotho, Mauritius, Montserrat, Namibia, Nevis, New Caledonia, Paraguay, South Africa, St. Helena, St. Lucia, St. Vincent, St. Kitts, Tanzania, Uruguay, Republic of Zimbabwe.	*Cactoblastis cactorum* (South American cactus moth).
* * *	* * *	*
Opuntia spp.	Antigua, Argentina, Ascension Island, Australia, Bahamas, Botswana, Brazil, Cayman Islands, Cuba, Dominican Republic, Dominica, Guadeloupe, Haiti, Jamaica, Lesotho, Mauritius, Montserrat, Namibia, Nevis, New Caledonia, Paraguay, South Africa, St. Helena, St. Lucia, St. Vincent, St. Kitts, Tanzania, Uruguay, Republic of Zimbabwe.	*Cactoblastis cactorum* (South American cactus moth).
* * *	* * *	*

* * * * *

Done in Washington, DC, this 16th day of February 2011.

Kevin Shea,

Acting Administrator, Animal and Plant Health Inspection Service.

[FR Doc. 2011–3991 Filed 2–22–11; 8:45 am]

BILLING CODE 3410–34–P

DEPARTMENT OF ENERGY

[Docket ID: DOE–HQ–2010–0002]

10 CFR Part 1021

RIN 1990–AA34

National Environmental Policy Act Implementing Procedures

AGENCY: Office of the General Counsel, U.S. Department of Energy.

ACTION: Proposed rule: re-opening of public comment period.

SUMMARY: The U.S. Department of Energy (DOE) is re-opening the public comment period for proposed amendments to its regulations governing compliance with the National Environmental Policy Act (NEPA), made available for public comment on January 3, 2011 (76 FR 214). This is being done in response to a request on behalf of multiple organizations.

DATES: The public comment period ended on February 17, 2011. The comment period is being re-opened and will close on March 7, 2011.

ADDRESSES: Submit comments, labeled "DOE NEPA Implementing Procedures, RIN 1990–AA34," by one of the following methods:

1. *Federal eRulemaking Portal: http://www.regulations.gov.* Follow the online instructions for submitting comments electronically. This rulemaking is assigned Docket ID: DOE–HQ–2010–0002. Comments may be entered directly on the Web site. Electronic files may be submitted to this Web site.

2. *Mail:* Mail comments to NEPA Rulemaking Comments, Office of NEPA Policy and Compliance (GC–54), U.S. Department of Energy, 1000 Independence Avenue, SW., Washington, DC 20585. Because security screening may delay mail sent through the U.S. Postal Service, DOE encourages electronic submittal of comments.

FOR FURTHER INFORMATION CONTACT: For general information about DOE's NEPA procedures, contact Ms. Carol Borgstrom, Director, Office of NEPA Policy and Compliance, at 202–586–4600 or leave a message at 800–472–2756. For questions concerning how to comment on this proposed rule, contact Ms. Yardena Mansoor, Office of NEPA Policy and Compliance, at *askNEPA@hq.doe.gov* or 202–586–9326.

SUPPLEMENTARY INFORMATION: On January 3, 2011, DOE published a Notice of Proposed Rulemaking in the **Federal Register** (76 FR 214) to invite public comment on proposed amendments to its existing regulations governing compliance with NEPA and announce a public hearing. The notice provided for the submission of comments by February 17, 2011, including at a public hearing held on February 4, 2011. The National Wildlife Federation, on behalf of itself and nine other organizations, requested DOE to extend the comment period to allow additional time for review of the proposed rule and the submission of comments. DOE has determined that re-opening the public comment period in response to this request is appropriate and hereby re-opens the comment period. DOE will consider any comments received between February 23, 2011 and March 7, 2011, and deems any comments received between publication of the Notice of Proposed Rulemaking on January 3, 2011, and March 7, 2011, to be timely submitted.

Issued in Washington, DC, on February 16, 2011.

Eric J. Fygi,

Acting General Counsel.

[FR Doc. 2011–3981 Filed 2–22–11; 8:45 am]

BILLING CODE 6450–01–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 39

[Docket No. FAA–2011–0043; Directorate Identifier 2010–NM–192–AD]

RIN 2120–AA64

Airworthiness Directives; Bombardier, Inc. Model DHC–8–400 Series Airplanes

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: We propose to adopt a new airworthiness directive (AD) for the products listed above. This proposed AD results from mandatory continuing airworthiness information (MCAI) originated by an aviation authority of another country to identify and correct an unsafe condition on an aviation product. The MCAI describes the unsafe condition as:

During production quality inspections of the aeroplane fuel motive flow system, it was discovered that some motive flow check valves (MFCV) were manufactured with an outlet fitting containing red anodized threads. These MFCV do not provide adequate electrical bonding between the valve and the adjacent fitting.

In the absence of proper electrical bonding within the motive flow system, the aeroplane fuel tank could be exposed to ignition sources in the case of a lightning strike.

* * * * *

The unsafe condition is the potential for ignition sources inside the fuel tanks, which, in combination with flammable fuel vapors, could result in a fuel tank explosion and consequent loss of the airplane. The proposed AD would require actions that are intended to address the unsafe condition described in the MCAI.

DATES: We must receive comments on this proposed AD by April 11, 2011.

ADDRESSES: You may send comments by any of the following methods:

- *Federal eRulemaking Portal:* Go to *http://www.regulations.gov.* Follow the instructions for submitting comments.
- *Fax:* (202) 493–2251.
- *Mail:* U.S. Department of Transportation, Docket Operations, M–30, West Building Ground Floor, Room W12–140, 1200 New Jersey Avenue, SE., Washington, DC 20590.
- *Hand Delivery:* U.S. Department of Transportation, Docket Operations, M–30, West Building Ground Floor, Room W12–40, 1200 New Jersey Avenue, SE., Washington, DC, between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays.

For service information identified in this proposed AD, contact Bombardier, Inc., Q–Series Technical Help Desk, 123 Garratt Boulevard, Toronto, Ontario M3K 1Y5, Canada; telephone 416–375–4000; fax 416–375–4539; e-mail *thd.qseries@aero.bombardier.com;* Internet *http://www.bombardier.com.* You may review copies of the referenced service information at the FAA, Transport Airplane Directorate, 1601 Lind Avenue, SW., Renton, Washington. For information on the availability of this material at the FAA, call 425–227–1221.

Examining the AD Docket

You may examine the AD docket on the Internet at *http://www.regulations.gov;* or in person at the Docket Operations office between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays. The AD docket contains this proposed AD, the regulatory evaluation, any comments received, and other information. The street address for the Docket Operations office (telephone (800) 647–5527) is in the **ADDRESSES** section. Comments will be available in the AD docket shortly after receipt.

FOR FURTHER INFORMATION CONTACT: James Delisio, Aerospace Engineer, Airframe and Mechanical Systems Branch, ANE–171, FAA, New York Aircraft Certification Office (ACO), 1600 Stewart Avenue, Suite 410, Westbury, New York 11590; telephone (516) 228–7321; fax (516) 794–5531.

SUPPLEMENTARY INFORMATION:

Comments Invited

We invite you to send any written relevant data, views, or arguments about this proposed AD. Send your comments to an address listed under the **ADDRESSES** section. Include "Docket No. FAA–2011–0043; Directorate Identifier 2010–NM–192–AD" at the beginning of your comments. We specifically invite comments on the overall regulatory, economic, environmental, and energy aspects of this proposed AD. We will consider all comments received by the closing date and may amend this proposed AD based on those comments.

We will post all comments we receive, without change, to *http://*

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Rulemaking to Amend 10 CFR Part 1021: National Environmental Policy Act Implementing Procedures

Comment On: DOE-HQ-2010-0002-0032
Re-opening of public comment period - National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0033
Comment on FR Doc # 2011-03981

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Government Agency Type: Federal
Government Agency: DOE

General Comment

wildlife needs to be protected from the murderous assaults of doe, which does not do proper environmental investigations before allowing profiteers to come in and destroy american land owned by the american public. birds need protection, as do reptiles and mammals. i think environmental assessments should NEVER Be allowed or used since they are cheap and dirty sloppy investigations of the environment.a corporate polluters like to use them. i also want to complain about the qulaity of legal work done by our govt. the lawyers hired by our govt seem to write contracts that let polluters get away with murder. complete and utter murder. we need to hire smarter lawyersr, the ones now are substandard. far too often are taxpayers called in to clean up a site. write a contract that puts the damn polluter on teh hook to clean up all that he dirties. we cannot continue to let polluters run wild in this country. the country is becoming a cesspool dur to govt agencies that have been regulatorily captured. i think doe has been regulatorily captured by profiteers with no concern for america or its environment. we need to bring doe back to working for the people of the usa instead of for the rich corporate polluters that are disgracing america.

UNITED STATES OF AMERICA
DEPARTMENT OF ENERGY

PUBLIC HEARING
ON THE

PROPOSED RULEMAKING FOR DEPARTMENT OF ENERGY
NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)
IMPLEMENTATION PROCEDURES

U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
Room 1E-245

Friday
February 4, 2011

DOE Officials:

Carol Borgstrom (Moderator)
Director
Office of NEPA Policy and Compliance
Department of Energy

Christy King-Gilmore
Attorney-Advisor
Office of the Assistant General Counsel for Environment
Department of Energy

Participants Identified:

Sean O’Neill
Ocean Renewable Energy Coalition

P R O C E E D I N G S

1:15 p.m.

MS. BORGSTROM: I should say good afternoon and welcome. I'm Carol Borgstrom. I'm the Director of the Office of NEPA Policy and Compliance at the Department of Energy. And on behalf of DOE, I thank you for taking the time to participate in this public hearing.

The purpose of this hearing is to receive oral comments from the public on DOE's proposed rulemaking, which was published in the Federal Register on January 3, 2011, regarding implementing procedures for compliance with the National Environmental Policy Act, or what we call, NEPA.

NEPA is our basic national charter for protection of the environment. It establishes policies, sets forth goals and provides means for carrying out those policies. NEPA requires federal agencies to integrate environmental values into their decision-making by considering the environmental impacts of proposed actions.

Accordingly, DOE conducts NEPA reviews for its proposed actions at one of three levels, determined in accordance with DOE’s NEPA implementing procedures at 10 CFR 1021. So-called, typical classes of actions are described in subpart D of DOE’s NEPA procedures, which identify DOE actions for which analysis at each of the three levels of review is normally required.

The three levels are environmental impact statements, the most detailed level of analysis; environmental assessments, which are brief documents to determine the need for an environmental impact statement; and categorical exclusions. I’d like to emphasize that a categorical exclusion is not an exemption from environmental review under NEPA. Rather, a categorical exclusion is a class of actions that a federal agency has determined do not, absent extraordinary circumstances, individually or cumulatively, have a significant impact on the human environment, and for which therefore, neither an environmental assessment nor an environmental impact statement is required.

Even when a categorical exclusion might apply to a particular action, DOE examines the proposal to determine if there is a reason to prepare an environmental assessment or environmental impact statement. A categorical exclusion determination is the most basic and frequently used form of environmental review under NEPA.

Now the majority of the changes that DOE proposes to make to its NEPA regulations are to the categorical exclusion provisions, with a small number of related changes proposed to other typical classes of actions. The proposed changes are based on the recommendations of DOE’s NEPA Compliance Officers, public responses to DOE’s December 2009 Request for Information, the experiences of other federal agencies, analyses of DOE experience and technical literature, and consultation with the Council on Environmental Quality in the Executive Office of the President.

The Department last updated its categorical exclusions in 1996. Since that time, DOE has gained substantial experience completing environmental reviews and implementing actions under its existing procedures. In addition, the range of activities in which DOE is involved has changed and expanded.

For example, in recent years, DOE has received more applications for financial assistance from private applicants for actions that promote energy efficiency and energy independence. DOE has received thousands of applications under grant and loan programs established by the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, and the American Recovery and Reinvestment Act of 2009.

Another change since 1996 is the growth and development of new technologies in the private and public sectors, including energy efficient and renewable energy technologies, and DOE's extensive experience with those technologies.

Through this rulemaking, DOE proposes to update its categorical exclusions to address the department's current activities and its experience and bring the provisions up to date with current technology and current regulatory requirements. In addition, DOE has established a policy to document and post on line its categorical exclusion determinations involved in classes of action listed in appendix B to subpart D of the regulations. And

DOE proposes to incorporate this policy into our regulations through this rulemaking.

The proposed revisions to DOE's categorical exclusions would promote predictability, and reduce uncertainty in their application.

The comments received here today and those submitted during the comment period, which extends through February 17th, will assist us in developing a final rule. All comments submitted on the proposed regulations during the comment period will be considered before DOE issues a final rule.

I will now describe the procedures for the hearing and provide other pertinent information.

The Federal Register notice indicated that DOE would designate an official or facilitator to preside at this hearing. I will perform that function today, with the assistance of Christy King-Gilmore, an attorney-advisor in the Office of the Assistant General Counsel for Environment. The public hearing will be informal and will not be a judicial or evidentiary type hearing.

I will call on speakers in the order in which they signed up. If you wish to speak and have not checked in at the registration desk, please do so, or we can accommodate your request here in the room if you raise your hand and come forward.

We intended to allot the speakers ten minutes for their oral statements as stated in the Federal Register notice. Again, the purpose of this hearing is to listen to and record your comments. We will not respond to your comments during today's hearing, but may ask questions to clarify your meaning.

If time permits, anyone not registered to speak may make an oral argument after all scheduled speakers have delivered their statements and also if time permits, we will allow speakers a second opportunity to speak if you so desire. A complete transcript of this hearing is being made and will be available on the DOE NEPA website, www.NEPA.energy.gov on the NEPA rulemaking page, and in our docket on www.regulations.gov.

In addition, all public comments submitted to date on this proposed rulemaking are available now in our docket on regulations.gov.

Now this information that I just read to you is provided on the handout sheet if you need the specific addresses and means for commenting. If you have a written statement to submit today, we will happily take that and insert it in the record, or you have any of the other means listed on the handout for commenting.

Okay. So we will consider all comments submitted during the public comment period, including those at this hearing. The final rule and DOE responses to comments will then be published in the Federal Register. We do appreciate your time in coming to this public hearing, and we will be pleased to receive your comments.

I should also mention evacuation procedures if we're asked to leave the building in a hurry, please follow those that are here ahead of you and it's to the left and out the stairs to the back.

I believe that's it for the opening remarks. Is there anybody who would like to make a statement at this time? Wow. I'll be sure to write that down.

I can recess this meeting. We are

committed to stay here until four o'clock, which was the published time for this hearing. We can recess until two. We have people standing at the front door to identify any visitors and direct them to this room, so I can't be sure that nobody will show up. But I propose we recess until two o'clock and see if anyone has come at that time. Is that agreeable? Anyone?

In the meantime, there are some resource materials on the table by the wall there, that includes the Notice of Proposed Rulemaking itself, the Technical Support Document, red-line strikeout of the Rule that shows explicitly what the proposed changes are, and then a version of the existing rule.

Christy, is there anything you'd like to add? Anybody?

Okay. Let's adjourn until two o'clock, thank you.

(Whereupon, at 1:25 p.m. the hearing was recessed.)

2:01 p.m.

MS. BORGSTROM: It's a little after two

o'clock and I'd like to reconvene this public hearing. Again, I see that no one has signed up to speak, but I would ask if there's anybody sitting in the room that would like to make a statement, this would be most welcomed. Anybody?

Seeing no hands, I propose that we adjourn until three o'clock. Is that agreeable to everyone? Sold. Okay. Thank you.

(Whereupon, at 2:02 p.m. the hearing was recessed.)

3:06 p.m.

MS. BORGSTROM: Okay. Thank you for your patience. We will reopen the proceedings. And I understand we have one person who would like to make a statement, and that's Sean O'Neill from the Ocean Renewable Energy Coalition. So if you would come forward, we would be happy to hear your comments.

MR. O'NEILL: Thank you very much. I'm here today to find out as much as I can about this proceeding, and also to let you know that in reviewing the supporting memo and the proposed rule, I can't be more impressed by the amount of work that you have done in a fairly short amount of time.

I've been involved in marine and hydrokinetics for at least five years, and the staff work that you've done in this short amount of time is just outstanding. You've really looked at a lot of stuff. I remember getting a phone call about four months ago, looking for information. I wasn't here. I was out of the country at the time, but people got in touch with our General Counsel, they got in touch with member companies of our coalition, and the work product was just outstanding. The people that you chose, the issues that you looked at, there was -- there's a lot of things in this industry that might be counterintuitive, and you were able to pick up on those and every nuance possible. So I can tell you, I think that the work that you're doing here is outstanding, and specifically, on the marine and hydrokinetic CX. Thank you.

MS. BORGSTROM: Thank you. Does anybody have any clarifying questions of the speaker? Very good.

Would anyone else like to make a statement?

Seeing none, I propose we recess until three o'clock, is that agreeable to everyone? Four o'clock? No. Oh, we're done at four. Why don't we recess until quarter of four, would that be okay, Christy, and if no one is here at quarter of four then we'll recess -- adjourn? Okay. So we'll recess until 3:45. Thank you very much.

(Whereupon, at 3:10 p.m. the hearing was recessed.)

3:48 p.m.

MS. BORGSTROM: Okay. I see that it's shortly after 3:45, so we'll reopen this hearing. Is there anybody who would like to make a comment?

Seeing none, we'll stay here until four o'clock and plan to adjourn at four o'clock.

(Whereupon, at 3:48 p.m. the hearing was recessed for a 12 minute period.)

MS. BORGSTROM: I'd like to call this meeting to order. I'd like to reconvene the public hearing on the DOE NEPA rulemaking. I'll ask one more time, is there anybody in the audience who would like to make a comment?

I see by the clock that it's four p.m. I propose that we adjourn. Is there any objection?

We are adjourned. Thank you.

(Whereupon, at 4:00 p.m., the hearing in the above captioned matter was adjourned.)

REPORTER'S CERTIFICATE

This is to certify that the attached proceedings before:

U.S. DEPARTMENT OF ENERGY

In the Matter of:

THE PUBLIC HEARING ON PROPOSED RULEMAKING FOR DEPARTMENT OF ENERGY NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) IMPLEMENTATION PROCEDURES

Were held as herein appears and that this is the original transcript thereof for the file of the Department, Commission, Board, Administrative Law Judge or the Agency.

Further, I am neither counsel for or related to any party to the above proceedings.

Wendy Greene
Official Reporter

Dated: February 16, 2011

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Comment On: DOE-HQ-2010-0002-0032
Re-opening of public comment period - National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0035
Comment on FR Doc # 2011-03981

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General Comment

Friends of the Earth is submitting full comments along with the International Center for Technology Assessment and the Center for Food Safety. Attached are the additional documents referenced in our comments.

The below proposed categorical exclusions to NEPA should be rejected and permanently disallowed by the DOE:
B3.6 Small-Scale Research and Development, Laboratory Operations, and Pilot Projects
B3.8 Outdoor Terrestrial Ecological and Environmental Research
B3.12 Microbiological and Biomedical Facilities
B3.15 Small-Scale Indoor Research and Development Projects Using Nanoscale Materials
B5.20 Biomass Power Plants
B5.25 Small-Scale Renewable Energy Research and Development and Pilot Projects in Salt Water and Freshwater Environments

The above provisions, in many instances, could in fact cause significant environmental impacts and therefore would be illegal to exclude from NEPA compliance.

Attachments

DOE-HQ-2010-0002-0035.1: Comment on FR Doc # 2011-03981
DOE-HQ-2010-0002-0035.2: Comment on FR Doc # 2011-03981
DOE-HQ-2010-0002-0035.3: Comment on FR Doc # 2011-03981
DOE-HQ-2010-0002-0035.4: Comment on FR Doc # 2011-03981

Nanotechnology, climate and energy: over-heated promises and hot air?

Friends of the Earth

Nanotechnology, climate and energy: over-heated promises and hot air?

"Very few people have looked beyond the shiny promise of nanotechnology to try and understand how this far-reaching new technique is actually developing. This report is an excellent glimpse inside, and it offers a judicious and balanced account of a subject we need very much to be thinking about."

– Bill McKibben, author, environmentalist, founder 350.org

Friends of the Earth

U.S. Edition

A report prepared for Friends of the Earth Australia, Friends of the Earth England, Wales, and Northern Ireland (EWNI), Friends of the Earth Europe and Friends of the Earth United States November 2010.

Written by Ian Illuminato, Friends of the Earth U.S. and Georgia Miller, Friends of the Earth Australia.

Design and layout by Lisa Matthes.

For an electronic copy of this report, or for further briefing papers from Friends of the Earth, please refer to the websites:

Friends of the Earth U.S.
http://www.foe.org

Friends of the Earth Australia
http://nano.foe.org.au

Friends of the Earth England, Wales, and Northern Ireland
http://www.foe.co.uk

Friends of the Earth Europe
http://www.foeeurope.org

This is a report by Friends of the Earth Australia, Friends of the Earth England, Wales, and Northern Ireland (EWNI), Friends of the Earth Europe and Friends of the Earth United States. Any mention of "Friends of the Earth" in this report refers to the above groups and not to Friends of the Earth International. The views expressed are those of the authors and do not necessarily represent those of Friends of the Earth; of its directors, officers, or staff; or of its funding organizations.

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executive summary

In a world increasingly concerned about climate change, resource depletion, pollution and water shortages, nanotechnology has been much heralded as a new environmental savior. Proponents have claimed that nanotechnology will deliver energy technologies that are efficient, inexpensive and environmentally sound. They predict that highly precise nanomanufacturing and the use of smaller quantities of potent nanomaterials will break the tie between economic activity and resource use. In short, it is argued that nanotechnology will enable ongoing economic growth and the expansion of consumer culture at a vastly reduced environmental cost.

In this report, for the first time, Friends of the Earth puts the 'green' claims of industry under the microscope. Our investigation reveals that the nanotechnology industry has over-promised and under-delivered. Many of the claims made regarding nanotechnology's environmental performance, and breakthroughs touted by companies claiming to be near market, are not matched by reality. Worse, the energy and environmental costs of the growing nano industry are far higher than expected.

We also reveal that despite their green rhetoric, governments in the United States, Australia, the United Kingdom, Mexico, Japan and Saudi Arabia are using public funds to develop nanotechnology to find and extract more oil and gas. The world's biggest petrochemical companies, including Halliburton, Shell, BP America, Exxon Mobil and Petrobras have established a joint consortium to fund research to increase oil extraction.

The performance of nano-based renewables has been considerably less than predicted. Efficiency of solar energy conversion by nano solar panels is still about 10 percent behind that achieved by silicon panels. The technical challenges of bringing renewable energy laboratory achievements to market have been prohibitive in many instances. The United States President's Council of Advisors on Science and Technology states that in 2009 only one percent of global nanotechnology-based products came from the energy and environmental sector.

The energy demands and environmental impacts of manufacturing nanomaterials are unexpectedly high. Manufacturing carbon nanofibers requires 13 to 50 times the energy required to manufacture smelting aluminum, and 95-360 times the energy to make steel, on an equal mass basis. A team of United States researchers has concluded that single walled carbon nanotubes may be "one of the most energy intensive materials known to humankind".

Due to the large energy demands of manufacturing nanomaterials, even some nano applications in the energy saving sector will come at a net energy cost. For example even though strengthening windmill blades with carbon nanofibers would make the blades lighter, because of the energy required to manufacture the nanoblades, early life cycle analysis shows that it could be more energy efficient to use conventional windmill blades.

Much-touted nano developments in the hydrogen sector are at a very early stage. It is improbable that cars powered by renewable energy generated hydrogen will be on the roads in the next ten or twenty years – the period in which emissions cuts are critical. In the meantime, development of hydrogen cars entrenches reliance on fossil fuels to produce the hydrogen.

Nanotechnology is not an unqualified environmental savior nor will its widespread use in everything from socks to face creams enable us to pursue 'business as usual' while substantively reducing our environmental footprint.

Most nanoproducts are not designed for the energy sector and will come at a net energy cost. Super strong nano golf clubs, wrinkle disguising nanocosmetics, and color-enhanced television screens take a large quantity of energy to produce, while offering no environmental savings. Such nanoproducts greatly outnumber applications in which nano could deliver net energy savings.

The environmental demands of nanomanufacturing are higher than that of conventional materials. Nanomanufacturing is characterized by very high use of water and solvents. Large quantities of hazardous substances are used or generated as byproducts. Only one tenth of one percent of materials used to manufacture nanoproducts found in computers and electronic goods are contained in the final products. That is, 99.9 percent of materials used in manufacturing become waste products.

Despite the serious uncertainties, there is a growing body of research demonstrating that some nanomaterials used in energy generation, storage and efficiency applications can pose health and environmental risks. Carbon nanotubes are touted for use in electronics, energy applications, and specialty car and plane parts. However, early research shows that some forms of nanotubes can cause mesothelioma, the deadly cancer associated with asbestos exposure.

The release of nanomaterials to the environment could also result in accelerated generation of potent greenhouse gas emissions. Antibacterial nano silver is used widely in clothing, textiles, cleaning products, personal care products and surface coatings. Yet preliminary study shows that when nano silver is exposed to sludge, similar to that found in typical waste water treatment plants, four times the typical level of the potent greenhouse gas nitrous oxide is released.

Nanotechnology is not an unqualified environmental savior nor will its widespread use in everything from socks to face creams enable us to pursue 'business as usual' while substantively reducing our environmental footprint. At best, such claims can be interpreted as the result of wishful thinking on the part of proponents; at worst they can be seen as misleading greenwash.

Nanotechnology is a powerful technology that has the potential to deliver novel approaches to the methods by which we harness, use, and store energy. Nevertheless, Friends of the Earth warns that overall, this technology will come at a huge energy and broader environmental cost. Nanotechnology may ultimately facilitate the next wave of expansion of the global economy, deepening our reliance on fossil fuels and existing hazardous chemicals, while introducing a new generation of hazards. Further, it may transform and integrate ever-more parts of nature into our systems of production and consumption.

background

Wasteful and inequitable consumption and production has had a devastating environmental impact (UNEP 2010). Desertification, salinity, polluted air and soils, lack of potable water, huge losses to biodiversity, plummeting fish stocks, and increasing competition for arable land between buildings, food crops and biofuels characterize the first decade of the 21st century.

At the same time as ecological systems and services have been stretched to a breaking point, economic inequity between the global rich and global poor has widened.[1] The years 2008 and 2009 saw the worst world food crisis ever. Despite decades of medical breakthroughs, between 1.7 and 2 billion people worldwide have inadequate or no access to life-saving basic medicines (UN Millennium Project 2005).

Climate change and global warming have been viewed as the meta problem, "the defining human development issue of our generation" (UNDP 2007, 1). If left unchecked, climate change is predicted to promote greater ocean acidification, loss of species, loss of arable crop land, and diminished fresh water resources. At the same time, more extreme weather events, crop failures and rising ocean levels may create a new wave of environmental refugees and shifting patterns of disease. The world's poorest people will disproportionately bear the negative impacts of these changes (United Nations Development Programme 2007).

The United States (US) National Aeronautics and Space Administration (NASA) has already reported the effects of global climate change on the environment. According to NASA,

> *"Glaciers have shrunk, ice on rivers and lakes is breaking up earlier, plant and animal ranges have shifted and trees are flowering sooner. Effects that scientists had predicted in the past would result from global climate change are now occurring: loss of sea ice, accelerated sea level rise and longer, more intense heat waves" (National Aeronautics and Space Administration n.d.).*

The International Panel on Climate Change (IPCC) has advised that for a 46 percent chance of

1 The gap between the global rich and the global poor is growing, although by some measures economic inequality between countries is decreasing. Milanovic (2005, cited in Cozzens et al. 2008) has examined global data, and concludes that inequality between countries' gross domestic product (GDP) per capita is rising. If GDP is weighted by population, inequality between countries is declining. Nonetheless, data analyzed by Milanovic and others demonstrate that inequality within countries is increasing.

stabilizing temperature rises below 2°C, the point at which major melting of sea ice and a 'domino effect' of warming could occur, greenhouse gas (GHG) emissions from Annex-I (industrialized) countries must fall by 25–40 percent on 1990 levels by 2020, and must fall by 85-90 percent by 2050 (Chapter 13, Box 13.7; IPCC AR4 WGIII 2007). Even using the IPCC's assumptions, which have been criticized by environmentalists as unreasonably conservative, this dramatic reduction in greenhouse gas emissions delivers only roughly even odds that global temperatures will not rise above 2°C (Spratt 2009; Zhou 2009).

Governments around the world have struggled to agree on policy targets for greenhouse gas reductions commensurate with recommendations from the IPCC, while industry has struggled to find new economic opportunities in a potentially carbon-restricted future marketplace. Renewed attention has been focused on the technology sector to deliver 'drop in' substitute energy, services, and goods that achieve emissions savings without requiring the public or industry to modify behavior, consumption or production (Oakdene Hollins 2007).

As concern about the potential of catastrophic climate change grows, there is strong public support for investment in sustainable, renewable energy alternatives to fossil fuels. But all too often industry and governments are prepared to promote new (or old) technologies with a thick veneer of 'greenwash', presenting them as environmental saviors despite evidence of serious environmental risks, costs or challenges (for example the renewed marketing of nuclear as a 'green' solution to climate change, or the oxymoron of 'clean coal'). The hype around nanotechnology fits this pattern.

Nanotechnology, the so-called 'science of the small', has been the subject of consistent and often unqualified promotion by governments and industry. Nanotechnology is being marketed as the ultimate 'techno-fix'. Some have even claimed that nanotechnology will break the tie between resource use and economic expansion, allowing us to continue business as usual growth, while reducing energy consumption and greenhouse gas emissions.

Nanotechnology proponents suggest that it will enable accelerated economic expansion, more extensive fossil fuel extraction, greater air travel and new generations of consumer goods – all at a vastly discounted environmental cost. Some of the following media headlines provide a sense of how hyperbolic this nano hype has become: "Nanotechnology and Carbon Capture Can Yield an Endless Supply of Fuel and Chemicals" (Parrish 2010); "nanotech processes can produce cheap solar panels by the acre, finally delivering on the promise of low-cost solar energy" (lightbucket 2008); "[nano will allow for] a permanent inexhaustible supply of carbon containing fuels or products" (Parrish 2010).

Nanotechnology, the so-called 'science of the small', has been the subject of consistent and often unqualified promotion by governments and industry. Nanotechnology is being marketed as the ultimate 'techno-fix'.

The results of Friends of the Earth's investigation demonstrate that these claims are misplaced. Far from offering 'silver bullet' solutions, nanotechnology may in fact impose a new level of energy and environmental costs.

what is nanotechnology and how is it used?

Nanotechnology is a powerful new technology for taking apart and reconstructing nature at the atomic and molecular level. It is being touted as the basis of the next industrial revolution and will be used to transform and construct a wide range of new materials, devices, technological systems and even living organisms.

Nanotechnology involves the design, characterization, production and application of structures, devices and systems by controlling shape and size at the extremely small 'nanoscale'. The International Standards Organisation (ISO) defines a 'nanomaterial' as having one or more dimensions that measure less than 100 nanometers (nm), or an internal structure or surface structure at this scale (European Commission 2010).

The fundamental properties of matter change at the nanoscale. The physical and chemical properties of nanoparticles can be quite different from those of larger particles of the same substance. Altered properties can include but are not limited to color, solubility, material strength, electrical conductivity, magnetic behavior, mobility (within the environment and within the human body), chemical reactivity and biological activity.

The altered properties of nanoparticles have created new possibilities for profitable products and applications. Most 'first generation' nanoproducts contain passive nanoparticles that impart novel properties, for example T-shirts that contain nanoparticles of silver to impart antibacterial properties, or car body parts made from polymer composites strengthened through addition of carbon nanotubes (see Glossary).

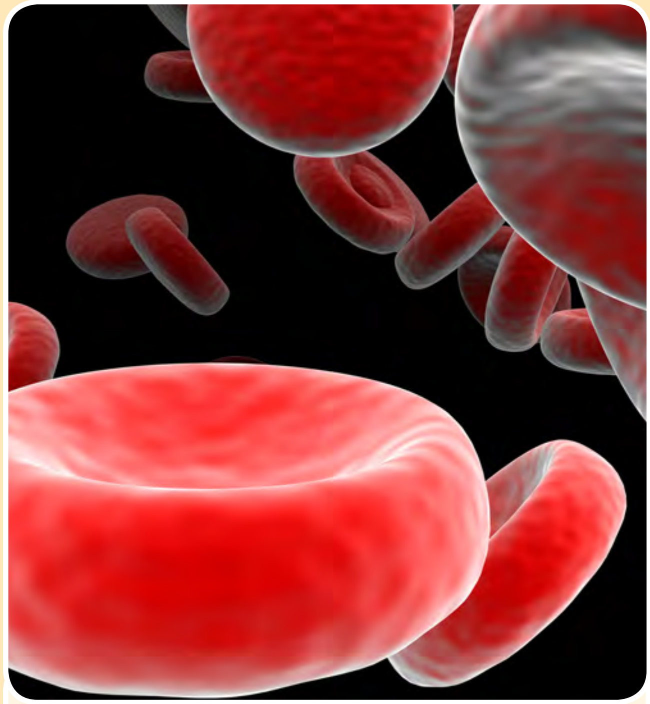
The use of nanoparticles, the potential of nanofabrication, and molecular manufacturing, have attracted keen interest from the research and business communities. In the US, the Department of Energy (DOE) has constructed five new nanoscale research centers with the mission to "support the synthesis, processing, fabrication and analysis at the nanoscale… [providing] the nation with resources unmatched anywhere else in the world" (CNMS n.d.). Much of this enthusiasm is backed by the belief that nanoscale engineering will allow for:

- More powerful, versatile and inexpensive solar panels;
- Stronger and lighter wind turbines;
- More extensive identification of oil and gas reserves and more effective extraction;

- More powerful and longer lasting batteries;
- Methods for harnessing hydrogen energy;
- Greater efficiency in lighting;
- Energy saving insulation materials;
- Lubricants able to increase the function and lifespan of machinery;
- Efficiency gains in fossil fuels through nano catalysts; and
- Stronger and lighter materials to improve transportation efficiency.

Most nanoparticles are not developed or used for energy efficiency or to reduce a product's environmental footprint.

Intentionally manufactured nanoparticles are already found in a wide range of other products, such as cosmetics, sunscreens, clothing, paints, cleaning products, sporting goods, household appliances, surface coatings, agricultural chemicals, food packaging, 'health' supplements, industrial catalysts and building equipment. Most nanoparticles are not developed or used for energy efficiency or to reduce a product's environmental footprint. The burgeoning commercial use of nanoparticles in these products will also have an impact on the energy demands and environmental costs of manufacturing. Early life analyses demonstrate that the ecological burden of nanomaterials manufacturing is far greater than that of conventional scale (larger) materials (Khanna et al. 2008; Sengul et al. 2008; see sections following).



To get some sense of scale, consider that a human hair is approximately 80,000nm wide, a red blood cell 7,000nm wide and a strand of DNA 2.5nm wide. A nanomaterial 100nm in size is approximately 800 times smaller than the width of a strand of hair, and 70 times smaller than a red blood cell. The smallest nanomaterials exist at the same scale as our bodies' DNA.

nano-based energy generation, storage, and savings

Following is a summary of the nanotechnologies most commonly promoted as solutions to the energy and climate crisis. Many of these technologies use nanomaterials or nanosystems to extend or alter the capacity of existing technologies. As with other technologies, nano applications are often combined into larger systems, for example, nanobatteries can be used alongside nano solar panels in solar energy farms, and nanocoatings, insulators, and energy storage devices can help store energy produced.

Renewable energy technologies such as solar power and wind offer important opportunities to move away from greenhouse gas-intensive fossil fuels. Nonetheless, all renewables have an environmental footprint. Our interest lies in whether nanotechnology provides solutions that improve on the functionality of existing technologies, the impact of nanotechnology use on a technology's life cycle emissions and energy demands (whether its use saves energy or requires more), and the extent to which nanotechnology imposes new environment or health burdens.

Measuring electricity

Units of electrical power are measured as watts. One thousand watts is equal to one kilowatt (kW). A megawatt (MW) is one million watts, a gigawatt (GW) is one billion watts, and a terawatt (TW) is one trillion watts.

Large-scale energy consumption and production is often measured in watt hours (Wh). The US Energy Information Administration (EIA) defines a watt hour as "an electric energy unit of measure equal to one watt of power supplied to (or taken from) an electric circuit steadily for one hour" (EIA n.d.). Megawatt hours measure the amount of electricity produced by an electric generator over time; a megawatt measures how much electricity the generator can produce (Renewable Energy Trust n.d.). For example, one kilowatt hour will power a 100 watt light bulb for 10 hours (Johnson 2009). Electricity generated worldwide in 2006 was 19,015 terawatt-hours (TWh; Johnson 2009).

Electricity consumption

There are substantial differences in household electricity consumption internationally (Table 1). Wealthy countries use far more electricity than poorer countries, but even among the industrialized countries there is large variation. Households in the United Kingdom (UK) use less than half the electricity used by households in the United States (US).

Table 1: Electricity consumption per household differs widely between countries

Country or Region	Electricity consumption per household (kWh; year measured)	Number of people per household (year measured)	Reference
United States	11,040 kWh (2008)	2.5 (2010)	(US EIA 2010)
Australia	7,987 kWh (2007)	2.6 (2006)	(ESCAP 2010)
United Kingdom	4,800 kWh (2007)	2.36 (2001)	(UK BERR 2007)
China	1,392 kWh (2007)	2.98 (2005)	(ESCAP 2010)
India	561.6 kWh (2007)	5.4 (2001)	(ESCAP 2010)
Bangladesh	336 kWh (2007)	5.6	(ESCAP 2010)

Nano and solar energy

Summary

Use of nanotechnology in thin film solar panels enables 'roll to roll' printing and easier manufacturing. Panels based on flexible steel and plastic also allow a greater range of applications, for example on portable objects. Manufacture of some forms of thin film and nano solar panels is possible at costs that are lower than that of conventional silicon panels, although recent massive Chinese investment in silicon PV panels has reduced their costs. Further, the solar conversion efficiency of nano-based solar panels still lags considerably behind that of silicon panels: 6-13 percent compared to around 20 percent. The nano sector has been plagued with problems scaling up laboratory achievements to commercial products. The durability of dye-sensitized nano solar panels and fullerene-based organic panels is less than ten years – fifteen to twenty years less than that of conventional silicon panels. This further reduces the life cycle energy efficiency of these nanopanels. Nanomaterials used in nano solar, including silver, cadmium and other heavy metals, pose toxicity risks for human health and the environment. End of life recovery of nanomaterials and recycling is uneconomic, requiring government intervention to prevent irresponsible disposal of panels and to recover rare metals and rare earths. The scarcity of metals such as indium and gallium may be a near term constraint to the widespread development of some thin film nano solar.

Background

Electricity can be produced using photovoltaic (PV) materials in solar panels that act as semiconductors. Beyond domestic use, PV panels are also beginning to be deployed in large-scale solar power stations. PV panels work by absorbing the sun's radiation, then transferring it to supply power. Photovoltaic solar panels rely on technologies as complex as those used in computer semiconductors (otherwise known as computer chips) which are used to store memory in small devices. Most PV panels are made from thick 'wafers' of silicon. The silicon is fragile, limiting the range of settings in which panels can be used. Manufacturing PV panels from silicon is also more costly than generating the same energy via fossil fuels.

Another growing area of solar power is 'solar thermal'. Unlike photovoltaics, solar thermal uses the energy in sunlight to generate heat, rather than electricity. Low and medium temperature collectors are commonly used to heat swimming pools or the water or air in homes or businesses. High temperature collectors concentrate sunlight using mirrors or lenses, then use this heat energy to generate electricity (concentrated solar power; NREL n.d.). Concentrated solar power can use existing energy storage technologies and conventional electric power generating plants (for example steam plants) that historically have been interfaced to the grid and distribution networks (NSTC Committee on Technology 2010). This makes it attractive to major utility companies and governments looking to use renewable energy while continuing centralized power generation.

A key attraction of solar thermal is the capacity to store energy in the form of heat. Although the costs are still high, a researcher at the US National Renewable Energy Laboratory (US NREL) suggests that solar thermal can now store up to

Friends of the Earth

around 16 hours' worth of energy (Beyond Zero Emissions 2009). A study by Stanford University researchers found that 93 per cent of California's annual grid electricity could be supplied by solar thermal power stations that had 15 hours storage. Solar thermal stations with storage could supply 95 per cent of the US annual grid, using land of 140 kilometers square (Manning 2009).

How is nanotechnology claimed to improve existing technology?

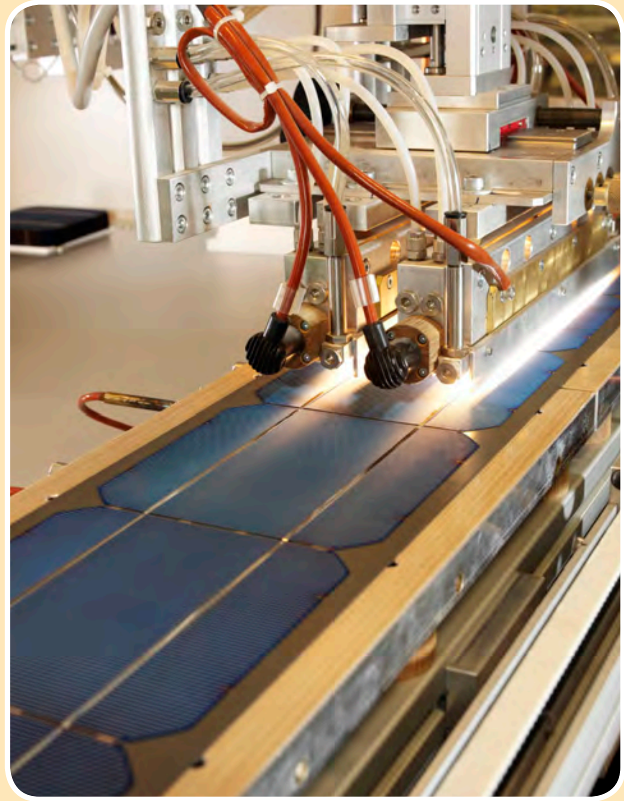
Nanotechnology is enabling the manufacture of thin film solar panels that use much less silicon. In the case of 'organic' or plastic based PV panels, no silicon is used. Nano solar proponents have asserted that by increasing solar energy conversion efficiency ('efficiency'), extending the range of places in which solar panels can be used, and reducing production costs, nanotechnology will enable solar panels to compete with fossil fuel energy.

A key breakthrough has been the development of 'roll to roll' printing (similar to newspaper printing) of nano PV components onto foil or plastic substrates. Roll to roll printing offers greater flexibility than the manufacture of silicon solar cells. It is also believed that thin film is cheaper to produce, although many companies do not disclose the cost per watt, and recent price reductions have been achieved with silicon panels (see sections following). The disadvantage is that roll to roll printing introduces a greater level of defects into panels (Gupta, et al. 2009).

Plastic and foil substrates used in some thin film don't need the bulky aluminum or glass frames of silicon solar panels. They can be incorporated onto a greater variety of building substrates, and even moving objects such as luggage or computers.

Companies that sell nano solar panels to solar power plants claim that the key benefit nanotechnology offers is the speed with which the panels can be deployed. In providing panels for a German power plant, Nanosolar claimed that a station 10MW in size could be "up and running in six to nine months compared to 10 years or more for coal-powered stations and 15 years for nuclear plants" (Vidal 2007).

There are three key areas in which nanotechnology is mooted for use in solar thermal: in coatings



to improve the collection capacity of concentrated solar power receivers; for use in heat energy storage liquids to improve their thermal properties; and in the development of efficient thermo-electric (heat-electricity) converters (NSTC Committee on Technology 2010). Companies are also selling nanomaterial-based coatings to insulate solar thermal storage.

How is nanotechnology used?

Nanomaterials have an increased surface area to volume ratio. Coupled with their novel optical and electrical properties, this could allow them to capture greater quantities of the sun's light than is possible in silicon panels. There are several nanomaterials being incorporated in thin film solar cells, including fullerenes, titanium dioxide, silver, quantum dots and cadmium telluride.

Quantum dots are nanoscale spheres of inorganic materials that show novel optical properties, enabling light from different wavelengths to produce visible light. Cadmium selenide quantum dots mixed with other nanoparticles, such as titanium dioxide nanotubes (hollow cylinders) have the potential to increase solar cell efficiency by absorbing different wavelengths of light at the same time, which is not possible with other solar cell systems (Berger 2008). The Stanford PULSE Institute for Ultrafast Energy Science has researched the potential of quantum dots to improve solar cell efficiency, demonstrating that in laboratory conditions one photon of light can generate multiple electrons (Tuttle 2009).

A thin film solar cell (TFSC), also called a thin film photovoltaic cell (TFPV), is a solar cell that is made by depositing one or more thin layers (thin film) of photovoltaic material on a substrate. The thickness range of such a layer is wide and varies from a few nanometers to tens of micrometers. Many different photovoltaic materials are deposited with various deposition methods on a variety of substrates. Thin film solar cells are usually categorized according to the photovoltaic material used:

- Amorphous silicon (a-Si) and other thin film silicon (TF-Si)
- Cadmium telluride (CdTe)
- Copper indium gallium selenide (CIS or CIGS)
- Dye-sensitized solar cell (DSC) and other organic solar cells
- Thin film silicon (uses amorphous, proto-crystalline, nano-crystalline or black silicon). Thin film silicon is opposed to wafer (or bulk) silicon (mono-crystalline or poly-crystalline).

A key potential nanotechnology application for solar thermal is in the fabrication of concentrated solar power 'receivers' and the development of high solar optical absorption materials and coatings that can operate at high temperatures under high solar concentration fluxes (NSTC Committee on Technology 2010). Nanocoatings on the receivers' surface could improve their thermal capture and thermal transfer properties as well as providing corrosion resistance (Berger 2009a).

Research into using nanomaterials to improve the thermal properties of liquids for heat storage at solar thermal power plants is at an early stage. However, researchers suggest that adding nanomaterials to fluids could be one of the ways in which the capacity for heat storage is increased (Beyond Zero Emissions 2009).

Proponents also hope that nanomaterials with thermoelectric properties will increase the efficiency of converting heat to electricity (NSTC Committee on Technology 2010). The hope is that thermal energy could be harvested from waste heat created during solar power generation by thermoelectric devices. As an example, functionalized carbon nanotube films are being explored as potential thermoelectric materials that could absorb heat and provide electricity. However, again, this research is at a very early stage.

Commercial presence

Nanophotovoltaics are increasing their commercial presence, although they still make up a small fraction of the sales of silicon panels. Global sales of PV were worth approximately US$38.5 billion in 2009. Jason Eckstein, solar analyst at nanotechnology analyst firm Lux Research, estimates that crystalline silicon has 75 percent of the world market for all solar technologies. Cadmium telluride thin film panels, primarily from First Solar, have 12 percent of the market, while CIGS has only a 1 to 2 percent share (Voith 2010). One organic electrical specialist and academic has observed that most companies developing plastic solar panels remain at research and development stage: "For now, we can safely claim that organic [plastic] photovoltaics has a nearly zero percent share of the market" (Jacoby 2010). Large-scale arrays of titanium dioxide-based nanofilaments (including nanotubes and nanowires) are already being used in photovoltaic cells (Berger 2009b).

First Solar is by far the largest supplier of nano solar cells. In 2009 it was the world's largest manufacturer of PV panels, shipping more than a gigawatt of solar panels during the year (RenewableEnergyWorld.com 2010). Company Nanosolar produces thin film solar panels made from a PV nanoparticle ink composed of Copper Indium Gallium Selenide (CIGS). This nano ink is printed onto flexible metal foil through a production process similar to a printing press, then encased in glass. Walmart recently partnered with two CIGS manufacturers, SolarCity and MiaSolé, to install thin film solar panels at 20 to 30 of Walmart's buildings in Arizona and California (Walmart 2010). Ironically, SolarCity will also be installing a large number of conventional silicon panels for Walmart, most of them made in China at low costs (Woody 2010).

Amidst the hype that nano solar technologies will soon deliver energy at half the price of oil, coal or gas, in 2007 nanotechnology analyst Cientifica's CEO warned that the obstacles to scaling up laboratory discoveries were considerable and that a 'reality check' was required regarding its promise.

Konarka, another supplier of nano solar cells, has recently opened what it claims is the world's largest roll-to-roll flexible plastic film solar manufacturing facility (Konarka 2010). The company has partnered with Traveler's Choice to develop a range of travel bags and luggage that incorporate its flexible solar panels, which can in turn power small hand held devices (Konarka n.d.). Konarka claims that in full sun, a solar bag can recharge a cellular phone in two hours. The line has recently become available in retail outlets in the northern hemisphere.

It is not clear whether any solar thermal stations are using nanomaterials in their storage fluids. However, some companies are marketing nanoproducts for use in solar thermal. Nansulate sells a nanomaterial-based coating which it claims improves the insulation properties of solar thermal storage (Nanotechnology Now 2010).

Does nanotechnology deliver?

There is debate about the extent to which nanotechnology offers real breakthrough potential in solar energy. Amidst the hype that nano solar technologies will soon deliver energy at half the price of oil, coal or gas, in 2007 nanotechnology analyst Cientifica's CEO warned that the obstacles to scaling up laboratory discoveries were considerable and that a 'reality check' was required regarding its promise (Harper 2007). The challenges associated with taking a nano solar lab discovery and scaling it up to deliver a marketable product have proven prohibitive for many companies. A Lux Research analyst has cautioned that even high profile companies making thin film photovoltaics who claim to be using nanotechnology to lower costs have struggled to scale up laboratory achievements and to still achieve a functioning product (Lubick 2009). As a recent New York Times article highlights, "producing CIGS cells on a mass scale has turned out to be a formidable technological challenge" (Woody 2010).

A group of US researchers has cautioned that amongst the buzz surrounding nano solar are "questionable claims on the scientific facts" (Gupta, et al. 2009). They are pessimistic about nano solar's prospects: "nanostructure solar cells are unlikely to play a significant role in the manufacturing of future generations of PV modules" (Gupta, et al. 2009). They blame unrealistic assumptions involved in theoretical work and a failure to take into account manufacturing and scale-up constraints for the misplaced hype about nano solar's potential.

One of the key areas where nanotechnology has offered an advantage until recently is in reducing production costs. As a general rule, thin film modules (sets of panels) are lower priced than silicon modules for equivalent energy powers (Solarbuzz 2010). In its October 2010 review of the solar module retail price environment, Solarbuzz found that the lowest retail price for a multi-crystalline silicon solar module was US$1.97 per watt from a US retailer. The lowest retail price for a mono-crystalline silicon module was $2.21 per watt (€1.61 per watt), from a German retailer. The lowest thin film module price was US$1.40 per watt from a US-based retailer (Solarbuzz does make the point that technical attributes and prices are variable).

In spite of this, the cost advantage associated with using thin film nano solar has been eroded in recent months. Falling costs of silicon have lowered the costs of manufacturing silicon cells. Massive investment by the Chinese government to expand significantly its solar production has helped drive the price of solar panels down 40 percent in the past year (Woody 2010). "The solar market has changed so much it's almost enough to make you want to cry," Joseph Laia, chief executive of thin film company MiaSolé told the *New York Times*.

Another area where nano solar offers an advantage over silicon solar is in flexibility of production and of panel use. The minority of nano solar panels which are based on plastics rather than silicon can be transported more easily and are far less fragile. The light weight panels can be used in a greater diversity of settings, including mobile applications such as laptops or travel luggage. Konarka is now offering solar panels for use on travel luggage, to power laptop computers or mobile phones (Konarka n.d.). Thin film flexible panels installed on roofs or other building structures are very low in weight, are not subject to wind lifting, and can be walked on (with care).

Conversely, nanotechnology has not delivered in the key area of solar power efficiency. Although nano-proponents hope that in the future nanotechnology will deliver higher efficiency solar panels than silicon panels, to date the efficiency of nano solar panels is considerably less than that of traditional silicon panels (Tables 2 and 3). Despite the achievement of high efficiency in laboratory trials, manufacturers have struggled to replicate these in commercial applications. An early laboratory discovery led to suggestions that future generations of quantum dot solar panels could deliver 44 percent efficiency under normal light conditions, and up to 68 percent under sunlight concentrated by a factor of 500 (NREL 2007). But so far higher efficiency for quantum dot panels has only been demonstrated in laboratories (Kongkanand, et al. 2008). Similarly, Nanosolar

Table 2: Efficiencies and cost per watt of PV panels reported by a sample of nano solar companies

Type of solar cell	Company	Efficiency (of production panels unless otherwise stated)	Cost per Watt
Nano (polymer-fullerene on flexible plastic)	Konarka	6.4% in 2009 (Wemett 2009)	<US$1.00 (Condon 2008)
Nano (CIGS on foil in glass)	Nanosolar	8-9% in 2010 (Cheyney 2010a)	Sell products for US$1/ watt (Madrigal 2009)
Nano (CIGS on flexible stainless steel)	Global Solar	11% in 2010 (Cheyney 2010b)	Company declines to disclose (Wesoff 2010)
Nano (cadmium telluride on glass)	First Solar	11.2% in 2010 (Osborne 2010)	US$0.76 (Osborne 2010)
Nano (CIGS on glass)	HelioVolt	12.2% in 2008 (of a 'champion' panel, not their average; Kho 2008)	Not yet commercial
Nano (CIGS on glass)	MiaSolé	14.3% in 2010 (Solar Daily 2010)	US$0.85 (Fehrenbacher 2010)

Table 3: Confirmed PV module efficiencies measured under the global AM1.5 spectrum (1000W/m2) at a cell temperature of 25°C *(from Table II Green, et al. 2010)*

Type of solar cell	Efficiency
Silicon (crystalline)	22.9 ± 0.6%
Silicon (large crystalline)	21.4 ± 0.6%
Silicon (multi-crystalline)	17.3 ± 0.5%
Silicon (thin film poly-crystalline)	8.2 ± 0.2%
CIGS	13.8 ± 0.5%
CIGS (cadmium free)	13.5 ± 0.7%
Cadmium telluride	10.9 ± 0.5%
Amorphous silicon/ Amorphous silicon-germanium/ Amorphous silicon-germanium (tandem)	10.4 ± 0.5%

achieved an NREL verified 15.3 percent efficiency in a 2009 laboratory sample of its CIGS panels, yet its commercial panels have only 8-9 percent efficiency (Cheyney 2010a; Nanosolar 2009).

Nano solar company MiaSolé received a lot of attention recently when its solar panels achieved 14.3 percent solar conversion efficiency (MiaSolé 2010). This was indeed a remarkable achievement; until now the average rate of solar conversion efficiency for nano-based cells was around 10 percent. Nonetheless, this still lags behind the twenty percent plus efficiency achieved for silicon solar cells (Tables 2 and 3). First Solar claims that its cadmium telluride thin film cells remain efficient in warm weather, on cloudy days and in situations of diffuse daylight (First Solar n.d.). Nonetheless, the efficiency of First Solar's panels is only 11.2 percent.

The durability of some nano solar panels is also considerably less than that of silicon panels. Nano solar has recently commissioned a report which estimated that its Copper-Indium-Gallium-(Di) selenide (CIGS) panels on flexible foil will last 25 years (Cheyney 2010b). However, dye-sensitized solar panels and fullerene-based organic panels have an active service life that is well below 10 years, compared to the 25-30 years expected from silicon cells (Reijnders 2010). Konarka's plastic panels last only 5-6 years. If the energy needed for producing these panels is taken into account, the overall life cycle energy efficiency of these solar panels is further reduced.

Bucking the 'smaller is better' trend, Gupta et al. (2009) conclude that ultra large-scale manufacturing of larger groups of silicon panels is required to lower costs of production, and predict that silicon-based PV manufacturing will continue to be the basis for future growth in the sector. The recent massive expansion of Chinese silicon solar panel production, the drop in silicon panel costs and the increase in Chinese market share of solar sales (Woody 2010) may lend support to this view.

It is not yet possible to establish whether or not nanotechnology will deliver in the area of solar thermal. Using nanomaterials to improve the efficiency of concentrated solar power receivers faces substantive hurdles. The US National Science and Technology Council observes that developing materials that have high solar absorbance and low thermal emittance is "very challenging as the two properties are seemingly mutually exclusive and tradeoffs need to be assessed" (NSTC Committee on Technology 2010, 5). Research into the use of nanofluids and nanocomposites to improve the efficiency of converting heat into electricity is also at a very early stage and faces several technical and design challenges.

Sustainability and life cycle issues

Proponents of thin film nano solar argue that the sector has years of growth before it has to worry about running out of raw materials (Edwards 2010). However, scarcity analysts have warned that the growth of nano solar may be imminently curtailed due to its reliance on scarce minerals such as indium and gallium, and rare earths such as selenium and telluride. The reserves of both indium and gallium are disputed. However, German researchers suggest that we have less than ten years before we run out of indium (Cohen 2007). Dutch researchers argue that because thin film nano solar based on cadmium telluride and CIGS is reliant on scare minerals such as indium and gallium, these technologies will never be able to contribute more than 2 percent of global energy demand, due to resource constraints (Kleijn and van der Voet 2010). They caution that governments should require careful resource constraints assessment before further funding of these thin

What is life cycle assessment?

Life cycle assessment (LCA, also known as life cycle analysis or cradle to cradle analysis) is a technique to assess each and every impact associated with a given process or product. This includes: raw materials mining or extraction; materials processing; product manufacture; product transport and distribution; product use; repair and maintenance; and end of life disposal or recycling. The goal of LCA is to obtain a complete understanding of the environmental demands and implications of a given process or product. This is particularly important to avoid shifting problems associated with one part of a product's life cycle (for example emissions in use) to another (for example high energy and chemical demands of manufacturing).

film technologies: "Large scale government funding for technologies that will remain marginal is not an efficient way to tackle the energy and climate crisis" (Kleijn and van der Voet 2010, section 4.2).

The United Nations Environment Programme (UNEP) has warned that despite concern within the high tech sector over scarcity and high prices of minerals such as indium and gallium, only around one percent of these crucial high-tech metals are recycled, with the rest discarded and thrown away at the end of a product's life (UNEP 2010a). UNEP commissioned a report that found that unless end-of-life recycling rates are increased dramatically, specialty and rare earth metals could become "essentially unavailable" for use in high tech products.

Companies such as Walmart have claimed that because thin film nano solar cells contain fewer raw materials, their overall life cycle environmental impact is lower than that of traditional silicon solar cells (Walmart 2010). However, such claims ignore evidence that the environmental burden and energy costs of producing nanomaterials are very high (see sections following).

There are few life cycle assessments (LCA) of nano solar PV panels, making it hard to determine net life cycle energy gains or costs comparative to silicon cells. Similarly, it is difficult to establish whether the manufacturing process for nano solar is more or less toxic, and environmentally burdensome, than the manufacture of silicon solar cells.

Based on PV production data from 2004–2006, one study compared the life cycle greenhouse gas emissions, criteria pollutant emissions, and heavy metal emissions from four types of major commercial PV systems: multi-crystalline silicon, mono-crystalline silicon, ribbon silicon, and thin film cadmium telluride (Fthenakis, Kim and Alsema 2008). It found that production of thin film cadmium telluride required the least amount of energy to produce, and so had the lowest harmful emissions based on current US and European electricity grid mixes. However, the researchers noted that differences in the emissions between different PV technologies are very small in comparison to the emissions from conventional fossil energies that PV could displace.

A recent LCA review of solar panels found that when the life span of a nano-crystalline dye sensitized solar panel is assumed to be 20 years, the grams of carbon dioxide equivalent emissions generated per kilowatt hour are roughly equivalent to those of amorphous (thin film) and poly-crystalline silicon panels, and less than those of mono-crystalline panels (Sherwani, Usmani and Varun 2010). However, when the life span was assumed to be 5 years, the emissions per kilo Watt hour of the nano-crystalline cell were higher. A group of US researchers recently presented findings that organic nano solar panels had reduced life cycle energy demands compared to inorganic panels (Science Daily 2010). However, this work is yet to be published and there are few details available.

In contrast to these findings, a study in the *Journal of Cleaner Production* assessed the environmental demands and performance of dye-sensitized nano solar cells and fullerene-based organic cells and found that they were not more environmentally friendly than silicon solar for the following reasons:

> *...high energy and materials inputs in the production of nanoparticles, a relatively low solar radiation to electricity conversion efficiency, a relatively short service life, the use of relatively scarce metals and relatively poor recyclability, if compared with the multi-crystalline Si [silicon] solar cell which currently is the market leader. Moreover, the lack of data and the inability of current methods to handle hazards of nanoparticles generate problems in conducting comparative life cycle assessment of nanoparticulate solar cells (Reijnders 2010, 307).*

Reijnders (2010) observes that "in actual development work [of nano solar] there seems to be no focus on achieving (net) environmental improvement. This is at variance with the attention to environmental improvement in the development of other types

The German sustainability research group Wuppertal Institute suggest that even if recycling schemes are mandated, persistent concerns about the health harm associated with cadmium mean that it should not be used in solar panels at all (Saurat and Ritthof 2010).

of solar cells." This is in direct contrast to the claims made by nano solar companies who promise to create green solutions for energy generation.

Concerns about the end of life toxicity risks of nanocomponents used in its solar cells, in particular cadmium, has prompted First Solar, Inc. to commit to an end-of-life collection scheme for its panels. This is a commendable initiative, although it is not the industry norm. Further, researchers warn that because the economics of recycling solar PV panels are unfavorable, voluntary initiatives are not enough (McDonald and Pearce 2010). They caution that voluntary initiatives will face future economic stress and that unless recycling is mandated, hazardous materials will inevitably enter local waste streams.

Given the very early stage of this research, no life cycle analyses are available for the use of nanomaterials in solar thermal applications.

Health and environment risks

Many nanomaterials used in the nano solar sector incorporate heavy metals and pose inherent toxicity. First Solar, which dominates the thin film PV market, uses cadmium telluride. Other applications in development use quantum dots that have cadmium cores. Early studies suggest that quantum dots could be transferred along food chains, could bioaccumulate or even biomagnify, and that in time coatings could degrade, exposing their toxic cores (see health and environment section following).

The health risks associated with carbon nanotubes, in particular their potential to cause mesothelioma and disease similar to that caused by asbestos, have also attracted international concern (see health and environment section following). These risks are likely to be most acute for workers exposed during manufacturing. Titanium dioxide nanotubes have a similar shape to carbon nanotubes. A test tube study on lung epithelial cells found that they had a strong dose-dependent effect on cell proliferation and cell death (Magrez, et al. 2009).

Early studies also show that nano forms of titanium dioxide, silver and carbon fullerenes, all touted for use in nano solar, can be toxic to people and the environment (see health and environment section following).

The Silicon Valley Toxics Coalition provides an excellent detailed report on other toxic aspects of the solar energy industry (Silicon Valley Toxics Coalition 2009).

Nano and wind energy

Background

Summary

The energy demands of manufacturing carbon nanofibers and nanotubes used to reinforce windmill blades are high compared to existing materials. Early life cycle analysis shows that although using nanocomposites will reduce the weight of windmill blades and may extend their service life, it may or may not reduce life cycle energy demands; use of nanotechnology could increase energy demands. In situations where the durability of wind turbines may be greatly diminished (for example at sea or in icy conditions) nanocoatings may extend windmill blades' service life. There is no life cycle analysis yet of the energy implications of the use of nanocoatings. There are serious health concerns regarding carbon nanotubes, mooted for use in nanocomposites for windmill blades and for coatings. Studies have shown that some forms of carbon nanotubes can cause mesothelioma, the deadly disease associated with asbestos exposure.

Electricity is produced from wind via the rotation of usually fiberglass or aluminum blades, somewhat similar to airplane propellers, which set in motion turbines that generate electricity (usually grouped into wind farms). According to the Global Wind Energy Council, global wind energy capacity was more than 120 GW in 2008 (Pullen, Qiao and Sawyer 2008), supplying over 1.5 percent of the world's electricity (World Wind Energy Association 2009).

Wind energy is valued as one of the most environmentally benign methods for producing energy. It has the potential to supply 10-12 percent of global electricity demand by 2020. As of 2008, wind energy was already saving 158 million tons of CO_2 every year – the equivalent to taking over 27 million US cars, or nearly 40 million Australian cars, off the road (Pullen, Liming and Sawyer 2008).

How is nanotechnology claimed to improve existing technology?

Researchers are attempting to use nanotechnology to create stronger, lighter and more durable windmill parts. Nanocoatings are being developed to protect windmill blades and to extend their service life. The use of nanoscale lubricants is also being investigated to reduce friction and to extend the service life of parts. Researchers have begun investigating nanoparticles for use in sensor technologies to alert to damage in wind turbines.

How is nanotechnology used?

Carbon nanotubes – cylinders made of carbon atoms that are 10,000 times thinner than a strand of human hair – are one of the nanomaterials that have been the subject of much hype. They are the stiffest and strongest fibers known and also have unique electrical properties. Finnish company Eagle Windpower Oy has used carbon nanotubes bound with epoxy in its small windmill blades (Understanding Nano.com 2009). The company claims that as a result, the blades are approximately 50 percent lighter than competing fiberglass blades and can start operating at low wind speeds of 2-2.5 meters per second. The company says that use of the nanotubes enables the station's wing size to be doubled, which results in 30 percent greater power production.

Increasing the blade size of windmills increases the amount of electricity that can be generated. Larger wind turbines can measure up to 60 meters in length. However, the limits of fiberglass-reinforced plastics have been reached in this field and there is now a materials development problem in achieving larger, more resilient wind energy systems. A hybrid material is under development, which uses vapor-grown carbon nanofibers to reinforce the interface of a fiberglass/epoxy matrix (Merugula, Khanna and Bakshi 2010). This could make windmill blades stronger and lighter, although the material still faces mechanical challenges.

The UK is launching a £100 billion (approximately US$156 billion) off-shore wind project using large turbines. The project is expected to produce about a third of the country's energy by 2020 (Babbage 2010). These turbines will be installed further off-shore than any existing wind farm, where engineers will have room to build massive wind turbines not suitable for use on land (Babbage 2010). However, off-shore wind turbines can easily be damaged by harsh weather conditions at sea (Hayman, Wedel-Heinen and Brondsted 2008).

Companies are attempting to use nanotechnology to create water repellant coatings that could prevent ice and moisture build up on wind turbines, enabling higher energy production (General Electric 2009). Nanotechnology-based coatings also have the potential to extend the service life of windmill blades used in harsh weather conditions, for example at sea.

Nanoscale lubricants are also being developed that act as tiny ball bearings; researchers hope that they will diminish friction and wear and tear in turbines, making them more efficient and longer lasting.

Commercial presence

The use of nanomaterials in commercial windmill applications does not appear to be widespread, although without mandatory labeling of nanomaterials used in composites, coatings and lubricants, it is difficult to know.

Eagle Windpower Oy, is using carbon nanotubes to strengthen and lighten its small windmill blades. It produces windmills small enough to be used for a single house (2-500kW). The company claims to be participating in several projects in developing countries, and to be in negotiations with a Finnish energy company to provide electricity for its service stations (Understanding Nano.com 2009).

Baytubes® (carbon nanotubes) made by Bayer AG are currently marketed for use to fortify wind turbines and allow for larger rotor blades (Bayer AG 2009). Bayer claims that "the lightweight design of the nanotubes – and thus of the hybrid materials in which they are incorporated – boosts the efficiency of the wind-to-power conversion process" (Bayer AG 2009).

Does nanotechnology deliver?

A recent life cycle analysis of carbon nanofiber-reinforced windmill blades found that because of the huge energy costs associated with manufacturing the nanofibers, even though using the nanofiber composites may reduce the weight and increase the strength of windmill blades, it may not deliver any energy savings over the life cycle of the blades (Merugula, Khanna and Bakshi 2010). Further, the researchers observed that there may be mechanical challenges to using the nanofibers: "weight savings by CNFs [carbon nanofibers] may implicitly assume a prohibitively thin [windmill] blade" (Merugula, Khanna and Bakshi 2010).

Effective nanosensors have yet to be developed. It is hoped that nanosensors could reveal very small cracks in wind turbines and other potential defaults in construction. The US National Renewable Energy Laboratory (NREL), part of the US Department of Energy (DOE), has tested various forms of carbon nanotubes including 'buckypaper' to create 'neurons,' which can theoretically detect strain and fractures in various materials used to build wind turbines. However, the NREL observes that there are considerable practical barriers to this application's successful use: the buckypaper was found to be "brittle and difficult to apply on large structures" (Schulz and Sundaresan 2006).

It is possible that nanolubricants will be useful in reducing friction and protecting windmill gears. However, there are several high performance non-nano oils that are well regarded for this purpose (Siebert and Holm 2009).

Sustainability and life cycle issues

It is unclear whether there are any energy savings associated with using nanomaterials such as carbon nanotubes or carbon nanofibers (CNF) to strengthen windmill blades. An early LCA study found that cradle to gate processing of CNF-windmill blades is 1.4 to 7.7 times more energy intensive than conventional material (Merugula, Khanna and Bakshi 2010). The researchers found that energy savings were dependent on variables including the manufacturing process, solvent handling and quantity of carbon nanofibers used. If CNF blades do result in both weight savings and increased life span, potential energy savings across the life cycle vary from insignificant to substantial. However, there may be practical constraints to using CNF hybrid materials; the authors conclude that "it is not yet substantiated whether replacement of long carbon fibers is advantageous both mechanically and energetically".

Further life cycle analysis is required to establish whether or not the performance and efficiency gains associated with lighter, stronger nanomaterial-reinforced blades are enough to compensate for the significant energy demands of their manufacture.

Health and environment risks

The health risks associated with carbon nanotubes, in particular their potential to cause mesothelioma and disease similar to that caused by asbestos, have also attracted international concern (see health and environment section following).

Nano and hydrogen energy

Summary

Dreams of a hydrogen-powered future, where the only emissions from cars are heat and water, have proven seductive to environmentalists, technophiles and politicians alike. Despite this, the reality is that today's hydrogen cars are powered by fossil fuels and release several times the greenhouse gas emissions of their petrol-powered counterparts. The putative hydrogen economy faces several key technical, sustainability and safety obstacles. Proponents hope that nanotechnology could help to boost the efficiency and bring down costs of renewable energy to generate hydrogen, provide new means to store hydrogen, increase the capacity and effectiveness, and reduce the costs of hydrogen fuel cells. However, developments in this field are at a very early stage. It is improbable that cars powered by renewable energy generated hydrogen will be widespread in the near future. Hydrogen-powered cars are therefore highly unlikely to make a significant contribution to cutting greenhouse gas emissions in the next ten or twenty years – the period in which such cuts are critical. In the meantime, development of hydrogen cars entrenches reliance on fossil fuels to produce the hydrogen. Further, the huge investment required to conduct research in this field and to support establishment of hydrogen power infrastructure may present a dangerous opportunity cost to the important measures we could be taking to improve mass transport options and to reduce reliance on private vehicles.

Background

The 'hydrogen economy' is a hypothetical future economy in which hydrogen is the primary form of stored energy for vehicles and industrial applications (Elcock 2007). In 2007 the then US President announced US$1.7 billion in public funding for a five year project to develop hydrogen-powered fuel cells, hydrogen infrastructure and advanced automotive technologies (Berger 2007a). At that time George W. Bush said that it would be practical and cost-effective for large numbers of Americans to choose to use clean, hydrogen fuel cell vehicles by 2020. The US Department of Energy's (US DOE) Hydrogen Program predicts that sufficient hydrogen 'technology readiness' will be achieved by 2015 to allow industry to make decisions on commercialization (US DOE n.d.). However, despite the highly optimistic and probably unachievable predictions of George W. Bush and the Department of Energy, achieving a future hydrogen economy faces several key technical, infrastructural, economic and safety constraints.

One of the most critical issues surrounding hydrogen's use is the reliance on fossil fuels to generate it. Hydrogen is a carrier of energy not a source in its own right. A primary energy source – coal, gas or electricity – is required to produce it. Hydrogen can be produced by using fossil fuels as a 'feedstock' (hydrogen source). This requires the separation of hydrogen from carbon components of the fossil fuels. Hydrogen can also be produced by using water as the feedstock. This requires electricity to separate the hydrogen and oxygen. The scale of the electricity demands associated with substituting cars powered by hydrogen generated only by electricity for petrol cars would be enormous (see below). The US "Hydrogen Posture Plan" makes clear that it envisages ongoing reliance on fossil fuels to generate hydrogen (US DOE, US DOT 2006).

Another barrier to the widespread adoption of hydrogen as a fuel source is the very low efficiency and high costs of fuel cells that convert hydrogen and oxygen into electricity, heat and water. The technical challenges associated with developing fuel cells are considerable. Fuel cells for hydrogen cars have been plagued by consistent over-promising and under-delivery by industry. In 2004 IBM predicted that fuel cells in cars would be a "daily fact of life" by 2010, and General Motors estimated that it would have a million fuel-cell cars in production by now (Elcock 2007). Neither prediction has been realized.

Beyond the need to avoid fossil fuel use in generating hydrogen is the key challenge of how to store it. Roughly speaking, about 1 kg of hydrogen is needed to drive 100 km. That requires 50,000 liters (~14,000 gallons) of hydrogen to be stored in a vehicle tank for a car to have a 500km range (Berger 2007a). There are three ways of doing this: as a high-pressure compressed gas; a cryogenic liquid; or as a solid. To be liquefied, hydrogen needs to be cooled to -253°C. The energy used to do this is equivalent to 30-40 percent of the energy the hydrogen contains (Fauset 2008). Compressed gas requires less energy but is far less efficient. Both compressed and liquefied hydrogen pose the threat of explosion of undetected leakage (see below).

The lack of safe storage capacity, the risk of explosion associated with transporting and storing hydrogen under high pressure, and the significant, possibly prohibitive expenses associated with hydrogen infrastructure are all barriers to hydrogen's use as a fuel (Berger 2007a; Fauset 2008). The cost of infrastructure to supply just 40 percent of US light-duty vehicles with hydrogen has been estimated to cost over US$500 billion (Fauset 2008).

How is nanotechnology claimed to improve existing technology?

Most interest in nanotechnology applications in the hydrogen sector is based on early stage or laboratory scale research. A report by the United Nations University suggested that in the future nanotechnology could help to make a hydrogen economy possible through applications in the following areas: hydrogen as an energy source; hydrogen generation via electrolysis; hydrogen generation from photolysis; hydrogen fuel cells for use in transport (for example cars and buses); hydrogen storage; light metal hydrides; carbon nanotubes storage; molecular sponges (Esteban, et al. 2008).

The key areas of research are to use nanotechnology to improve the viability of hydrogen generation from renewable sources, to increase the capacity and practicality of hydrogen storage, and to increase the efficiency and lower the costs of fuel cells (Berger 2007a). There is much interest in using nano solar to help reduce costs and increase efficiencies of producing hydrogen from renewable sources (Berger 2007a; US DOE, US DOT 2006; NREL 2009). The US Department of Energy suggests that nanotechnology is essential to increase the viability of renewable energy to play any role in generating the electricity to produce hydrogen from water (US DOE, US DOT 2006).

Researchers are also investigating the potential for nanomaterials to be used for hydrogen storage and for nanobatteries to support renewable energy systems or to act as supplementary power sources in hydrogen cars (Esteban, Weberisk and Leary 2008; Nanowerk 2007). The most significant role for nanotechnology may be in the development of hydrogen fuel cells, electrochemical devices that convert a fuel such as hydrogen or methanol directly into electricity (Esteban, et al. 2008).

How is nanotechnology used?

The application of nanotechnology to solar energy is discussed in preceding sections. Developments in nanobatteries, including lithium ion batteries, are discussed in following sections.

One of the areas where researchers hope that nanotechnology could deliver a technical breakthrough is in photovoltaic cells that produce electricity to produce hydrogen from water. Experiments with nanowire arrays and other nanostructured materials have shown that they improve the efficiency of these cells (Berger 2007a).

Swiss company Hydrogen Solar has developed a Tandem Cell™ which it hopes will eventually generate hydrogen to power vehicles, refineries, industrial and domestic equipment (Hydrogen Solar n.d.). The Tandem Cell™ is designed to use the sun's energy to directly power electrolysis to generate hydrogen. The front cell absorbs the high energy ultraviolet and blue light in sunlight, using nano-crystalline metal oxide thin films to generate electron-hole pairs. The longer wavelength light in the green to red region passes through the front cell and is absorbed in a Graetzel Cell producing electrical potential under nearly all light conditions. Together, the cells provide the potential required to split the water molecules in the electrolyte. The cell currently has very low efficiency (3 percent); the company acknowledges that "we also need to optimise all other aspects, including the counter-electrodes, the electrolytes and the mechanical design" (Hydrogen Solar n.d.).

Researchers are also trying to develop nanomaterials that can store large quantities of hydrogen in a small space, while minimizing the risk of explosion. Nanomaterials of interest include metal hydrides and chemical hydrides such as ammonia borane to which hydrogen can be bound chemically (Davis, et al. 2009). Hydrogen can also be physically bound to carbon nanotubes or metal nanoclusters (Elcock 2007), or attached to carbon nanotubes via reversible hydrogen bonds (Nikitin, et al. 2008). The stored hydrogen can then be released by heat, electricity, or chemical reaction. Based on computational modeling, some researchers have predicted that using carbon nanotubes to store hydrogen may someday enable a car or bus to be powered by a brief case sized hydrogen battery (The X-Journals 2009).

Researchers are also investigating the potential for nanomaterials to increase the efficiency and lower the costs of fuel cells that use hydrogen and oxygen to produce electricity (Cientifica 2007a). Building fuel cells can be costly, especially the platinum electrode material used inside the devices (Berger 2007a). By using nanoparticles of platinum, reactivity is increased. The reactivity of nanoparticles of platinum is greater than the reactivity of larger particles of platinum; more reactive atoms are exposed as the size of particles decreases and their relative surface area increases. By increasing the reactivity of platinum, researchers hope that less platinum could be used. This could reduce the costs of production. Researchers are also investigating whether or not it is possible to use nanoscale non-precious metal catalysts in place of the platinum (Berger 2006).

Commercial presence

It doesn't appear that hydrogen energy is currently produced, stored or converted with the aid of nanomaterials outside of a laboratory, although once again, it is very difficult to verify this. Honda has two hundred models of its FCX Clarity hydrogen car available for lease (American Honda Motor Co., Inc. 2010). This car contains lithium ion batteries which incorporate some nanocomponents. These are used to provide an alternative power source to the hydrogen (Esteban, et al. 2008).

Hydrogen fuel cell vehicles themselves are not presently widespread on the market. Issues with creating hydrogen fuel station infrastructures, cost, and safety are persistent and significant. However, limited numbers of some makes are available, including by BMW's H7. VW, Nissan, and Hyundai/Kia also have fuel cell vehicle prototypes on the road.

Does nanotechnology deliver?

The only way for hydrogen-powered cars to be free of greenhouse gas emissions is if hydrogen is produced by electrolysis of water, powered by only renewable electricity, and if the subsequent energy-intensive liquefaction process is also powered by only renewable energy. However, Corporate Watch cautions that producing hydrogen by using electricity requires far more energy than producing it from coal or gas.

News service Nanowerk's Berger observes that the "holy grail" of nanotechnology research "would be a highly efficient device that you fill with water, put in the sun, and get hydrogen without using any outside source of energy" (Berger 2007a). However, the technical obstacles faced by manufacturers

Replacing the UK's vehicle fuels with electrolysis hydrogen would take more than the country's present electricity consumption (Fauset 2008). It appears highly unlikely that in the near term nanotechnology will enable sufficient efficiency increases in renewable energy, and sufficient drops in its costs, to enable a doubling of existing electricity consumption made possible solely by renewables.

trying to commercialize thin film nano solar panels for roofs suggest that such an application may be unachievable in any foreseeable time frame.

The development of panels that use the sun's energy directly to power hydrogen production from water would be a huge step forward. However, this research is at a very early stage, efficiencies obtained so far are very low (3 percent) and its developers acknowledge the need for much more technical work and improvement.

It also appears unlikely that nanotechnology will be able to solve the serious safety problems that have plagued prototypes of hydrogen cars and which make the storage, distribution and use of hydrogen fuel a serious public risk (see below).

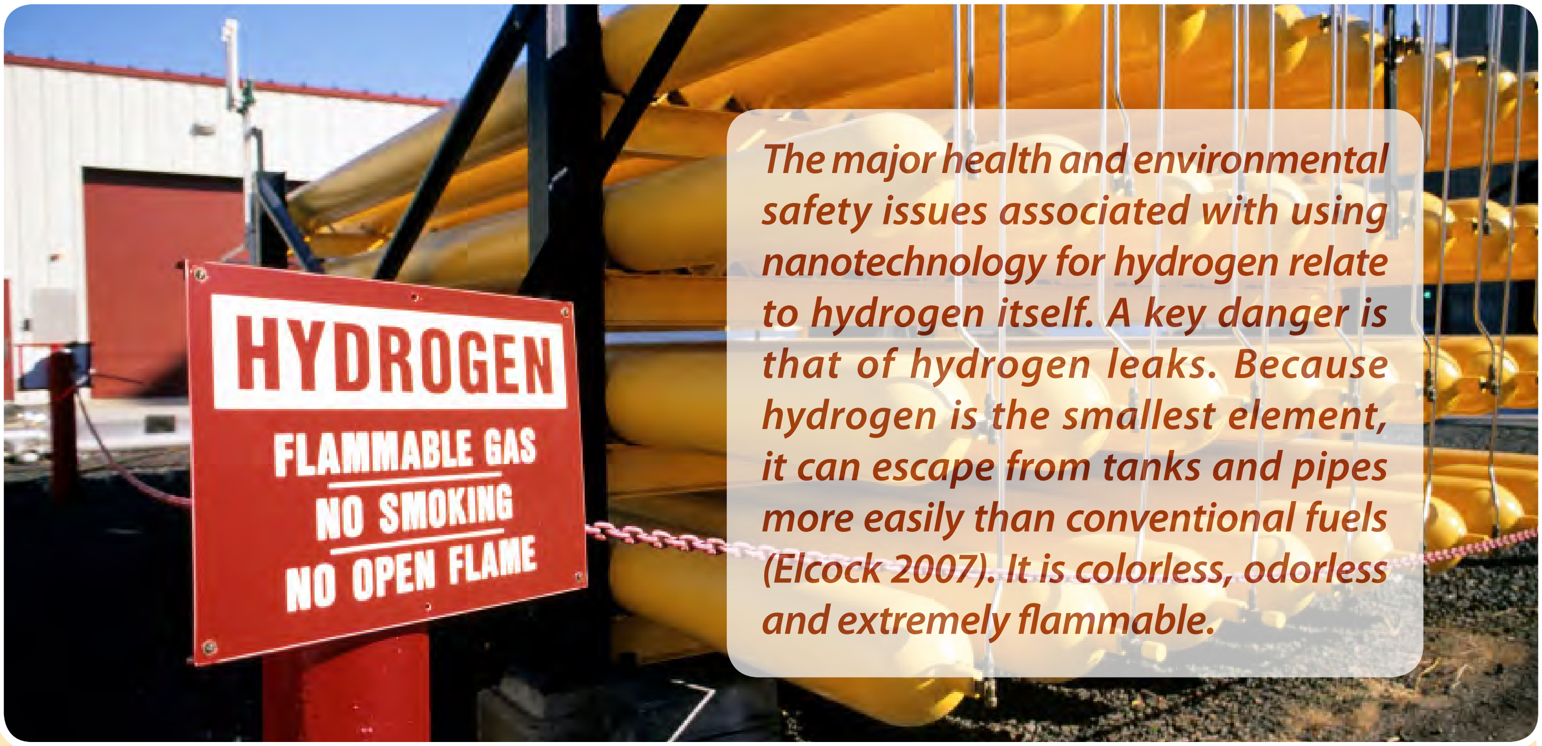
Sustainability and life cycle issues

Researchers hope that nanotechnology could help reduce the quantity of platinum required by fuel cells. Even so, the scarcity of platinum is a constraint to widespread adoption of fuel cells. It has been estimated that if 500 million vehicles were re-equipped with fuel cells, losses (dissipation) of platinum (via exhaust fumes) would mean that all the world's sources of platinum would be exhausted within 15 years (Cohen 2007).

The most serious sustainability and life cycle issues of these applications relate to how hydrogen is produced, rather than the nanomaterials themselves. Even if nanomaterials enable improvements in hydrogen storage and fuel cell function, if hydrogen continues to be produced using fossil fuels, this will merely exacerbate the greenhouse gas emissions associated with private vehicle use.

The vast majority of the hydrogen currently produced in the US comes from natural gas (methane; NREL 2009). The problem with using methane to create hydrogen is that when the carbon is separated from the hydrogen it is released into the atmosphere as carbon dioxide. The IPCC states that even in a large modern plant, manufacturing hydrogen from natural gas emits 9.1 kg carbon dioxide per kilogram of hydrogen (IPCC 2005). Further, natural gas is not a renewable source of energy (Oil and Gas Accountability Project n.d.).

Corporate Watch warns that producing hydrogen from electricity and compressing or liquefying it to use as a vehicle fuel – the main hydrogen application being considered - could have a worse impact on the climate than using petrol if it is not based on renewable energy (Fauset 2008). For example powering BMW's hydrogen car with hydrogen produced from water using electricity from the UK grid would create around four times the emissions of the car's petrol equivalent. Powering the same car with hydrogen produced from natural gas (methane) would still create



The major health and environmental safety issues associated with using nanotechnology for hydrogen relate to hydrogen itself. A key danger is that of hydrogen leaks. Because hydrogen is the smallest element, it can escape from tanks and pipes more easily than conventional fuels (Elcock 2007). It is colorless, odorless and extremely flammable.

around two and a half times the emissions of the BMW's petrol equivalent, and around six times the emissions of a Toyota Prius (Fauset 2008).

Swiss energy analysts caution that the generation of hydrogen by electricity on-site at hydrogen filling stations would require a 3 to 5 fold increase of electric power generating capacity. The energy output of a 1 GW nuclear power plant would be needed to serve twenty to thirty hydrogen filling stations on frequented European highways (Bossel and Eliasson 2003).

Berger observes that "While politicians and the energy industry talk about the clean future of the hydrogen economy, the [US] DOE's Hydrogen Energy Roadmap foresees up to 90 percent of hydrogen production coming from fossil fuels – coal, gas, oil – the rest mostly from nuclear power plants" (Berger 2007a).

Health and environmental safety

The major health and environmental safety issues associated with using nanotechnology for hydrogen relate to hydrogen itself. A key danger is that of hydrogen leaks. Because hydrogen is the smallest element, it can escape from tanks and pipes more easily than conventional fuels (Elcock 2007). It is colorless, odorless and extremely flammable. Hydrogen also burns invisibly, raising the danger not only of undetected leaks but also of undetected fires. Corporate Watch cautions that a raging hydrogen fire could be undetectable until you stepped into it and went up in flames (Fauset 2008).

Hydrogen is flammable over a wide range of concentrations and its ignition energy is twenty times smaller than natural gas or petrol (Fauset 2008). A report commissioned by the US Department of Energy warned that operation of electronic devices such as mobile phones can cause ignition and 'common static' (generated by sliding over a car seat) is about ten times what is needed to ignite hydrogen (Arthur D. Little, Inc. 2002).

Toyota had to recall its hydrogen car prototypes in 2003 due to leaking issues detected by drivers (Fauset 2008). Cars such as Honda's FCX have been fitted with sophisticated hydrogen leakage sensors (Esteban, et al. 2008). Despite this, the possibility of undetected leaks at hydrogen refueling stations is troubling; there are no ready and reliable detection methods suitable for wide scale deployment. Until 2005, NASA's safety guidelines for hydrogen handling recommended detecting leaks in its hydrogen tanks by getting someone to walk round pushing a broom in front of them to see if the bristles caught fire (paragraph 601b(4); NASA, Office of Safety and Mission Assurance 1997).

Energy analysts have also warned that although pipe delivery of hydrogen could be energy inefficient and result in substantial leakage, road-delivery of hydrogen fuel would pose serious safety problems. Because compressed hydrogen carries so little energy value, fifteen times the number of tankers would be needed compared to supplying petrol. Swiss analysts predict that one out of seven accidents involving trucks would involve a hydrogen truck; every seventh truck-truck collision would occur between two hydrogen carriers (Bossel and Eliasson 2003).

The use of nanomaterials such as carbon nanotubes in hydrogen fuel cells also poses health and environmental risks. The health risks associated with carbon nanotubes, in particular their potential to cause mesothelioma and disease similar to that caused by asbestos, have attracted international concern (see health and environment section following).

Nanotechnologies to expand oil and gas extraction

"All the easy oil and gas in the world has pretty much been found. Now comes the harder work in finding and producing oil from more challenging environments and work areas."

- William J. Cummings, Exxon-Mobil company spokesman, December 2005 (Donnelly 2005)

"Nanotechnology offers tremendous potential for the oil and gas industries and is our best hope for extending the lifeline of our current energy resources. Nanotechnology provides numerous solutions for mapping new reservoirs, for retrieving more oil from current wells, and for making our fuel usage cleaner and more environmentally friendly."

- Nano Petroleum, Gas and Petrochemicals Industries Conference 2009 (SabryCorp n.d. a)

Background

Industry observers have warned that we are approaching the maximum rate of petroleum extraction, after which we face a permanent and growing gap between supply and demand – what is called peak oil. Earlier this year the UK Industry Taskforce on Peak Oil and Energy Security warned that the UK may be rocked by oil shortages, supply

Summary

The world's biggest petrochemical companies are collaborating to fund research and development to use nanotechnology to double the oil and gas that can be extracted from known reserves, and to find new reserves. Similar research is being publicly funded in Australia, Mexico, the US, the UK, Japan, Saudi Arabia and other countries. The use of nanotechnology to identify new oil and gas reserves, to double extraction from existing reservoirs, and to make viable extraction from currently marginal reserves will inevitably result in the massive release of additional greenhouse gases. The environmental cost will be exacerbated by the enormous quantities of nanomaterials predicted to be used in 'enhanced oil recovery' (EOR). Nanotechnology may also result in the opening up of new drilling sites in currently unviable areas. Areas such as the Arctic, the Amazon, the Congo and elsewhere which have high ecological value and are home to indigenous peoples, have to some extent been protected by the marginal economic value of oil reserves. These areas may become more vulnerable to drilling expansion if nanotechnology increases oil recovery and reduces extraction costs.

and price volatility as early as 2015 (Industry Taskforce on Peak Oil and Energy Security 2010).

Many environmentalists – and even some members of the UK taskforce - have heralded the approach of peak oil with calls for a shift to less energy-intensive economic production and consumption, and to more rapid development and deployment of renewable energy. However, some governments, for example in Mexico and Saudi Arabia, have stated publicly that use of nanotechnology to extract more oil and gas is one of their top strategic research priorities (IEA 2009; Kingdom of Saudi Arabia 2007). Investing in new EOR technologies is also one of the top strategic priorities for the US Department of Energy (US DOE n.d. a), which includes nanotechnology research (Karoub 2004). Nanotechnology research to increase oil and gas reserve discovery and oilfield extraction is also publicly funded in the UK (UK EPSRC n.d.), in Australia through the Commonwealth Scientific and Industrial Research Organisation (CSIRO n.d. a; CSIRO n.d. b), and in Japan (Endo, et al. 2008).

How is nanotechnology claimed to improve existing technology?

The petroleum industry and government investors hope that nanotechnology based sensors, coatings, membranes and devices will help find new oil and gas reserves, expand extraction capacity at existing wells, lower extraction and handling costs, and achieve efficiency gains.

The Nano Petroleum, Gas and Petrochemicals Industries Conference in November 2009, held in Cairo, Egypt, outlined the anticipation of nanotechnology's application in exploration, drilling, production, engineering, well logging, refining, processing and transport of fossil fuels. The conference website openly acknowledged the extent to which the fossil fuel sector is counting on nanotechnology to prolong its existence (SabryCorp n.d. a).

How is nanotechnology used?

Proponents hope that nano and microscale sensors can be developed that can be injected into oil and gas well bores. These sensors will migrate through the fractures and pores in the reservoir rock and collect real time data regarding the physical, chemical and spatial characteristics of the well space and the oil and gas within.

The CSIRO, in conjunction with two Australian universities, is developing nano chemical sensors to enhance discovery rates of untapped oil or gas deposits beneath the seabed (CSIRO n.d. b). The CSIRO has developed highly sensitive hydrocarbon sensors that incorporate printed gold nanoparticle film attached to electrodes. These sensors can effectively detect tiny seepages of hydrocarbons released from the seabed, and can provide real time molecular information indicating fluid type. The sensors could be run continuously during marine surveys to obtain profiles of hydrocarbons in water that can be mapped in a similar way to seismic, electromagnetic and magnetic data.

In the UK, the Engineering and Physical Sciences Research Council is funding research by BP and the University of Surrey to develop 'smart injectable nanoparticles' that can be administered to reservoirs. The nanoparticles are being designed to better identify and map unrecovered oil, increasing rates of oil extraction (EPSRC n.d.; Gill 2009).

Temporary moratoriums on deep-sea oil drilling followed the tragic oil rig explosion in the Gulf of Mexico on April 22 this year. Difficulties associated with stemming the flood of oil at deep sea levels resulted in the worst environmental disaster in US history. Nonetheless Mexican and Japanese public funding has supported development of

Petrochemical companies suggest that nanotechnology will enable far greater rates of extraction from existing reserves, perhaps doubling the amount of oil that can be accessed by "reducing the 50 to 70 percent of today's discovered resources that remain in place, and extending the useful life of hydrocarbons to support the world's energy needs" (Chapman and Thomas 2010).

carbon nanotube rubber composites for use in oil drilling at even greater depths (Endo, et al. 2008). The composites can be used in sealing materials and O-rings that can withstand extreme heat and pressure. The aim is to enable drilling in even harsher temperatures and pressure, allowing companies to extract oil that was previously unreachable because of its depth.

Nanomembranes are also being developed to better filter impurities from oil and gas. Other applications of nanotechnology in the petroleum sector include: nanocoatings to reduce corrosion of drilling components; nanocomposites to reduce the weight and increase the strength of drilling components, also enabling deeper drilling; nanocomposites to increase the strength and reduce the weight of pipes; nanolubricants to reduce friction in drilling equipment; and nanocoatings to provide improved barriers to extreme weather events (Kingdom of Saudi Arabia 2007; SabryCorp n.d. b).

Does nanotechnology deliver?

It is not yet clear to what extent nanotechnology will succeed in finding new oil and gas reserves, or increasing the viability of currently marginal oilfields.

Commercial presence

It is not clear whether or not any nanotechnology-based products are already in commercial use by the petrochemical sector; it appears that nanotechnology developments remain largely at research and development stage. However, research activity in the area is substantial.

The petrochemical industry's interest in nanotechnology is so great that 10 of the world's biggest companies have joined forces to develop new nano-based methods for oil and gas field detection and mapping (Table 4). Together with the University of Texas and Rice University, the petrochemical giants have established the Advanced Energy Consortium (AEC; Advanced Energy Consortium n.d.).

Table 4: Big oil members of the Advanced Energy Consortium, dedicated to developing nanotechnology to expand oil and gas extraction

BP America	Marathon
Conoco Phillips	Petrobras
Baker Hughes	Schlumberger
Halliburton	Total
Oxy [Occidental Petroleum Corporation]	Shell

The way in which manufactured nanoparticles move and transform in soil and aqueous and marine environments remains poorly understood, and nano-ecotoxicology attracts minimal funding. In contrast, the AEC has attracted "a world class team of interdisciplinary researchers" within a US$30 million consortium to track and map the movement of injected nanoparticles, nanocapsules and nanobots in oil and gas reservoirs (Advanced Energy Consortium 2008; Chapman and Thomas 2010). The AEC has commissioned research projects at top universities internationally. Petroleum giant Shell was so keen to promote academic-industry collaboration on nanotechnology research that it sponsored a dedicated forum in 2008 for 30 of the world's top experts in nanotechnology and 30 Shell professionals to explore how nanotechnology could be used in detection, extraction and production of oil and gas (Parker 2008).

Sustainability and life cycle issues

The most serious environmental implication of the petroleum industry's quest to use nanotechnology to expand extraction and production of oil, petrol and gas is clear: more fossil fuels extracted and burnt will result in more greenhouse gas emissions. The industry is interested in developing more efficient fuel processing and use. However, there is no expectation that increased efficiency will result in environmental savings commensurate with the extra oil reserves nano extraction is predicted to unleash. If the AEC is correct its nano applications will double the oil available for extraction from existing reserves.

A further environmental cost of using nanotechnology to extract fossil fuels is the energy costs of nanomaterials manufacturing and the toxicity of nanomaterials intentionally released into the environment. This would be many orders of magnitude greater than the environmental costs associated with other nanoproducts because of the huge quantity of nanomaterials involved. Usually nanomaterials are used in small quantities. However, Sergio Kapusta, Shell's Chief Materials Scientist, told E&P Magazine cautions that unlike other nano applications, using nanomaterials to track, map and help recover oil would require huge quantities: "To inject nanomaterials in a water flush [sent through a reservoir], you're talking tons, not milligrams, of material" (Parker 2008). Manufacturing tons of nanomaterials would come at a huge energy and environmental cost. Further, Kapusta acknowledged that, if attempted today, most of the particles would be lost between the injection point and the destination – there is little control over where the particles go.

An indirect environmental and social cost of nanotechnology's deployment to increase oil and gas extraction could be the opening up of new regions for drilling. Nanotechnology is being developed to increase the rates and reduce the costs of oil and gas extraction, to make currently marginal oil reserves economically viable. Areas such as the Arctic and Amazon Basin are home to indigenous peoples who have resisted destruction of their natural environments and way of life for oil and gas extraction. These areas also have high ecological value. To date regions like these have been partially protected from oil and gas drilling by virtue of the higher costs of drilling in remote areas, or of the comparatively smaller amounts of readily recoverable oil. Nanotechnology could change this equation, exposing wild country and the homelands of indigenous peoples to oil and gas exploitation.

Finally, there is an opportunity cost inherent in investment in nano-based petrochemical extractives. More research dollars invested into improving extraction of fossil fuels mean fewer dollars for renewable energy research, or for infrastructure spending to reduce fossil fuel consumption such as more effective public transport.

Health and environmental safety

Some of the nanomaterials developed for use in this sector may pose health and environmental risks. These risks would be particularly acute were tons of nanomaterials to be intentionally released to the environment to track and map hydrocarbon reservoirs.

Nanobatteries

Summary

Lithium ion batteries (Li-ion) have attracted strong interest for their use in electric cars and also to support large-scale energy storage. The use of nanomaterials has enabled the development of Li-ion batteries that are smaller, more efficient and have greater storage capacity. On the other hand, where nanomaterials are used in Li-ion batteries, the energy demands associated with their manufacture may increase the batteries' life cycle impacts. For example production of single walled carbon nanotubes (SWCNT) is more energy intensive than graphite, which is typically used as a Li-ion battery anode. SWCNT production also generates additional carbon dioxide, waste acid and dissolved metals. The incorporation of nanomaterials in Li-ion batteries also increases the energy demands of recycling. Life cycle analysis is required to determine whether or not the use of nanomaterials in Li-ion batteries will deliver net environmental savings or costs. There are also health and environmental concerns regarding some of the nanomaterials proposed for use in Li-ion batteries.

Background

Batteries have a long history; some records indicate that battery technology might have been used as far back as 2000 years ago in the Middle East. Modern 'miniature batteries' were invented in 1950 in the

US. These 'alkaline' batteries paved the way towards portable electronic devices, such as portable radios, stereos and other appliances. Today, nanomaterials are being used to improve upon lithium ion (Li-ion) technology, a type of battery that has better energy storage than any other battery on the market.

How is nanotechnology claimed to improve existing technology?

Nanotechnology is enabling the commercial production of smaller, lighter, longer lasting, and more powerful batteries. Most research efforts are geared towards creating more efficient and cheaper batteries for electric and hybrid vehicles. Nanomaterial use is also slated for various electronics and to increase the capacity and decrease the recharge/ discharge time of energy stored from renewable sources such as solar and wind devices (Green Car Congress 2009; ScienceDaily 2009). It is also hoped that nanotechnology could increase the safety of Li-ion batteries, which are vulnerable to overheating and flammability.

How is nanotechnology used?

Nanomaterials and their quantum physical properties, such as increased surface to volume ratio and the capacity to absorb lithium have the ability to increase energy densities for Li-ion batteries. In laboratory tests, silicon nanowires can store greater quantities of lithium and can hold a charge ten times greater than normal lithium batteries (Stober 2007).

In other experiments with Li-ion batteries, strong, light-weight and flexible 'carbon nanotube papers' have been used to replace the graphite anodes. Replacing the graphite with the carbon nanotubes increased the battery's capacity threefold (Rochester Institute of Technology n.d.). The researchers also observed that carbon nanotubes have superior thermal and electric conductivity.

Other nanomaterials used in developing next generation batteries include nano lithium iron phosphates, nano titanium oxide, and other nano-metals and nano-crystalline materials.

Altairnano's batteries have a capacity of up to 1MW for larger scale energy storage. These batteries use nano-structured lithium titanate spinel oxide electrode materials to replace the graphite electrode materials found in current Li-ion batteries. The company claims that by using the nano-structured component, there's more surface area available to the ions—up to 100 times more surface area than with conventional, graphite electrodes. This enables the systems to rapidly recharge and discharge large amounts of electricity (Green Car Congress 2009).

It is not yet clear whether or not the use of nanomaterials in the production of Li-ion batteries achieves performance gains sufficient to cancel out the greater energy demands and environmental burden of manufacturing the nanomaterials.

Commercial presence

Nanobatteries are already on the market for use in vehicles and in household products, such as power tools.

Nanoparticles and thin films made of high-melting-point materials such as iron and titanium are being used as electrode materials by several Li-ion battery manufacturers, including Valence Technology and Altairnano. The Toshiba Corporation of Japan offers a rechargeable Li-ion battery made from nanoparticles that they claim can recharge in a few minutes and can be discharged and recharged 1,000 times (Toshiba Corporation 2005). DeWalt, a manufacturer of power tools also employs nanomaterials in its products. The company sells rechargeable batteries for their tools that contain NANO™ phosphate lithium ion cells, which they claim can deliver two to three times more run-time compared to their 18V batteries, have a long battery life and durability up to 2,000 recharges (DeWalt 2010).

A company that has garnered a lot of attention is A123 Systems, Inc. in the US, which produces a battery they can install into a Toyota Prius hybrid vehicle, turning the car into a plug-in hybrid. The company claims the car is capable of achieving 100-plus miles per gallon for the first 30 - 40 miles of electrically assisted driving (A123 Systems n.d.). A123 Systems claims this will allow for up to a 60 percent reduction in fuel consumption and greenhouse gas emissions (although the company does not take into account greenhouse gas emissions associated with making the batteries; A123 Systems n.d.). The company provides installation centers throughout North America, where hybrid vehicles can be converted quickly. This is an impressive technology, although life cycle analysis is required in order to establish whether the energy costs of manufacturing these batteries substantially undermine the higher efficiency of the converted car.

A123 Systems also mass produces other patented Nanophosphate™ technology batteries for applications ranging from power tools to grid stabilization for power stations, such as wind farms. The company claims some of their batteries can "reduce the associated emissions of CO2, SO2, and NOx [carbon dioxide, sulfur dioxide and nitrous oxides] by as much as 80 percent over traditional power plant ancillary services" (A123 Systems n.d.).

Altairnano's 1MW Li-ion batteries are already commercially available (Green Car Congress 2009).

Does nanotechnology deliver?

Nanotechnology has led to improvements in the performance of batteries, as discussed above. However, it is not yet clear whether or not the use of nanomaterials in the production of Li-ion batteries achieves performance gains sufficient to cancel out the greater energy demands and environmental burden of manufacturing the nanomaterials.

Sustainability and life cycle issues

The manufacturing of batteries can be environmentally intensive (US EPA 2008). The addition of nanomaterial components further raises the energy demands of battery manufacture. In a presentation during a meeting of the Organization for Economic Co-operation and Development (OECD), Kathy Hart from the US Environment Protection Agency (EPA) spoke of the need to develop life cycle assessments for nanotechnology applications like those used in Li-ion batteries. Hart warned that "the manufacture of nano-structured materials uses significant amounts of energy, which can result in significant environmental impacts" (Hart 2008).

Researchers caution that where carbon nanotubes are used in Li-ion batteries, "it is difficult to assess whether the performance enhancements in the battery justify the material- and energy-intensive upstream production process" (Seager, Raffaelle and Landi 2008). Life cycle assessment of electric vehicle batteries has found that although lead-acid, nickel-cadmium and nickel-metal hydride batteries have comparable environmental impacts, the impacts of lithium ion batteries may be lower (Matheys, et al. 2007). However, where nanomaterials are used in Li-ion batteries, the

Embedding nanomaterials in Li-ion batteries may cause problems for recycling.

energy demands associated with their manufacture may increase the batteries' life cycle impacts. For example compared with graphite that is typically used as a Li-ion battery anode, production of SWCNT is electricity and/ or fossil fuel intensive, and generates additional carbon dioxide, waste acid and dissolved metals (Sengul, Theis and Ghosh 2008).

The performance of Li-ion batteries which use SWCNT (for example as an anode, in place of graphite) is still largely untested on all but laboratory scales (Seager and Linkov 2009). Whether or not the nanotubes will deliver net environmental savings or costs depends on the environmental impacts of SWCNT production, the quantity of SWCNT in the battery, and the effectiveness of SWCNT in either increasing the number of miles driven per unit of energy input or reducing pollution output (Seager, Raffaelle and Landi 2008). See sections following for a discussion of the demands of nanomaterials manufacturing.

Further, embedding nanomaterials in Li-ion batteries may cause problems for recycling. The operating temperature for the smelting process must be increased substantially to extract nanomaterials fully and to avoid contamination of air, water and recyclable materials. This requires greater energy and results in higher levels of carbon dioxide emissions (Olapiriyakul and Caudill 2009).

Health and environmental safety

The use of nanomaterials such as carbon nanotubes in Li-ion batteries poses health and environmental risks. The health risks associated with carbon nanotubes, in particular their potential to cause mesothelioma and disease similar to that caused by asbestos, have attracted international concern (see health and environment section following).

Silicon nanowires, also being researched for application in Li-ion batteries, are of concern because of their high length to diameter ratio. Few toxicology studies have been conducted on silicon nanowires. However, a study on zebrafish embryos found that silica nanowires were highly and selectively toxic. The study further demonstrated that the silicon nanowires were teratogenic (able to cause birth defects), causing abnormalities and embryonic death (Nelson, et al. 2010).

Nano supercapacitors

Background

A capacitor differs from a battery in the way it stores energy. Batteries employ a chemical reaction to store energy, while capacitors instead use electrostatic action (the sudden and momentary electric current that flows between two objects at different electrical potentials caused by direct contact or induced by an electrostatic field).

Supercapacitors (also known as ultracapacitors) are between a battery and traditional capacitor in design and performance. They can store energy for shorter periods of time but can charge and discharge very rapidly. Supercapacitors can be used for a wide variety of applications such as cell phones, medical equipment (defibrillators), and in buses that start and stop frequently (Halper 2006). They are not commonly used as a main power supply, but rather to provide power boosts or back-up for batteries, or to bridge short power interruptions, such as in regenerative breaking in hybrid electric vehicles (Buchmann 2010).

Supercapacitors are also potential candidates for improving hybrid electric and other electric vehicles as they can provide a rapid surge of energy to start a vehicle, which cannot be done with normal batteries (Cientifica 2007a). The technology is also suited for storing energy from renewable sources, such as solar and winds (Cientifica 2007a).

How is nanotechnology claimed to improve existing technology?

Supercapacitors can store much more energy and can charge much more quickly than traditional capacitors. This is made possible by their use of nanomaterials that have a high surface area to which the charge is attached (Cientifica 2007a). The charge stored on this massive surface is not subject to the same thermodynamics as battery oxidation-reduction reactions. This means that unlike traditional capacitors or Li-ion batteries, supercapacitors can be recharged hundreds of thousands of times (Woodbank Communications 2005). They can also be much smaller than batteries.

How is nanotechnology used?

Researchers have found ways to create printable thin film supercapacitors constructed from single-walled carbon nanotubes with very high energy and power densities (Kaempgen, et al. 2009). Similar developments have been achieved by US researchers who have been able to produce lightweight, highly flexible batteries and simple supercapacitors by printing on paper (Berger 2009c). The Stanford researchers found that coating a sheet of paper with ink made of carbon nanotubes and silver nanowires makes a highly conductive storage device. They suggest that in the future such applications could be used to power electric cars or to store electricity on the grid.

Other interesting battery developments have come about through nanotechnology research. Researchers at the Massachusetts Institute of Technology (MIT) have gone so far as to manipulate viruses to construct nanowires to make tiny batteries (MIT 2006). Zinc oxide nanowires are also being researched to make nano-generators that could be attached to clothing and designed to charge with body movement or wind. The researchers hope that such clothing could one day power an iPod or other electronic device, although their peers suggest that would be "very difficult to generate an output useful enough to power up devices" (Fildes 2008).

Commercial presence

High initial capital costs of supercapacitors have restrained their uptake; cheaper competing technologies such as batteries have been preferred for applications that require moderate power supply. Nonetheless, utilities are increasingly using devices such as supercapacitors to ensure the continuous supply of power during the period between a power blackout and the resumption of back-up power (Business Wire 2009). Supercapacitors are also slowly entering battery dominated devices such as digital cameras and flashlights.

Analysts suggest that the automotive sector will be the key driver of growth for supercapacitors in the coming decade, especially in hybrid vehicles. Some suggest that advancements in supercapacitor technology could displace the Li-ion battery as the dominant automotive battery technology before 2015 (Business Wire 2009). From 2010 onwards, in automotive sector applications, supercapacitors are expected to experience an annual revenue growth of 50 percent or higher (Business Wire 2009).

Sustainability and life cycle issues

We have not been able to find any life cycle analyses of supercapacitors that use nanomaterials. As discussed in following sections, the energy demands and environmental burden of manufacturing nanomaterials is high.

Health and environmental safety

The use of nanomaterials such as carbon nanotubes in supercapacitors poses health and environmental risks. The health risks associated with carbon nanotubes, in particular their potential to cause mesothelioma and disease similar to that caused by asbestos, have attracted international concern (see health and environment section following).

Nanocoatings and insulators

How is nanotechnology claimed to improve existing coatings and insulation?

Nanomaterials are used extensively in coatings that repel dirt and generate 'self-cleaning' surfaces for structures, household surfaces and buildings. Other nanocoatings are antimicrobial.

Nanostructured insulation is able to offer more effective insulation. Some nanocoatings are also used to insulate.

How is nanotechnology used?

Nanoscale insulators in the form of aerogels or 'frozen smoke' are extremely light and made of silica. As they are nearly transparent, they can be used in place of glass in skylights and roofing. As these contain countless nanoscale pockets of air, proponents claim they provide two to eight times better insulation than fiberglass or polymer foams (Cientifica 2007a).

Nanocoatings can also be used as insulation; insulation coating is created from a maze of nanoscale tunnels and can slow down heat transfer (Nansulate n.d.). Researchers hope that lighter nanomaterial insulation for cars and airplanes, based on multi-walled carbon nanotubes, could deliver energy savings by increasing fuel efficiency (Lecloux and Luizi 2009).

Nanotechnology based superhydrophobic materials can repel water and prevent icing. This could protect structures and building surfaces from harsh weather and icing (General Electric 2009).

Windows coated with nanomaterials such as nano titanium dioxide can repel dirt and self-clean, reducing cleaning costs. Nanomaterials such as titanium dioxide are also being promoted for their antimicrobial properties. Other nano paints can protect buildings and highway structures from dirt, cutting down on maintenance and cleaning (Overs 2009).

Nanomaterial coatings are also being developed as anti-fouling agents and surface treatments for boats. One company claims that its nanocoatings create a barrier against debris and build up on the hulls of boats and ocean vessels (Envere Marine n.d.). One company markets its nano titanium dioxide window applications on the basis that "biological contamination" is reduced and windows are kept clean (Bio Shield Inc. n.d.).

Some manufactures of nanocoatings also claim they can reduce the use of detergents. Numerous silver nano coatings have been introduced with antimicrobial properties including Bactiguard (Bactiguard AB, Sweden), HyProtect (Bio-Gate AG, Germany), Nucryst's nano-crystalline platform technology (Nucryst Pharmaceuticals Corp., USA), Spi-ArgentTM (Spire Corp. USA), Surfacine (Surfacine Development Company LLC, USA), and SylvaGard (AcryMed Inc., USA) (Wijnhoven 2009). These are used as medical antimicrobials in textiles and surface coating products including wall paints, self-sterilizing hospital gowns and bedding. Nano silver is also used widely in domestic products such as household cleaning aids, appliances, clothing, mattresses, computer keyboard coatings, food packaging and personal care products.

The use of photocatalytic nanocoatings for concrete pavements has also been mooted in an effort to reduce urban air pollution. By reacting with pollution in the air, the nanocoating is intended to break down harmful substances (Hassan 2010).

Market presence

Nanomaterial coatings are some of the most common nanoproducts on the market. There are nearly 100 examples of nanocoatings listed on the Woodrow Wilson Center's Project on Emerging Nanotechnologies nano consumer products database (Project on Emerging Nanotechnologies 2010). Nanoscale insulators have been on the market since 2003 (Cientifica 2007a).

Does nanotechnology deliver?

Nanocoatings do offer self-cleaning and antibacterial surfaces, although concern has been raised that the growing use of antibacterial coatings could have a negative public health impact (see following section). Further, life cycle analysis is required to determine whether or not nanocoatings and insulation offer energy and emission savings compared to conventional materials.

It is also unclear whether or not nano insulation offers substantial functional advantage and practical value over existing insulation materials and technologies. A report commissioned by the government of the UK found that nano insulation products that are currently commercially available are "relatively niche" and "do not appear to be replacements for mass insulation" (Oakdene Hollins 2007, 71). The report also noted that the cost of nano insulation applications will remain prohibitive until its environmental implications are assessed and any strong environmental advantage demonstrated. The authors observed that "there is little independent verification of the efficiency of these products so far". Finally, the authors pointed out that although there is much innovation in the insulation sector, not much of it uses nanotechnology.

Sustainability and life cycle issues

There has been inadequate life cycle assessment of the net environmental impacts of using nano-coatings or insulating materials rather than conventional materials. Given the increased energy demands associated with nanomaterials manufacture, and the toxicity concerns associated with both nanomaterials and production processes, it is not yet clear whether there is a sustainability advantage in using the nanoproducts.

An early hybrid life cycle assessment of the use of titanium dioxide coatings in concrete to reduce urban air pollution found mixed results (Hassan 2010). Costs included: increase in global warming, fossil fuel depletion, water intake, ozone depletion, and impacts on human health. Benefits

included: reduced acidification, eutrophication, air pollutants, and smog formation. The authors conclude that there is a net environmental benefit in using the nanocoating, although other researchers have cautioned that the methodology used may have underestimated the environmental and energy demands of manufacturing the nano titanium dioxide (Khanna and Bakshi 2009).

Environment and health risks

There are health and environmental concerns about nanomaterials used in nanocoatings and surface treatments. On a number of surface types, but especially tiles, coatings containing nano-titanium dioxide have been shown to release nanoparticles when subject to UV light and conditions simulating wind and human contact (Hsu and Chein 2007). Swiss researchers have detected titanium dioxide nanoparticles shed from paint on building exteriors in nearby soil beds and streams (Kaegi, et al. 2008). They found significant releases of titanium dioxide nanoparticles in urban runoff after a rainstorm.

See following sections on the health and environment risks of nanomaterials for a discussion about the potential negative ecological impact of nanomaterials and the potential for disruption by photocatalytic and antibacterial nanomaterials of carbon and nitrogen cycling.

Nanolubricants

Nanolubricants are also on the market. Israeli company ApNano Materials, Inc. sells engine and gear box lubricants based on "tungsten disulfide fullerene-like nanopowders" (NanoLub® n.d.). These can be used in automobiles, aircrafts, and marine equipment, as well as for aerospace applications. The company claims that independent testing shows that its lubricant diminishes engine friction, reducing fuel use in vehicles by more than 5 percent (AzoNano 2009). However, there are no life cycle energy assessments currently available that compare fuel savings with the energy demands of manufacturing the nanolubricant.

Fuel Catalysts

Background

Catalysts initiate or accelerate chemical reactions without being consumed by them (a process called catalysis). Catalysts added to fuel can result in a more complete combustion of fuel. This can allow a combustion engine to maximize energy extraction while minimizing emissions.

How is nanotechnology claimed to improve existing technology?

Nano fuel catalysts could reduce the amount of fuel wasted in car, bus and other vehicle engines. Nanoparticles are attractive ingredients in fuel catalyst because of their increased surface area and heightened surface reactivity. This can make the fuel catalyst more effective using less catalyst material.

Market presence

There are growing numbers of nanoparticle fuel catalysts on the market that claim to improve greater fuel efficiency. The Environ ™ Company's nanotechnology based fuel catalyst has been available in the Philippines as of 2005. The company claims that it achieves fuel savings of 8-10 percent and a reduction in emissions of 14 percent (Oxonica 2005).

Fuelstar™ is another manufacturer of nano based fuel catalyst (made of sub oxide tin), based in New Zealand. It claims that its product offers similar efficiency savings for cars, trucks, boats, ships, locomotives, power stations and mining equipment (Fuelstar™ n.d.). The company guarantees 8 percent fuel savings or your money back. The company claims their product is especially helpful in biodiesel fuels that tend to crystallize, for eliminating diesel bacteria in tropical climates, and also prevents gelling of diesel fuel in cold conditions (Fuelstar™ n.d.).

Fuel savings and emission reductions are also noted by other companies, such as Energenics, which recently demonstrated fuel savings of 8-10 percent on a mixed fleet of diesel vehicles in Italy (Cerion Enterprises 2009).

Does nanotechnology deliver?

The use of nano fuel catalysts has resulted in fuel efficiency savings in the order of 8 percent; further, studies on the nano cerium oxide product Envirox have confirmed that it reduces particulate matter and unburned hydrocarbons in vehicle emissions (Park, et al. 2008). This is substantial, but it does not necessarily mean that the catalysts deliver energy and environmental savings overall. None of the companies offer LCA comparisons of the energy and environmental burden associated with production of the nanomaterials compared to the efficiency savings their products are claimed to deliver.

Sustainability and life cycle issues

And as is the case with other nanoproducts, it is unclear whether the energy demands of manufacturing nano catalysts will outweigh the efficiencies in fuel consumption and reductions in emissions.

Environment and health risks

There are concerns that nanometals from fuel catalysts could be emitted in engine exhaust or that nano fuel catalysts could alter the toxicity of other emitted particles. This could pose new risks to people inhaling the particles, or the environmental systems into which emissions are released. *In vitro* hazard data regarding the potential health or environmental risks of fuel catalysts such as nano cerium oxide is limited and precludes a full assessment of fuel catalysts' health effects (Health Effects Institute 2001; Prospect: Global Nanomaterials Safety 2010).

A recent UK study found that at current levels of exposure to nano cerium oxide as a result of the addition of Envirox to diesel fuel, pulmonary oxidative stress and inflammation are unlikely (Park, et al. 2008). These are the precursors for respiratory and cardiac health problems. The study was conducted by Envirox in conjunction with academics. It is unclear whether higher levels of exposure, associated with greater uptake of such nano fuel catalysts, would pose unacceptable health risks.

Fuel catalyst products in the US must be registered under EPA's "New Fuel and Fuel Additive Registration Regulations," which requires manufacturers to analyze the emissions generated by their product (US EPA 2004). However, it is unclear how effective this regulation is while detection methods for nanoparticles are still in their infancy. It is difficult to imagine that company studies on emissions are able to provide accurate information on nanoparticle emissions.

Reinforced parts for airplanes and cars

How is nanotechnology claimed to improve existing technology?

Proponents hope that by using super strong, stiff and lightweight carbon nanotubes to reinforce car and airplane parts, they can achieve substantial weight savings that reduce fuel consumption.

Market presence

Carbon nanotubes are being used to reinforce specialty parts for planes, cars and high performance plastics, in fuel filters, electronic goods and carbon-lithium batteries (Cientifica 2007a). Although parts of aircrafts and vehicles have been built with carbon nanotubes, the nanocomposites currently on the market lack the structural properties to completely take the place of conventional materials in many applications (Greene 2009).

Nanotechnology applications have not been reported in commercial aircraft airframes until recently. The first application in the general aviation sector was announced in 2008. Avalon Aviation's Giles G-200 (single engine fully acrobatic) flew with Unidym's carbon nanotubes incorporated into its carbon fiber composite engine cowling. The nanotubes provided increased strength and flexibility to combat the effects of aerodynamic stress and engine vibration (Bax & Willems Consulting Venturing 2009).

In 2006 a Canadian nanotube supplier claimed that Boeing was keen to add single walled carbon nanotubes to its lightweight polymer composites to improve structural integrity and provide lightning protection (McCarthy 2006). Ninety percent of the outer structure of the new Boeing 787 consists of lightweight polymer-based composites in an effort to achieve fuel savings. We haven't been able to find updated information about whether or not the nanotubes are in use on commercial Boeing 787 planes.

Does nanotech deliver?

A report for the European Commission concluded that despite the expectations, technical and performance issues meant that nanotechnology had yet to be taken up widely or to deliver efficiencies in vehicles:

> *"… nanotechnology has not significantly contributed to lighter vehicles structures and powertrain systems nor to more efficient or alternative propulsion systems. Failing to meet the full set of industrial requirements (e.g. production volumes, automation and/ or quality assurance) is preventing further deployment into*

Friends of the Earth

mass-markets whereas stringent performance requirements (e.g. stiffness, strength, wear-resistance) at reasonable cost has limited its use on vehicle parts such as windows or bumpers" (Bax & Willems Consulting Venturing 2009).

Given the high energy demands of manufacturing carbon nanotubes, the use-phase must be extremely efficient to justify the large energy investment of manufacturing nanomaterials (Seager and Linkov 2009). Early life cycle analysis suggests that it is uncertain whether or not use of carbon nanocomposites will deliver energy savings in cars (see next section).

A key concern of Friends of the Earth's is that although any net life cycle energy saving and increase in fuel use efficiency will deliver environmental gains (especially in the automotive sector), such gains could be rapidly eroded by growth in the personal and industrial goods transport sector.

Boeing has announced its intention to achieve 20 percent fuel savings in its 787 planes. The use of carbon fiber (not nano) reinforced plastic polymers is reported to have helped it achieve a 3 percent fuel reduction (Brady and Brady 2007). No information exists regarding whether or not the use of carbon nanotubes could deliver further efficiency savings, or whether the major weight reductions have been achieved without nanotechnology.

Sustainability and life cycle issues

Early life cycle analysis has found that whether or not use of carbon nanofiber composites delivers energy savings in cars depends on certain variables (Khanna and Bakshi 2009). Carbon nanofiber (CNF) composites required 1.6-12 times the energy of steel to produce (Khanna, Bakshi and Lee 2008). Where they are used at lower loadings, 1.4-10 percent savings in lifetime fuel (gasoline) use are predicted. These fuel savings offset the extra energy associated with CNF manufacture, delivering net energy savings. Where CNF are used at higher loading (9-15 percent), their use may result in an overall increase of the fossil energy of the life cycle. Sources of uncertainty in the analysis include: the manufacturing efficiency of CNF, the extent to which nanocomposites can practically replace existing steel panels, whether or not CNF composites offer the required functionality and aesthetics in use, and distance travelled by the car.

A key concern of Friends of the Earth's is that although any net life cycle energy saving and increase in fuel use efficiency will deliver environmental gains (especially in the automotive sector), such gains could be rapidly eroded by growth in the personal and industrial goods transport sector.

Efforts to achieve widespread use of carbon nanotubes and carbon nanofiber in the automotive and airplane sectors require huge investment and pose substantial safety risks. Safety risks are particularly serious for workers manufacturing the nanotubes and the products in which nanotubes are used. Nonetheless, the efficiency gains may be as little as a few percent. Far greater environmental savings could be achieved by investing in efficient mass transport alternatives to daily commuting by private vehicle and to taking short haul flights, by discouraging the air freighting of perishable foods and by moving goods by rail rather than road or air wherever possible.

Further, the use of nanocomposites could substantially reduce the potential for building materials, car parts or other high performance plastics to be recycled. Separating nanomaterials from the composites in which they are embedded would be far more difficult – and perhaps energetically costly – than recycling the same unit of steel or aluminum.

Health and environment risks

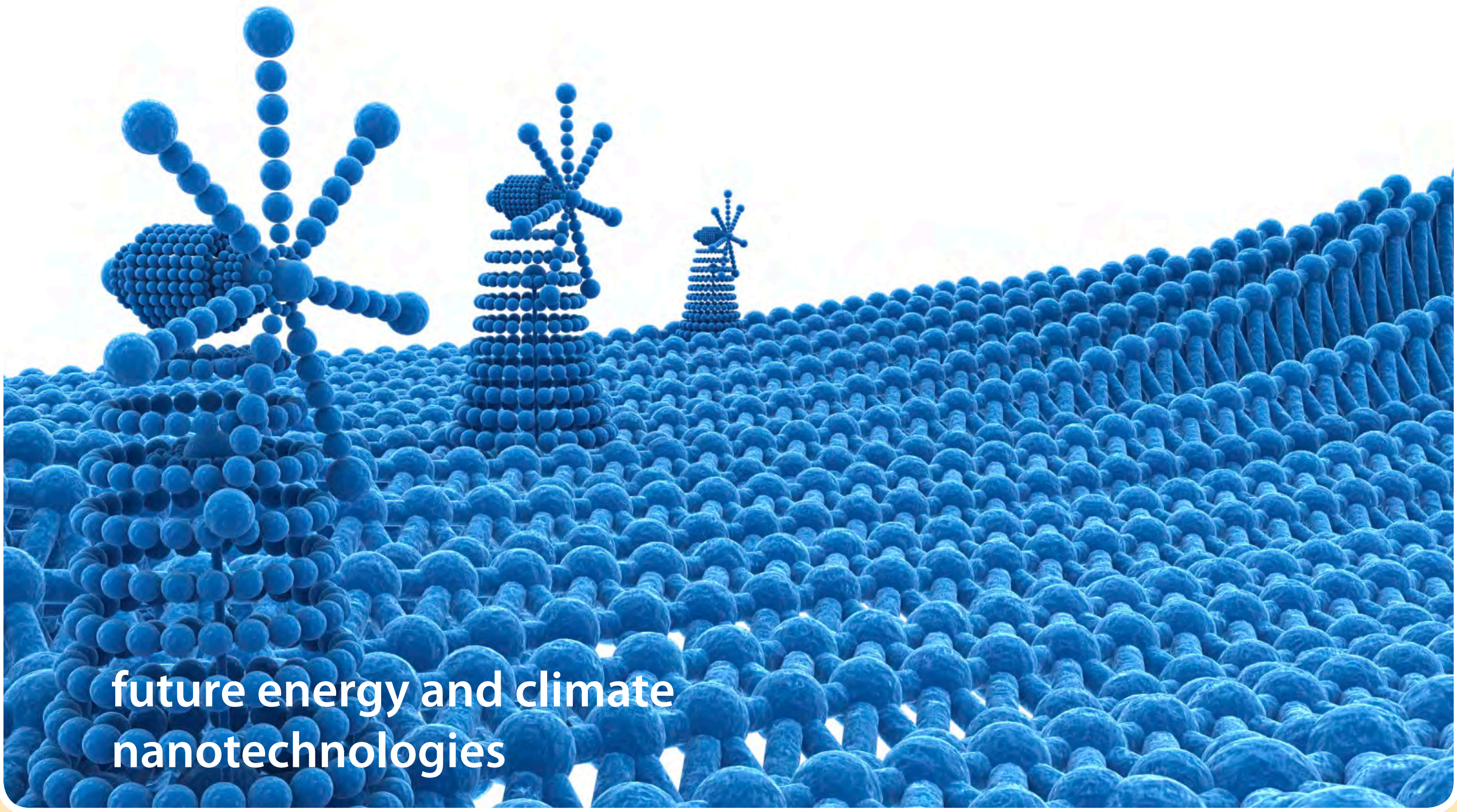
The health and environment risks associated with carbon nanotubes are discussed in detail in sections following. A key concern is that some forms of carbon nanotubes have been shown to cause mesothelioma, the deadly disease associated with asbestos exposure.

most nanoproducts are not being developed for energy savings and will carry a net energy cost

Nanotechnology proponents are keen to point to the potential for nanotechnology to deliver energy savings via applications such as solar cells, lithium-ion batteries for electric cars or lightweight components for airplanes or cars. In many instances it is difficult to establish whether there are in fact energy and environmental savings associated with these products, given the huge energy demands of nanomaterials manufacture, difficulties in recycling nanomaterials and significant uncertainties in conducting accurate life cycle analyses (Olapiriyakul and Caudill 2009; Reijnders 2009; Seager et al. 2008; Seager and Linkov 2009). However, it is seldom acknowledged that most nanoproducts on the market are likely to come at a net energy cost because they offer no potential during their use to recoup the huge energy investment associated with manufacturing the nanomaterials.

There are substantially greater numbers of nanoproducts on the market that offer no potential for energy savings than those that do. The nanoproducts that dominate current sales and product inventories, such as cosmetics and personal care products, are not only energy intensive to manufacture, but offer no potential for energy savings through their use. This is true of many – if not most – nanoproducts on the market, such as diet products, toothpastes, food additives, supplements, clothing, food packaging, cutlery, baby toys, household cleaning products, golf clubs and tennis racquets, antibacterial computer mouse pads and keyboards, and high performance televisions. "As is typical of rapidly growing industries, nanotechnology manufacturers are more focused on maximizing production and technological development than on environmental efficiency or sustainability" (Seager and Linkov 2009, 426).

In 2004 the UK Royal Society estimated that the skincare products sector was the biggest commercial user of manufactured nanoparticles – at least two orders of magnitude ahead of structural or environmental applications, information and communication technologies, or other sectors (UK RS/RAE 2004, 27). The product inventory maintained by the US Woodrow Wilson Center's Project on Emerging Nanotechnologies is not comprehensive and lists only products whose manufacturers identify nano content in their products. Nonetheless, it is interesting to note that in 2010, the inventory remains dominated by health and fitness nanoproducts, particularly cosmetics and personal care products (Project on Emerging Nanotechnologies 2010).



future energy and climate nanotechnologies

Nano solar has been predicted to deliver game changing functionalities and applications, for example spray on, energy generating plastic-based paint that can harvest infrared light five times more effectively than current solar cell technology (Lovgren 2005). However, most of these 'breakthrough' applications, along with the predicted dramatic efficiency gains or cost savings, remain at early laboratory or 'proof of concept' stages, far from being anywhere near practical applications. Whether or not such applications will be practically achieved – and what sort of time frame it will entail – remains uncertain.

Nanotechnology has a sort of science fiction quality to it, and proponents predict there will be a mass of future products that make it seem even more so. Things like tiny batteries made from viruses; 'nano antennas' and 'nanowires' able to capture energy from wind, sun and body movement to be used in clothing, camping equipment and hand bags; infrared-harvesting, plastic-based paint; and super-capacitors that will make our electronic devices incredibly small and our cars more efficient. Most of these technologies are still at a laboratory stage of development. Only a few such products are available to the (affluent) shopper, such as Konarka's range of travel wear, which incorporates small solar panels for recharging laptops or mobile phones.

An application that has consistently captured the imagination of the science community is nano-based infrared light generators. Infrared light, which has a longer wavelength than visible light, is impossible for the human eye to see, although we can feel it as heat. More than half of the light emitted from the sun is infrared and holds the potential to generate electricity similarly to the harvesting of UV and other visible light forms through solar panels. Infrared radiation can also be emitted from just about anything -- people, the ground, machines, engines, and factories to name a few.

Nano antennas have been constructed to capture infrared rays and turn them into electricity. Metal nanoparticles such as gold can be used to create tiny antennas, which can be printed on to sheets of plastic to produce electricity (Stricker 2008). Researchers hope that this technology could eventually help create solar panels that are able to collect energy from the sun during the night or in adverse weather conditions. However, although the antennas are currently very good at capturing the sun's energy, they are not very effective at converting it. Nonetheless, a physicist who spearheaded this technology at the Idaho National Laboratory hopes that once they overcome these technical challenges, the antennas could have the potential to replace traditional solar panels. He suggests that in the future antenna-based panels could be used to create portable battery packs and could even be imbedded into clothing (Stricker 2008).

Silicon nanowires may enable development of cheap thermoelectric devices that convert heat into electricity. This technology is predicted to require another 10 years of development (President's Council of Advisors on Science and Technology 2010). The University of California, San Diego (UCSD) has produced a similar technology. Their nanowires, built from indium phosphide, can increase the efficiency of plastic thin film solar cells (UCSD 2008).

Huge amounts of public funding are already invested in nanotechnology research and development in the energy and environment sectors. Without rigorous life cycle analysis it is very possible that this money will be devoted to applications that offer negligible or no environmental savings, while imposing a new generation of environmental and health hazards.

Nanoscale has also inspired highly futuristic wind energy concepts. A Mexican designer has developed the concept of using nanoscale wind turbines to create 'Nano Vent-Skin,' basically a thin covering of nanoscale wind turbines that connect with other photovoltaic systems. The wind turbines measure only 25mm by 10.8mm. The hope is that they can be placed on buildings and other edifices to generate power, for example if placed along the inside of railway tunnels the turbines could use the wind of a passing train to power the lights of the next station (Otegui 2008).

'Breakthrough' promises versus real-life barriers

Critically reviewing the barriers to nanotechnology product development and commercialization is essential for two key reasons. Firstly, the urgency of climate change demands that we act now to cut emissions. If nanotechnology products and applications are not going to provide certain and rapid solutions, we should instead focus on the practical and policy measures that will. Secondly, we must question the opportunity cost of continuing to direct large quantities of public funding into nanotechnology research when other sectors, for example mitigation measures, go begging for funds.

Many predictions regarding nanotechnology's capacity to deliver 'breakthrough' energy and climate benefits are based on applications that are still at a laboratory prototype stage. It is difficult to determine whether these products will work in the real world and on a large scale, or whether they'll remain intriguing but unviable ideas. However, such an examination is absolutely essential to deciding whether the huge hype – and public funding of research and development – for energy applications that use nano is warranted.

There are strong commercial incentives for industry to exaggerate the positive social and environmental effects of nanotechnology and to understate the technical or commercial obstacles to successful product development. Nanotechnology proponents put forth any number of promises in order to persuade target audiences and to mobilize resources to support industry development (Shelley-Egan 2010). However, pursuit of this 'hype strategy,' based on inflated promises, can direct investment into unfeasible areas of research rather than more practical fields (Shelley-Egan 2010).

Many proponents, including scientists, have predicted rapid commercialization of nanotechnology breakthroughs on the basis of extremely early stage, laboratory based work. Some researchers have cautioned that in the promotion of nano solar, manufacturing constraints and barriers are commonly ignored, and much of the work in the published literature is based on unrealistic expectations (Gupta, et al. 2009). Lux Research analyst Kristin Abkemeier emphasizes that the scaling up problems experienced by nano solar are not isolated: "The same is true with other nanotechnologies; it's not happening as soon as people thought it would" (Lubick 2009).

The CEO of nanotechnology analyst Cientifica has cautioned that practical barriers against taking a research discovery and turning it into a viable nanoproduct are significant: "The companies using nanotechnology to produce thin film solar systems have burned through a quarter of a billion dollars of venture capital money over six years, and still haven't cracked the manufacturing and reliability issues which will make the technology economic" (Harper 2007).

Enormous financial resources are directed to nanotechnology's energy and environmental applications. In 2008, this sector accounted for 29 percent of all nanotechnology funding by the US Federal Government, 14 percent of all US corporate nanotechnology funding and 41 percent of US venture capital funding. Further, energy and environmental applications were the subject of 21 percent of nanotechnology publications and 59 percent of all nanotechnology patents (President's Council of Advisors on Science and Technology 2010). Yet the same year only 1 percent of actual nanotechnology-based products came from the energy and environmental sector, including items such as nano-enabled filtration membranes or batteries (President's Council of Advisors on Science and Technology 2010). The US President's Council of Advisors on Science and Technology (PCAST) foresees that the majority of nanotechnology applications with biggest potential energy and environmental benefits remain at "embryonic or proof-of-concept stages and have not yet begun a trajectory toward the marketplace."

In addition to the fundamental technical challenges, key barriers in the commercialization of energy and climate nanotechnologies include: a high cost of production (including potentially to the environment), lagging efficiency and reliability, and toxicity (Ulrich and Loeffler 2006). There are many steps involved in bringing a new technology to market. From an invention or research discovery, research begins in the laboratory to create a laboratory prototype, which can then move to the industrial demonstrator stage where results can be introduced to companies, who can then bring the product to industrialization, which in turn can lead to market entry of the technology (Ulrich and Loeffler 2006). According to Cientifica, breakthroughs in bottom up engineering through nanotechnology, which could offer new energy technologies, are still 10 to 15 years away.

Whether or not research and development of certain energy technologies receives funding will often be up to governments. The PCAST report supports observations made by nanotechnology analyst Lux Research that the private sector is increasingly reluctant to be involved in nanotechnology research and development that has a long commercialization trajectory. "Venture capitalists are increasingly averse to areas of nanotechnology that have long times to market and high capital requirements... As a result, there is a need for novel approaches and funding mechanisms to support the transfer of technologies with long incubation times from the laboratory to the market" (President's Council of Advisors on Science and Technology 2010, 27).

Huge amounts of public funding are already invested in nanotechnology research and development in the energy and environment sectors. Without rigorous life cycle analysis it is very possible that this money will be devoted to applications that offer negligible or no environmental savings, while imposing a new generation of environmental and health hazards. Scarce public funding is being made available to directly tackle climate change through practical, low-risk measures that could deliver outcomes now; the research funding poured into nanotechnology could come at a high opportunity cost.

does nanotechnology deliver?

To put into perspective the hype around nanotechnology's potential to save us from dangerous climate change, nanotechnology analyst Cientifica predicted in 2007 that "taken as a whole, the use of nanotechnologies can contribute to the reduction of global CO_2 [carbon dioxide] emissions in 2010 by 0.00027%" (Cientifica 2007, 6).

In their 2008 report, the UK Royal Commission on Environmental Pollution recognized that nanotechnology's potential benefits had been overstated, that taking many nano applications from the laboratory to a commercial scale was proving very difficult, and that the energy demands, low yields and waste associated with nanomaterials manufacture were significant problems (UK RCEP 2008). The Royal Commission also emphasized that the potential for nanomaterials to pose serious new toxicity risks remained uncertain.

Friends of the Earth shares these concerns that in critical areas, nanotechnology doesn't deliver.

Energy demands of nanomanufacturing

The manufacture of nanomaterials is extremely energy intensive and has a high ecological footprint. This is related to: highly specialized production environments, high energy and water demands of processing, low yields, high waste generation, the production and use of greenhouse gases such as methane and the use of toxic chemicals and solvents (Eckelman *et al*. 2008; Khanna et al. 2008; Sengul et al. 2008).

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Why does it take so much energy to produce nanomaterials? The example of single walled carbon nanotubes (SWCNT)

Synthesis of SWCNT usually occurs in conditions of extreme heat. The general approach involves extremely high temperatures to vaporize a carbon source impregnated with metal catalyst in an inert environment (Seager, Raffaelle and Landi 2008). There are different techniques: arc discharge and carbon vaporization occur at thousands of degrees Celsius, while catalytic chemical vapor deposition (CVD) takes place at the relatively lower temperatures of 500 to 1000°C (Sengul, Theis and Ghosh 2008).

As the vapor cools, some carbon condenses into SWCNT, while the rest remains as carbon soot and waste products, some of it nano-structured. The inability to manufacture SWCNT precisely and the commonly low yields are a key problem (Reijnders 2009). Less than 10 percent by mass of the carbon vaporized may produce SWCNT (Seager, Raffaelle and Landi 2008).

After synthesis comes 'purification'. Even so-called high purity SWCNT may contain a large fraction of simpler forms of carbon or even metal contaminants. Depending on the end use, extensive purification may be required. First a strong acid wash is used to remove metals. Secondly, temperature is used to oxidize the simpler carbon to carbon dioxide, while retaining the SWCNT. Purification after synthesis can increase the energy demands of manufacture by up to 50 percent (Gutowski, Liow and Sekulic 2010).

Carbon nanotubes are touted as one of the most 'promising' nanomaterials for energy savings applications. Yet American researchers who evaluated the energy and exergy requirements for manufacturing carbon nanotubes concluded that single walled carbon nanotubes may be "one of the most energy intensive materials known to humankind" (Gutowski, Liow and Sekulic 2010).

Different nanomaterials require varying amounts of energy to manufacture. This is affected by feedstock materials (materials from which nanomaterials are produced) and production processes. There is also considerable variation in the reporting of manufacturing energy demands (Gutowski, Liow and Sekulic 2010). Despite this, various analyses have concluded that manufacturing nanoparticles is much more energy intensive than their non-nano counterparts (Tables 5 and 6).

Life cycle energy requirements for carbon nanofibers are 13 to 50 times those of primary aluminum used for smelting (an extremely energy intensive material) and 95-360 times those of steel, based on equal mass (Khanna, Bakshi and Lee 2008). The argument has been made that as the manufacturing sector matures, substantive efficiency savings will be achieved in manufacturing carbon nanotubes and other nanomaterials. However, even assuming a highly optimistic tenfold increase in efficiency, carbon nanofibers would still be three to ten times more energy intensive by mass than aluminum and steel (Khanna, Bakshi and Lee 2008). Kushnir and Sanden (2008) calculated that fullerenes and carbon nanotubes were two to 100 times more energy intensive to produce than aluminum, even using idealized production models. Sengul et al. (2008) evaluated the energy demands of nanomanufacturing integrated nano-circuits, nano-devices for electronics, nanotubes, nanowires and nanorods, quantum dots, fullerenes and dendrimers and found them to be extremely high, in addition to having high waste to product ratios.

In a survey of life cycle impacts of nanomaterials, the energy demands of milling processes for titanium dioxide were found to require significantly less energy than the more specialty processes associated with manufacturing carbon nanofibers or semiconductors (Meyer, Curran and Gonzalez 2009). Nonetheless, production of

1 kg of carbon nanotubes may embody the energy of 167 barrels of oil

Based on their review, Gutowski *et al*. (2010) suggest that "it is quite reasonable to expect an order of magnitude estimate of the embodied energy requirements for carbon nanotubes to be in the region of 0.1 – 1 TJ/ kg". One terajoule is one trillion joules. To put this into perspective, consider that it is the equivalent of the chemical energy found in about 167 barrels of oil. Or to put it another way, a woman's weight (63kg) in carbon nanotubes would embody the same energy as the atomic bomb that exploded over Hiroshima (63 TJ).

titanium dioxide nanoparticles results in 3-6 times more carbon dioxide equivalent emissions per kg than bulk form titanium dioxide (Osterwalder, et al. 2006). As much as 60kWh/kg and 16kWh/kg may be required for production of titanium and magnesium nanoparticles, respectively (Donaldson and Cordes 2005). Further, this milling process is not suitable for nanocomponents that require surface functionalization or specialty blending, which require more intricate manufacturing.

The huge energy demands of manufacturing nanoparticles are exacerbated by the sometimes extremely low yields of production. Although proponents emphasize nanotechnology's capacity for precision, these claims are not matched by reality. "In contrast to the suggestion that the precision of nanotechnology is conducive to eliminating waste products, processes for producing nanoparticles with narrow product specification often generate relatively large nanoparticulate non-product outputs" (Rejinders 2008, 299).

Dry synthesis methods for nanoparticle production (for example grinding down larger particles) yield poor particle size distributions that are vulnerable to contamination (Meyer, Curran and Gonzalez 2009). An inability to control manufacturing to achieve required diameters and lengths results in carbon nanofiber yields that are only 10-30 percent of the feedstock (Khanna, Bakshi and Lee 2008). Sengul *et al*. (2008) report highly variable yields for carbon nanotube production, from 20-100 percent for chemical vapor deposition processes, around 30 percent for arc discharge and up to 70 percent for laser ablation. However, in some cases less than 10 percent (by mass) of carbon input may produce single walled carbon nanotubes (SWCNT; Seager, Raffaelle and Landi 2008). Up to 90 percent of fullerenes produced may be sent to landfill because they have defects (RCEP 2008).

The variability of nanomaterials produced by different manufacturers can be large; many scientists have already experienced this and have also noted the batch to batch variation from single manufacturers (Klaine, et al. 2008). Large quantities of waste or defective materials are produced, some of which contains nanomaterials or their byproducts, which may be hazardous (Som, et al. 2010).

Table 5: Energy demands and environmental costs of manufacturing nanomaterials

Nanomaterial	Type of analysis, any constraints	Energy demands	Other environmental costs or benefits?	Study authors
Titanium dioxide nanoparticles	Energy, exergy and life cycle analysis were conducted on the Altair titanium dioxide nanoparticle hydrochloride process. Emissions associated with the supply chain of material and energy flows originating outside the process boundaries were not included. Energy required to obtain the ore was not included. EHS impacts of titanium dioxide nanoparticles not included.	The gross energy demands of manufacturing 40nm titanium dioxide nanoparticles were calculated to be close to 7,000 MJ/ hour, where 97kg of titanium dioxide nanoparticles were produced per hour. Distillation and spray hydrolysis were the most energy demanding; distillation requires 4,515.96 MJ/ hour.	The carbon dioxide emitted from the combustion of methane represents the largest contribution to global warming of the process. Hydrochloric acid used in the process is a potential health risk.	(Grubb and Bakshi 2008)
Single walled carbon nanotubes	Life cycle analysis of three established synthesis methods. Use and end-of-life phase are not considered. Health and environmental effects of single-walled carbon nanotubes were excluded. Authors note near absence of EHS data.	Environmental impacts from energy used in manufacture were approximately four orders of magnitude greater than for the other emissions. Although electricity use costs were only 1 percent of base case manufacturing costs, they contributed to 99 percent of environmental impacts.	Impacts considered were climate change, eutrophication, acidification, land use, mineral depletion, ecotoxicity, ozone layer depletion, carcinogens, airborne organics and inorganics. Non-energy emissions generated by the chemical vapor deposition method were an order of magnitude greater than the arc ablation or high pressure carbon monoxide synthesis methods. 40.62g of methane gas was generated for every gram of single walled carbon nanotube produced.	(Healy, Dahlben and Isaacs 2008)
Single-walled carbon nanotubes	Life cycle cradle to gate energy and environmental impact analysis for single-walled carbon nanotubes produced using a range of synthesis methods (CVD, arc ablation and HiPCo). No consideration of EHS impacts of SWCNT themselves.	SWNT synthesis is hugely intensive – 1,440,000 to 2,800,000 MJ per kilogram of SWNTs produced.	CVD had the greatest negative EHS impact, with strongly negative outcomes for 9 of 13 categories assessed. Arc ablation had the lowest.	(Isaacs, Tanwani and Healy 2006)
Carbon nanofiber	Life cycle cradle to gate energy and environmental impact analysis for vapor grown carbon nanofibers produced using a range of feedstocks. Comparison made to steel, aluminum and polypropylene on an equal mass basis. Authors note that most of the synthesis data "are either missing or proprietary" so careful assumptions were made. Several aspects were not included due to lack of reliable data, meaning that LCA results will represent only conservative lower bound estimates. Health and environmental impacts of CNFs were omitted due to lack of data.	Life cycle energy demands range from 2, 872 MJ/ kg for benzene feedstock to 10, 925 MJ/ kg for methane. Requirements for aluminum, steel and polypropylene are 218, 30 and 119 MJ/kg respectively. That is, on an equal mass basis, CNFs were 13 – 50 times more energy intensive than primary aluminum – a very energy intensive material. Even a tenfold potential future decrease in CNF life cycle energy requirements would mean they required 3 – 10 times more energy to produce than steel or aluminum on an equal mass basis.	CNF production has the highest environmental burden in all categories assessed: ozone layer depletion, radiation, climate change, respiratory inorganics, respiratory organics, carcinogens, land use, acidification and eutrophication, ecotoxicity and use of fossil fuels. The global warming potential of 1kg of CNFs is equivalent to 65kg of aluminum or 47kg of steel.	(Khanna, Bakshi and Lee 2008)
Carbon nanoparticles (fullerenes and nanotubes)	Energy requirements for cradle to gate are assessed for a range of synthesis methods (all energy flows up to nanomaterial production and purification). Use and end-of-life phase are not considered. Energy or material flows for capital infrastructure are not considered. Authors note that for several aspects of synthesis there is insufficient information for accurate estimates.	Carbon nanoparticles were 2 to 100 times more energy intensive than aluminum on an equal mass basis, even with idealized production models.	Not addressed. Some synthesis methods use methane, benzene or carbon monoxide as feedstocks, or require large quantities of solvent.	(Kushnir and Sanden 2008)
Various oxide nanoparticles	Cradle to gate analysis of energy requirements, CO2 equivalent emissions and economic costs for wet and dry methods for oxide nanoparticle synthesis. Khanna et al. (2008a) note that due to omissions or approximations of data relating to the energy demands, release and impact of emissions of nanomanufacturing, the LCA accuracy is limited.	Plasma processes, required for manufacturing complex oxide nanoparticles, or heavier particles, such as zirconia, are very energy intensive.	Production of nanoparticle titanium dioxide results in 3 – 6 times more carbon dioxide equivalent emissions per kg produced than bulk form titanium dioxide. Multi-step 'wet' processes are suitable for light elements such as titania, but although these processes use less energy, they require large amounts of toxic solvents.	(Osterwalder, et al. 2006)

Environmental footprint of nanomanufacturing

The energy demands of nanomaterials manufacture, and the life cycle energy efficiency of nanoproducts, are only one component of their ecological footprint. The global warming potential of manufacturing, the chemical burden of manufacturing, the huge water demands of production, the impact of manufacturing on resource depletion and land use, occupational exposure to both nanomaterials and other toxic chemicals used in manufacturing, public exposure to nanomaterials during product use, and the release of both nanomaterials and other toxic byproducts into the environment all contribute to nanomaterials' life cycle environmental burden (Khanna et al. 2008; Meyer et al. 2009; Sengul et al. 2008).

Life cycle analysis (LCA) is intended to be a comprehensive tool for environmental sustainability assessment (Som, et al. 2010). Unfortunately because of the significant uncertainties with the health and environmental risks associated with nanomaterials, and with the end-of-life recycling and disposal, most life cycle analyses that have been carried out to date on nanoproducts exclude these risks from analysis (Healy, et al. 2008; Khanna, et al. 2008; Khanna and Bakshi, 2009; Merugula, et al. 2010; see below).

Greenhouse gas emissions of the life cycle of nanomaterials are in part related to the energy demands of manufacture, as most energy supplies are heavily reliant on fossil fuels (Gutowski, et al. 2010; Healy, et al. 2008). Several studies have found that many nanomaterial manufacturing processes for fullerenes, carbon nanotubes and titanium dioxide nanoparticles are not only very energy intensive but also use and release hydrocarbons such as methane (Grubb and Bakshi 2008; Khanna et al. 2008a; Kushnir and Sanden 2008; Merugula, *et al.* 2010; Meyer et al. 2009; Sengul et al. 2008). The reliance of some nanomaterials manufacturing processes on methane as a feedstock is a key contributor to their global warming potential (Grubb and Bakshi 2008; Meyer, et al. 2009).

Many nanomaterials manufacturing processes use large quantities of toxic, basic or acidic chemicals and organic solvents. Many of these chemicals are persistent (do not readily break down in our bodies or in the environment), accumulate in the body and are toxic (Sengul, Theis and Ghosh 2008). Aromatic hydrocarbons, chemicals which have these characteristics, are used as precursors for the growth of carbon nanotubes and are also formed as byproducts. Emissions of 15 different aromatic hydrocarbons have been identified (Sengul, Theis and Ghosh 2008). The production of titanium dioxide nanoparticles uses large amounts of either sulfuric or hydrochloric acid (Grubb and Bakshi 2008). In conventional methods

One assessment of single walled carbon nanotube (SWCNT) manufacture found that 40.62g of methane gas were generated for every one gram of SWCNT produced (Healy, Dahlben and Isaacs 2008). The global warming potential of methane is 56 times that of carbon dioxide over a 20 year time frame, and 21 times that of carbon dioxide over a 100 year time frame (UNFCCC n.d.).

for purification of nanoparticles such as gold, used for example in dialysis extraction, centrifugation or chromatography, as much as 15 liters of solvent may be used per gram of nanoparticle produced (Sweeney, Woehrle and Hutchison 2006). Production of fullerenes and carbon nanotubes results in a high proportion of waste that contains a variety of carbon structures (Som, et al. 2010). There has not been a full characterization of the substances in such wastes and it is not clear how to dispose of them safely – or whether it can be disposed of safely. Nonetheless, the byproducts of manufacturing carbon nanotubes have proven to be toxic to aquatic organisms (Templeton, et al. 2006).

The manufacturing of nanomaterials may also drive resource depletion. Sengul et al. (2008) cite Mazurek (1999)'s estimation that 99.9 percent of materials used to manufacture one dimensional nanoproducts used in computers and electronic goods are not contained in the final products, but become waste products. They further observe that: "Many of the materials used in nanomanufacturing are rare, with demand sometimes exceeding production. This raises concerns about availability, price and the suitability of substitutes" (Sengul, Theis and Ghosh 2008, 352). Dutch researchers argue that because thin film nano solar based on cadmium telluride and CIGS is reliant on scare minerals such as indium and gallium, these technologies will never be able to contribute more than 2 percent of global energy demand, due to resource constraints (Kleijn and van der Voet 2010). The United Nations Environment Programme suggests that without rapid efforts to dramatically boost the recovery of rare metals from products at end of life, many high tech applications face resource constraints in the near future (UNEP 2010a).

Health risks of nanomaterials

The gaps in our understanding of nanomaterials' biological behavior and of their new toxicity risks are large; our capacity to measure, assess, compare and mitigate these risks is in its infancy. Researchers at the Technical University of Denmark have recognized that " knowledge gaps pervade nearly all aspects of basic EHS [Environmental, Health, and Safety] knowledge, with a well recognized need for improved testing procedures and equipment, human and environmental effect and exposure

assessments and full characterization of NM [nanomaterials]" (Grieger, Hansen and Baun 2009).

The European Food Safety Authority has stated clearly that the extent of uncertainty is such that design of reliable risk assessment systems for nanomaterials is not yet possible: "Under these circumstances, any individual risk assessment is likely to be subject to a high degree of uncertainty. This situation will remain so until more data on and experience with testing of ENMs become available" (EFSA 2009, 2-39).

Community groups and scientists calling for urgent research into the health and safety of nanomaterials have been joined by some industry members. During a recent Nano Renewable Energy Summit in Denver, Jim Hussey, the CEO of biomaterials company NanoInk and board member of the NanoBusiness Alliance, told the *New Haven Independent* that: "There are no good, well-controlled studies to prove the safety of our nanomaterials…Frankly, we have none. We need to lead the world in environmental health and safety nanotech testing. We either get ahead of this or it will roll over us as an industry… There is no question that the invasion of cells by nanoparticles could be carcinogenic" (Motavalli 2010).

As particle size decreases, in many nanoparticles the production of free radicals increases; the production of free radicals is a key mechanism for nanotoxicity. Test tube studies have shown that some nanoparticles now in commercial use are toxic to cells (Gerloff, et al. 2009), can damage DNA (Xu, et al. 2009), negatively affect protein expression (Chen, et al. 2008a), nucleate protein fibrillation (Linse, et al. 2007), and cause programmed cell death (Hussain, et al. 2010). Mice studies have found that nanoscale titanium dioxide, touted for use in many energy applications, use can cause genetic instability (Trouiller, et al. 2009) and can pass from pregnant mice to their offspring, damaging their genital and cranial nerve systems (Takeda, et al. 2009). The transfer of fullerenes from pregnant mice to their offspring has also been demonstrated, severely disrupting development of embryos (Tsuchiya, et al. 1996).

Particularly high concerns exist regarding the potential for exposure to nanotubes to cause mesothelioma. The UK's Royal Society (UK RS/RAE 2004) and risk specialists at the world's second largest reinsurance agent (Swiss Re 2004) have warned that carbon nanotubes may behave like asbestos once in the lungs. Since then, a series of *in vivo* experiments have demonstrated that when introduced into the lungs of rodents, carbon nanotubes cause inflammation, granuloma development, fibrosis (Lam, et al. 2004; Muller, et al. 2005; Shvedova, et al. 2005), artery 'plaque' responsible for heart attacks and DNA damage (Li, et al. 2007). Early studies have shown that some forms of carbon nanotubes can also cause the onset of mesothelioma – cancer previously thought to be only associated with asbestos exposure (Poland, et al. 2008; Sakamoto, et al. 2009).

In addition to the ecological concerns associated with burgeoning use of nano-antimicrobials, there could be a public health cost. Microbiologists and hospital managers have voiced their fears that increasing use of powerful nano- antibacterials in every day consumer products could promote more rapid development of bacterial resistance to nano silver (AM 2009; Salleh 2009). "The wide and uncontrolled use of silver products may result in more bacteria developing resistance, analogous to the world-wide emergence of antibiotic-and other biocide-resistant bacteria" (Silver 2003, 350). This could diminish the utility of nano silver as a medical aid, where it is increasingly used as an alternative to antibiotics to which bacterial resistance already exists. Some reviewers have suggested that clinical bacterial resistance to silver is low and can be managed effectively (Chopra 2007). However, others have cautioned that resistance may already be widespread but undetected (Silver, Phung and Silver 2006). A random collection of enteric (gut) bacteria from a Chicago hospital found that 14 percent had genes for silver resistance (Silver 2003).

The most common nanomaterial in products can produce significant greenhouse gas emissions

Nano silver is reported to be the most common nanomaterial in products; it is frequently used in odor-killing socks and clothing, but also in washing machines, mattresses, kitchenware and other household products. A report in *New Scientist* suggests that its burgeoning use in antibacterial applications could be coming at a huge climate cost. In addition to the energy required to create nano silver, exposure of sludge similar to that found in waste water treatment plants to silver nanoparticles resulted in four times the release of nitrous oxide (Knight, 2010). The United Nations Framework Convention on Climate Change (UNFCCC) considers nitrous oxide to be 310 times more effective at trapping heat in the atmosphere when compared to carbon dioxide over a 100-year time period, which makes it an extremely potent greenhouse gas (UNFCCC n.d.). The public should be made aware that avoiding these types of products can reduce their carbon footprint. Labeling laws are required to ensure people's right to choose nano silver-free products. Equally importantly, regulations should require a greenhouse gas emissions assessment alongside a basic safety assessment, to ensure that climate damaging products are not brought to market.

The potential for nanomaterials to accumulate in the body is a particular concern. Transfer of nanomaterials such as quantum dots between species of different levels of the food chain (trophic levels) has been demonstrated (Bouldin, et al. 2008). In its annual report, the University of California's Center for Environmental Implications of Nanotechnology (UC CEIN 2010) notes that its researchers have found substantive evidence of nanomaterials' bioaccumulation. Their initial experiments have shown that titanium dioxide stimulates the growth of a wide range of freshwater algae, leading to accumulation of titanium dioxide in the tissues of higher trophic levels. Other studies examining the effects of exposure to cadmium selenium quantum dots showed that accumulation and magnification occurs at lower trophic levels (bacteria and protozoa). The report warned that this could mean an even more extreme condition at higher trophic levels, including fish and mammals (UC CEIN 2010).

Many nano solar applications now use quantum dots with cadmium cores, or cadmium telluride films. An inhalation study using rats found that cadmium telluride was far less toxic than cadmium itself (Zayed and Philippe 2009). Nonetheless cadmium telluride is toxic to human breast cells and to prostate cells *in vitro* (Liu, et al. 2008). Quantum dots have been shown to cause acute cytotoxicity to liver cells (Derfus, Chan and Bhatia 2004) and skin cells in *in vitro* studies (Ryman-Rasmussen, Riviere and Monteiro-Riviere 2007). These studies showed that the presence of surface coatings can substantially reduce quantum dot toxicity, although another study found that poly-L-lysine coatings increased toxicity (King-Heiden, et al. 2009). However the long term persistence of coatings in the environment and in animals is poorly understood.

An *in vivo* mice study has shown that 8.6 percent of quantum dots remained in the liver five days after intravenous exposure, from where clearance was difficult; this suggested that long term persistence of small fractions of the quantum dots may occur (Chen, et al. 2008b). In their study of quantum dot transfer from green algae to daphnids, Bouldin and colleagues observed that: "coatings present on nanocrystals provide protection from metal toxicity during laboratory exposures but that the transfer of core metals from intact nanocrystals may occur at levels well above toxic threshold values, indicating the potential exposure of higher trophic levels" (Bouldin, et al. 2008, 1958). A study on zebrafish embryos found that quantum dots were more toxic than exposure to cadmium ions alone (King-Heiden, et al. 2009). The researchers attributed this to both the *in vivo* partial breakdown of coatings allowing release of cadmium ions, oxidative stress associated with the production of ROS by the quantum dots, and toxicity of other quantum dot components.

Environmental release of nanomaterials could pose risks to not only environmental systems, but also to human health. Som et al. (2010) warn that health risks associated with indirect exposure of humans to nanoparticles in the environment cannot be ignored. They give the cautionary example of children facing harmful lead exposure through uptake of soil and dust contaminated by lead-based paints falling off walls and facades.

Environmental risks of nanomaterials

There is a serious paucity of nano-ecotoxicological data. However, a review of the literature regarding toxicity to aquatic invertebrates concluded that "the limited number of studies has indicated acute toxicity in the low mgl^{-1} [milligrams per liter] range and higher of engineered nanoparticles to aquatic invertebrates, although some indications of chronic toxicity and behavioral changes have also been described at concentrations in the high μgl^{-1} [micrograms per liter] range" (Baun, et al. 2008, 387). Early studies have revealed that nanoparticles of zinc oxide are very toxic to the development of sea urchin embryos. Effects are seen at

concentrations that are approximately 10-100 times smaller than those previously reported for aquatic systems (UC CEIN 2010). There is also preliminary evidence that some nanoparticles could have a negative impact on algae and plants, and impair the function or reproductive cycles of bacteria and fungi which play a key role in nutrient cycling that underpins ecosystem function (Navarro, et al. 2008).

Microorganisms are of great importance environmentally. They are the foundation of aquatic ecosystems and provide key environmental services ranging from primary productivity to nutrient cycling and waste decomposition (Klaine, et al. 2008). Yet the same antimicrobial properties of nanoparticles such as silver and titanium dioxide that make them useful for self-cleaning or germ-killing reasons could also interfere with beneficial bacteria in natural environments or waste treatment facilities (Klaine, et al. 2008). A preliminary study found that when small quantities of nano silver were added to activated sludge, the population of microbes and its activities declined, and four times the normal quantity of nitrous oxide was released (Knight 2010). This raises concerns not only regarding the potential for nano contaminants to disrupt the bacteria-driven waste processing of sewage treatment plants, but also regarding potentially vastly enhanced levels of greenhouse gas emissions from these plants.

Another recent study has demonstrated that nanoparticles of titanium dioxide inhibited the growth and nitrogen fixation activity of blue-green algae (Cherchi and Gu 2010). Blue-green algae are a type of bacteria that produce their own food via photosynthesis. Nano titanium dioxide induced both a dose and time dependent stress response. The study authors cautioned that the release of nano titanium dioxide in aquatic environments could potentially impact important biogeochemical processes, such as carbon and nitrogen cycling (Cherchi and Gu 2010). These cycles form the foundations of ecosystem function. This study is especially concerning in light of new studies that show that nano titanium dioxide is released into streams in effluent from sewage treatment plants (see below).

Nanomaterials may also pose ecological risks through their mobilization of heavy metals or other pollutants in the environment. Nanomaterials may bind to organic chemical pollutants or transition metals, which may increase their toxicity (Moore 2006). Nanomaterials may also alter the transport and bioavailability of these pollutants (Navarro, et al. 2008), delivering them to sites within the environment or human body to which they would not normally have access (the Trojan horse effect). Nanomaterials have been shown to act as carriers of co-existing contaminants. A far higher bioaccumulation of cadmium in carps was found when nanoparticles of titanium dioxide were present (Zhang, et al. 2007). C_{60} fullerenes were found to alter the bioaccumulation and toxicity of two other environmental contaminants towards *Daphnia magna*, an aquatic invertebrate used by regulators as an indicator species; the toxicity of pentachlorophenol was decreased, while the toxicity of phenanthrene was increased (Baun, et al. 2008). The toxicity and bioaccumulation of heavy metals in nano-form may become important environmental challenges (Bystrejewska-Piotrowska, Golimowski and Urban 2009).

There has been some suggestion that because many commercially used nanomaterials are soluble, or partially soluble, they pose no new risk of nanoparticle-mediated toxicity. That is, some have assumed that these nanoparticles rapidly dissolve into ions once released into waste water or aquatic systems. However, increasing numbers of studies have demonstrated that in nanoparticle form zinc oxide, silver, copper, cobalt oxide, manganese oxide, quantum dots and other soluble and partially soluble materials exert both ion and particle-mediated toxicity (Asharani, et al. 2008; Bai, et al. 2009; Brunner, et al. 2006; Griffitt, et al. 2009; King-Heiden, et al. 2009; Limbach, et al. 2007). Further, some studies have shown that these soluble or partially soluble nanoparticles accumulate in nanoparticle form in the organs, cells and cell nuclei of exposed animals (Asharani, *et al.* 2008; Griffitt, *et al.* 2009; Limbach, *et al.* 2007).

Because small quantities of potent nanomaterials can be used in place of much larger amounts of conventional materials, a common expectation has been that nanomaterials will lower energy and resource use and pollution. As is clear from the discussion above, the ecological cost of nanomaterials production processes is far greater than that associated with bulk materials. Moreover, irrespective of their being used in smaller quantities, the toxic burden of nanomaterials is predicted to be far greater than that of bulk materials by mass. In 2006 the Woodrow Wilson International Center for Scholars' Project on Emerging Nanotechnologies predicted that 58,000 metric tons of nanoparticles will be produced world-wide from 2011 to 2020 (Maynard 2006). They estimated that given the potency of nanoparticles, this could have an ecological impact equivalent ranging from five million to a massive 50 billion tons of conventional materials.

Not all nanoproducts that are specifically designed to save energy may offer net energy savings over their life cycle compared to conventional materials.

There is growing evidence that release of nanomaterials into the environment occurs even when they are embedded in composite materials. In nanocomposites containing organic polymers, there can be a substantial increase in degradability under solar or UV irradiation, as compared with non-nano polymers (Reijnders 2009; Som, et al. 2010). Thermal degradation may be enhanced by the incorporation of nanoparticles. Even when stability is important to nanocomposite design, nanoparticles may still be released. Reijnders concludes that given evidence that manufactured nanoparticles used in composites and coatings may be hazardous, "Claims that nanocomposites are 'environmentally safe,' 'environment(ally)-friendly' or 'eco-friendly' and that TiO^2 [titanium dioxide] nanoparticles are 'non-toxic' do not seem to have a firm foundation in empirical data" (Reijnders 2009, 874).

Exposure and nanoparticle transport modeling has predicted that up to 95 percent of nanoparticles used in cosmetics, coatings and cleaning agents and up to 50 percent of nanoparticles used in paints may end up in sewage treatment plants (Mueller and Nowack 2009). Waste and water treatment plants are not well equipped to remove nanoparticles before treated waste water (effluent) is discharged (Reijnders 2009). Kiser et al. (2009) have detected nanoparticles of titanium dioxide in sewage and biosolids. They found that titanium dioxide particles had an affinity for solids and the majority was removed in the treatment process. However, 10-100 micrograms per liter of titanium dioxide particles still remained in tertiary treated effluents which are released into streams and natural systems. Further, the authors warn that titanium dioxide concentrations in biosolids are likely to be much higher. Biosolids are then used as agricultural fertilizers, placed in landfills, incinerated, or dumped into oceans (Kiser, et al. 2009). Swiss researchers modeled the environmental concentrations of several commercially used nanomaterials and predicted that nano silver, titanium dioxide and zinc oxide released from sewage treatment effluents may already pose risks to aquatic organisms (Gottschalk, et al. 2009).

Some authors have suggested that nanoparticles will rapidly agglomerate or aggregate once released into the environment, thereby reducing the potential for them to exert nano-specific toxicity. However, agglomeration and aggregation processes, and disagglomeration and disaggregation processes are not well understood. Researchers at the University of California Center for Environmental Implications of Nanotechnology (UC CEIN) have demonstrated that bacteria can disagglomerate a common metal oxide (UC CEIN 2010). They note that this has implications for nanomaterial transport in porous media in the environment.

Importantly, there is preliminary evidence that agglomerates or aggregates of nanoparticles may still be toxic. Where toxicity is driven by the surface structure of a particle, the toxic properties of agglomerated or aggregated nanoparticles may be very similar to that of the primary nanoparticles that compose them. Bai *et al.* (2009) found that although in solution the nanoparticle zinc oxide they studied readily formed clusters of small and large aggregates, the (aggregated) nanoparticle zinc oxide exerted a greater toxic effect on developing zebrafish embryos than the corresponding concentration of zinc ions. Griffitt *et al.* (2009) also found that in solution nano silver and nano-copper readily formed suspensions that

Table 6: Life cycle assessment of nanoproducts compared to conventional products

Nanoproduct	Purpose of nano-component	Type of analysis, any constraints	Energy demands	Other environmental costs or benefits	Study authors
Nano titanium dioxide coated concrete pavement	The photocatalytic coating is designed to trap and absorb smog and air pollutants.	Hybrid life cycle assessment of nano TiO2 coated concrete pavement. Uses both LCA and Economic Input-Output modeling, with additional data added for energy requirements of nano titanium dioxide manufacture. Emissions data used are from the 2008 EIOLCA model developed by Carnegie Mellon which Khanna and Bakshi (2009) caution is based on coarse and aggregated data for a range of US industry sectors.	Not addressed.	Costs: Will increase global warming, fossil fuel depletion, water intake, ozone depletion, and impacts on human health. Benefits: will reduce acidification, eutrophication, air pollutants, and smog formation. Authors conclude that there is a net environmental benefit.	(Hassan 2010)
Carbon nanofiber (CNF) polymer composites	To enable production of strong, lightweight panels to replace steel panels in cars, thereby reducing car weight and increasing fuel efficiency.	Life cycle analysis comparing overall energy demands/ savings of CNF composite to steel. No account made of human health and environmental toxicity of CNFs, or end of life release of CNFs, primarily due to data gaps.	Depends on certain variables. CNF composites required 1.6-12 times the energy of steel to produce. Where CNFs are used at lower loadings, 1-4-10 percent savings in lifetime fuel (gasoline) use are predicted. These fuel savings offset the extra energy associated with CNF manufacture, delivering net energy savings. Where CNFs are used at higher loading (9-15 percent), their use may result in an overall increase of the fossil energy of the life cycle. Sources of uncertainty include: manufacturing efficiency of CNFs, the extent to which nanocomposites can practically replace existing steel panels, whether or not CNF composites offer the required functionality and aesthetics in use, and distance travelled by the car.	Not addressed. However, authors note that process LCAs (eg Khanna et al. 2008) have found CNF manufacture has a higher environmental burden compared to steel.	(Khanna and Bakshi 2009)
Clay nanocomposites	To enable production of strong, lightweight panels to replace steel or aluminum in cars, thereby reducing car weight and increasing fuel efficiency.	Life cycle analysis comparing overall energy and environmental demands/ savings of clay nanocomposites compared to steel. However, assessment does not use up-to-date data for nanomaterials production. Khanna and Bakshi (2009) have cautioned that the Economic Input-Output LCA (EIOLCA) model used in this study for information regarding energy and environmental impacts of nanocomposite production relies on coarse and aggregated data for different US industrial sectors. Specific process details are missing. Khanna et al. (2008a) note that due to omissions or approximations of data relating to the energy demands, release and impact of emissions of nanomanufacturing, the LCA accuracy is limited.	Life cycle energy savings are obtained by substitution of steel parts by nanocomposites in both 'lower bound' and 'upper bound' scenarios. The lower bound scenario would deliver less carbon dioxide emission reductions than would substitution of steel by aluminum (230kg per vehicle, compared to 310kg per vehicle), whereas the upper bound scenario would deliver more (414kg per vehicle).	The EIOLCA predicts that both upper and lower bound nanocomposite scenarios would deliver environmental savings in the areas of greenhouse gas emissions and toxic releases, with modest water savings. The lower bound scenario would result in greater generation of hazardous waste.	(Lloyd and Lave 2003)

Cont'd, Table 6: Life cycle assessment of nanoproducts compared to conventional products

Nanoproduct	Purpose of nano-component	Type of analysis, any constraints	Energy demands	Other environmental costs or benefits	Study authors
Platinum group metal (PGM) nanoparticles and nanofabrication for automotive catalysts	To use nanofabrication for better control of the shape, size and position of PGM particles in automotive catalysts. Aim to reduce PGM loading levels while maintaining performance, delivering resource and energy savings	Life cycle analysis comparing overall energy demands/ savings of reducing PGM use. However, assessment does not use up-to-date data for nanomaterials production or address any additional energy demands of nanofabrication. Khanna and Bakshi (2009) have cautioned that the Economic Input-Output LCA (EIOLCA) model used in this study relies on coarse and aggregated data for different US industrial sectors. Specific process details are missing. GaBi software is also used to calculate cradle to gate energy and environmental costs of noble metals. It is not clear that this is relevant to nanomaterials. Khanna et al. (2008a) note that due to omissions or approximations of data relating to the energy demands, release and impact of emissions of nanomanufacturing, the LCA accuracy is limited.	The authors do not assess the energy implications of nanofabrication of PGM catalysts. Nonetheless, they observe that reducing quantities of PGM required by the automotive sector will deliver energy savings: "If the benefits of also lowering vehicle emissions are retained, the nanotechnology would make a large life cycle environmental contribution".	Does not address environmental demands of nanofabrication. However, does state that PGM production requires large amounts of energy, water and ore and generates large quantities of tailings. Reduced PGM use will deliver savings in these areas.	(Lloyd, Lave and Matthews 2005)
Carbon nanofiber (CNF) reinforced windmill blades	To reinforce the interface of a glass fiber/ epoxy matrix. The aim is to enable production of lighter and more long-lived large windmill blades.	LCA of energy demands/ returns of CNF reinforced windmill blades, comparative to traditional material. No assessment of non-energy environmental or safety aspects.	Depends on certain variables, mainly manufacturing process, solvent handling and quantity of CNTs used. Cradle to gate processing of the CNF-windmill blades is 1.4 to 7.7 times more energy intensive than the original material. If CNF blades do result in both weight savings and increased life span, potential energy savings across the life cycle vary from insignificant to substantial. However, there may be practical constraints to using CNF hybrid materials; the authors note that "weight savings by CNFs may assume a prohibitively thin blade". The authors conclude that "it is not yet substantiated whether replacement of long carbon fibers is advantageous both mechanically and energetically".	Not addressed.	(Merugula, Khanna and Bakshi 2010)
Nano silver impregnated T-shirts	The antibacterial properties of silver may mean the T-shirts require less frequent washing, and at reduced temperatures.	LCA compared net energy savings of nano silver T-shirt compared to conventional polyester T-shirt under range of scenarios. Both flame spray pyrolysis and plasma/ sputtering nano silver manufacturing methods were compared. No assessment of non-energy environmental or safety aspects.	Depends on certain variables; in 2 of 3 scenarios nano silver use in T-shirts increased energy demands. Net energy savings are only achieved in the 'breakthrough' scenario where there is increased efficiency in nano silver manufacturing, comprehensive consumer uptake and behavioral change (reduced washing and at lower temperatures). The uncertainty in the assessment was relatively high.	Not addressed. Authors note that different nano silver production technologies have different environmental impacts. Further, nano silver released to the environment may negatively affect the function of sewage treatment plants.	(Frischknecht, Büsser and Krewitt 2009)

contained a substantial number of aggregates and agglomerates >100nm in size. Nonetheless, nano-copper was significantly more toxic to the exposed zebrafish than dissolved copper ions alone, and nano silver resulted in a dramatically higher silver gill content and silver body burden than dissolved silver ions alone. Chronic exposure of juvenile carp to sub-lethal doses of fullerene aggregates with average diameters of approximately 349 and/or 1,394 nm over a 32 day period caused significant oxidative stress, and reduced length and body weight (Zhu, et al. 2008).

Life cycle energy demands of nanoproducts compared to conventional products

It is important to conduct life cycle analysis on nanoproducts compared with conventional products, rather than simply assessing the energy demands of nanomaterials production, given that small quantities of nanomaterials may be used in a product.

The assumption is commonly made that because nanomaterials are used in such small quantities, their contribution to the energy demands of the products in which they are used will be negligible (Meyer, Curran and Gonzalez 2009). However, early nanoproduct comparisons have found that this is not the case. Carbon nanotube-reinforced polymer composites are also more energy intensive than conventional materials such as aluminum or steel that they may be designed to replace. Khanna and Bakshi (2009) use a cradle to gate analysis to calculate that for equal stiffness design, carbon nanofiber-reinforced polymer composites were 1.6 to 12 times more energy intensive than steel.

The product-use phase therefore governs whether or not any net energy savings can be realized for a given nanoproduct; the use-phase must be extremely efficient to justify the disproportionately large energy investment of manufacturing nanomaterials (Seager and Linkov 2009). Carbon nanocomposites may be extremely strong and light, but in applications such as civil infrastructure this will not result in use-phase energy savings (Khanna and Bakshi 2009). Where no energy savings can be anticipated via the use-phase of a nanoproduct, it is highly likely that the nanoproduct's life cycle energy demands will be more intensive compared to its conventional counterpart.

Not all nanoproducts that are specifically designed to save energy may offer net energy savings over their life cycle compared to conventional materials. Healy et al. (2008) observe that there are likely to be clear energy savings associated with the use of single walled carbon nanotubes (SWCNT) in microelectronics: a single SWCNT can form a switch that would require no power to maintain in the on or off position, yet would deliver significant energy savings through the use-phase of electronic devices. However, some nanoproducts that are designed to save energy such as lithium ion batteries or nanostructure-based solar cells may actually not offer net energy savings, or not be able to be produced en masse, because of problems associated with efficiency, materials purification, scaling up, use or cost constraints (Gupta et al. 2009; Seager et al. 2008).

Early life cycle analyses have shown that for a range of products, including nano silver T-shirts, carbon nanofiber-reinforced windmill blades and carbon nanotube polymer composites for cars, whether or not net energy savings or costs occur depends on a complex range of variables and assumptions (Frischknecht, et al. 2009; Khanna and Bakshi 2008; Merugula, et al. 2010). These LCAs have found that nanoproducts can impose net energy costs. These LCAs have been performed with inadequate understanding of nanomaterials performance in nanoproducts, realistic manufacturing processes and actual use conditions. Further, they exclude entirely consideration of the environmental and human health toxicities associated with the nanomaterials themselves, due to a lack of information. Nonetheless, they provide an interesting preliminary overview of the capacity for nanoproducts designed to achieve energy efficiency to deliver in this aspect (see Table 6).

Will efficiency gains result in environmental savings – or just expanded production?

Energy efficiency measures must form a key part of efforts to achieve dramatic and rapid cuts in greenhouse gas emissions. However, without tackling the economic growth model, and profligate patterns of production and consumption, any efficiency gains made possible by nanotechnology are likely to be absorbed by expanded production.

Uncertainty surrounds the net energy costs of nanoproducts designed to achieve energy savings. As previously discussed, only those products that deliver substantial efficiency boosts in the product-use phase will recoup the huge energy investment of the nanomaterials manufacturing process. Most nanoproducts on the market offer no such potential, and so will come at a net energy cost. There is a common assumption – often implicit – that any efficiency gains achieved by nanotechnology will necessarily deliver environmental savings (eg Karn 2008). However, even where products do underpin efficiency breakthroughs, there is no guarantee that this will deliver real environmental savings, when set in a context of ongoing economic growth and no meaningful behavioral change. An analysis of US energy efficiency measures and their impact on energy consumption found that technical efficiency measures led to slightly higher energy consumption when not accompanied with lifestyle change (Adua 2010).

Environmental scientist and renewable energy advocate Mark Diesendorf advocates that pursuit of energy efficiency must form a central part of climate change mitigation measures; he observes that efficiency gains are the cheapest and fastest way to reduce our greenhouse gas emissions (Diesendorf 2009). Diesendorf warns that we should not let fear of the rebound effect stand in the way of pursuing energy efficiency. However, he suggests that 'packages' of household energy efficiency and renewable energy investment could be offered to consumers, such that energy savings are increased, the net cost of each package is zero, and so is the rebound. In this way, household economic savings achieved by energy efficiency could pay for most of the additional costs of cleaner energy supply [of course, this does not address industry, which is a majority user of electricity]. Diesendorf also backs proactive government policies to ensure that efficiency translates into environmental savings, rather than being consumed by greater growth. The evidence is compelling that without such measures, nanotechnology-enabled efficiencies will be consumed through growth and increasing complexity of goods produced.

The New Economics Foundation (NEF) warns that throughout history, efficiency gains have simply underpinned expanded production and consumption (NEF 2010). Between 1980 and 2001, the Organization for Economic Cooperation and Development (OECD) countries experienced an average annual growth rate of 2.6 percent. In the same period, these countries' energy intensity declined 1.4 percent per year, partly due to energy efficiency measures, and partly due to the increasing shift of energy intensive industries to non-OECD countries (US EIA 2004). Nonetheless, energy consumption still rose

1.2 percent per year. That is, energy efficiency measures were able to assist in reducing the energy required per unit of economic output – and were therefore of environmental and economic value - but energy demand continued to grow.

Efficiency measures achieved by technological change frequently deliver smaller environmental or resource savings than was anticipated due to the 'rebound effect'. This refers to behavioral or systemic change in response to new efficiencies, which offset the gains of the new technology or other measures taken (Adua 2010). NEF cites the example of automobile efficiency to illustrate the rebound effect. Since 1975 fuel consumption has improved by only 5 percent in the Volkswagen Golf, despite huge improvements in engine efficiency. The failure of efficiency gains to translate into fuel consumption savings is related to a 50 percent increase in weight in the car over the same period, and a greater number of energy-demanding gadgets for entertainment and comfort (NEF 2010). That is, rather than achieving fuel savings, efficiencies have underpinned growth in the car weight and entertainment options.

The rebound effect has been observed in the semiconductor industry and in electronic goods more generally. Efficiency savings and lower production costs in this sector have driven expanded production, and more complex and more energy intensive products (Khanna, Bakshi and Lee 2008). Despite major reductions in energy consumption and ultrapure water use, chemical use per product and chemical waste generation have increased in semiconductor facilities due to greater wafer production and more complex processes (Sengul, Theis and Ghosh 2008). Electronic wafer cleaning, associated with high use of chemicals and surfactants, has increased fivefold in the past 25 years. Gutowski et al. (2009) surveyed 20 different manufacturing processes and found that the intensity of materials and energy used per unit of mass of material processed has increased by at least six orders of magnitude during the past several decades. That is, about one million times the energy per unit of mass of material produced is required in today's manufacturing processes. The researchers concluded that the increase of material and energy demands was primarily a consequence of the introduction of new manufacturing processes, driven by the desire for small-scale devices and more complex product features (Gutowski, Liow and Sekulic 2010).

Rather than delivering real environmental savings, carbon nanotube-reinforced lightweight planes could simply lead to bigger planes or more flights being taken, while imposing a new generation of health hazards and environmental costs.

Consumers are also vulnerable to the rebound effect; reduced production costs can mean reduced product costs, which can simply encourage greater consumption. The journal Environmental Science and Technology reports the European Commission environmental policy officer's personal opinion that "improving technology and boosting the efficiency of production has not reduced carbon emissions. Instead, as goods are produced more efficiently, they become cheaper, leaving consumers with more discretionary cash to buy more stuff" (Pelley 2009). Lending support to this view, Nielsen Wire reports that the number of televisions per United States household in 2009 was 43 percent higher than in 1990 (Nielsen Wire 2009). In 2010, the number of televisions per United States household was greater than the number of people per household (2.93 vs 2.5; Nielsen Wire 2010).

An editorial in *Nature Nanotechnology* (- 2007, 325) argued that "reducing demand, increasing efficiency and developing low-carbon forms of energy will all be necessary" to combat climate change. It observed, somewhat facetiously, that "there is not much nanotechnology can do to reduce demand – if people want to drive everywhere or watch 48-inch television screens science cannot stop them." However, the relationship between nanotechnology product commercialization and consumer demand bears some scrutiny.

Nanotechnology may be used to market products as 'green', therefore convincing consumers that further increases in their consumption may be offset by technology breakthroughs. Alternatively, nanotechnology may simply be used to market new generations of must-have clothing, cosmetics or electronic appliances, triggering new waves of consumption of ever more energy intensive products. For example Samsung is reported to be preparing to launch a carbon nanotube-television in 2011 (Wong 2010). The television's breakthrough point of marketability is improved image contrast and motion reproduction.

In this way, rather than delivering real environmental savings, carbon nanotube-reinforced lightweight planes could simply lead to bigger planes or more flights being taken, while imposing a new generation of health hazards and environmental costs. In addition to questioning the energy demands and toxicity of nanoparticle production, we need to question the logic that underpins the quest for economic growth at all costs and the rapacious appetite of wealthy consumers for ever more complex and small-scale prestige appliances that may be updated with increasing frequency. Without a change in the growth mentality, without industry restructuring and without changed consumer behavior, there is little possibility any energy efficiency gains made by nanotechnology will deliver environmental benefits rather than simply driving greater economic expansion.

Further, should energy savings be achieved by nanomanufacturing or production systems, we should be wary of pursuing energy efficiency at the expense of significant non-energy environmental costs. Early evidence of the significant quantities of potentially toxic waste generated by nanomaterial production and the ecotoxic behavior of many

Companies are not conducting risk assessments on nanomaterials they use, or taking steps to protect workers from unsafe exposure

There is disturbing evidence that a majority of companies using manufactured nanomaterials are not conducting basic risk assessments, or providing relevant risk information regarding the nano-ingredients in the products they sell, let alone taking proactive measures to reduce the toxicity of the nanomaterials they sell, or to limit the broader environmental costs of nanoproduction.

A survey of Swiss and German companies that work with nanomaterials found that of those companies who elected to respond, 65 percent did not ever perform any risk assessment on their nanomaterials (Helland, et al. 2008).

A survey commissioned by the Australian government of Material Safety Data Sheets (MSDS) provided by suppliers in relation to nanomaterials found that over 84 percent did not provide nano-relevant risk information (Safe Work Australia 2010). Despite serious safety concerns about the potential for some forms of carbon nanotubes to cause asbestos-like pathogenicity, 11 of the 12 MSDS that related to carbon nanotubes compared their potential risk to graphite.

An international survey of companies and institutions involved in nanotechnology research, development and commercialization found commissioned by the US-based International Council On Nanotechnology found similar results (University of California, Santa Barbara 2006). Reported practices in the handling of nanomaterials, with some exceptions, were based on criteria unrelated to any perceived risks stemming specifically from working with nano-scale materials.

The international survey also found that companies were not routinely alerting their customers to the need for safety measures regarding disposal of nanowaste: "When asked, organizations generally recommended disposal of nanoproducts as hazardous waste, though they did not frequently report conveying this information to their customers" (University of California, Santa Barbara 2006, 7).

nanoparticles themselves demand that the environmental burden of nanoproducts be scrutinized rigorously alongside their life cycle energy demands. Often when a technological or manufacturing process is supposedly improved, the problems or environmental costs are shifted to another area of the life cycle. We should employ life cycle analysis to help prevent this type of oversight (Grubb and Bakshi 2008).

Is 'green nano' a greenwash?

Nanotechnology is often promoted as a cleaner, greener, superior alternative to existing manufacturing and technologies. The title of the 2002 Australian Government report "Smaller, cleaner, cheaper, faster, smarter" is emblematic of this tendency (Commonwealth Department of Industry, Tourism & Resources 2002). The field of green nano is used to demonstrate nanotechnology's environmental credentials. Green nano has two ostensible goals: producing nanomaterials without harming the environment or human health, and producing nanoproducts that provide solutions to environmental challenges (Karn 2008). A third and less openly acknowledged goal of promoting green nano is promoting public acceptance of the emerging industry: "Actively engaging in the development of green nano can play a significant role in reassuring the public and maintaining the power and potential of nanotechnology to realize benefits for society, the economy and the environment" (Eckelman, Zimmerman and Anastas 2008, 320).

Some researchers have predicted that because such large sums of money are being spent by governments on nanotechnology research and development, funding priorities will be targeted to deliver societal benefit (Lloyd and Lave 2003). Unfortunately such predictions are not reflected in the funding figures to date. The Woodrow Wilson Center's Project on Emerging Nanotechnologies conducted a detailed analysis of the 2006 US National Nanotechnology Initiative (NNI) budget request and found that only 1 percent of US$1.06 billion - $11 million - was allocated to research that was highly relevant to addressing nanotechnology risks (Maynard 2006). Maynard noted that this was in contrast to the $38.5 million figure cited by the NNI, "rais[ing] doubts about the validity and the basis of the NNI figures" (Maynard 2006, 18). In 2009, from a total of US $1.7 billion, the NNI states that $76 million was spent on environment, health and safety research (NSTC 2010). This figure is still only 4.47 percent of the total budget, and it is not clear how much of this work is highly relevant to risk research. For comparison, in the same year 26.78 percent ($459 million) was spent on nanotechnology research by the Department of Defense.

Beyond risk research, despite the public relations focus on socially and environmentally responsible green nano, the field attracted a mere 0.02 percent of the United States National Nanotechnology Initiative research funding from 2000-2004 (Dunphy Guzman, Taylor and Banfield 2006); as of 2007 it continued to attract a very small proportion of US government research funding (Eckelman, Zimmerman and Anastas 2008). As Allenby and Rejeski (2008, p268) observe: "Despite early calls for a life cycle approach to nanotechnology development, proactive management of emerging risks, and the greening of production infrastructure, little has happened as the normal wheels of technological progress grind forward."

In addition to the very low research funding, and commercial and political priority attached to the field of green nano, the huge uncertainties surrounding nanomaterials' behavior in environmental systems are a major obstacle to scientists' capacity to achieve the much-touted "safety by design." Nora Savage of the United States EPA cautions that no one knows yet what nanomaterials will do in the presence of other chemicals, or if they might heighten other chemicals' risks: "I know people are trying to design environmentally benign nanomaterials… but all toxicity tests to date show that behaviors change with agglomeration, as coatings degrade, [and so on]. As they end up in the water, it's going to be much more complex" (Lubick 2009, 1249). The uncertainty about potentially substantially increased toxicity of nanomaterials such as cadmium core quantum dots should coatings degrade has been emphasized by researchers (Bouldin, et al. 2008; Chen, et al. 2008b; King-Heiden, et al. 2009).

Industry has been extremely reluctant to voluntarily provide information to governments about the commercial use of nanomaterials, let alone what is known of nanomaterial risks. The

United Kingdom's two year voluntary reporting scheme resulted in only 12 submissions (Breggin, et al. 2009), despite the UK Department of Trade and Industry estimating that there were then 372 organizations involved in micro- and nanomanufacturing in the UK (Berger 2007b). Only 29 companies and trade associations participated in the US EPA's "Basic Program" as part of the Nanoscale Materials Stewardship Program (NMSP); another seven companies committed to submit information at a future date. In its interim report on the NMSP, the US EPA estimated that "approximately 90 percent of the different nanoscale materials that are likely to be commercially available were not reported" (US EPA 2009, 27). Further undermining the usefulness of the scheme, a number of the submissions EPA did receive did not contain exposure or hazard-related data. The EPA also noted that the low rate of engagement – seven companies - in its 'In-Depth Program' "suggests that most companies are not inclined to voluntarily test their nanoscale materials" (U.S. EPA 2009, 27).

In an article that explores the industrial ecology of emerging technologies, Allenby and Rejeski quote Princeton historian Ed Tenner's observation of the "tendency of advanced technologies to promote self-deception." They note that "the chance of such self-deception increases exponentially in the case of so-called 'national prestige technologies', such as nanotech" (Allenby and Rejeski 2008, 268). They warn that: "In our view, it is all too likely that industrial ecology may have missed the off-ramp to a green nanotech future about 5 years ago". They caution that the United States and other governments keen to cash in on nanotechnology's economic promise are largely avoiding attempts to steer nanotechnology development into greener channels.

In a study commissioned by the European Parliament, Fiedeler questioned the common assumption that nanotechnology holds the potential to provide a substantial contribution to the solution of various ecological problems, including high consumption of energy and materials and the generation of waste (Fiedeler 2008). In a review of current examples and concepts of nanoproducts and applications, Fiedeler concluded that because nanomaterials themselves may introduce new toxicity risks, and because the nanomaterials production process may itself involve the production and use of hazardous materials, "it is unclear whether the current use of NT [nanotechnology] really provides new opportunities for the avoidance of hazardous substances" (Fiedeler 2008, 314).

Arguably, given the concerns about both nanomaterials and nanomaterial production processes, a first step in the green nano hierarchy would be to avoid or eliminate use of nano until its environmental implications are better understood and its safety is demonstrated. In his review, Fiedeler cautioned that each nano-application should be assessed in detail on a case by case basis. "Because such an assessment is complex and time consuming, proposals for substitution [of hazardous substances with nanomaterials] should only be analyzed if the benefit would be outstanding or if no existing solution is already available" (Fiedeler 2008, 313). In short, Fiedeler proposed that before we even ask of a nanoproduct "will it achieve what it is claimed to achieve," that we first ask: "do we need this nanoproduct" and "do alternatives to this nanoproduct exist?" Similarly, other researchers have suggested that at the product design stage, the question should be asked whether there are any alternatives to use instead of manufactured nanomaterials that achieve the same functionality (Som, et al. 2010). Unfortunately, in the rush to market new cosmetics, electronic goods, sports equipment and clothing, this is not a question many companies are prepared to ask.

In the view of Friends of the Earth, the illusion of green nanotechnology is just that – an illusion that is promoted by a range of nanotechnology proponents keen to practice self-deception. Green nano does not currently exist in any meaningful sense – as an area of research, as industry practice, or as a viable alternative to the status quo. Yes, the environmental burden of nanomaterials manufacture could certainly be reduced, but neither researchers nor industry will know enough in the near future to design environmentally benign nanomaterials or methods for their manufacture. In the meantime, the inconvenient truth is that nanomaterials manufacturing is a dirty, energy and water intensive process that both uses and produces many toxic chemicals, while nanomaterials themselves pose serious and poorly understood health and environmental risks.

regulatory gaps

The need to adopt the precautionary principle to manage the serious but uncertain risks associated with nanotechnology has been recognized explicitly by governments from five continents. At the 2008 International Forum on Chemical Safety in Dakar, 71 governments, 12 international organizations and 39 NGOs recommended "applying the precautionary principle as one of the general principles of [nanotechnology] risk management" (IFCS 2008).

Swiss Re, one of the world's largest reinsurance agents, has also called explicitly for application of the precautionary principle in management of nanotechnology risks. In its detailed report into nanotechnology, the reinsurance agent warns: "In view of the dangers to society that could arise out of the development of nanotechnology, and given the uncertainty currently prevailing in scientific circles, the precautionary principle should be applied whatever the difficulties" (Swiss Re 2004, 47).

The United Kingdom's Royal Society, the world's oldest scientific institution, recommended in 2004 that given the evidence of serious nanotoxicity risks, nanoparticles should be treated as new chemicals and subject to new safety assessments before being allowed in consumer products. It also recommended that nano-ingredients in products should be labeled, to give people the chance to make an informed choice. Further, the Royal Society recommended that factories and research laboratories should treat nanomaterials as if they were hazardous, and that releases of nanomaterials to the environment should be avoided as far as possible until it could be demonstrated that the benefits outweighed the risks (UK RS/RAE 2004). The European Union's Scientific Committee on Emerging and Newly Identified Health Risks also recognized the many systemic failures of existing regulatory systems to manage the risks associated with nanotoxicity (EU SCENIHR 2006).

Unfortunately, in most countries the overwhelming majority of nanomaterials remain effectively unregulated. Regulatory systems in the United States, Europe, Australia, Japan and other countries treat all particles the same; that is, they do not recognize that nanoparticles of familiar substances may have novel properties and novel risks (Bowman and Hodge 2006; Bowman and Hodge 2007). Although many nanomaterials now in commercial use pose greater toxicity risks than the same materials in larger particle form, if a substance has been approved in bulk form, it remains legal to sell it in nano form. There is no requirement for: new safety testing; product labeling to inform consumers, workers or employers; or new occupational exposure standards or mitigation measures to protect workers or to ensure environmental safety. Incredibly, there is not even a requirement that the manufacturer notify the body that regulates its products that they are using nanomaterials.

The most significant efforts to close the legal gaps in nanotechnology regulation have been made in Europe. Europe has already amended its cosmetics directive to require nano-specific notification and assessment of most nanomaterials used in sunscreens and cosmetics (European Commission 2009). This is anticipated to take effect in 2012 or 2013. More pertinently to this report's focus, following a proposal from its environment committee, the European Parliament has committed to a review of all European regulation to investigate its ability to cope with the new challenges and risks of nanotechnology (Euractiv.com 2009). The European Commission is set to complete its regulatory review of nanomaterials by the end of 2011. It will focus specifically on the inclusion of nanomaterials under the REACH regulation on chemicals, and the results will be included in the 2012 REACH review.

The European Parliament's environment committee has proposed measures under its Restriction of Hazardous Substances (RoHS) Directive for a ban on nano silver and on long, multi-walled carbon nanotubes (European Parliament Press Service 2010). The Committee also called for other electrical and electronic material containing nanomaterials to be labeled. The proposed measures now face (considerable) debate. The Wuppertal Institute, a German sustainability research center, has also argued for the extension of the RoHS Directive to cover photovoltaics (Saurat and Ritthof 2010). This would require an end to the use of toxic heavy metals such as cadmium in the new generation of nano solar panels.

In Australia, in late 2009 the National Industrial Chemicals Notification and Assessment Scheme proposed for consultation new measures that would seek to close the legal loopholes surrounding nanomaterials used in industrial chemicals and cosmetics (NICNAS n.d.). However, these proposals remain at consultation stage. The federal government has explicitly rejected calls for a mandatory register of manufactured nanomaterials in commercial use (Lauder 2010) or new regulations to protect workers from occupational exposure (Hall 2009).

In the United States, both the Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) have recognized the current gaps in the regulation and oversight of nanomaterials, but their actions thus far have been wholly inadequate. The EPA has continued to delay regulation for nanomaterials despite legal action brought forward by a coalition of consumer rights organizations, led by the International Center for Technology Assessment (ICTA) and including Friends of the Earth (Kimbrell 2008). The Agency has opened many comment periods with regard to nanosilver technologies and their appropriate regulation, though these have yet to produce significant regulatory changes. The FDA has followed a similar path of 'all talk, no action'. Manufacturers are able to bring to market nanoproducts in many sectors without any premarket assessment, testing, data or approval by FDA.

The United Nations University concluded that the potential risks of nanotechnologies are an obstacle to the widespread rollout of nanoproducts to address climate change: "One of the major obstacles highlighted is the lack of a robust transparent regulatory regime able to address concerns that have been expressed by some about potential human health and other environmental risks associated with some forms of this technology" (Esteban, et al. 2008). Friends of the Earth recognizes that without credible, transparent and precaution based regulation, the entire nanotechnology sector faces an uncertain and high risk future.

Preventing the dumping of hazardous nanowaste on to poor communities and countries is of the utmost importance. Strict, mandatory regulation is required to ensure extended producer responsibility by companies for the nanoproducts they manufacture. It must be the responsibility of companies to take back products where they are faulty or otherwise at end of life, to recycle wherever possible, and to pay for responsible disposal of other components. International effort is also required to prevent the export of nanowaste from Northern to Southern countries. This should include efforts to strengthen the *Basel Convention*, an international treaty that controls transboundary movement of hazardous waste and its disposal. It is not acceptable that as a leading proponent of nanotechnology and technological development, the United States has so far refused to sign this treaty. Further, it is essential that stricter measures are introduced to prevent the dumping of used electronic equipment under the guise of export.

There is an urgent need for regulation to require the design of nanoproducts that may be more readily recycled. If we are to prevent imminent shortages of rare metals used in electronics and energy applications, the United Nations Environment Programme has warned that taking measures to promote recycling of high tech products is essential (UNEP 2010a).

Finally, beyond the important issue of managing nanomaterial risks, this report provides clear evidence for the need to ensure that energy and greenhouse gas emissions analysis is conducted as part of the regulatory process. The widespread use of nano silver in frivolous consumer products such as odor-eating socks may pose a serious risk of accelerating release of nitrous oxide from bacteria (see above). This is a compelling reason to halt the sales of such products.

technology assessment and accountability is required at the international level

Beyond policy making at the national level, intergovernmental bodies must urgently address regulatory gaps surrounding nanotechnology and begin to assess the environmental and socio-economic impacts of new technologies, as well as create ways to encourage meaningful public participation in decision making.

Climate related nanotechnologies could potentially gain access to global markets and receive widespread government support through market based mechanisms, such as the Clean Development Mechanism (CDM) of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (UNFCCC n.d.).

'Technology transfer' from Northern to Southern countries is one of the four key topics being discussed as part of the UNFCCC international negotiations that are seeking to solve the climate crisis. The other topics are mitigation, adaptation and financing (ETC Group 2009). Decisions about technology transfer are now in the hands of the UNFCCC Expert Group on Technology Transfer. This group seeks to pair venture capital with projects in the developing world—all too often focused towards generating profit.

While the CDM was set up to help cap greenhouse gases (GHGs) in order to combat dangerous climate change, it has also become an opportunity for venture capitalists to gain large amounts of funding and support for questionable projects. Under the guise of technology transfer, the CDM opens all doors for new climate technologies to gain traction and financial support. This makes it critical to stop bad technologies from getting approved through this mechanism. Through the CDM, nanotechnologies could quickly be adopted and imposed on developing nations despite the fact that they are untested and unproven for safety and efficacy. Other high risk and unproven technologies, such as geo-engineering and biochar have already been the subject of intense lobbying and advocacy at the UNFCCC.

One of the roles of the CDM is to distribute certified emission reduction (CER) credits (equivalent to one ton of carbon dioxide) to developed nations that can be traded and sold, allowing developed nations to meet Kyoto emission reductions without a direct reduction of emissions. Developed nations can submit a project for approval by the CDM Executive Board (CDM EB) to work bi-laterally with a developing country. All that is required to back up the proposal is a claim that the project would contribute to sustainable development in the developing country. Carbon trading is surrounded by speculation and is a questionable method for fending off climate change (Lohmann 2006). Many projects approved by the CDM are biomass projects, which encourage land grabbing and undermine biodiversity.

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Civil society groups (including Friends of the Earth) have taken action at the UNFCCC, highlighting the need to discard unhelpful and dangerous technologies while supporting those that have the potential to help (ETC Group 2009). A civil society declaration was prepared for the UNFCCC climate negotiations that took place last year in Copenhagen. The declaration stated the following:

Precaution demands the careful assessment of technologies before, not after, governments and inter-governmental bodies start funding their development and aiding their deployment around the globe. There is already a precedent in international law: the Cartagena Protocol on Biosafety, ratified by 157 countries, gives effect to this principle on genetically modified organisms. National and international programs of public consultation, with the participation of the people who are directly affected, are critical. People must have the ability to decide which technologies they want, and to reject technologies that are neither environmentally sound nor socially equitable.

We therefore demand that a clear and consistent approach be followed internationally for all new technologies on climate change: States at COP 15 [Conference of Parties 15] must ensure that strict precautionary mechanisms for technology assessment are enacted and are made legally binding, so that the risks and likely impacts, and appropriateness, of these new technologies, can be properly and democratically evaluated before they are rolled out. Any new body dealing with technology assessment and transfer must have equitable gender and regional representation, in addition to facilitating the full consultation and participation of peasants, indigenous peoples and potentially affected local communities.

Read the full declaration at http://www.etcgroup.org/en/node/4956.

Another intergovernmental body highly influential in technology adoption is the International Energy Agency (IEA). One of the main goals of the IEA is to ensure "energy technology collaboration" between countries. Despite this, the agency's members include only wealthy nations, with a total lack of representation by the Global South (IEA 2010). It is therefore likely that the IEA operates in wealthy countries' interests.

The Delegation of Bolivia to the United Nations Framework Convention on Climate Change has explicitly denounced the promotion of elite, high risk technologies under the guise of addressing climate change. "[Bolivia] rejects the practices and technologies harmful to humankind and the environment, including agrochemicals, corporate-controlled seeds and intensive water use, genetic engineering, particularly genetic use restriction technology, biofuels, nanotechnology, and geo-engineering" (UNFCCC Delegation of Bolivia 2010).

equity and access: concerns that nano will widen the gaps

Nanotechnology proponents have emphasized its utility for poorer communities and Southern (less industrialized) countries. However, its development trajectory suggests that applications and solutions that are demonstrated to have value in mitigating climate change may be inaccessible to poor communities. In a field in which aggressive patenting has begun, Northern (industrialized) countries dominate. Further, the corporate and national interests of Northern countries appear to be shaping nanotechnology's development and deployment. There are concerns that nanotechnology product manufacture and waste disposal will be located in poorer communities and countries, exacerbating existing environmental injustice. At a broader level, nanotechnology's expansion may deepen existing inequities at a time when Southern countries are facing the brunt of climate change.

Climate change raises some of the sharpest equity dilemmas: the world's poorest people are most vulnerable to the adverse consequences of greenhouse gas emissions that they are the least responsible for. The United States' Department of Energy states that in 2001, per capita consumption of fossil fuels in OECD countries was 450 percent higher than in non-OECD countries. The G-7 highly industrialized countries (United States, Japan, Germany, Britain, France, Canada and Italy) consumed even more fossil fuels per person than the rest of the OECD (US EIA 2004). The huge climate debt owed by Northern countries has been emphasized at international forums, including the Cochabamba Peoples' Conference in Bolivia.

High profile nanotechnology proponents such as the late Richard E. Smalley have argued that breakthroughs in nanotechnology for energy will be of most benefit to poor people (The James A. Baker III Institute for Public Policy 2005). An international survey of nanotechnology experts also predicted that nanotechnology applications in energy production, conversion and storage would be the biggest contribution the sector could make to helping achieve the (anti-poverty) Millennium Development Goals (Salamanca-Buentello, et al. 2005). By boosting poorer countries' access to more reliable and more sustainable forms of energy, the hope is that nanotechnology will offer Southern countries new opportunities for economic growth and development, while minimizing the environmental cost.

However, this optimistic view has been challenged by senior scientists. The United Kingdom's Royal Society observed that nanotechnology breakthroughs—as with previous technical breakthroughs—may be inaccessible to poor or marginalized groups (UK RS/RAE 2004). In many instances, it is the accessibility of a technology or service that requires improvement, not simply technical capacity. Efficient and relatively cheap technologies already exist to address energy, public health, sanitation, medical, and agricultural needs of poor people, yet these are often not accessible to those who have most need of them (Invernizzi, Foladori and Maclurcan 2008).

Intellectual property and patents are dominated by wealthy countries

Nanotechnology may concentrate ownership and control of essential platform techniques, processes, and products (ETC Group 2005). Should predictions of nanotechnology's potential as a platform technology prove accurate, countries and companies that are making early investments, patenting aggressively, and can afford to defend patent claims, are likely to cement and expand their control of key industries and trade – including in energy applications. Companies that are investing heavily in nanotechnology applications such as energy that have a long lead time from lab to product are eager to make a financial return. It is unlikely that such companies will make their technology freely available to poor communities. US company Nanosolar has been described as "notoriously secretive" about its nano solar technology. *The Guardian* observes that Nanosolar "is quite open about wanting to restrict access to the technology to give it a market advantage" (Vidal 2007).

In 2007 the Kingdom of Saudi Arabia observed that the number of producers of nanomaterials had already decreased as consolidation had increased, and that multi-national chemical companies now dominate the market (Kingdom of Saudi Arabia 2007). Addressing questions of nanotechnology ownership and access will be critical if climate change applications can be made to work (Fauset 2008).Corporate Watch emphasizes that it is important to question who owns technology hardware (power stations, pipelines), as well as who controls patents and other intellectual property. They caution that technologies such as nano solar are likely to be dominated by a few companies owning fundamental patents and charging royalties for their use. Corporate Watch point out that over four thousand patents on 'clean technologies' had been granted in 2006 in the USA alone. It is conceivable that possible solutions to climate change could be held to ransom.

Carbon nanotubes have diminished crop yields, increased crop uptake of pollutants in experimental studies

Carbon nanotubes are one of the nanomaterials most commonly mooted for use in energy and climate applications. Yet a preliminary study has found that two types of carbon nanomaterials - C70 fullerenes and multi walled nanotubes (MWNT) - delayed rice flowering by at least 1 month (Lin, et al. 2009).

They also reduced significantly the yield of exposed rice plants (fullerenes reduced seed set by 4.6%, MWNT by 10.5%). Seeds exposed for only 2 weeks to fullerenes passed these onto the next generation of seeds.

A separate study found that exposure to carbon nanotubes made wheat plants more vulnerable to uptake of pollutants (Wild and Jones 2009). Carbon nanotubes pierced the cell wall of wheat plants' roots, providing a 'pipe' through which pollutants were transported into living cells.

These studies raise concerns about the potential for waste from nanomaterial or nanoproducts manufacturing facilities or disposal sites to contaminate farmland. Carbon nanomaterials could reduce yields of one of the world's most important staple crops and leave another more vulnerable to pollutant uptake.

Beyond the potential for corporations or institutions to control key products or applications in the energy sector, nanotechnology could potentially increase the patenting of key research tools or even particular nanocompounds. Bowman notes that: "Of particular concern is the progressive blurring of the invention/discovery interface under Article 27 [of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement)] that may produce uncertainty over the types of nanoproducts that can be patented… wide interpretation of Article 27(1) may result in the monopolization of fundamental molecules and compounds" (Bowman 2007, 313). Strong protection of scientific and technological intellectual property, including the patenting of research tools, can also constrain the capacity of scientists in Southern countries to carry out their own research and development (Forero-Pineda 2006). Without active international cooperation, Southern countries must exert considerable energy to access scientific results and information.

In an analysis of nanotechnology patent grants up to 2003, Northern countries were well ahead of Southern countries in registering nano patents; the United States was the most active nation in the world for registering patents, followed by Japan, Germany, the United Kingdom and France (Hullman 2006). There is a wide disparity among Southern countries in nanotechnology investment, development and patenting. In recent years patent grants have grown in high growth emerging economies (Liu and Zhang 2007). In particular, the patent growth rate in China has been remarkable; since 2005 China has held the largest number of nanotechnology patents internationally (Preschitschek and Bresser 2010). Nonetheless, the majority of patents worldwide are still held by Northern countries, and the majority of Southern countries hold few nanotechnology patents. Patenting trends therefore reflect not only a North-South but also a South-South divide.

Nanotechnology is being driven by the interests of wealthy countries

Beyond questions of ownership and accessibility, some observers have suggested that nanotechnology development is driven by Northern interests and does not reflect a prioritization of poor people's needs. Northern countries not only dominate in overall nanotechnology publications, but also have the highest impact publications. The country with the highest impact nanotechnology publications is the United States, followed by European countries then Japan (Kingdom of Saudi Arabia 2007). European countries have the greatest degree of international collaboration in nanotechnology published research. The dominance by Northern countries of high impact nanotechnology research can mean that the interests of Northern governments, industry and consumers shape the development trajectory. "Since nanotechnology's development is essentially guided by corporations' search for profits, a majority of innovations are directed to Northern, affluent societies" (Invernizzi, Foladori and Maclurcan 2008, 136).

Private sector investment in techno-scientific research is traditionally oriented towards delivering products for potential customers with wealth and access, rather than the needs of the poor and disenfranchised (Woodhouse and Sarewitz 2007). But even in public research institutions and universities, there is strong pressure on scientists to produce commercially useful research and to pursue intellectual copyright. Jamison (2009) argues that the links between researchers and industry have become so intimate that science has entered a new, market oriented mode of knowledge-making, where profitability is central. He suggests that this diminishes the possibility that nanotechnology will be developed for altruistic or public interest purposes, and results in willful neglect of its social, cultural, and environmental implications.

There is ongoing debate about the role of technology in causing or deepening inequality on a global scale. Many observers suggest that technology deepens existing inequality, even where it is not the main force creating it; Woodhouse and Sarewitz (2007) caution that new techno-scientific capacities introduced into a non-egalitarian society tend to benefit disproportionately already privileged people. Others point to the complex dynamics of inequality and suggest that in some contexts emerging technologies could reduce rather than increase inequalities (Cozzens, Gatchair and Thankur 2006).

Despite ongoing disagreement about technology's role in deepening inequity, our experience in recent decades demonstrates conclusively that technological innovation alone will not redress inequity. During the last 30 years, a period of significant technological progress and innovation in which microelectronics, information technologies, medical treatments, and telecommunications were developed, the gap between the global rich and the global poor has widened. When global inequality has increased during the expansion of such powerful technologies over recent decades, the obvious question is "why would it be any different for nanotechnologies?" (Invernizzi, Foladori and Maclurcan 2008).

Nanotechnology appears likely to exacerbate existing environmental injustices, such as the exposure of poorer communities to toxic substances and wastes in their workplaces or neighborhoods. Southern countries may find themselves shouldering a disproportionate amount of risk by becoming manufacturing centers for nanoproducts that Northern workers would prefer not to handle.

Nanotechnology may exacerbate existing environmental injustice

Nanotechnology appears likely to exacerbate existing environmental injustices, such as the exposure of poorer communities to toxic substances and wastes in their workplaces or neighborhoods. Southern countries may find themselves shouldering a disproportionate amount of risk by becoming manufacturing centers for nanoproducts that Northern workers would prefer not to handle. Since Southern countries usually have weaker environmental regulations, it is possible that international companies will choose to locate manufacturing plants in these countries, exposing local communities to greater risks (Invernizzi, Foladori and Maclurcan 2008). Governments in Southern countries have generally been reluctant to introduce strong environmental policies and regulations for fear of driving out high tech industry (Tu and Lee 2010). Electronics manufacturing sites in Taiwan, China, Thailand, Mexico and the Philippines have been associated with toxic contamination of neighboring environments and farmlands, while lax regulations have left pollution unmonitored and unmanaged (Tu and Lee 2010).

Southern countries and poor communities may also be targets for nanowaste disposal by Northern countries and companies. Southern countries have historically borne the brunt of waste products: "In a globalized world, it has been shown that many waste products end up in developing countries, or countries of transition, where the disposal or recycling is not well organized and thus products may end up in landfills or even on unpoliced dumping sites throughout the area" (Som, et al. 2010, 166). The United Nations Environment Programme warned years ago of a "mountain" of hazardous electronic waste ('e-waste') being dumped by the Global North in the Global South (BBC 2006). Despite a European ban on the exporting of defunct electronic goods, large-scale trafficking continues. The United States, which has not ratified the Basel Convention which controls export of hazardous waste, is estimated to export up to 80 percent of its defunct electronic goods (Lewis 2010). Africa and South Asia are common destinations. Workers at unpoliced, makeshift recycling plants face routine unsafe exposure, while burning e-waste is common.

beyond nanotechnologies: alternative action for the energy and climate change crises

In many ways nanotechnology offers the ultimate attempted techno-fix to problems that require integrated social, economic and political solutions. We are concerned that rather than providing real solutions to our most pressing problems, nanotechnologies will underpin a new wave of industrial expansion that will magnify existing resource and energy use and exacerbate environmental destruction.

A 2008 Corporate Watch report on the subject of techno-fixes highlights the need for governments and society to "get realistic." The report suggests that "technologies are a useful part of the solution, but techno-fixation isn't. Other changes are even more important than technology, and equally technically possible. Whether or not they are achieved depends on the actions we take now" (Fauset 2008).

Friends of the Earth suggests that rather than putting all our faith – and public funding - into nanotechnology, hoping that it will deliver "drop-in" substitute solutions that prolong the *status quo*, we should undertake actions to avoid dangerous climate change by pursuing substantive reform at a number of levels:

Reduce energy demand

Industry observers have predicted that world energy demand is likely to be 1000 EJ/yr by 2050 - about double what it is now (Trainer 2010). An Exajoule (EJ) is equal to 10^{18} joules. '

Simple living' advocate Ted Trainer emphasizes that there are strong environmental reasons to back a swift transition to renewable energy and that ongoing reliance on fossil fuels is impossible because of its effect on greenhouse gas emissions. Nonetheless, he concludes that because of efficiency, intermittency and variability constraints, and financial costs, renewable energy cannot support the demands of an energy intensive consumer society, especially one committed to ongoing economic growth (Trainer 2010).

Senior Research Fellow Felice Frankel and Harvard University Professor George M. Whitesides also emphasize the need to question the limits of renewable energy to meet growing energy demand. In their book about the nanoscale they observe that "solar electricity is a good idea, but not a good enough idea to save us from ourselves. Either we have to find more energy elsewhere, or use less" (Frankel and Whitesides 2009). These authors provide an important reality check. We cannot rely on technologies to solve our climate and environment issues, while committing to ongoing patterns of economic growth and burgeoning energy intensity; fundamental structural change of economic and production systems is required.

Renounce over consumption

Spiraling patterns of profligate consumption and waste are unsustainable – irrespective of any potential for technology-driven efficiencies of production. As Professor Stevels, from the Dutch Design for Sustainability Lab at Delft University of Technology, warned the journal *Environmental Science and Technology*, technological fixes alone will not achieve much needed reductions in carbon dioxide emissions and pollution. Professor Stevels says that reducing consumption is essential and advises policy makers to: "Be courageous, tell your citizens the unpleasant and inconvenient truth—do not suggest that technology alone will be good enough" (Pelley 2009).

The need to dramatically reduce consumption, especially in wealthy countries, is a key point made by Trainer (2008; Trainer 2010). Trainer recognizes that there is an historical and unjust gap between the environmental impacts of rich and poor and because of this debt, Southern countries are entitled to a proportionately greater share of the world's resources. However, he observes that if by 2070 there are nine-plus billion people on the planet and all of them have the "living standards" Australians are predicted to have by then, assuming 3 percent annual growth from now, total world economic output would need to be 60 times greater than it is now. "If by that point in time we have reduced present environmental impacts by 50 percent, we would have made a Factor 120 reduction in the rate of impact per unit of economic output or consumption [that is, reduced the environmental impact per unit of economic output by 120 times]… This is far beyond the realm of credibility" (Trainer 2008).

Transition to a steady state economy

The idea that governments and industries in wealthy countries should seek a 'steady state' economic pathway, rather than one based on unbounded economic growth was once unthinkable. However, this has been the key proposal from the UK's Sustainable Development Commission's (SDC) "Redefining Prosperity" project and its "Prosperity without growth" report (Jackson 2009). The report, authored by the SDC's Economics Commissioner Professor Tim Jackson, emphasizes that the profits and benefits of growth have been distributed in a massively inequitable manner. It recognizes that for poorer countries, higher income levels and greater material prosperity can deliver important health, educational and social outcomes. However, it argues that people in wealthy countries can lead more fulfilling lives and increase their "social prosperity" without further economic growth. This is an important idea whose time has truly come.

The President of the United States and many of his predecessors have attempted to green corporate actions and interests. In President Barack Obama's 2010 Earth Day statement, he mixed the need to safeguard our planet with the country's financial interests: "We have…renewed our commitment to passing comprehensive energy and climate legislation that will safeguard our planet, spur innovation and allow us to compete and win in the 21st century economy" (White House 2010). Averting dangerous climate change requires us to challenge this core aim to "compete and win in the 21st century economy." Unless governments and industry abandon their commitment to endless economic expansion, no amount of efficiency measures will ever enable us to live sustainably on a finite planet.

Support renewable energy solutions

Viable renewable energy technologies exist now to meet a large proportion of our energy needs. This has been the key premise of reports such as Beyond Zero Emission's "Zero Carbon Australia Stationary Energy Plan" (Beyond Zero Emissions 2010). This report argues that it is technically feasible and affordable to shift Australia's entire fossil fuel energy use to existing solar and wind energy technologies in the next ten years. The report has received high level backing and endorsement, including from the International Energy Agency and the President of the Australian Academy of Technological Sciences and Engineering. Trainer has questioned assumptions made in the report regarding the likelihood that Australia's levels of 2008 energy demand can be substantially reduced,

while allowing for ongoing economic growth. He also questions assumptions regarding the capacity of renewables to overcome intermittency problems (Trainer 2010a). Nonetheless, even if these criticisms are founded, the report's findings make clear that a significant proportion of Australia's energy needs could be met using existing renewable energy technologies, within the next 10 years, given the political will for action.

In their review of the capacity of silicon photovoltaics to replace fossil fuel energy at a global scale, New Zealand researchers have concluded that from a materials and technology viewpoint, with better storage solutions and some acceptance of partially intermittent supply, renewable energy sources including silicon photovoltaic technologies, wind energy and large-scale hydro could replace the current 2010 electricity supply system. However, they caution that further economic growth will run up against material constraints: "unless a steady state economic system is soon put in place, overshoot is inevitable" (Lloyd and Forest 2010). They conclude that further use of fossil fuels should be to strategically assist a transition to a renewables-based and less energy intensive economy, rather than in simply trying to "prop up" the world economy and business as usual (Lloyd and Forest 2010).

Invest in mass transport and non-motorized transport systems

While there is much discussion in the media and from politicians about actions that individuals can take to reduce their climate impact, there is less recognition of the need for infrastructure investment to support large-scale behavioral change. The transportation sector is one of the most energy intensive and is responsible for a significant proportion of greenhouse gas emissions. Infrastructure investment and policies to get freight off roads and onto rail would help reduce the emissions associated with industrial transport. Investing to ensure the availability of safe, sustainable, affordable transport systems for personal transport is essential to diminish reliance on inefficient private vehicle transport. Investment in high speed rail networks between major cities that provide viable alternatives to short haul flights is essential.

Integrated, multi-modal public transport systems, combined with support for walking and cycling, could reduce urban congestion associated with daily commuting, improve people's enjoyment of urban spaces, make a positive contribution to public health, and make a key contribution to reducing greenhouse gas emissions associated with private transport. Financial measures such as congestion taxes, when coupled with support for more affordable and accessible public transport, can also assist.

Support for non-motorized options is essential, especially in communities that are not already reliant on private vehicle transport. Communities working with UK NGO Practical Action have created climate friendly transportation projects employing novel bicycle designs, animal power, and other non-motorized modes of transportation. These allow communities to function without motorized vehicles or large highway infrastructures that are oriented towards the wealthy who can afford cars (Practical Action n.d.). To complement these projects, earth roads have also been built as alternatives to highways. For example, earth roads made of low-tech in situ materials have been built in Sri Lanka, which are able to withstand torrential rain.

Smarter urban design and town planning

Also at the level of collective planning, urban design can play a vital role in shaping less car dependent, less energy intensive and more livable communities and cities. Urban design plays a role in the density of housing, the size of houses proportional to land, proximity to major transport centers and employment opportunities, the availability of green space and agricultural land, the orientation of streets and buildings, the efficiency requirements of building and street tree planting.

Sustainable, re-localized agriculture

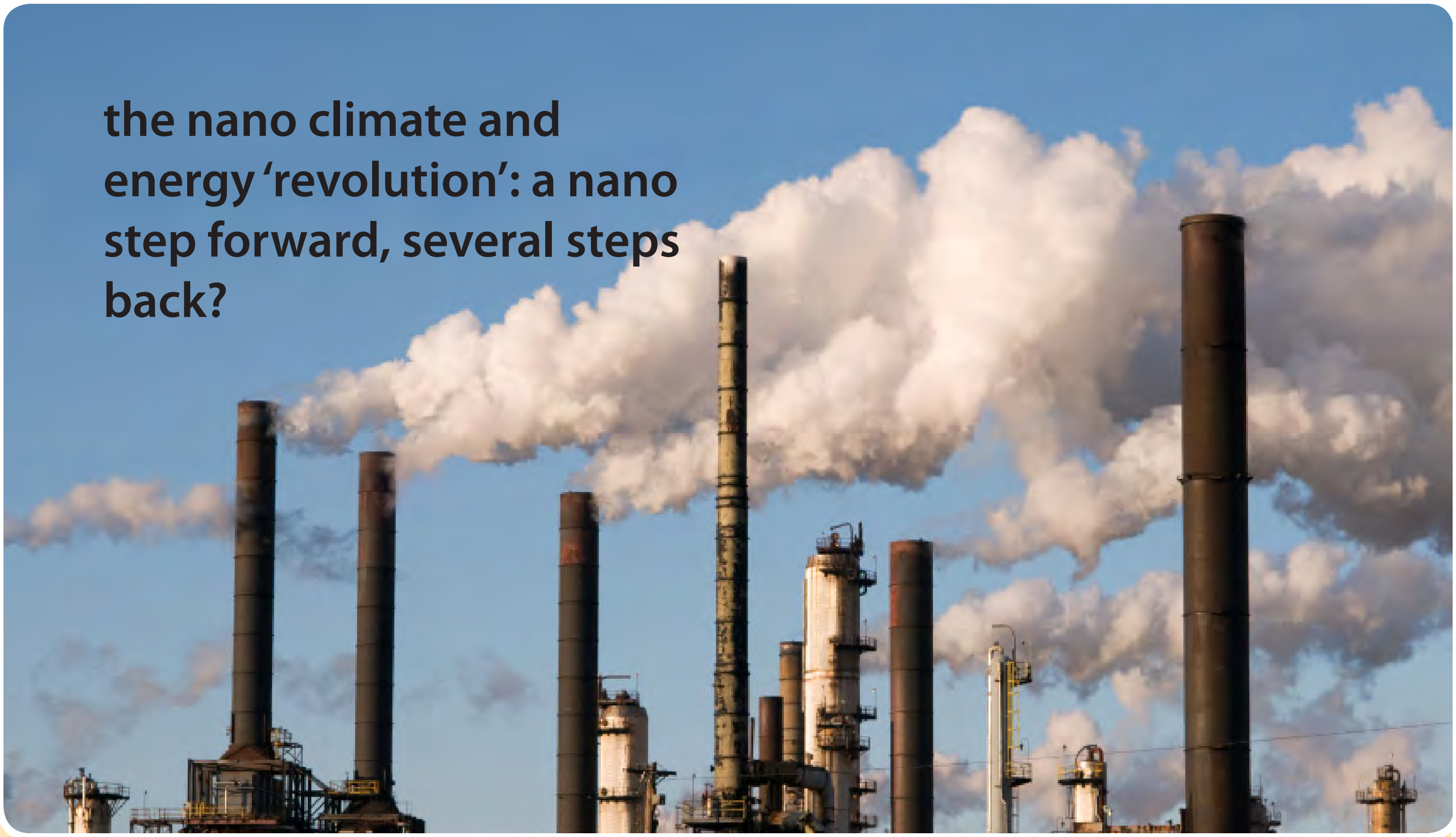
Friends of the Earth backs calls from La Via Campesina and others for stronger measures to support small scale farmers, and to maintain and redevelop local food markets. This offers strong social benefits, including improved resilience against fluctuating world food prices and employment opportunities for regional and rural communities. Re-localizing agriculture also offers strong environmental benefits, including reduced greenhouse gas emissions associated with transporting food around the world.

Further, we advocate for greater government support for agro-ecological and organic agriculture. Organic agriculture could help reduce small farmers' capital costs and reliance on agribusiness companies. Agro-ecological initiatives in Brazil have delivered yield increases of up to 50 percent, improved incomes for farmers, restored local agricultural biodiversity and reinvigorated local rural economies (Hisano and Altoé 2002). A 22-year trial in the United States found that organic farms produced comparable yields, but required 30 percent less fossil fuel energy and water inputs than conventional farms, resulted in higher soil organic matter and nitrogen levels, higher biodiversity, greater drought resilience and reduced soil erosion (Pimental et al. 2005).

Encouraging a dependence on unproven nanotechnologies and other techno-fixes will jeopardize our ability to successfully confront the climate change crisis.

International agreement on targets to reduce emissions, explicitly recognizing Northern countries' climate debt

The World People's Conference on Climate Change and the Rights of Mother Earth held in Cochabamba, Bolivia was attended by more than 35,000 participants from 150 countries around the world - ranging from environmental justice groups to indigenous rights organizations to governmental representatives, United Nations officials, and heads of state. The People's Agreement, a declaration set forth during the conference, called for governments of developed countries to fulfill their first round reductions and obligations established by the Kyoto Protocol. Further, The People's Agreement called for them to adopt during the second period, which lasts until 2017, more radical commitments of greenhouse gas emission reductions. The People's Agreement called for reductions of at least 50 percent within their territories, based on 1990 levels, so that the increase in global temperature does not exceed 1° C.



the nano climate and energy 'revolution': a nano step forward, several steps back?

When it come to climate change, the nanotechnology industry has over-promised and under-delivered. The energy demands of making nanomaterials are unexpectedly high, many nanomaterials used in these applications have been shown to pose toxicity problems, while the difficulties in bringing products to market have been underestimated. In addition, many nano applications rely on rare metals whose supply is limited.

Perhaps of most concern, nanotechnologies are being developed by the world's biggest petrochemical companies to identify new oil and gas reserves and to increase extraction. Public funds are also being invested for this purpose in countries around the world including Australia (CSIRO n.d. a), the United Kingdom (UK EPSRC n.d.), the United States (US DOE, n.d.) (Karoub, 2004), Mexico (IEA 2009), Japan (Endo, et al. 2008) and Saudi Arabia (Kingdom of Saudi Arabia 2007). At a time when we need to end our reliance on fossil fuels, we must ensure that public funding is not funneled into this type of research.

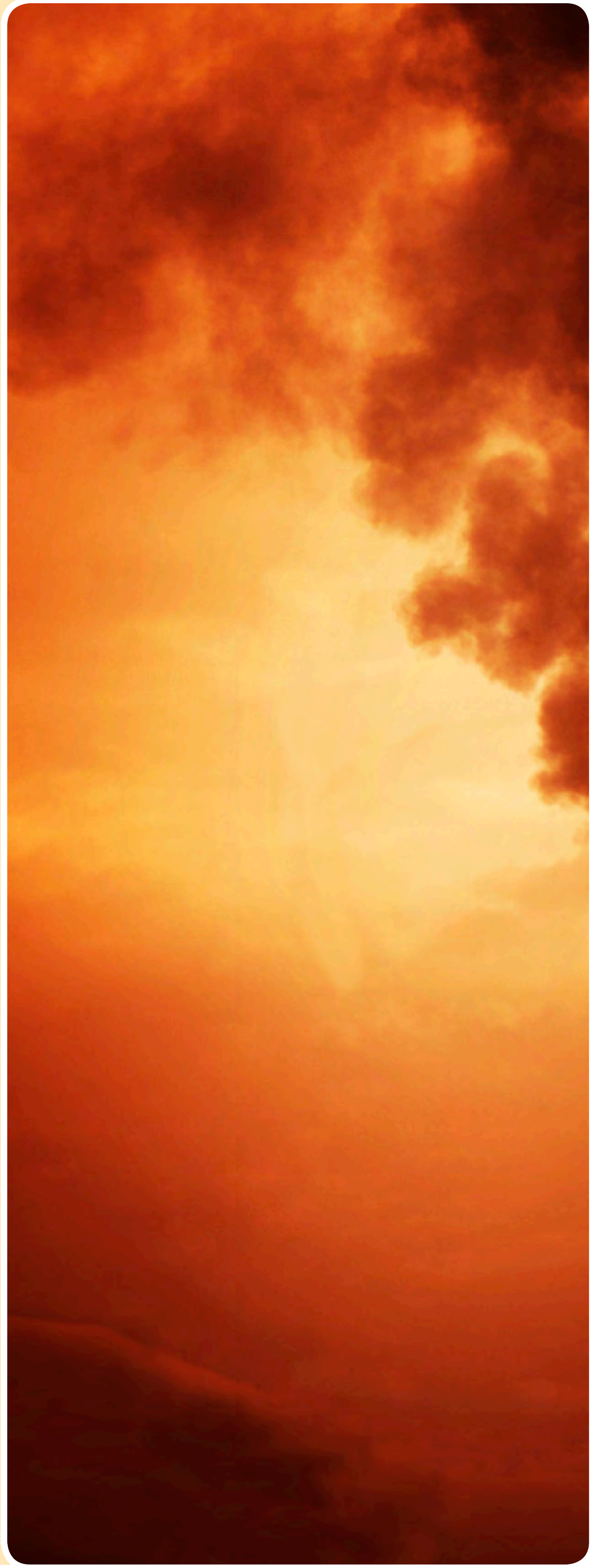
Friends of the Earth recognizes that some nanotechnologies will offer useful opportunities to improve renewable energy technologies. For example, nanomaterials used in supercapacitors have the ability to dramatically increase the energy that can be stored from wind power. However, our investigation reveals that many of the products designed to save energy will in fact result in greater emissions and energy demands over the product life cycle. This is because of the high energy demands of nanomanufacturing and of recycling nanoproducts. The potential for nanowaste to interrupt carbon and nitrogen cycling is a serious concern.

Valuable public funding should be directed at areas that have the most capacity to deliver near term reductions in greenhouse gas emissions. Companies and industries sectors should be required to demonstrate how their research, development or products has the potential to contribute to greenhouse gas emissions reductions – and how they have taken the energy demands of nanomaterials manufacture into account. This will not necessarily, or often, be nanotechnology applications. Some areas of nanotechnology research are a dangerous distraction from the real emissions mitigation we need to be undertaking – and represent a substantial opportunity cost for mitigation measures that could instead be receiving public funding. The hydrogen sector is one highly funded area of nanotechnology research that we conclude has no real capacity to contribute solutions to the climate change crisis.

Some areas of nanotechnology research are a dangerous distraction from the real emissions mitigation we need to be undertaking – and represent a substantial opportunity cost for mitigation measures that could instead be receiving public funding.

It is important to recognize that the number of nanoproducts on the market that offer no potential for energy savings greatly outnumber the applications that do. The nanoproducts that dominate current sales and product inventories, such as cosmetics and personal care products, are not only energy intensive to manufacture, but offer no potential for energy savings through their use. This is true of many – if not most – nanoproducts on the market. "As is typical of rapidly growing industries, nanotechnology manufacturers are more focused on maximizing production and technological development than on environmental efficiency or sustainability" (Seager and Linkov 2009, 426).

Friends of the Earth argues that high tech 'drop-in' techno-fixes will not be enough to save us from climate change; we need system level change. Encouraging a dependence on unproven nanotechnologies and other techno-fixes will jeopardize our ability to successfully confront the climate change crisis. In many instances the cheapest and most effective energy savings will be achieved through demand reduction and policy to support it.



friends of the earth recommendations

During the past five years, Friends of the Earth has called for a moratorium on the commercialization of nanoproducts until nanotechnology-specific regulation is introduced to protect the public, workers and the environment from their risks and until the public is involved in decision making. The United Kingdom's Royal Society and Royal Academy of Engineering has similarly called for a prohibition on the intentional release of nanomaterials into the environment until the benefits can be demonstrated to outweigh the risks (UK RS/RAE 2004). However, despite a growing body of toxicological evidence, few steps have been taken to address these urgent concerns.

A precautionary approach to nanotechnology is essential for all classes of nanoproducts. Without government action a whole new generation of more energy intensive nanoproducts will flood the market; we need regulations to evaluate not only safety but energy and greenhouse gas (GHG) implications of nanotechnologies. Specifically we need regulation to:

- Safeguard people and the environment from nanotoxicity risks, including those of antimicrobial products
- Evaluate the energy demands and GHG emissions associated with nanoproduct manufacture
- Ensure producers' responsibility for end of life product recovery and recycling
- Require manufacturer take-back and recycling programs; support product design to maximize recyclability
- Require labeling to support people's right to know
- Establish comprehensive and precautionary legislation to manage the risks associated with nanotechnology in general
- Ban export of dangerous nanowaste and defunct nanoproducts, especially to the Global South

All nanomaterials must be subject to new safety assessments as new substances, even where the properties of larger scale counterparts are well known. All manufactured nanomaterials must also be subject to nano-specific health and environmental impact assessment and must be demonstrated to be safe prior to approval for commercial use. The assessments of nanomaterials must be based on the precautionary principle and the onus must be on manufacturers to comprehensively demonstrate the safety of their product. No data, no market. All relevant data related to safety assessments, and the methodologies used to obtain them, must be placed in the public domain. Friends of the Earth also calls for greater prioritization of research into life cycle analysis and energy demands of nanomanufacturing, and clear criteria for decision making about priorities for publicly funded research. Rigorous assessment of nanoproducts would require complex, time consuming, and expensive detailed scientific analysis. This should only be undertaken for technologies with the utmost of potential and where a simpler substitution is not available.

A precautionary approach to nanotechnology is essential for all classes of nanoproducts. Without government action a whole new generation of more energy intensive nanoproducts will flood the market; we need regulations to evaluate not only safety but energy and greenhouse gas implications of nanotechnologies.

Suggestions for workers and the public

Workers need protection from the risks of occupational exposure to nanomaterials. This is particularly important given the evidence that some forms of carbon nanotubes behave like asbestos and can cause mesothelioma. It would be unforgivable to let nanotechnology repeat the asbestos tragedy. Occupational health is important everywhere, but especially in the Global South where workers have already faced unsafe workplace and environmental exposure from the electronics sector. This requires strong, precaution based regulation to prevent the use of nanomaterials whose safety has not been demonstrated. Governments must also enact strong 'right to know' legislation, requiring industry disclosure of nanomaterials handling to all affected workers. Workers should talk with their colleagues or union representatives about opportunities for collective action to secure a safe work place. The public needs the freedom to choose nano-free products through clear and mandatory labeling. Many people will want to avoid nanoproducts not only because of toxicity risks, but also as a means to reduce their carbon footprint. People should also explore opportunities for collective action to ensure that the health of people and the environment is not jeopardized by nanotechnology. Holding governments to account for their prioritization of public funding is essential. Public funding for research and development should be directed to areas that offer immediate opportunities for greenhouse gas emissions cuts, rather than propping up petrochemical exploration and extraction.

Glossary

Antioxidant
A molecule which slows or prevents destructive oxidation (the interaction of substances with oxygen in a process that can lead to their breakdown). Oxidative stress can damage cells.

Biocide
A biocide is a pesticide used in non-agricultural applications, mainly as an anti-microbial agent.

Biopolymer
Any polymer (a long repeating chain of atoms) found in nature. Examples include starch, proteins and DNA.

Bioavailability
Bioavailability measures the extent to which a substance can reach the systemic blood circulation and its availability at the site of action.

Carbon fullerene ('buckyball')
A fullerene is a pure carbon molecule composed of at least 60 atoms of carbon which has a shape similar to a hollow soccer ball or a geodesic dome.

Carbon nanofibers
Feature a 'stacked cup' fiber configuration. Have diameter varying between 70 and 200 nm and a length of 50 to 100 μm.

Dendrimer
Dendrimers are three-dimensional, synthetic macromolecules with branching parts, usually formed using a fabrication process at the nanoscale.

Granuloma
A small mass or nodule of chronically inflamed tissue that is usually associated with an infective process or injured tissue, for example as seen in Crohn's disease, tuberculosis, sarcoidosis etc.

In vitro
Experiment performed in a test tube or culture.

In vivo
Experiment performed in a living organism.

Nanocomposite
Materials that are created by mixing nanomaterial fillers into a base material, for example plastic polymers.

Nano-sensor
Nanoscale chemical, biological or physical sensory points or system used to detect and convey information about a given environment, eg temperature, pH, location, or the presence of diseased tissue.

Nanotubes
A nanomaterial which resembles a cylinder. Often made of carbon, but also titanium dioxide, boron and other elements. Single walled carbon nanotubes (SWCNT) are composed of a single cylinder of carbon atoms, while multi walled carbon nanotubes (MWCNT) comprise multiple concentric cylinders of carbon atoms. Nanotubes are very strong and light and excellent conductors of electricity.

Nanowires
A nanowire is an extremely thin wire with a diameter on the order of a few nanometers (nm) or less.

Biopersistent
Materials that our bodies are not able to decompose into substances which can be used or excreted.

Oxidative stress
An imbalance between the production of reactive oxygen and a biological system's ability to readily detoxify the reactive intermediates or easily repair the resulting damage.

Polymer
A substance made of many repeating chemical units or molecules. The term polymer is often used in connection with plastic, rubber, or elastomer.

Quantum dots
Quantum dots are nanoscale spheres of inorganic materials that show novel optical properties, enabling light from different wavelengths to produce visible light.

Reactive oxygen species (ROS)
Very small molecules which are highly reactive due to the presence of unpaired valence shell electrons, includes oxygen ions, free radicals and peroxides. ROS form as a natural byproduct of the normal metabolism of oxygen and have important roles in cell signaling. However, during times of environmental stress ROS levels can increase dramatically and result in significant damage to cell structures (oxidative stress).

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In this report, Friends of the Earth puts the 'green' claims of the nanotechnology industry under the microscope. Our investigation reveals that the industry has over-promised and under-delivered. Many of the claims made regarding nanotechnology's environmental performance are not matched by reality. Worse, the energy and environmental costs of the nanotechnology industry are far higher than expected.

Carbon nanotubes are touted as one of the most promising nanomaterials for energy savings applications. Yet they may be one of the most energy intensive materials known to humankind. Researchers calculate that the embodied energy in a single kilogram of carbon nanotubes may be as great as 167 barrels of oil. A woman's weight in nanotubes would embody the same energy as the atomic bomb that exploded over Hiroshima (63 terajoules).

"Very few people have looked beyond the shiny promise of nanotechnology to try and understand how this far-reaching new technique is actually developing. This report is an excellent glimpse inside, and it offers a judicious and balanced account of a subject we need very much to be thinking about."

- Bill McKibben, author, environmentalist, founder 350.org

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Friends of the Earth | International Center for Technology Assessment | etc group

May 26, 2010

The Honorable Henry Waxman
Chairman
Committee on Energy and Commerce
2125 Rayburn House Office Building
United States House of Representatives
Washington, D.C. 20515

The Honorable Joe Barton
Ranking Member
Committee on Energy and Commerce
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Offering Testimony from Civil Society on the Environmental and Societal Implications of Synthetic Biology

Dear Representatives,

We are writing on behalf of international civil society organizations who for some years have been engaged in tracking developments in Synthetic Biology and analyzing the societal and environmental impacts of this emerging technological platform.[i] We understand that on Thursday May 27, 2010 the U.S. House of Representatives Energy and Commerce Committee will hold a hearing on recent developments in synthetic biology and its implications for health and energy. We respectfully request that the committee consider the following testimony as a critical contribution to your work on this matter. We also ask that the committee consider holding a further hearing on this matter so that the voices of those in civil society who have long been concerned about the environmental, public health and socio-economic impacts of synthetic biology as a field can be heard in this hearing process.

We note that this hearing comes immediately before another hearing dealing with the unfolding BP oil spill in the Gulf of Mexico. With this in mind, we urge representatives to consider the importance of asking hard questions about the threats of new experimental technologies *before* they are deployed, not after terrible accidents have already occurred.

Wake up call – time for a pause:

Last week, the J. Craig Venter Institute announced the creation of the first living organism with a synthetic genome claiming that this technology would be used in applications as diverse as next generation biofuels, vaccine production and the clean up of oil spills. We agree that this is a significant technical feat however; we believe it should be received as a wake-up call to governments around the world that this technology must now be accountably regulated. While attention this week has been on the activities of a team from Synthetic Genomics Inc, the broader field of synthetic biology has in fact quickly and quietly grown into a multi-billion dollar industry with over seventy DNA foundries and dozens of ‘pure play’ synthetic biology companies entering the marketplace supported by large investments from Fortune 500 energy, forestry, chemical and agribusiness companies. That industry already has at least one product in the marketplace (Du Pont's 'Sorona' bioplastic), and another recently cleared for market entry in 2011 (Amyris Biotechnology's 'No Compromise' biofuel) as well as several dozen near to market applications. We believe the committee should consider the implications of this new industry as a whole in its deliberations not just the technical breakthrough reported last week. Without proper safeguards in place, we risk introducing synthetically constructed living organisms into the environment, intentionally or inadvertently through accident and worker error, that have the potential to destroy ecosystems and threaten human health. We will see the widespread commercial application of techniques with grave dual-use implications. We further risk licensing their use in industrial applications that will unsustainably increase the pressure of human activities on both land and marine ecologies through the increased take of biomass, food resources, water and fertilizer or displacement of wild lands to grow feedstocks for bio-based fuel and chemical production.

We call on Congress to:

1) Implement a moratorium on the release of synthetic organisms into the environment and also their use in commercial settings. This moratorium should remain in place until there is an adequate scientific basis on which to justify such activities, and until due consideration of the associated risks for the environment, biodiversity, and human health, and all associated socio-economic repercussions, are fully and transparently considered.

2) As an immediate step, all federally funded synthetic biology research should be subject to a comprehensive environmental and societal impact review carried out with input from civil society, also considering indirect impacts on biodiversity of moving synthetic organisms into commercial use for fuel, chemicals and medicines. This should include the projects that received $305 million from the Department of Energy in 2009 alone.

3) All synthetic biology projects should also be reviewed by the Recombinant DNA Advisory Committee.

On synthetic biology for biofuels - time for a reality check.

Much of the purported promise of the emerging Synthetic Biology industry resides in the notion of transforming biomass into next generation biofuels or bio-based chemicals where synthetic organisms work as bio-factories transforming sugars to high value products. On examination much of this promise is unrealistic and unsustainable and if allowed to proceed could hamper ongoing efforts to conserve biological diversity, ensure food security and prevent dangerous climate change. The sobering reality is that a switch to a bio-based industrial economy could exert much more pressure on land, water, soil, fertilizer, forest resources and conservation areas. It may also do little to address greenhouse gas emissions, potentially worsening climate change.

By way of an example, the team associated with Synthetic Genomics Inc who have recently announced the creation of a synthetic cell have specifically claimed that they would use the same technology to develop an algal species that efficiently converts atmospheric carbon dioxide into hydrocarbon fuel, supposedly addressing both the climate crisis and peak oil concerns in one fell swoop. Yet, contrary to the impression put forth by these researchers in the press, algae, synthetic or otherwise, requires much more than just carbon dioxide to grow - It also requires water, nutrients for fertilizer and also sunlight (which therefore means one needs land or open ocean - this can't be done in a vat without also consuming vast quantities of sugar).

In order for Synthetic Genomics or their partners to scale up algal biofuel production to make a dent in the fuel supply, the process would likely exert a massive drain on both water and on fertilizers. Both fresh water and fertilizer (especially phosphate-based fertilizers) are in short supply, both are already prioritized for agricultural food production and both require a large amount of energy either to produce (in the case of fertilizers) or to pump to arid sunlight-rich regions (in the case of water). In a recent life-cycle assessment of algal biofuels published in the journal Environmental Science and Technology researchers concluded that algae production consumes more water and energy than other biofuel sources like corn, canola, and switch grass, and also has higher greenhouse gas emissions.[ii] “Given what we know about algae production pilot projects over the past 10 to 15 years, we've found that algae's environmental footprint is larger than other terrestrial crops," said Andres Clarens, an assistant professor in U.Virginia.'s Civil and Environmental Department and lead author on the paper.[iii] Moreover scaling-up this technology in the least energy-intensive manner will likely need large open ponds sited in deserts, displacing desert ecosystems. Indeed the federally appointed Invasive Species Advisory Committee has recently warned that non-native algal species employed for such biofuel production could prove ecologically harmful and is currently preparing a fuller report on the matter.[iv]

Meanwhile it is not clear that the yield from algal biofuels would go far to meeting our energy needs. MIT inventor Saul Griffiths has recently calculated that even if an algae strain can be made 4 times as efficient as an energy source than it is today it would still be necessary to fill one Olympic-size swimming pool of algae every second for the next twenty five years[v] to offset only half a terawatt of our current energy consumption (which is expected to rise to 16 TW in that time period). That amounts to massive land use change. Emissions from land use change are recognized as one of the biggest contributors to anthropogenic climate change.

Moving Forward - Time for new regulation

The rapid adoption of synthetic biology is moving the biotechnology industry into the driving seat of industrial production across many previously disparate sectors with downstream consequences for monopoly policy. Meanwhile its application in commercial settings uses a set of new and extreme techniques whose proper oversight and limits has not yet been debated. It also enables many more diverse living organisms to be produced using genetic science at a speed and volume that will challenge and ultimately overwhelm the capacity of existing biosafety regulations. For example, Craig Venter has claimed in press and in his patent applications that when combined with robotic techniques the technology for producing a synthetic cell can be perfected to make millions of new species per day.[vi] Neither the US government nor any other country has the capacity to assess such an outpouring of new synthetic species in a timely or detailed manner. The Energy and Commerce Committee urgently needs to suggest provisions for regulating these new organisms and chemicals derived from them under the Toxic Substances Control Act, Climate Change legislation and other legislation under its purview before allowing their release into the environment. It also needs to identify how it intends to ensure that the use of such organisms whether in biorefineries, open ponds or marine settings does not impinge on agriculture, forestry, desert and marine protection, the preservation of conservation lands, rural jobs or livelihoods.

To conclude, Congress must receive this announcement of a significant new lifeform as a warning bell, signifying that the time has come for governments to fully regulate all synthetic biology experiments and products. It is imperative that in the pursuit of scientific experimentation and wealth creation, we do not sacrifice human health, the environment, and natural ecosystems. These technologies could have powerful and unpredictable consequences. These are life forms never seen on the planet before now. Before they are unleashed into the environment and commercial use, we need to understand the consequences, evaluate alternatives properly, and be able to prevent the problems that may arise from them.

If you have, any questions please contact: Jim Thomas at jim@etcgroup.org or *1-514-273-9994,* Eric Hoffman at ehoffman@foe.org, or 202-222-0747, or Jaydee Hanson at jhanson@icta.org or 703-231-5956.

Sincerely,

Jim Thomas
Program Manager
ETC Group (Action Group on Erosion, Technology and Concentration)
http://www.etcgroup.org/en/issues/synthetic_biology

Eric Hoffman
Genetic Technology Policy Campaigner
Friends of the Earth
http://www.foe.org/healthy-people/biofuels-synthetic-biology

Jaydee Hanson
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International Center for Technology Assessment
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[i] For an introductory overview of societal issues raised by Civil Society around Synthetic Biology see ETC Group, "Extreme Genetic Engineering: An Introduction to Synthetic Biology" (Ottawa, ON: ETC Group, 2007). Available online at http://www.etcgroup.org/en/node/602

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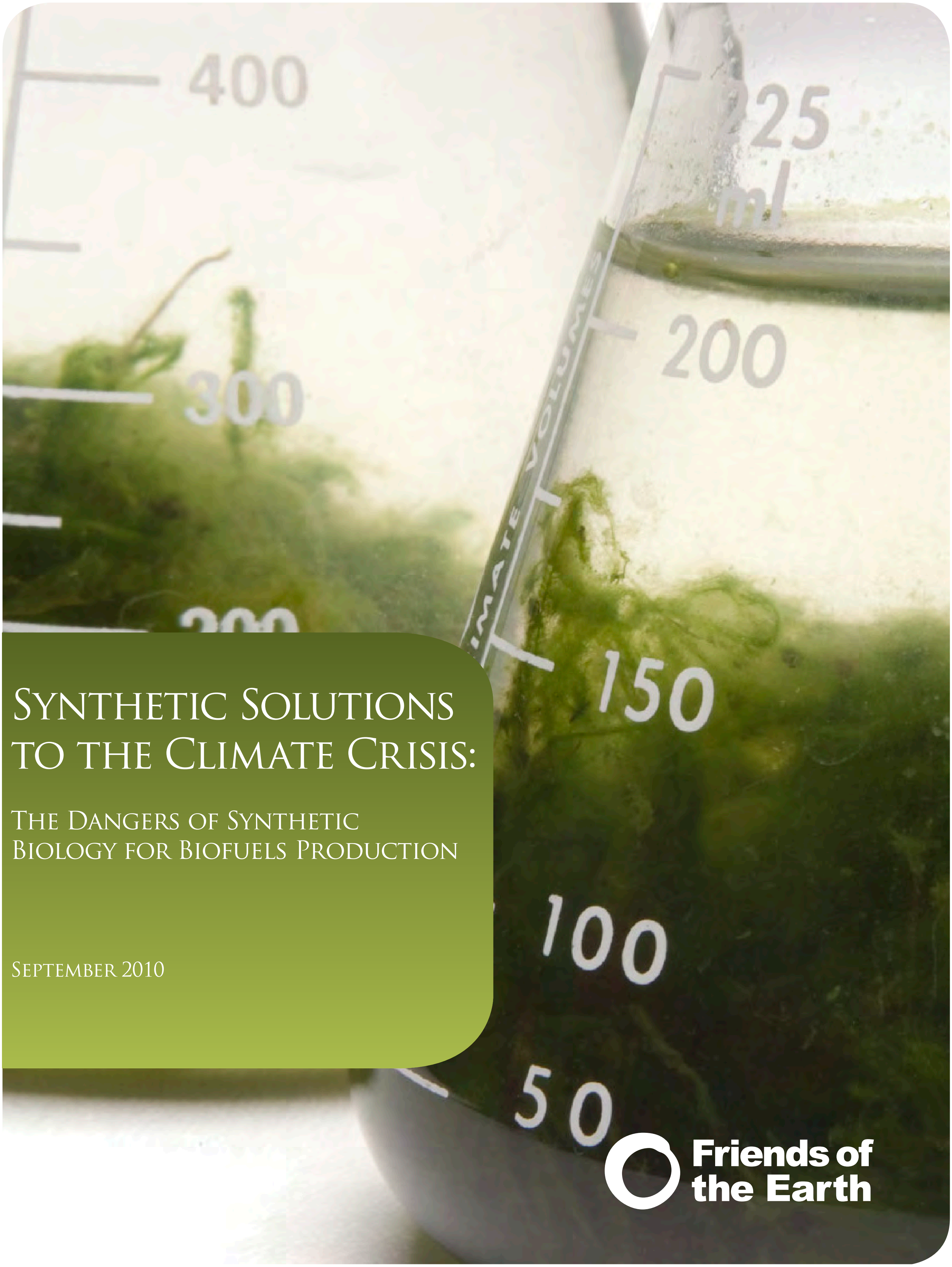
[v] Saul Griffith's presentation to the Long Now Foundation "Climate Change Recalculated" available online at http://www.longnow.org/seminars/02009/jan/16/climate-change-recalculated/

[vi] For Venter's claim see US Patent Application US20070264688A1: "Synthetic Genomes". For discussion of the implications of this see Jim Thomas, ETC Blog "Synthia gets a Shotgun" accessed online at http://etcblog.org/2007/12/09/synthia-gets-a-shotgun-goodbye-genetic-engineering/ 9th December 2007.



Synthetic Solutions to the Climate Crisis:

The Dangers of Synthetic Biology for Biofuels Production

September 2010

Friends of the Earth

Executive Summary

Biotechnology is portrayed as a panacea for climate change and other societal ills. However the claims that genetically engineered plants and microbes can sequester more carbon in the soil and produce more fuels when processed than conventional methods have yet to be proven. In the wake of these unfulfilled promises emerges a more extreme form of genetic engineering, also touted as the solution to the climate crisis – synthetic biology.

Genetic engineering involves inserting genes from one species into another but the goal of synthetic biology is to create life forms from scratch using synthetic, computer-generated DNA or in some cases without the use of DNA entirely.

Synthetic biology is not a sustainable solution to the climate crisis and has the potential to create an entirely new set of problems. Genetic contamination – where the genetic makeup of a man-made organism effectively roots out or destroys an indigenous species in the natural environment – is a serious threat to biodiversity, the environment, and public health. This happened when genetically engineered crops like corn were introduced in the U.S. in the early 1990s and contaminated entire strains. Synthetic biology exacerbates this problem since no one knows how organisms with synthetic DNA will act in the open environment. They could die immediately – or they could find a niche and devastate ecosystems as other invasive species have done.

In spite of this threat, commercial applications for producing biofuels through synthetic biology are under way. Brand new forms of algae, yeast, and other organisms are being designed with synthetic DNA to produce fuels or to more efficiently break down existing land-based crops to be fermented into fuels.

This research is backed primarily by the oil industry. Additionally, the federal government provides these corporations with hundreds of millions in taxpayer money to research and patent organisms for fuel and then sell that fuel back to the public. Oil companies have already destroyed the environment and should not be rewarded for putting profits ahead of protecting human health and the environment.

The only way to safeguard against possible environmental disaster is to place an immediate moratorium on the release and commercial use of all synthetic organisms into the environment and conduct full environmental and social impact statements on all synthetic biology research. Dangerous and unproven synthetic biology projects have diverted investments away from safe and clean technologies like wind and solar, and energy efficiency. A moratorium would revive research and development of these renewable energy sources, end dependence on fossil fuels and safeguard the environment and all those that depend on it.

Introduction

Scientists have been manipulating the genetic code since the early 1970s when they began genetically engineering bacteria, plants, and animals.[1] Over the years genes have been inserted into crops to make them resistant to certain herbicides or to produce toxins in their cells that kill insects;[2] fish and rabbits are injected with genes from jellyfish and coral to make them glow for purely aesthetic purposes.[3]

Since then, biotechnology has been portrayed as a panacea for climate change and other societal ills. The Biotechnology Industry Organization (BIO), the industry's largest trade group, declares that these technologies are fueling,[4] feeding[5] and healing the world.[6] Monsanto, a biotech giant, claims that its genetically engineered seeds will produce drought resistant crops and sequester carbon.[7] The industry also says that that genetically engineered plants produce more ethanol,[8] or other fuels,[9] when processed. By injecting DNA from one organism with a desired trait—say drought resistance—into another plant, scientists can tweak naturally existing plants, yeasts, algae, and bacteria to make "better"[10] ones. But "better" more often refers to the profits they can bring in once patented rather than the benefits to people or the planet. Already a handful of corporations have benefited from biotechnology at the expense of the environment, the climate, and public health.[11]

GloFish® has added a fluorescent protein gene to zebrafish like this one.

The field of genetic modification is growing in complexity. Previously, genetic engineering involved taking a short segment of DNA from one organism and inserting it into another organism to engineer a new, genetically modified creature. Scientists are now able to manipulate genetic material like never before due to advances in genetic engineering, DNA sequencing, nanotechnology, and robotics. Combining these technologies, some scientists are attempting to create life from scratch or re-design existing life. The proponents of this more complex genetic engineering call it "synthetic biology." Its supporters claim that synthetic biology will be the source of the new "green" and "renewable" fuel supply.[12] The science behind synthetic biology and how it is used to produce biofuels will be reviewed in Section 1.

Section 2 will discuss the dangers synthetic biology poses to our environment and public health, as well as risks to national security.

Section 3 addresses the hype around synthetic biology and the false belief that fuels created through synthetic biology will save the planet from climate change. Proponents of synthetic biology are banking on the appeal of a 'green' techno-fix to win over the public, in spite of the very serious risks involved.[13]

Section 4 critiques this false notion that biofuels produced through synthetic biology are a solution to the climate and energy crisis. It's unlikely that synthetic organisms will be able to produce the amount of fuel and energy needed to become competitive with other sources of energy without seriously harming the environment and public health, and perpetuating inequality around the world.

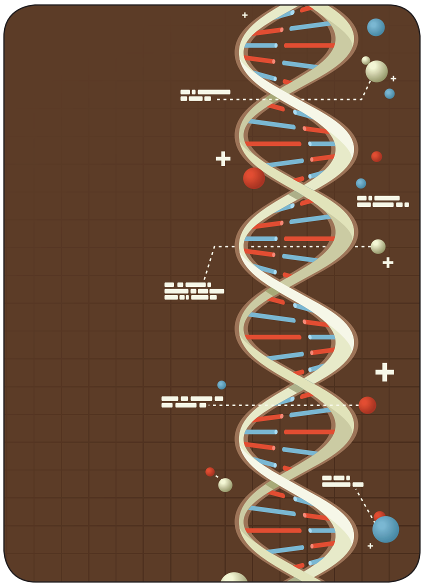
Section 5 will show the oil industry and agribusiness' connections to the synthetic biology field. With the support of oil giants, such as Exxon Mobile and BP, synthetic biology startup companies have started producing fourth generation biofuels from man-made organisms. The patenting procedure for synthetic life forms and how companies can manipulate the system to control the fuel supply will then be discussed.

Amyris Biotechnologies is one such company. It's producing biofuels and medicines with synthetic yeast, and is a prime example of how synthetic biologists use their connections with Big Oil and the government to promote unproven and unregulated products. The harms caused by Amyris' biofuels production efforts in Brazil will be highlighted in Section 6.

Next, Section 7 will highlight the other major funder of synthetic biology research – the U.S. government. With the help of federal contracts, grants, and friends in high places, synthetic biology companies have been able to receive significant amounts of public funding to start their operations and patent their organisms. These companies are also being supported by U.S. biofuels policies that are promoting new and alternative sources of biofuels.

Section 8 reveals how synthetic biologists hope to thwart any attempts at oversight and lays out the argument for precaution.

The report concludes with policy recommendations to regulate synthetic biology in Section 9 and why such regulations are necessary to protect the environment and public health from the unique dangers posed by synthetic organisms.



The use of genetic engineering has grown at an incredible rate in agriculture production, the medical field, and more recently to produce biofuels.

1. The Science of Synthetic Biology

A Brief History of Genetics:

To better understand the new dangers posed by synthetic biology, it is important to briefly cover major advances in genetics and our understanding of how genes function. The father of genetics is Gregor Mendel, a German monk, who in 1865 discovered that traits are inheritable through experiments with pea plants. It wasn't until the 1900s that the importance of this discovery was fully recognized. In the 1920s it was believed that genes constitute the basis of life and evolution and those nucleic acids were a major component of chromosomes. Alfred Hershey and Martha Chase proved in 1952 that genes, in fact, were the carriers of genetic information.[14]

In 1953 James Watson and Francis Crick made the historic discovery that DNA was formed by a double-strand helix of nucleotides.[15] Until this time, scientists did not know how DNA was composed or constructed. This knowledge opened up the door to the idea that we could re-construct DNA. Only twenty years after the structure of DNA was discovered, the first genetically engineered organism, a form of *E. coli*, was created in a process known as genetic recombination. Recombinant DNA led to the birth of the first genetic engineering company in 1977, Genentech, who started making drugs with this new technology.[16]

Since that time, the use of genetic engineering has grown at an incredible rate in agriculture production, the medical field, and more recently to produce biofuels.

Recombinant DNA, better known as genetic engineering, has previously relied on taking genes from one organism and inserting it into a new organism. The combinations of genes were limited to DNA that could be found in nature. The discovery of DNA synthesis has changed that and now DNA and genes can be created from scratch without needing to find them in nature. This emerging field is known broadly as synthetic biology.

Defining Synthetic Biology:

Synthetic biology is “the design and construction of new biological parts, devices and systems that do not exist in the natural world and also the redesign of existing biological systems to perform specific tasks.”[17]

Instead of inserting genes from one species into another, what is considered genetic engineering, synthetic biology aims to create life from scratch with synthetic DNA or without the use of DNA entirely. DNA is synthesized on a computer and “printed” out, which can then be shipped anywhere in the world through the mail. While the range of practices referred to as “synthetic biology” varies, they all involve taking genetic engineering to a new extreme.[18]

Approaches to Synthetic Biology:

There are several approaches to creating synthetic life forms currently being used, each of which is working on a different scale. At the most basic level is the production of synthetic DNA through the arrangement of nucleotide bases: adenine, thymine, cytosine, and guanine—represented by the letters A, T, C, and G. Once a DNA sequence has been uploaded or typed into a computer, it can be “printed” out onto a sheet of glass from bottles of A, T, C, and G.

The first synthetic gene was created in 1970 with 207 nucleotides.[19] DNA synthesis has evolved greatly since the 1970s and can now be done relatively cheaply and quickly by gene synthesis companies that are popping up across the globe. Customized DNA strands can be purchased online and delivered through the mail for just $0.40 a base pair—compared to $10-$20 per base pair just ten years ago.[20] These base pairs can then be arranged into genes that, through RNA (ribonucleic acid), code for desired proteins. [1]

Proteins are built out of the twenty known amino acids. Codons, a serious of three chemical bases, determine which amino acid will

1 *To see a map of synthetic DNA companies, government laboratories, research institutions, and universities conducting synthetic biology research and policy centers examining issues surrounding synthetic biology, please visit: http://www.synbioproject.org/library/inventories/map/*

be produced in a given cell. Much of the synthetic biology research is occurring at the codon level, since it is through codons that scientists can chose among "biological instructions" for the desired trait expression. Some synthetic biologists are even creating new artificial amino acids (outside the twenty found in nature) by combining codons in ways never done before[21] or even trying to create life without DNA entirely.[22]

Dr. Clyde Hutchinson, Chair of the scientific advisory board of Synthetic Genomics, and Professor Emeritus of Microbiology and Immunology at the University of North Carolina at Chapel Hill.

Drew Endy, formerly of Massachusetts Institute of Technology and currently at Stanford University, founded the BioBricks Foundation. The Foundation is a registry of standard DNA sequences that code for certain functions.[23] For example, DNA "parts" can be created that make an organism glow. One could request this "biobrick," put it into an organism they want to engineer, and in theory the organism should then be able to glow. These open-source "bricks" (often compared to toy "Lego" bricks) can be used by researchers across the world to construct new genes and DNA sequences.

Craig Venter of Synthetic Genomics and the J. Craig Venter Institute created another approach. His research team produced an organism with the minimum number of genes needed to survive. One could then add any DNA sequence to this "minimal genome" and produce fuel for cars, medicine, or any other synthetic product.

In May 2010 Synthetic Genomics announced that it had made the world's first organism with a completely synthetic genome. "This was the first self-replicating species that we've had on the planet whose parent is a computer,"[24] according to Venter. The announcement was also the first time the majority of the public and policymakers had heard of synthetic biology or considered the field's risks and benefits.

Another approach attempts to create life forms without DNA, like the field of "xenobiology," which combines nucleic acids in ways never done before in nature. Naturally, the four nucleic acids (A, T, C, and G), are linked together by the backbone of DNA – a sugar group (2-deoxyribose) and phosphate. Xenobiologists hope to combine the nucleotide bases to different sugars in the backbones, to create things such as threose nucleic acid (TNA), hexose nucleic acid (HNA), and glycol nucleic acid (GNA) – all of which never existed before in nature.[25] The hope is that these organisms will not be able to cross-breed with naturally occurring organisms, eliminating some risks of genetic engineering, but xenobiology carries its own risks, such as invasive species with novel genetic constructs, that have yet to be assessed.

Others hope to build life up from scratch by creating a "protocell." To do this, researchers are combining inanimate chemicals and arranging them in such a way that they hope will eventually lead to the creation of synthetic life. Some hope these protocells will provide insight into the origin of life and may lead to the creating of new organisms that don't even need a DNA-like structure to survive and multiply.[26] This protcell approach is the closest in theory to creating "life from scratch" of all approaches to synthetic biology.

Synthetic Biology for Biofuels Production:

Synthetic biology is being used in two different processes for biofuels production: first is using synthetic enzymes to break down biomass into sugars for fuel, and second is creating microbes that produce fuel directly.

Enzymes, which are proteins that catalyze reactions, are being engineered into microbes that can break down biomass much quicker than traditional methods. Synthetic DNA that codes for these enzymes is inserted into microbes that then produce these synthetic enzymes. These enzymes can now be tailored towards specific types of biomass, such as woodchips or corn stalks, and increase the rate at which they are broken down into sugars that can then be fermented into ethanol or other types of fuels. Examples of how synthetic enzymes are being used to break down biomass will be discussed in section 5 and even further in section 6 when Amyris Biotechnologies' efforts to use yeast with synthetic enzymes to break down Brazilian sugarcane are discussed.

The second approach being used to produce biofuels is through creating organisms, largely algae, that produce biofuels directly. Synthetic algae or other microbes do not necessarily require biomass to produce fuel, unlike organisms with synthetic enzymes, and instead can produce lipids that are processed into fuels from sunlight, water, and fertilizers. Synthetic biologists hope to change the organisms so that the oil they produce is chemically similar or identical to the oils that are currently used in today's transportation and energy infrastructure.[27] These microbes would become "living chemical factories"[28] that can be engineered to pump out almost any type of fuel or industrial chemical.

The Evolution of Understanding Genetics - A Precautionary Tale:

Scientists have learned an incredible amount about genetics since Watson and Crick first discovered the DNA double-helix in 1953. And while it's now possible to construct synthetic DNA, engineering organisms out of synthetic DNA strands is unchartered territory.

It was thought that with the Human Genome Project we would find a one-to-one correlation between genes and traits. We now know this to be a grossly inaccurate belief. Some believed they would find hundreds of thousands of genes, but in reality humans have somewhere between 20,000-35,000 protein-coding genes,[29] which is not much more than that of a nematode or roundworm. It was even discovered in 2009 that corn plants have more than double the number of genes humans do.[30]

Genes, sections of our DNA that actually code for proteins, only make up around 2 percent of our genome. Until recently, scientists believed the other 98 percent was simply "junk DNA." But scientists are learning that the "junk" is actually quite important and likely regulates gene expression. Scientists are also learning that

"If the society that powered this technology collapses in some way, we would go extinct pretty quickly."

- Drew Endy, founder, International Genetically Engineered Machine (iGEM)

inheritable changes in DNA can be caused by environmental and other factors, in the emerging field of epigenetics.[31]

Understanding of genetics is evolving rapidly and has disproved many previously held beliefs and assumptions. What remains to be seen is how synthetic organisms will affect the environment and whether scientific understanding of the role of DNA will precede its application in industry. Precaution would lead us to further study the still-unknown role genetics plays in the creation and development of organisms before creating novel life forms with synthetic DNA.

2. The Dangers of Synthetic Biology

Synthetic biology alters the genetic material responsible for creating every living thing on Earth. Challenging and attempting to improve upon the original design of life ignores the evolutionary balance of the natural world. All life is interconnected, and these new forms of man-made life will undoubtedly interact with the Earth's natural ecosystems. As the scientific field of ecology has shown, altering just one part of an ecosystem can affect all the living beings within it. While ecosystems are always in flux, organisms tend to have a set place in the food chain with certain prey and predators. Synthetic organisms may lack the predators that normally keep populations in check.

Drew Endy, a leader in the field of synthetic biology, recognizes the danger this new technology poses. Scientists are now able to create synthetic organisms that produce biofuels and medicine and unfettered. Synthetic biologists claim that they might one day develop to methods to create new crop species and livestock, designer children and made-to-order pets.[32] "We are talking about things that have never been done before. If the society that powered this technology collapses in some way, we would go extinct pretty quickly." Endy continues, "You wouldn't have a chance to revert back to the farm or the pre-farm. We would just be gone."[33] These are strong words of warning from the same person who promotes "Do-it-Yourself" synthetic biology in people's basements[34] and helped create iGEM – the International Genetically Engineered Machine competition[35] – which encourages undergraduate students to build novel biological systems with "BioBricks."[2]

Environmental Risks:

Whether a synthetic organism is released unintentionally from a lab or intentionally into the environment, the threat to our ecosystem is the same. Since the widespread use of genetically engineered

2 While not all work from the DIYbio and iGEM community falls under the umbrella of synthetic biology, much of the work is indeed synthetic biology. iGEM encourages students to design their own BbioBricks," or standard DNA parts that can be synthesized and engineered into organisms anywhere around the world. DIYbio hopes to spread the tools of biology and bioengineering to anyone who is interested, and much of this work does occur in people's basements or garages.

(GE) crops, we have seen that GE plants have the ability to share genes across species,[36] evolve and mutate over time[37], and drastically affect entire ecosystems.[38] GE crops generally use genes that have been in the environment, but some of these new synthetic biology creations are using DNA that are human-made and not found in nature. While other types of pollution such as synthetic chemicals break down over time and do not breed, synthetic biological creations are designed to self-replicate and once released into the environment they would be impossible to stop and could wipe out entire species. This type of pollution, known as genetic pollution, can be devastating since it cannot be cleaned up. Once it has escaped, it can never be removed from the environment.

Dr. Allison Snow, an ecologist at Ohio State University, explained at the Presidential Commission for the Study of Bioethical Issues meeting in 2010 what this scenario might actually look like: "As a hypothetical example of a worst case scenario, a newly engineered type of high-yielding blue-green algae (cyanobacteria) could be grown in thousands of acres of outdoor ponds for biofuels. Algae grown in open ponds will be engineered to be very hardy and they could be more competitive than native strains. The new type of engineered algae might spread to natural habitats—to lakes, rivers, and estuaries, where it might flourish and displace other species. In some cases, this could result in algal blooms that suffocate fish and release toxic chemicals into the environment. So it would be a bad decision to go ahead with this kind of application."[39]

A drawing from Aurora Algae™ showing the scale that open-air operations will be working at within a year or two.

This leads to another major concern - the effect synthetic organisms will have on the ecosystem when they are created to survive outside the lab. Many hope synthetic organisms could be used to break down environmental pollutants such as oil spills.[40] As a report written by Michael Rodemeyer for the Wilson Center's Synthetic Biology Project highlights, "synthetic organisms intended for non-contained use will be specifically engineered to survive and function in the environment into which they are being released. As a result, they are more likely to be fit for survival and competition in the natural environment than organisms intended solely for contained use, making the risk of reproduction, spread, and evolution more probable."[41]

Experts in the field agree that there is no way to contain synthetic or genetically engineered organisms—particularly algae. According to Lissa Morganthaler-Jones, CEO and co-founder of Livefuels Inc., a small number of genetically engineered algae have already leaked from the lab into the environment. "They have been carried out on skin, on hair and all sorts of other ways, like being blown on a breeze out the air conditioning system," she said.[42] Isaac Berzin, founder of GreenFuel Technologies Corp., the first algae-to-biofuels company, believes that a leak hasn't happened yet but that it is inevitable. "Of course it's going to leak, because people make mistakes," said Berzin.[43]

Synthetic biologists like to talk about designing in a "kill-

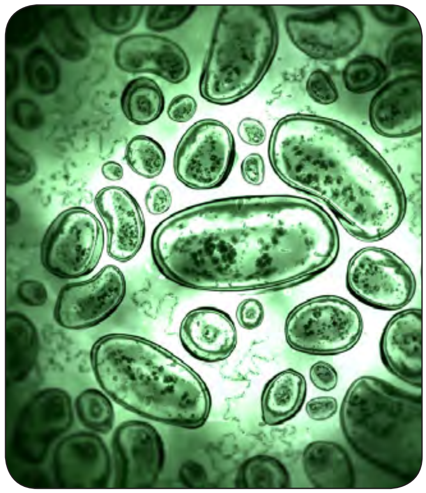
The fact that we can't predict the novel risks created by synthetic biology is why we need strong regulations from the beginning.

switch" or "suicide genes," that could be used to stop any organisms from getting out of control if they are released into the environment. Craig Venter has described how his team of researchers "will be able to engineer synthetic bacterial cells so they cannot live outside of the lab or other production environments. This is done, for example, by ensuring that these organisms have built in dependencies for certain nutrients without which they cannot survive. They can also be engineered with so called 'suicide genes' that kick in to prevent the organism from living outside of the lab or the environment in which they were grown."[44] Other examples include algae designed without swimming flagella or an inability to absorb the low levels of carbon dioxide found in seawater.[45]

Unfortunately, ecology has shown that one cannot just engineer safety into synthetic organisms. Even if the novel organisms are domesticated and seem innocuous, argues Dr. Snow, "mutations or unexpected properties might allow them to multiply in some environments. Physical or biological confinement (which could be based on engineered suicide genes or chemical dependencies) may not work forever or in all cases because mutations, human error, or unexpected events might allow [genetically engineered organisms] GEOs to escape and reproduce." Dr. Snow continues, "It would take only a few survivors to propagate and spread if biological confinement breaks down. The potential for rapid evolutionary change is especially high in microbes. Some will die out but others may thrive and evolve. GEOs that can exchange genes with related lineages or other species could evolve even faster—allowing synthetic genes to persist in hybrid descendants. So, we cannot assume that all domesticated or supposedly 'suicidal' GEOs are unable to persist in the environment."[46] Issac Berzin agrees: "You know where you start… but you don't know where you are ending. Algae adapt to their environment. Once you release it into the environment, guess what? They change. They get used to the worst toxins known to man… We live on a small planet, so it doesn't matter if disaster comes from Africa or China or New York. We are all going to be affected when it happens."[47]

Once a synthetic organism enters the environment, either through intentional or unintentional release, the ways in which these organisms will interact with the natural environment is unpredictable, potentially devastating, and permanent. A synthetic organism designed for a specific task, such as eating up oil from oil spills in the ocean, could interact with naturally occurring organisms and adversely harm the environment. The synthetic organism could displace existing organisms or interfere with the existing ecosystem. Once it found an ecological niche in which to survive, it would be difficult if not impossible to eradicate.[48]

The fact that we can't predict the novel risks created by synthetic biology is why we need strong regulations from the beginning. According to a 2006 report from the *New Atlantic*, synthetic organisms "will lack a clear genetic pedigree and could have 'emergent properties' arising from the complex interactions of its constituent genes…Accordingly, the risks attending the accidental release of such an organism from the laboratory would be extremely difficult to assess in advance, including the possible spread into new ecological niches and the evolution of novel and potentially harmful characteristics."[49] It is the uncertainty of risk that must prompt us to establish strong regulations from the beginning to ensure these fears are not realized. As Dr. Snow has highlighted, what makes assessing risk even more difficult is that most of the information from private industry is kept under lock and key as proprietary information.[50]



There is a real danger that the technology could be used to make deadly viruses and other biological weapons.

Public Health and National Security Concerns:

Beyond concerns that synthetic biology could wreak havoc on Earth's biodiversity, there is a real danger that the technology could be used to make deadly viruses and other biological weapons. In 2002, researchers at the State University of New York at StonyBrook recreated the polio virus (which took generations to eradicate) from mail-ordered DNA sequences.[51] In 2005, the U.S. Armed Forces Institute of Pathology recreated the 1918 Spanish Influenza, which killed between 20-50 million people worldwide, to "help them better understand — and develop defenses against — the threat of a future worldwide epidemic from bird flu."[52] What would happen if these deadly viruses – which proved to work in a lab – were created with ill intention and released or unintentionally leaked from a lab?

As a 2006 *Washington Post* article on bioterrorism highlighted, it is possible and completely legal for a person to produce the 1918 influenza virus or the Ebola virus genomes. It is also legal for someone to provide kits, detailed procedures, and any other needed materials to reconstitute the full viral DNA genome, and they could advertise and sell these viruses as well.[53] In fact, in June 2006 a journalist for *The Guardian* had synthetic DNA fragments for the *Variola major* virus that causes smallpox sent to his house from a commercial gene synthesis company to show how easily it could be done. As the ETC group highlights, the genome map of the *Variola major* is available on the internet in several public databases and the ability to purchase and combine synthetic DNA gets easier every day.[54] It was also discovered through a 2005 *New Scientist* investigation that only five of twelve DNA synthesis companies checked their orders systematically to ensure that they were not synthesizing and selling DNA that could be used to assemble the genome of a dangerous pathogen.[55] Concerns also exist of creating brand new viruses or toxins by combining DNA from different pathogenic organisms in novel ways.[56]

The U.S. Pentagon is even looking into the potential of synthetic biology to be used as a weapon. The U.S. military invested $6 million in 2010 in research to create synthetic organisms that could live forever or be turned off with a "kill switch"[57]—a security measure that would in theory kill the organisms in case of an emergency or if they got out of control. One potential military use of this technology would be to create bacteria that eat all living plant matter and food in an enemy's territory. President Obama's 2010 budget provided $20 million to the Defense Advanced Research Projects Agency (DARPA), a research arm of the Pentagon, for synthetic biology research.[58]

Naturally born microbes like the 1918 influenza virus and HIV are devastating enough, and there's no telling how devastating an engineered microbe could be. But it is feasible that an engineered organism, without natural predators, could cause widespread virulent disease, destroy the world's basic crops, or lead to the emergence of a new super-species. Synthetic biology creates a unique problem in that it is impossible to predict these risks. We can predict that a synthetic organism with a trait that makes it more competitive will out-compete its natural counterpart, as is seen with other invasive species.

3. The Hype Around Synthetic Biology as our Climate Solution

> *"Synthetic biology…has the potential to reduce our dependence on oil and to address climate change. Research is underway to develop microbes that would produce oil, giving us a renewable fuel that could be used interchangeably with gasoline without creating more global warming pollution. Research could also lead to oil-eating microbes, an application that, as the Gulf spill unfortunately demonstrates, would be extremely useful."*[59] *– Representative Henry Waxman (D-CA)*

The above quote sounds like the CEO of a synthetic biology start-up company talking to venture capitalists but in fact it is the opening statement by the chair of the House of Representatives Committee on Energy and Commerce during its first hearing on the implications of synthetic biology.

At that same hearing, Dr. Jay Keasling of the University of California at Berkeley, the Lawrence Berkeley National Laboratory, and Amyris Biotechnologies stated: "Through advances in synthetic biology, we can engineer…industrial microorganisms to produce biofuels that will work within our existing transportation infrastructure…these new, advanced biofuels reduce the production of greenhouse gases, as they are derived from plants that use sunlight and atmospheric carbon dioxide to grow. These biofuels will reduce our dependence on foreign oil and could rejuvenate U.S. agriculture."[60] Section 6 discusses Amyris' biofuels production efforts, proving they are far from carbon neutral and will only exacerbate strains on agricultural production.

Aristides Patrinos, president of Synthetic Genomics and a former member of President George W. Bush's team at the Department of Energy states that synthetic biology is the "holy grail" of energy production: "Advances in genomics and specifically synthetic genomics are the real 'game-changers' that can help us reach the goal [of removing 100 billion tons of carbon from the world's economy this century] …Our first goal is to put our vast knowledge and experience in the field of synthetic genomics to work in helping to solve the energy crisis…But one of the ultimate and disruptive technological goals of our synthetic genomics research is the use of carbon dioxide as a feedstock for the production of biofuels and biochemicals. Imagine that: carbon dioxide as a feedstock. This would be the 'holy grail' of bioenergy production: the transformation of a fossil fuel into a renewable resource."[61] This quote is the 'holy grail' of hyperbole and shows just how much hype surrounds synthetic biology without much thought to its repercussions.

In 2007, many of the world's top synthetic biologists met in Ilulissat, Greenland for the Kavli Futures Symposium on synthetic biology and nanotechnology. The outcome of this meeting was the "Ilulissat Statement" which said, among other things, that "the early 21st century is a time of tremendous promise and tremendous peril. We face daunting problems of climate change, energy, health, and water resources. Synthetic biology offers solutions to these issues**:** microorganisms that convert plant matter to fuels or that synthesize new drugs or target and destroy rogue cells in the body…Fifty years from now, synthetic biology will be as pervasive and transformative as is electronics today."[62] Steven Chu, current U.S. Secretary of Energy signed this statement while he was still director of the Lawrence Berkeley National Laboratory. Other signatories include Freeman Dyson, Drew Endy, Jay Keasling, and John Glass from the J. Craig Venter Institute, the leaders in the growing field of synthetic biology.

Many scientists and engineers use synthetic biology to reengineer the processing, refining, and growing of biological material for use as transportation fuel (biofuels) and electricity (biomass). Their goal is to maximize the production of biofuels from an acre of land in order to reduce global warming emissions and oil consumption.

The world's largest oil, agricultural, and pharmaceutical companies are already pouring hundreds of millions of dollars into synthetic biology research at their own companies, at smaller start-up corporations, and at universities. Many small, privately held firms are doing the same thing. In the United States, more than 15 companies and many top university biology departments are starting major synthetic biology programs to develop synthetic organisms that produce biofuels. Even the U.S. government is funding major synthetic biology projects for biofuels production and Secretary of Energy Chu has a background in synthetic biology.

These promises are unfortunately illusory and in reality the only thing green about synthetic biology is the color of the algae being used and the $4.5 billion dollars the industry stands to make over the next few years.[63]

The world's largest oil, agricultural, and pharmaceutical companies are already pouring hundreds of millions of dollars into synthetic biology research.

4. Synthetic Biofuels – A Synthetic Solution

The New Bio-Economy and the Threat to Socio-Economic Justice:

Even with so much hype, researchers have been unable to produce biofuels at the rate necessary to compete with traditional sources of energy. Synthetic biologists believe that the next generation of biofuels will overcome this barrier and be more efficient and sustainable than the previous generations of biofuels. They claim synthetic biology can free up land and other resources so fuels are not competing with food crops.

Unfortunately, this is far from true. Biofuels created through synthetic biology will create what ETC Group calls the "sugar economy" or the "bioeconomy:"

> [Synthetic biology] enthusiasts envision a post-petroleum era in which industrial production is fueled by sugars extracted from biological feedstocks (biomass). The biotech industry's bioeconomy vision includes a network of biorefineries, where extracted plant sugars are fermented in vats filled with genetically engineered – and one day, fully synthetic – microbes. The microbes function as "living chemical factories," converting sugars into high-value molecules – the building blocks for fuels, energy, plastic, chemicals, and more. Theoretically, any product made from petrochemicals could also be made from sugar using this biological manufacturing approach.[64]

If microbes can be genetically engineered and synthetically built to break down any type of biomass, than any source of biomass becomes a commodity that can be turned into fuel. As ETC Group asks, "Will *all* plant matter become a potential feedstock? Who decides what qualifies as agricultural waste or residue? *Whose* land will grow the feedstocks?"[65]

A 2008 issue of *Nature* argues that synthetic biology "might be tailored to *marginal lands* where the soil wouldn't support food crops"[66] (emphasis added) while ignoring the fact that these lands are often the source of livelihood for small-scale farmers, pastoralists, women, and indigenous peoples.[67] Steven Chu, before he became the U.S. Secretary of Energy, argued that there was "quite a bit" of arable land available for rain-fed energy crops and that Sub-Saharan African and Latin America could benefit from growing biomass for fuel.[68] Again, Chu fails to realize that these "marginal lands" are actually used to grow food for local communities and assumes they would rather grow fuel crops for wealthy nations. *The Economist* even suggested that "there's plenty of biomass to go around" and that "the world's hitherto impoverished tropics may find themselves in the middle of an unexpected and welcome industrial revolution."[69] In other words, poor nations should shift their economies to produce fuels for rich nations, exacerbating land grabbing efforts[70], deepening their dependence on the Global North, and limiting their ability to create self-sustaining local economies.

Synthetic biology enthusiasts work under the false assumption that there will be an endless supply of biomass and land to fuel their biofuels revolution. Even the U.S. Department of Energy, a major funder of synthetic biology research, has said "almost all of the arable land on Earth would need to be covered with the fastest-growing known energy crops, such as switchgrass, to produce the amount of energy currently consumed from fossil fuels annually."[71] There is a limit to how much biomass can be sustainably produced on the planet. Can even the most productive synthetic organisms produce enough fuel to meet the world's energy needs or will the world be led down an unpromising path with no real solution?

Deforestation in Brazil will only worsen as synthetic organisms are used to break down biomass for fuels.

The Real Environmental Impacts of Synthetic Biology:

Even algae, which synthetic biology cheerleaders claim are the solution to our fuel crisis since they do not require land-based biomass to produce fuels, are not as promising as they seem. Synthetic Genomics, which created the first synthetic cell, has specifically claimed that it would use the same technology to develop an algal species that efficiently converts atmospheric carbon dioxide into hydrocarbon fuel, supposedly addressing both the climate crisis and peak oil concerns in one fell swoop. Yet, contrary to the impression put forth by these researchers in the press, algae, synthetic or otherwise, require much more than just carbon dioxide to grow - they also require water, nutrients for fertilizer and also sunlight – and consequently they need land or open ocean. This cannot be done in a vat without also consuming vast quantities of sugar.

In order for Synthetic Genomics or their partners, such as Exxon, to scale up algal biofuels production to make a dent in the fuel supply, the process would likely exert a massive drain on both water and on fertilizers. Both fresh water and fertilizer (especially phosphate-based fertilizers) are in short supply,[72] both are already prioritized for agricultural food production and both require a large amount of energy either to produce (in the case of fertilizers) or to pump to arid sunlight-rich regions (in the case of water). In a recent lifecycle assessment of algal biofuels published in the journal *Environmental Science and Technology* researchers concluded that algae production consumes more water and energy than other biofuels sources like corn, canola, and switchgrass, and also has higher greenhouse gas emissions.[73] "Given what we know about algae production pilot projects over the past 10 to 15 years, we've found that algae's environmental footprint is larger than other terrestrial crops," said Andres Clarens, an assistant professor in University of Virginia's Civil and Environmental Department and lead author on the paper.[74]

Moreover scaling-up this technology in the least energy-intensive manner will likely need large open ponds sited in deserts, *"Can massive quantities of biomass be harvested sustainably without degrading soils, destroying biodiversity, increasing food insecurity and displacing marginalized peoples?"*

- ETC Group

displacing desert ecosystems. Indeed the federally appointed Invasive Species Advisory Committee has recently warned that non-native algal species employed for such biofuels production could prove ecologically harmful and is currently preparing a more complete report on the matter.[75] A similar plant owned by Sapphire Energy is already under construction in New Mexico that will take up 300 square acres of algal ponds for biofuels production.

Algae are arguably one of the most important organisms on the planet due to their special role in nature. Algae exist in almost every environment and produce upwards of 50 percent of all the oxygen in the air. They are the basis of many food chains and new species of algae are still being discovered.[76] While genetically engineered plants are problematic in their own right, synthetic biology raises the bar for the level of harms that can be caused. As the CEO of Livefuels Inc. said, "With [genetically engineered] corn, you can expect one crop a year, but with algae, you could get one crop a day"[77] Since algae reproduce almost daily. In other words, a single corn stalk could only reproduce with the limited number of seeds on its cobs in one given year whereas algae numbers double daily. This poses a brand new risk and makes the chance of an environmental crisis all the more likely. Al Darzins, a molecular biologist and principal group manager in bioenergy at the National Renewable Energy Laboratory has said that he is "absolutely convinced that if you're going to be using genetically modified algae in the future -- growing out in an open pond -- that before that happens on a very large scale there has to be some sort of risk assessment on what's going to happen to the potential ecology."[78]

The social and environmental questions this technology raises were best asked by the ETC Group:

> Advocates of synthetic biology and the bio-based sugar economy assume that unlimited supplies of cellulosic biomass will be available. But can massive quantities of biomass be harvested sustainably without eroding/degrading soils, destroying biodiversity, increasing food insecurity and displacing marginalized peoples? Can synthetic microbes work predictably? Can they be safely contained and controlled? No one knows the answers to these questions, but that's not curbing corporate enthusiasm. In the current social and economic context, the global grab for next generation cellulosic feedstocks threatens to repeat the mistakes of first-generation agrofuels on a more massive scale.[79]

Most synthetic biology projects described in this report are still in their early research phases. The industry already has at least one product in the marketplace (Du Pont's 'Sorona' bioplastic), and another recently cleared for market entry in 2011 (Amyris Biotechnology's 'No Compromise' biofuels) as well as several dozen near to market applications. Amyris' artemisinin will likely be the first medical application, as discussed in section 6 – but it will be tested on poor Africans – raising serious ethical and socio-economic issues of its own.

It is too early to know how productive synthetic bioproducts can be in producing biofuels or if they can actually work on a large scale. We do know that they will require an incredible amount of land, water, and fertilizer for either biomass or algal production – all of which are in short supply and are needed for agricultural food production.

Large investments in synthetic biology could prevent us (or distract us) from examining the root causes of climate change and the energy crisis: over-consumption and a dependence on dirty fuels. The same time and money could be invested in the development of truly sustainable forms of energy, such as wind and solar, as well as energy efficiency. We know we must put a price on carbon, make homes and cars more efficient, drive less and buy less, and stop subsidizing dirty forms of energy[80] - such as oil, coal, corn ethanol, and now biofuels made from synthetic biology.

Instead we are trying to force living organisms to produce fuels that fit our failing dirty system. Is it really easier to build novel life forms from synthetic DNA with unknown consequences on the environment and human health than fund sustainable solutions that we know can work? Or do we simply want to come up with a quick techno-fix that allows us to over-consume dirty fuels without changing our lifestyles in the slightest? Real-world sustainable solutions already exist; we must build the political will to actually rebuild our energy economy in a sustainable and just way.

5. Big Oil Plus Big Bio Equals Big Profits

One of the largest funders of synthetic biology research is the oil industry. As natural stocks of oil become depleted, these companies have begun to fund and create joint partnerships with biotechnology corporations to produce biofuels through synthetic microbes.

The following is a list of synthetic biology corporations and the research they are conducting on biofuels production, organized by research type. This list is a sample and not comprehensive, since deals are now being announced on a regular basis. Their links to Big Oil, corporate agribusiness and other dirty corporations are highlighted.

Synthetic Enzymes to Break Down Biomass for Fuel:

Amyris Biotechnologies is working with **BP,**[81] **Shell,**[82] and French oil company **Total**[83] to use its synthetic yeast to produce enzymes to break down sugarcane into fuels. Amyris is opening a plant in Brazil so it can have easy access to cheap sugarcane (see case study on Amyris in section 6 for more information on the company). The former director of BP's domestic fuel production is now in charge of Amyris.[84]

BP created a joint venture with **Verenium,** a Massachussetts-based biotechnology company, to provide $45 million[85] for cellulosic ethanol production through the use of Verenium's synthetic enzymes. Verenium also received $500,000 from agriculture biotechnology powerhouse **Syngenta** for tailoring its DirectEvolution™ technology to break down Syngetna's genetically engineered crops for biofuels.[86]

Agriculture for food or fuel?

Cellulosic ethanol company **Mascoma** has partnered with **General Motors**[87], **Marathon Oil**[88], and **Royal Nedalco**[89], a Netherlands-based ethanol corporation, to engineer yeast and bacteria with enzymes to break down cellulose for ethanol production. Their process of "consolidated bioprocessing" combines the digestion and fermentation process into one step with the help of these synthetic organisms.

General Motors has also invested an undisclosed amount to Illinois-based **Coskata,** which uses synthetic bacteria and gasification technology in a patented process to turn anything from wood to old tires into pure ethanol, a process that would supposedly "leap-frog cellulosic production."[90]

Genencor, a division of Danisco, has entered into joint ventures with two agribusinesses, **Cargill** and **DuPont,** to create synthetic enzymes. For the grain processing giant Cargill, Genencor's technology will be used to break down corn into ethanol, corn syrup, and other projects in a deal that is worth around $70 million.[91] Genencor and Dupont created a venture named *DuPont Danisco Cellulosic Ethanol LLC*, a $140 million initial investment to turn non-food sources such as corn stover and sugar cane bagasse into ethanol with the use of Genencor's patented enzyme technology.[92] DuPont owns Pioneer Hi-Bred, a leading genetically engineered seed company.

Royal Dutch Shell has partnered with Canadian cellulosic ethanol company **Iogen**[93] to create cellulosic ethanol with the use of synthetic enzymes to break down plant fibers.

Codexis, a leader in the development of the synthetic biology industry, received $60 million from **Shell** in 2009 alone - almost double the amount it received the year before, for enzyme creation.[94] Codex also receives major funding from **Chevron**.[95]

Synthetic Microbes to Directly Produce Fuel:

Synthetic Genomics, J. Craig Venter's company, plans on using its basic, stripped-down form of a simple bacterium to create an organism that might be able to take carbon out of the atmosphere, produce hydrogen fuel or methane, or as feedstock for other fuels. In 2007 Synthetic Genomics entered into a long-term partnership with **BP** to use synthetic biology to develop new biological conversion processes for petroleum. BP also made an equity investment in Synthetic Genomics.[96] The company received $600 million from **Exxon Mobil** over five years to develop biofuels from synthetic algae.[97] The algae would produce oil that closely resembles naturally-occurring petroleum, which can can enter Exxon's processing facilities without any changes of equipment or further processing.

LS9 was founded by George Church, a professor of Genetics at Harvard University and a leader in the field of synthetic biology. The California-based biotechnology company has re-engineered microbes to produce hydrocarbons that are similar to those found in petroleum, possibly creating a new source of crude oil. In 2009, LS9 finished raising $25 million in venture capital with help from **Chevron**.[98]

Solazyme, an algal energy firm based in San Francisco, uses genetically engineered marine algae to turn biomass into biodiesel through its patented process. [99] Solazyme entered into an agreement of an undisclosed amount with **Chevron**.[100]

Gevo, which produces biobutanol, received an undisclosed amount from **Virgin Fuels** in 2007 to develop butanol and isobutanol from biomass for airplanes.[101] This fuel would be used in Virgin Group's airline company, which prides itself as being the first airline to fly with biofuels.[102]

Corporate Money to Universities:

Corporate money has even spilled over into public research institutions. In one particularly controversial research agreement, **BP** invested $500 million in the **University of California Berkeley** to develop fuels through synthetic biology.[103] UC Berkeley is leading the initiative with the Lawrence Berkeley National Laboratory (LBNL) and the University of Illinois at Urbana-Champaign, to develop microbes that break down different feedstocks into a number of biofuels including biodiesel, butanol, and hydrogen. BP also invested an undisclosed amount into **Arizona State University** to develop biodiesel-producing bacterium.[104]

UC Irvine has also seen private money flow in to fund synthetic biology research for biofuels. **CODA Genomics** (which has since been renamed **Verdenzyme**) provided $1,670,000 in funding to engineer yeast with synthetic DNA that can turn switchgrass, hemp, corn, wood, and other natural materials into ethanol.[105]

While these investments are small compared with the profits Big Oil is bringing in, which top $40 billion a year,[106] it is a significant source of funding for the start-up synthetic biology corporations running the projects and the only thing keeping some of them operational. These investments have less to do with a dedication to sustainable energy production and more to do with bottom-line profits. The oil industry recognizes that alternative energy sources are gaining traction as the U.S. looks for alternatives to foreign oil. [107] Investments in synthetic biology are a strategic move by oil companies to control the future of fuel.

Eyebrows should be raised when the funders of alternative energy "solutions" to climate change are the same corporations who have polluted our climate and environment through emissions and oil spills for decades. These are the same corporations that are simultaneously funding climate skeptics whose only goal is to convince the public and policymakers that climate change is not even happening.[108] One must question if these companies are dedicated to truly transforming our energy sector or if they are just trying to placate policymakers through investments in "clean" technologies and own any future fuel that may come into use through patent protections.[3]

Exxon, the world's largest and wealthiest publicly traded oil company, is notorious for not funding alternative energy sources. It therefore came as a surprise to many that their first major investment into alternative fuels went to synthetic biology research in 2009 – $600 million to Synthetic Genomics (only around 1 percent of Exxon's $44.22 billion profits from that year). Synthetic algae-based fuel was appealing to Exxon since fuels from algae can be designed to have similar molecular structures to petroleum products and therefore can be used in their existing processing infrastructure. Exxon and Synthetic Genomics also hope to create algae that can absorb large amounts of carbon dioxide in an attempt to offset other "dirty" energy sources. This move by Exxon is nothing short of green-washing their dirty reputation. It is short-sighted to create new and unpredictable life forms that fit with our current infrastructure instead of investing in a new, clean, and sustainable infrastructure.

The development of biofuels through synthetic biology is dependent on cooperation and funding from Big Oil. As Venter has stated in regards to developing a biofuels sector, "These changes can't take place without a leader in the fuel industry."[109] By investing in synthetic biology, oil and agriculture corporations are betting against the development of a truly clean energy supply and infrastructure.

Patents on Life & the Control of a Future Fuel Supply:

Investments in synthetic biology by Big Oil corporations are nothing short of a way to own and control a potential future fuel supply. What is more frightening about the current corporate rush to fund synthetic biology is that unlike oil or natural gas, these organisms are *alive* – and will be owned by the Exxons and the BPs of the world.

Investments in synthetic biology by Big Oil corporations are nothing short of a way to own and control a potential future fuel supply.

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3 *Companies should be applauded if they begin to embrace sustainable sources of fuel. But Big Oil continues to argue climate change is not even real – contrary to decades of strong scientific evidence - and they continue to fight for lax or non-existent regulations of oil production, whether it is oil from the ground or algae. It is clear that their interest lie in profit and not protecting the environment or public health. We need companies committed to sustainable energy production, not corporations who may abandon a promising technology to support a dangerous technology—such as synthetic biology—because it could make them a quick profit.*

In 1980, the Supreme Court ruled in *Diamond v. Chakrabarty* that genetically engineered life forms could be patented. While the case was referring to more traditional genetic engineering, the court's ruling extends to the products of synthetic biology: "…the patentee has produced a new bacterium with markedly different characteristics from any found in nature and one having the potential for significant utility. His discovery is not nature's handiwork, but his own: accordingly it is patentable subject matter."[110]

As the ETC Group highlights in its comprehensive report *Extreme Genetic Engineering*, patents have already been granted on many of the processes and products involved in synthetic biology, including patents on: methods for building synthetic DNA, synthetic genes and DNA sequences, synthetic pathways, synthetic proteins and amino acids, and novel nucleotides that replace the letters of DNA. [111]

In 2007, the J. Craig Venter Institute applied for a frighteningly broad patent of its "minimal bacterial genome" called *Mycoplasma laboratorium.* This organism was an attempt to create life with the minimum number of genes by cutting out as many DNA sequences as possible without removing its ability to reproduce or survive. U.S. patent number 20070122826 describes creation of the first-ever, entirely synthetic living organism – a novel bacterium whose entire genetic information is constructed from synthesized DNA. This patent claims exclusive monopoly on: the genes in the minimal bacterial genome, the entire organism made from these genes, a digital version of the organism's genome, any version of that organism that could make fuels such as ethanol or hydrogen, any method of producing those fuels that uses the organism, the process of testing a gene's function by inserting other genes into the synthetic organism, and a set of non-essential genes. [112]

While this patent was denied, the claim shows the extent to which synthetic biologists are testing the limits in the battle to control the fundamental building blocks of life and actual living organisms. The patenting of living organisms is an issue worthy of its own report, but it is important to note here since it is through patents that these corporations hope to control the production, processing, and distribution of fuels. Also of concern, as mentioned in section 2, is the potential for a synthetic and patented organism to escape into the environment. First, much of the information on these organisms is being kept secret as proprietary so proper risk assessments cannot be conducted beforehand. Second, once the synthetic organisms escape researchers might not be able to study them to develop clean-up mechanisms since this may violate the patent – as is seen in researchers' inability to study the full risks of genetically engineered crops.[113]

6. Case Study: Amyris

Background on Amyris:

Amyris Biotechnologies was founded in 2003 by Jay Keasling. Dr. Keasling serves as the Deputy Laboratory Director of the Lawrence Berkeley National Laboratory, the Chief Executive Officer of the U.S. Department of Energy's (DOE) Joint BioEnergy Institute and a professor of chemical and bioengineering at the University of California Berkeley. A leader in the emerging field of synthetic biology, Keasling first gained notoriety for his production of arteminisic acid – a precursor to the important anti-malarial medicine artemisinin – through the creation of *E. coli* with synthetic DNA. Unlike traditional genetic engineering that often transfers one or two genes, this process transfers at least 14 genes into the bacteria, [114] one of which was synthetic amorphadiene syntase.[115]

While the desire to produce affordable anti-malarial drugs is laudable, it is important to note that thousands of farmers throughout Africa and Asia depend on the natural production of arteminisin.

With the help of $43 million from the Bill and Melinda Gates Foundation, a non-profit partnership was established between Amyris, the Gates Foundation, and the Institute for OneWorld Health to scale-up and eventually commercialize synthetic arteminisin production.[116] Arteminisic acid is traditionally found in the sweet wormwood plant, *Artemisia annua*, but natural production levels are low and cannot currently meet current world demand.

While the desire to produce affordable anti-malarial drugs is laudable, it is important to note that thousands of farmers throughout Africa and Asia depend on the natural production of artemisinin.[117] Instead of promoting the growth of these markets, which would bring a sustainable source of income to thousands of the world's poor, the Gates Foundation has instead decided to fund an American corporation, in a sense ignoring innovative approaches to sweet wormwood production that empower the world's poor and are already being utilized. For example, Anamed (Action for Natural Medicine) is promoting sustainable artiminisin production with "artemisia starter-kits" that include seeds and instructions on how to plant, harvest, and use the plant to create an anti-malarial tea in places where other medicine is unavailable.[118] The Anamed Artemisia Programme includes more than 1,000 people in more than 75 countries.

As the above story exemplifies, there are often low-cost, low-tech solutions to many of the problems being addressed by synthetic biology without the risks of social upheaval and environmental degradation. Amyris' biofuels production will have similar socio-economic effects that will lead to environmental degradation and disempowerment of local communities.

Since Amyris would not make money from its non-profit artemisinin endeavor they had to look for a new application of their technology. Keasling had been involved in energy production research for some time at the Joint BioEnergy Institute and is close to Steven Chu, the U.S. Secretary of Energy who was his predecessor at the

Lawrence Berkeley National Laboratory, so biofuels production was a logical source of profit for Amyris.

Amyris is using similar synthetic biology methods to create biofuels as they did for anti-malarial medication. This technology is based on the creation of synthetic pathways that lead to the production of isoprenoids – molecules used in a wide variety of energy, pharmaceutical, and chemical applications. Using yeast with synthetic DNA, Amyris claims they are able to convert plant-based feedstocks into 50,000 different isoprenoids. The image to the right, from Amyris, shows how this process is being used for fuel production.

Instead of creating alcohols such as ethanol, which cannot be used in pipes or other infrastructures since it is too corrosive, their yeasts are able to turn sugar into combustible hydrocarbons that resemble diesel fuel, gasoline, and jet fuel and can therefore be used in traditional engines.

Biofuels Production in Brazil:

Amyris' feedstock of choice is sugarcane. To guarantee a long-term supply, Amyris started creating partnerships in the world's largest sugarcane producing country – Brazil. They also opened a fully-owned subsidiary, Amyris Brazil, in Campinas, São Paulo, near Brazil's cane processing industry.

In 2008, Amyris and Crystalsev, of Brazil's largest ethanol distributors and marketers, created a joint venture "Amyris-Crystalsev." This venture named Brazil's former Minister of Agriculture Roberto Rodrigues to its Strategic Advisory Board. In December of 2009 the company bought a 40 percent stake in Sao Martinho Group's (one of the largest sugar and ethanol producers in Brazil) Boa Vista mill to process sugar cane. A few days later they announced deals with Bunge, an international food conglomerate who processes and trades sugarcane in Brazil, Cosan Guarani, a subsidiary of the French sugar corporation Tereos and Brazilian-based Açúcar Guarani, which cultivates and processes sugarcane. Amyris has also partnered with Brazilian sugarcane company Canavialis, which was bought by Monsanto in 2008,[120] to produce jet fuels for the U.S. Department of Defense from sugarcane grown in Alabama.[121,122]

These agreements would allow Amyris to build "bolt-on" facilities attached to their current ethanol plants to produce Amyris' fuels. According to Amyris' filing for Initial Public Offering with the U.S. Securities and Exchange Commission, they "expect these arrangements to provide [them] with access to over ten million tons of sugarcane crush capacity annually, which [they] intend to expand over time with these and other mills."[123] Amyris also licensed its propriety technology to Santa Elisa, the second largest ethanol producer in the country.

To scale-up their fuel production capabilities Amyris received

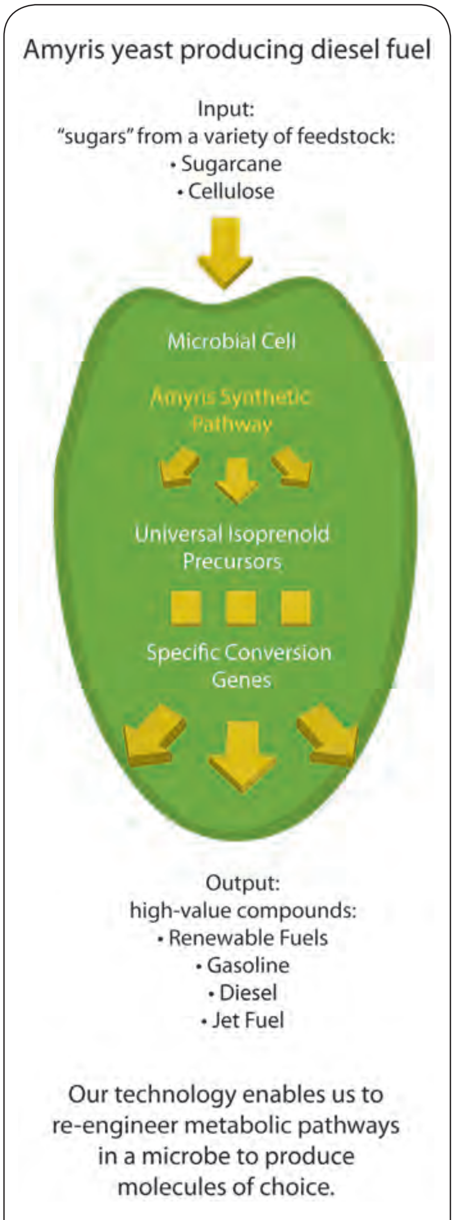


Image Courtesy of Amyris Biotechnologies[119] help from experts in the field. They hired the former President of U.S. Fuel Operations for BP, John Melo, as their Chief Executive Officer. Ralph Alexander – formerly the CEO of BP's Gas, Power and Renewables and Solar segment and a member of the BP executive group – was brought on board as the Chair of Amyris' Board of Directors. BP also gave $500 million to UC Berkeley and the Lawrence Berkeley National Lab to develop biofuels through synthetic biology[124] – both with ties to Jay Keasling and his biotech start-up.

Sugarcane production for biofuels is accelerating deforestation, water contamination, and increasing atmospheric pollution.

The Problem:

Amyris claims that their product will be "a perfect renewable fuel" that can reduce "lifecycle [greenhouse gas] emissions of 80 percent or more compared to petroleum fuels."[125] While it is unclear where Amyris gets its calculations from, it is known that most studies on the environmental impact of biofuels do not take into account the mode of production for the feedstocks and it is likely that Amyris did not look into the emissions from industrial sugarcane production. As *Time Magazine* has noted in reviews of general biofuels impacts, "it is as if these scientists image that biofuels are cultivated in parking lots."[126] But unfortunately sugarcane cannot be grown in parking lots and requires nutrient-rich soils and large amounts of land and water to be grown.

What we do know is that sugarcane production in Brazil is far from sustainable and the recent increase in demand for biofuels is accelerating deforestation, soil degradation, water contamination, destruction of native vegetation, and increasing atmospheric pollution from sugar cane fires – particularly in the Cerrado. The Cerrado (a savannah) is home to nearly 160,000 species of plants and animals, many of which are endangered. According to a 2008 report by Maria Luisa Mendonça, nearly 22,000 square kilometers of savannah are cleared every year. Estimates claim that over half of the region has already been devastated, and at this rate it will be completely destroyed by the year 2030.[127]

Despite this fact, the Brazilian government has targeted the Cerrado as a location for new biofuels plants – including the Boa Vista Mill that Amyris partially owns. Due to the Cerrado's flatness, soil quality, and access to water, it is an ideal location for sugar cane production[128] and is the only region the government allows sugarcane to even be planted. The Brazilian Institute of Geography and Statistics has shown that in 2007, sugarcane production occupied about 5.8 million hectares of the Cerrado.[129]

To plant sugarcane, all native plants and trees must be uprooted, affecting not just the environment but local communities. As one report from the Society, Population, and Nature Institute (ISPN) has noted, deforestation for sugarcane production "directly harms rural populations who survive off the biodiversity of the Cerrado. The other terminal consequence is that small food farmers leave their lands, having been lured into temporary employment in the sugarcane fields. This will diminish the food production in the area, which only serves to aggravate the migration to urban slums."[130]

Brazil's monoculture sugarcane production has other environmental impacts outside of land-use changes. Eighty percent of Brazil's sugarcane crops are set on fire to reduce cane straw, making manual harvesting and transportation easier. Smoke from these fires has been shown to harm nearby communities and native animals.[131] Sugarcane plantations require an incredible amount of water and often divert local rivers away from communities and farmers growing food. They have also led to increased use of fertilizers and pesticides.[132] The sugar plantation industry also has a dark history of slave labor and worker exploitation that it has yet to eliminate.[133]

Amyris will need an incredible amount of sugarcane to compete against oil, gas, and ethanol production. Amyris' pilot project in California produced 2.4 million gallons of fuel at annual capacity. They plan to make 200 million gallons of synthetic biofuels a year by 2011. The needed feedstock to produce at this capacity does not grow on parking lots but rather on priceless land that is home to diverse life. Further, the spread of sugarcane production is pushing other forms of agriculture deeper into previously forested lands such as the Amazon. While the direct emissions from Amyris' fuel might be less than burning traditional fossil fuels, when we take these other environmental effects into account the picture begins to look much less green.

The Cerrado, the center of Brazil's industrial sugarcane industry.

The chart on the next page highlights Amryis' close ties to Big Oil, the U.S. government, and Brazilian sugarcane and ethanol producers. Similar webs would be drawn for most synthetic biology corporations and the following is provided as way of example.

7. Public Money for Private Profit: Federal Support for Synthetic Biology

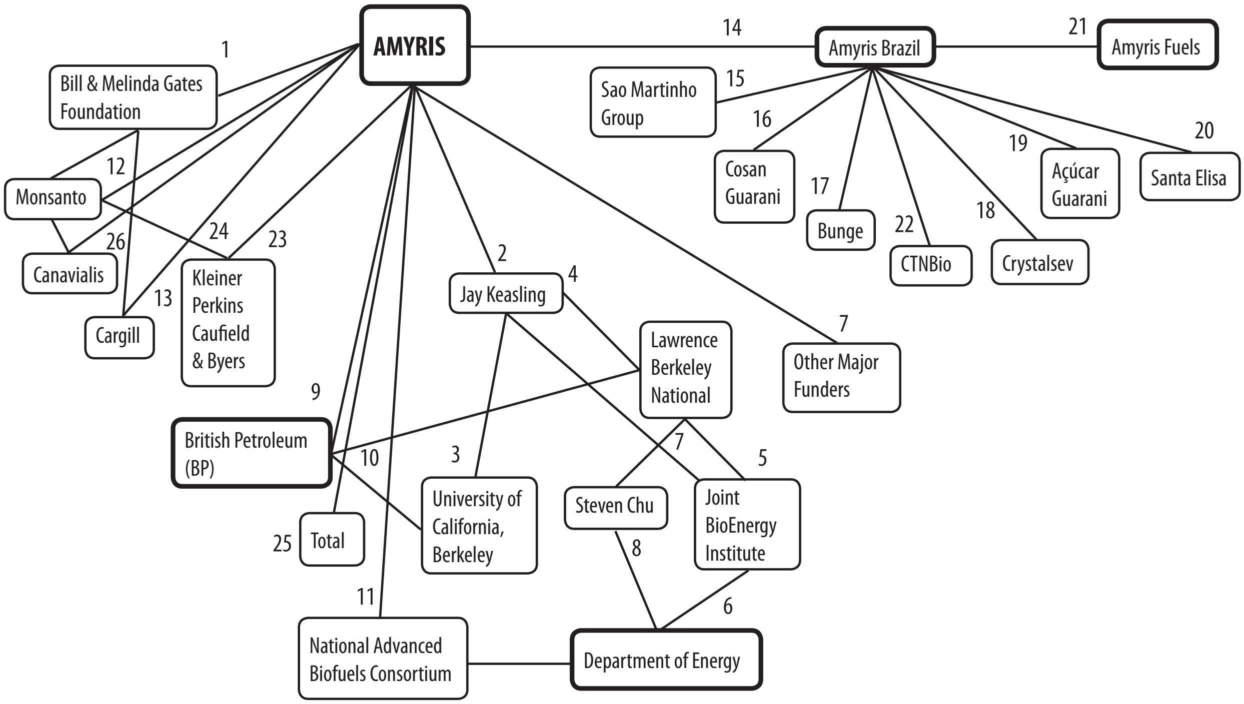
The Revolving Door:

The federal government, particularly the Department of Energy (DOE), has been one of synthetic biology's biggest supporters. This comes as no surprise since the revolving door between industry and government has been swinging smoothly.

Aristides Patrinos was the associate director of the U.S. Department of Energy's Office of Biological and Environmental Research under President George W. Bush. He oversaw both the Human Genome Project and the Genomes to Life program, the latter of which supports synthetic biology research for biofuels and other technological fixes, such as carbon sequestration.[134] Patrinos left the Bush administration in 2006 to become president of Craig Venter's emerging company Synthetic Genomics.

Secretary Steven Chu has been a leading proponent of synthetic biology. As head of the Lawrence Berkeley Lab, Secretary Chu advocated for using synthetic biology to create brand new organisms based on the microbes normally found in the guts of termites to

AMRYIS' LINKS TO BIG OIL, THE U.S. GOVERNMENT, AND BRAZILIAN SUGARCANE AND ETHANOL PRODUCERS



1. The Bill & Melinda Gates Foundation provided $43 million to create Amyris for their production of synthetic anti-malarial medicine.
2. Dr. Jay Keasling founded Amyris Biotechnologies in 2003 with funding from the Gates Foundation.
3. Keasling is a Professor of Chemical Engineering and Bioengineering at the University of California, Berkeley.
4. Keasling is the Director of the Lawrence Berkeley National Laboratory, a Department of Energy lab conducting synthetic biology research run by UC Berkeley.
5. Keasling is also the chief executive officer of the Joint BioEnergy Institute, a partnership including the Lawrence Berkeley National Laboratory, who aims to produce next-generation biofuels.
6. JBI is one of the Department of Energy's three new Bioenergy Research Centers.
7. Steven Chu is the former director of the Lawrence Berkeley National Laboratory where he used synthetic biology to produce ethanol.
8. Steven Chu is the current U.S. Secretary of Energy under President Obama. DOE is one of the largest funders of synthetic biology research, over $305 million in 2009 and a similar amount is expected to be spent in 2010.
9. John Melo, CEO of Amyris, was formerly the President of U.S. Fuels Operations for British Petroleum (BP). Ralph Alexander, Director of Amyris' Board of Directors, is Chief Executive Officer of Innovene, BP's former $20bn olefins and derivatives subsidiary and was also Chief Executive Officer of BP's Gas, Power and Renewables and Solar segment and was a member of the BP group executive committee.
10. BP gave $500 million to UC Berkeley and the Lawrence Berkeley National Lab to develop biofuels through synthetic biology.
11. Amyris is a partner in the National Advanced Biofuels Consortium, which received $33.8 million from the Department of Energy in 2009.
12. Carole Piwnica, a member of Amyris' Board of Directors, also sits on Monsanto's advisory board.
13. Peter Boynton, Chief Commercial Officer of Amyris, worked for Cargill for 18 years.
14. Amyris Brazil is a subsidiary of Amyris strategically located in Campinas, São Paulo, near Brazil's cane processing industry. This company was created with the intent to scale-up Amyris' technology leading towards full-scale commercialization.
15. Amyris recently bought a 40% stakeholder in Sao Martinho Group's (one of the largest sugar and ethanol producers in Brazil) Boa Vista mill to process sugar cane.
16. Cosan Guarani is a Brazilian sugar processor (subsidiary of French sugar corporation Tereos) which recently joined a partnership with Amyris.
17. Bunge, an international food conglomerate who processes and trades sugarcane in Brazil, recently joined a partnership with Amyris.
18. Amyris and Crystalsev, of Brazil's largest ethanol distributors and marketers, have created a joint venture "Amyris-Crystalsev." Fernando Reinach, on Amyris' board, serves as an advisor to this venture.
19. Açúcar Guarani cultivates and processes sugarcane. They also entered into partnership with Amyris along with Cosan Guarani, Bunge, and Crystalsev at the end of 2009.
20. Amyris has licensed its technology to Santa Elisa, the second largest ethanol producer in Brazil.
21. Amyris' Chicago-based subsidiary that distributes ethanol.
22. CTNBio, the Brazilian Federal Science and Technology Department, approved Amyris Brazil's request for the release of genetically modified yeast for commercial production to produce farnesene in early 2010. Luciana di Ciero, formerly with the University of Sao Paulo is now Amyris Brazil's Regulatory & Institutional Relationships manager. She has been a strong promoter of biotechnology.
23. Venture firms Kleiner Perkins and Khosla Ventures each owned 15.4 percent before the IPO, TPG Biotechnology Partners II, L.P owns 12.1 percent, Advanced Equities Financial Corp owns 6.4 percent. Other investors includ DAG Ventures, and Cornelio Brennand - a Brazilian real estate and energy group.
24. John Doerr, a partner at Kleiner Perkins Caufield & Byers, is a former design engineer for Monsanto.
25. In June 2010, Amyris announced that it has formed a partnership with major international oil and gas company Total (based in France) to work jointly on R&D of synthetic pathways for organisms to produce fuels.
26. Amyris has partnered with Brazilian sugarcane company Canavialis, which was bought by Monsanto in 2008, to produce jet fuels for the U.S. Department of Defence from sugarcane grown in Alabama.

Amyris Biotechnologies has officially filed to raise $100 million in an IPO. The company, which will go public under the symbol AMRS, already raised a total of $244 million in funding and plans to start producing its synthetic organism-based biofuel at commercial scale in 2011.

produce ethanol from cellulose.[135,4]

In Secretary Chu's first year in charge of the Department of Energy (DOE), the Department spent more than $305 million on synthetic biology research and a similar amount is expected to be spent in 2010.[136] Most of this research funded by the DOE is done out of the Joint Bioenergy Institute (JBEI), a six-institution partnership led by Lawrence Berkeley National Laboratory.[137] A report from the Synthetic Biology Project out of the Wilson Center has shown that the U.S. government has spent more than $430 million on synthetic biology research since 2005. Only 4 percent of this has been used to research the ethical, legal, and social implications of synthetic biology.[138] The report did not show the amount of funding going to assess environmental risks, most likely since no funding is being put towards this purpose.

In Secretary Chu's first year in charge of the Department of Energy, the Department spent more than $305 million on synthetic biology research and a similar amount is expected to be spent in 2010.

Federal Grants to Synthetic Biology Companies:

Major programs funded by the federal government are highlighted below as examples of the types of projects under development. This list is not meant to be comprehensive:

Sapphire Energy has received $50 million from DOE and a loan guarantee for $54.5 million from the U.S. Department of Agriculture (USDA) to build a pilot plant in New Mexico for the production of algal fuel. While they will be using natural algae initially, their use of biotechnology and synthetic biology is no secret.[139] Sapphire has on staff the former CEO of **Monsanto** and a former executive of **BP**.[140]

Novozymes has received $29.3 million from DOE for a number of projects to develop synthetic enzymes.[141] The *Cellic® CTec2* enzymes break down cellulose from different feedstock types (including corn cobs and stalks, wheat straw, sugarcane, and woodchips) into sugars that are fermented into ethanol.

In 2003, DOE provided **Genencor** (a division of Danisco USA) $17 million through its National Renewable Energy Laboratory (NREL) to use synthetic enzymes for biofuels production[142]

Boston-based **Mascoma** received $26 million from DOE in 2008 for the development of cellulosic ethanol from woodchips through the use of "propriety microorganisms and enzymes."[143]

In 2008, DOE announced $33.8 million in funding to go to four synthetic biology projects focused on enzyme production over four year. Besides Novozymes (mentioned above), three other companies received funding for similar work: **DSM Innovation Center Inc.** is using its proprietary fungal systems to develop new approaches to improve enzymes for the conversion of pre-treated cellulosic biomass into sugars for fermentation into cellulosic ethanol. **Genencor**

4 These synthetic organisms could theoretically take termites' ability to break down wood (as they are so famous for doing in people's houses) and turn it into energy. This raises the question as to what would happen to all of the trees and wood in the environment, our houses, and buildings across the world if these organisms were to leak out of the laboratory.

plans to reduce the enzyme-dose level required for biomass conversion to sugar by improving the specific performance of a fungal-based enzyme. **Verenium Corporation**'s project will use their synthetic enzymes to produce a more cost-effective enzyme solution for biomass saccharification that would supposedly lead to more economic cellulosic ethanol production.[144]

The Danforth Plant Science Center of Missouri was the recipient of $15 million in 2009[145] and $44 million in 2010 (as the leader of The National Alliance for Advanced Biofuels and Bioproducts)[146] from the DOE for its research into algae-based biofuels. Danforth, through its Center for Advanced Biofuels Systems and the National Alliance For Advanced Biofuels and Bio-Product (NAABB), hope to develop new strains of algae that can produce biofuels more efficiently and affordably than their natural counterparts. The Danforth Center is closely linked to the biotech giant Monsanto, so much so that Tom Philpott of *Grist Magazine* referred to it as "essentially that company's NGO research and PR arm."[147] Much of its start-up funds were provided by the Monsanto Fund, and the president and CEO of Monsanto sits on the Danforth Center's Board of Directors.[148]

The former director of Danforth, Roger Beachy, was appointed by President Obama to run the USDA's newly-formed National Institute for Food and Agriculture (NIFA) in 2009. NIFA provides over $400 million in agriculture research across the country per year. One of NIFA's main priorities is the development of next-generation biofuels through the use of biotechnology. NIFA's 2009 budget for biofuels and bio-based products was around $2.5 million[149] and is expected to expand in 2010.[150] Of that funding, a significant amount was given to synthetic biology research.

Kuehnle Agrosystems received $350,000 to create three synthetic forms of algae that can be used for biofuels production and other commercial uses. **Allopartis Biotechnologies** received $80,000 from NIFA for the development and modification of proteins to break down biomass.[151]

The USDA had also provided synthetic biology funding through NIFA's predecessor, the Cooperative State Research, Education, and Extension Service (CSREES). In 2009, USDA gave $1.8 million to **Gevo** for the development of synthetic yeast that can turn cellulosic-derived sugars into isobutanol, a second generation biofuels/bio-based product that can be used for fuel or plastics.

Outside of its synthetic biology research for eternal organisms that was discussed earlier, the Department of Defense (DOD) has also been investing in synthetic biofuels development. In 2009, the DOD provided $8.5 million to **Solazyme** for the production of over 200,000 gallons of algae-based jet fuels, specifically for the F-76 Navy ships.[152] Solazyme's synthetically engineered algae are grown in the dark and fed sugars from cellulose.

Amyris Biotechnologies has partnered with Brazilian sugarcane company **Canavialis**, which was bought by **Monsanto** in 2008,[153] to produce jet fuels for DOD from sugarcane grown in Alabama.[154,155]

The above list is just a sample of the hundreds of millions of dollars of public money that is going to private interests to help develop the field of synthetic biology. These synthetic organisms are almost always patented. Since such significant funding is being provided by taxpayers, the public has the right to demand a strong regulatory framework to protect the environment and human health from this new technology.

It should also be noted that funding projects that were highlighted are specifically for synthetic biology research. The U.S. government has also been a major source of funding for more "traditional" genetic engineering research. According to the Union of Concerned Scientists, "in the 11-year period of 1992 to 2002, the USDA spent approximately $1.8 billion on biotechnology research,"[156] an amount that has no doubt increased since that time.

Support Through Federal Biofuels Policy:

The U.S. government is supporting synthetic biology not only directly through grants but also indirectly through federal biofuels policies, particularly biofuels tax credits and the Renewable Fuel Standard (RFS).

The U.S. has a long history of supporting the production and use of biofuels without much concern for their environmental impact. The rush to produce biofuels without considering the indirect impact is fueled by the desire to reduce the use of foreign oil, particularly in times of high oil prices or under the auspice of national security, and also to create an additional market for U.S. agricultural commodities. Unfortunately, the development of conventional biofuels in the U.S., such as corn ethanol and soy biodiesel, has resulted in widespread environmental damage in the form of increased water and air pollution from agrochemicals as well as land-use competition with food production and natural ecosystems.[157] In the last several years this has encouraged development of new forms of biofuels, ones that do not have adverse impacts. However, in an attempt to avoid these problems, other ones have arisen, including the development of synthetic organisms.

Ethanol and corn ethanol, in particular, have benefited from tax subsidies for more than 30 years which have been renewed every few years. At present, this credit is worth $0.45 per gallon blended with gasoline.[158] Biodiesel also has a separate credit worth $1.00 per gallon blended with diesel fuel.[159] And, lastly, cellulosic biofuels have their own production tax credit worth $1.01 per gallon.[160] Cellulosic biofuels is a liquid fuel produced from any lignocellulosic or hemicellulosic matter available on a renewable basis. As was discussed in section 5, organisms are being genetically engineered with synthetic enzymes to break down the cellulose into sugars which can be converted to fuel. While there are naturally occurring enzymes that are being developed for this purpose, the market is

The U.S. government is supporting synthetic biology not only directly through grants but also indirectly through federal biofuels policies, particularly biofuels tax credits and the Renewable Fuel Standard (RFS).

leaning towards synthetic ones since proponents claim they will be more efficient.

The second main policy driving biofuels production in the U.S. is the Renewable Fuel Standard, which mandates the consumption of an increasing amount of biofuels each year. Created originally in 2005, and expanded upon in 2007, the RFS mandates that a total of 36 billion gallons of biofuels be blended into fossil transportation fuels by the year 2022.[161] Of those 36 billion gallons, approximately 15 billion gallons are allotted for "conventional" biofuels, which is widely assumed will be filled by corn ethanol.

The remaining mandate is for so-called "advanced" biofuels, which includes any other form of biofuels besides that which is produced from corn starch. Of the "advanced" biofuels portion, 16 billion gallons are supposed to come from cellulosic biofuels.[162] Cellulosic biofuels in the RFS are defined include those renewable fuels derived from cellulose, hemicelluloses or lignin. The remaining portion of the "advanced" biofuels category will likely be filled with sugar ethanol and some soy biodiesel, though could also be filled with non-cellulosic next-generation biofuels, such as those produced from algae.

The RFS mandate serves as an indirect subsidy for the industry because it creates a guaranteed market for biofuels. This means that biofuels must be purchased at whatever price the industry demands irrespective of market demand. It is widely expected that cellulosic biofuels will not be able to achieve the RFS mandate levels, especially in the near term and EPA has already reduced the mandate accordingly. While the RFS does contain some minimal environmental performance standards, including protections for forests and other natural ecosystems, as well as global warming emission thresholds[5], there is no incentive to produce biofuels from naturally-occurring biomass or to reduce the use of invasive species.

Tax credits for cellulosic biofuels and the RFS mandate for "advanced" biofuels are both supporting developments in synthetic biology. Without these two policies it would be much more difficult, if not impossible, for biofuels produced from synthetic organisms or any other method to compete with other sources of energy. The government must use tax and energy policy to support safe, proven, and sustainable sources of clean energy – not dangerous and unproven technologies such as synthetic biology that threaten to do more harm than good.

8. Safety Rules Can't Keep Up

Federal regulation:

The field of synthetic biology is void of any regulation, allowing researchers to freely manipulate the basic code of life without any

5 *Biofuels produced at biofuel plants that already existed prior to 2007 will not have to comply with the emissions standards.*

oversight. Three federal agencies—the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), and the Department of Agriculture (USDA)—have refused to regulate any new form of genetically modified or synthetic organisms.

The first federal guideline that attempts to oversee the emerging field of synthetic biology came from the Department of Health and Human Services (HHS) in 2010. This guideline provides rules for screening synthetic DNA in an attempt to flag any DNA sequences that may be used to create anything a biological weapon or any other dangerous virus or toxin. Unfortunately, following the guidelines is entirely voluntary for DNA synthesis companies[163] whose profits are derived from selling more – not less – of their product. It is entirely possible for a bad actor to purchase synthetic DNA and build a potentially deadly virus under the current rules. The Recombinant DNA Advisory Committee (RAC) of HHS has also decided to review some synthetic biology research but will not look at projects using synthetic DNA of 100 oglionucleotides or less. This decision was made at the request of the synthetic biology and biotechnology industries since it is at this level – 100 base pairs of DNA or less - that much of the synthetic biology research is currently being conducted. Decisions of oversight should be based on potential risk of harm not convenience for the industry.

Decisions of oversight should be based on potential risk of harm not convenience for the industry.

HHS's soft voluntary screening process is far from adequate. There are no industrial safeguards in place to protect lab workers from infection or contamination from synthetic biology products, nor are there any protocols to prevent the release of synthetic biology products into the environment. A recent case of a Pfizer worker who says she has been intermittently paralyzed by a genetically engineered virus she was working on shows that these dangers are real and serious.[164] Anyone can order online manufactured pieces of DNA, and build a synthetic organism in their basement, since there are no regulations on the rapidly growing market of manufactured DNA. Used DNA synthesizing machines can be purchased online through auction sites for as little as $1,000. As a May 2010 *New York Times* headline expressed, our "safety rules can't keep up with [the] biotech industry."[165]

Self regulation:

Proponents of synthetic biology are framing this technology in two very different lights to different audiences. To corporate investors and venture capitalists synthetic biology is being portrayed as a new, emerging, and exciting technology that is manipulating life in ways never even imagined before. When discussing regulations, on the other hand, they change face and portray synthetic biology as nothing more than a simple extension of current genetic engineering technology that should not be placed under any different or stronger regulations. Synthetic biologists should not be allowed to have it both ways.

Scientists working on "traditional" genetic engineering technologies hoped to preempt any government regulations by drafting the *Asilomar Declaration of 1975*. This declaration was a short-lived moratorium on some of their work but was hailed as a prime example of industry self-regulation. As we have seen in the years since, genetic engineering technology has moved forward at a rapid pace without any real self-regulation and barely any government oversight.[166]

Synthetic biologists have made several unsuccessful "Asilomar-type" attempts at self-regulation. In 2006, Stephen Maurer of the Information Technology and Homeland Security Project at UC Berkeley's Goldman School of Public Policy proposed a list of self-governance guidelines based on interviews of those working in the field. These guidelines included a boycott of gene synthesis companies that do not screen orders for dangerous pathogens, the development of software that could check if genetic sequences could be used to create dangerous pathogens, and a hotline for synthetic biologists to call if they had ethical concerns about their work.[167] These soft, voluntary attempts at self-regulation did not convince the strongest supporters of synthetic biology that they would have any effect. At a public event to discuss these regulations, Drew Endy said "I don't think [these proposals] will have a significant impact on the misuse of this technology."[168]

The second annual synthetic biology conference, SynBio 2.0, in May 2006 was being portrayed as "Asilomar 2.0," the meeting where synthetic biologists came together and wrote a set of self-regulations that would protect the environment and help perpetuate the field. Unfortunately, civil society was blocked from attending this conference to share the views of communities that will be most impacted by this technology. In response 38 civil society organizations,[169] including Friends of the Earth, the International Center for Technology Assessment and ETC Group, drafted an open letter to the conference attendees dismissing the proposals for self-governance as severely inadequate. Sue Mayer, director of GeneWatch, said "Scientists creating new life-forms cannot be allowed to act as judge and jury. The implications are too serious to be left to well-meaning but self-interested scientists. Public debate and policing is needed."[170]Asilomar 2.0 failed to produce any results. Synthetic biologists were too concerned about hurting the gene synthesis, synthetic biology efforts, and their own personal progress to agree on even weak attempts at self-regulation.

The J. Craig Venter Institute and MIT also attempted to draft self-regulations the following year in their report "Synthetic Genomics: Options for Governance."[171] This document was limited in scope to biosecurity and biosafety, focused solely on U.S. governance, and failed to consult civil society. One of the report's main criteria for effective governance was whether a regulation would "minimize costs and burdens to government and industry."[172] This is not a goal for regulation but rather an argument for no oversight. Protecting the environment and human health should be the main priority when regulating any technology. In the end, the report's recommendations were more soft approaches such as monitoring and controlling gene synthesis firms and DNA synthesizers, educating synthetic biology practitioners and strengthening Institutional Biosafety Committees (IBCs).

It is clear that self-regulation will not work since the industry is more interested in promoting the quick growth of synthetic biology. Even so, attempts of self-regulation by the synthetic biology community have failed, largely due to their inability to agree on even the weakest of rules. The best way to ensure that synthetic biology efforts do not cause unintended environmental or public health harms is for the federal government to establish strong precautionary regulations before this technology develops too far.

Instead of turning to biofuels to save the environment, investments can be made in clean energy technologies and updating the energy grid.

Synthetic Biology is Not Our Only Option:

Many proponents threaten that if regulations are established, it will lead to devastating results. As Jay Keasling of Amyris once said, "If we choose to regulate the industry, we have to be willing to pay the price for that, which means there won't be cheap anti-malarial drugs developed and there won't be potential biofuels developed or other drugs for diseases and cleaning up the environment and all the things that come from this area."[173] Keasling does not mention that any medicines would still require FDA approval – a form of regulation under which the pharmaceutical industry has still been able to thrive.

Arguments like Keasling's create a false dichotomy between sustainable fuels and environmental degradation; between life-saving medicine and wide-spread disease. While the potential benefits of synthetic biology, such as anti-malarial medicine, could better society the choice is not that simple. Malaria could be prevented by helping communities around the world escape poverty so they can afford bug nets and build up water infrastructure so mosquitoes do not have still water on which to lay and hatch eggs. Moreover, many of the areas with the worst malaria are areas still in the midst of civil war where millions of people are forced into swamps to survive and then go to refugee camps where mosquitoes hop from person to person and spread malaria. While synthetic artemisinin may be a tool in the fight against malaria, it is not the only available tool and would not eradicate the root causes of malaria and poverty. And like most malarial drugs, it will become less effective over time.

For fuel production, the choice is not just between dirty fossil fuels and products from synthetic organisms. Instead of turning to biofuels to save the environment, investments can be made in clean energy technologies and updating the energy grid so it can be connected to wind turbines, solar panels, and electric cars across the country. Investments in energy efficiency can reduce the strain on energy resources. There wouldn't be a need for synthetic bacteria to eat up oil spills if no one was using dirty oil for energy and if the corporations that contaminate the environment were held accountable. Oil created from synthetic organisms that mimics the structure of natural oil only deepens dependence on an out-dated energy infrastructure. And as a recent study has shown, biofuels from algae may not even reduce overall emissions.[174]

The risks synthetic biology pose to human health and the environment are serious since synthetic biology has the ability to create organisms that have never existed before and their complexity will only increase over time. We must establish a regulatory framework before this technology evolves too far and it is too late.

A federal moratorium on the release of synthetic organisms into the environment and on their use in commercial settings should be implemented.

The precautionary principle could guide the governance of synthetic biology to ensure that any harm caused by this technology do not outweigh any potential benefits. The fact that all the risks associated with novel living organisms are unpredictable supports the need to move forward with precaution. Researchers and corporations would be responsible for proving that none of these dangers are realized. In other words, synthetic microbes should be viewed as dangerous until proven to be safe – not the other way around.

What is needed is broad debate in society about the risks and benefits of synthetic biology and its impact on the environment, human health, human rights, security, and social justice. Conversations at the local, national, regional, and international level would ensure that all communities impacted by this technology would have input in its development – whether this is a technology that should be used, which applications are appropriate, and which are not. Since projects are being conducted across the world and organisms can travel between political borders it is important to ensure these conversations are international in scope. Only after these conversations have taken place in a fair, open, transparent, and democratic way should the real-world release and commercialization of synthetic or partially-synthetic organisms even be considered. If the risks and harms are found to be too great than this technology should not move forward.

9. Policy Recommendations

Moratorium on the Release of Synthetic Organisms

A federal moratorium on the release of synthetic organisms into the environment and on their use in commercial settings should be implemented until the impacts on the environment, biodiversity, human health, and all associated socio-economic repercussions, are examined. This moratorium should extend to "DIY-bio" research that is not affiliated with an institution or firm since there is no guarantee that research outside of professional laboratories can be contained.

Research in laboratories affiliated with an institution or firm should only be allowed to continue under strict regulations that ensure organisms do not escape into the natural environment. If this burden cannot be met, the research should be halted. At this point, synthetic biology research and products should stop at the laboratory door.

Permanent Ban on the Open-Air Use of Synthetic Organisms

A permanent ban on open-air experiments with synthetic organisms in ponds and areas not fully contained is needed to prevent the spread of organisms into the natural environment.

Environmental Impact Statements on All Federally Funded Research

Environmental Impact Statements (EIS) should be required for all synthetic biology research funded by the federal government, as required under the National Environmental Policy Act. [175] With hundreds of millions of taxpayer dollars going to private researchers to develop synthetic biology, their full environmental and societal impact should be analyzed before the research begins.

Federal Study on the Impacts of Synthetic Biology

Congress should appropriate the necessary funds to the Department of Health and Human Services, the USDA, EPA, or FDA to direct the National Academies of Science to conduct a study on the full environmental, public health, safety, and societal impacts of synthetic biology. This study should also research the ability (or inability) to contain such organisms. The last study on biological containment was conducted in 2004[176] and the section on the containment of viruses, bacteria, and other microbes was far from comprehensive.

Human Applications of Synthetic Biology must go through the Recombinant DNA Advisory Committee

All human applications of synthetic biology should be reviewed by the National Institute of Health's Recombinant DNA Advisory Committee (RAC) and the research made public. The go-to regulatory body, the FDA, does not have to disclose the results of its reviews and in the past has failed to demonstrate that it can adequately evaluate the safety of products with human applications and it should not be reviewing synthetic DNA drugs in secret. The RAC should change its policy to waive oversight for projects using synthetic oglionucleotides of 100 base pairs or less. Synthetic DNA of any length poses new risks that should be reviewed on a case-by-case basis.

Create a Federal Regulatory Body to Oversee All Synthetic Biology Research and Commercial Products

Congress should create a similar counterpart to the National Nanotechnology Initiative (NNI) to oversee developments in synthetic biology. Unlike the NNI, this body should have regulatory authority over research and should direct all federal funds that go towards synthetic biology projects to ensure that the money is used to study the environmental, public health, and socio-economic risks of this research. This organization can oversee and direct projects across the federal government and will be a central location for the public to see all projects that are being funded or are in development

Define Synthetic Biology and Any of its Chemical Products under TSCA

The Toxic Substances Control Act (TSCA) should be revised to include new language to define and regulate products created from synthetic biology. This definition should cover all synthetic organisms and products made from these organisms.

Do Not Extent Biofuels Tax Credits to Projects using Synthetic Biology

Efforts are underway to extend biofuels tax credits to algae biofuels operations. Congress should specify that if this tax parity were created it should only apply to naturally occurring algae. We do not fully understand – nor are we prepared for – the risks associated with genetically engineered and synthetic algae. Instead of promoting this unproven dangerous technology with tax credits, Congress must work to protect the environment and public health from the dangers of synthetic organisms and use the tax code to promote proven, safe technologies.

Direct the National Invasive Species Council (NISC) to Review Novel Risks from Synthetic Organisms

Executive Order 13112 created the National Invasive Species Council to ensure that federal programs and activities to prevent and control invasive species are coordinated, effective and efficient. NISC should review the novel risks posed by synthetic organisms and revise the National Invasive Species Management Plan to incorporate conclusions from the review. Organisms with synthetic DNA should be reviewed as potential invasive species, even if the DNA closely resembles that of naturally occurring organisms.

DNA Synthesis Companies Must have Mandatory Purchase Guidelines

Commercial DNA synthesis companies should be required by the Department of Health and Human Services (HHS) to screen all orders to verify that buyers are associated with recognized research institutions, and that the ordered DNA cannot be used to create select agents such as biological weapons or known viruses. All synthetic DNA orders should be stored in a database to ensure synthetic DNA can be traced back to the buyer and seller at any time.

Those Creating or Using Synthetic DNA Must be Licensed

Anyone using DNA synthesis machines, for both commercial and non-commercial use, must be registered with the Department of Health and Human Services. Those who are using synthetic DNA, for both commercial and non-commercial use, must be licensed by the Department. This should be applied even to those conducting DIY (do-it-yourself) biology experiments. If licensing and registration can be required for tattoo artists or hairdressers, it is reasonable to require those creating synthetic organisms to acquire basic education, training, and licensing.

Synthetic Biology Included in Regulation of Nanotechnologies

Synthetic biology is working on the nano-scale and should be regulated in a similar fashion as other nanotechnologies. Contrary to what supporters of synthetic biology want the public to believe, this technology is an extreme version of genetic engineering and its potential to create new life forms is unprecedented. Synthetic biology is converging with other nanotechnologies, robotics, and information technology. Any regulations should look at these emerging technologies as whole and not isolated parts.

Convention on Biological Diversity

The scientific body (the Subsidiary Body on Scientific, Technical and Technological Advice – SBSTTA 14) of the UN's Convention on Biological Diversity (CBD) recently proposed draft text that would establish an international moratorium on the release of all synthetic organisms into the environment until **"**there is an adequate scientific basis on which to justify such activities and due consideration of the associated risks for the environment and biodiversity, and the associated socio-economic risks, are considered." This language was proposed in May 2010 at the CBD meeting in Nairobi and waits final censuses by all parties at the October 2010 meeting in Japan.[177] If passed, there would be an international moratorium on the release of synthetic organisms. The United States should ratify the Convention on Biological Diversity, encourage the passage of this text, and vote in favor of a moratorium on the release of synthetic organisms into the environment.[6]

Conclusion

Synthetic biology for biofuels production is a false solution to our climate crisis. The risks are too great and their promises are too illusory to be a worthy investment. There is still disagreement as to what exactly fits under the wide umbrella of "synthetic biology" but what is clear is that this new and extreme form of genetic engineering will not be a sustainable solution to our problems of fuel production and consumption. Synthetic organisms require too much land, water, and chemical inputs to produce biomass feedstocks or to produce oil directly through algae to truly be a long-term answer to our energy and climate crisis.

Our understanding of genetics is still elementary. It would be more worthwhile to gain a better and more complete understanding of how genes, DNA, and epigenetics works before researchers begin creating new genomes on a computer. Our ability to synthesize

6 *The Convention on Biological Diversity, an international legally binding treaty, was signed in 1992 and entered into force in 1993. The convention recognized for the first time in international law that biological diversity is "a common concern of humankind" and aims to preserve biodiversity, counter the loss of biological diversity around the world, and promote the fair and equitable use of genetic resources. The United States has signed the Convention, but it has failed to be ratified by the U.S. Senate.*

DNA has far outpaced our basic understanding of what the DNA actually does. That alone should be reason to pause before moving forward.

This is not a call to halt scientific progress. Experimentation is necessary for our scientific knowledge to expand to discover methods and products that benefit people and our environment. It is through scientific inquiry that humans have been able to discover some of the most important medicines, sources of food and products that we use in our daily lives. We should be investing in proven methods of producing energy sustainably from renewable sources, such as wind and solar, while increasing energy efficiency – not a dangerous and unproven technology. Synthetic biology may prove to be a useful tool in learning more about genetics and how life works. This research has promise but must remain in the laboratory.

What is needed is precaution. Craig Venter's announcement that he created the world's first organism with a fully synthetic genome was a wakeup call to the public and policymakers. It was undeniably a scientific feat, but it also shows the potential power in this emerging technology. It was also the first time many people had even heard of synthetic biology or that synthetic DNA even existed. We must step back to review all the environmental, economic, social, and public health implications of this research. Only then, if the benefits outweigh the risks and researchers and corporations have proved that this technology will not damage the environment or public health, should we move forward with any research. The burden of proof lies with those promoting this technology, not on the public. Synthetic biology should be treated as dangerous until proven safe, not the other way around.

BP's Deepwater Horizon oil spill disaster could be the worst environmental disaster in America's history. It is worth noting in this report for two reasons. First, many had longingly wished that we could use synthetic algae in the Gulf of Mexico to eat the spilling oil,[178] including those from the industry[179] and our own government.[180] If this were actually done, we would have intentionally released genetically engineered algae with synthetic DNA into the Gulf which would have easily made their way into the Atlantic Ocean. It would be absolutely impossible to recall these algae if something went wrong and they would have permanently contaminated our oceans with a potentially invasive species.

The second reason to mention this disaster is the fact that the Department of the Interior waved BP's Environmental Impact Statement for the Deepwater Horizon rig since the chances of a massive oil spill were "unlikely."[181] Proponents of synthetic biology argue repeatedly that the chances of synthetic organisms escaping and harming people or the environment is "unlikely" and so any regulation will just hamper scientific progress and the forthcoming "clean and green" revolution in fuel production. If the BP oil disaster has taught us anything it is that we must use precaution when we are dealing with new and potentially harmful technologies – whether it is deep-sea drilling or creating synthetic organisms.

The answer to our climate crisis does not lie in handing over our energy future to the same bad actors in the oil, biotechnology, and agribusiness sector that have repeatedly damaged and contaminated our environment while walking away with record profits and while fighting any attempt to protect the public through appropriate regulations. We cannot reward these corporations' total disregard for the wellbeing of people, communities, and the environment in which we live with government contracts and patents on organisms that spit out petroleum.

We know how to end our climate crisis and produce fuels sustainably. The answer lies in clean renewable technologies such as wind, solar, and energy efficiency.

Thankfully, we know how to end our climate crisis and produce fuels sustainably. The answer lies in clean renewable technologies such as wind, solar, and energy efficiency. If we were to dedicate our public research and development funding to these three things we would be well on our way to bringing the climate back under control and forging a sustainable energy future. This would also be a more just future since people's water, air, and food would not be poisoned by dirty fuels and genetically engineered organisms.

Far too often we have been presented with quick technological fixes to our problems only to discover they do not live up to their hype. Even worse, these techno-fixes usually produce a whole new set of problems that are often worse than the original problems they set out to solve. It is time that we invested in tried and true sustainable solutions to our climate crisis. We must use this opportunity to press for strong regulation of synthetic biology while demanding investments in long-term sustainable and renewable sources of energy.

The longer we delay investing in sustainable solutions to our climate crisis, including renewable energy such as wind and solar, and energy efficiency, the worse off we will be. Synthetic biology is a dangerous and expensive distraction from these real solutions. The public should demand proper regulation of synthetic biology. Genetically engineered crops have failed to feed the world or cool the climate but have led to increases in pesticide use, lose of biodiversity and risks to public health. We must not be duped into thinking extreme genetic engineering will be a safer bet.

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Friends of the Earth's mission is to champion a healthy and just world.

To learn more, go to www.foe.org.

December 16, 2010

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Cc: *Dr. Steven Chu, Secretary, Department of Energy*
Kathleen Sebelius, Secretary, Department of Health and Human Services
Dr. Francis Collins, Director, National Institutes of Health
Janet Napolitano, Secretary, Department of Homeland Security
Tom Vilsack, Secretary, Department of Agriculture
Lisa Jackson, Administrator, Environmental Protection Agency
Dr. Margaret Hamburg, Commissioner, Food & Drug Administration
Dr. Thomas R. Frieden, Director, Centers for Disease Control and Prevention
Robert Mueller, Director, Federal Bureau of Investigation
Dr. John Holdren, Director, White House Office of Science and Technology Policy
Nancy Sutley, Chair, Council on Environmental Quality

Dear Dr. Gutmann,

Thank you for this opportunity to comment on the Commission's recommendations on synthetic biology. We applaud the transparency and openness of the Commission's deliberations. Unfortunately this process has not resulted in recommendations that recognize the serious threats synthetic biology pose to the environment, workers' health, public health, and social justice.

The undersigned 58 organizations from 22 countries do not support the Commission's recommendations on synthetic biology. They are an inadequate response to the risks posed by synthetic biology because they: 1) **ignore the precautionary principle**, 2) **lack adequate concern for the environmental risks of synthetic biology**, 3) **rely on the use of "suicide genes" and other technologies that provide no guarantee of environmental safety**, and 4) **rely on "self regulation," which means no real regulation or oversight of synthetic biology.**

A precautionary regulatory framework is necessary to prevent the worst potential harms. This requires a ***moratorium on the release and commercial use of synthetic organisms until a thorough study of all the environmental and socio-economic impacts of this emerging technology has taken place.*** This moratorium should remain in place until extensive public participation and democratic deliberation have occurred on the use and oversight of this technology. This deliberative process must actively involve voices from other countries - particularly those in the global South – since synthetic biology will have global impacts and implications.

The Precautionary Principle Should Guide Synthetic Biology Regulations

The Commission's recommendations fail to implement the precautionary principle, and instead referenced the so-called "prudent vigilance" concept. The precautionary principle is recognized by international treaties including the United Nations Convention on Biological Diversity, the Cartagena Biosafety Protocol, the new Nagoya/Kuala Lumpur SubProtocol on Liability and Redress for Damages Due to the Transboundary Movement of Transgenics, and the UN Framework Convention on Climate Change. Although "prudent vigilance" is used as a guiding principle by the Commission in its recommendations, it is a completely new concept, apparently invented by the Commission without legal or policy precedent. When dealing with novel synthetic organisms that pose serious risks to the environment and public health, we cannot rely on a new concept with no agreed upon definition, framework, or precedent.

The precautionary principle often is mischaracterized as anti-science, anti-technology, or anti-progress. This is far from the truth. The precautionary principle, as outlined by the Wingspread Consensus Statement on the Precautionary Principle, states: "*When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof. The process of applying the Precautionary Principle must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action.*"[i]

Precaution does not derail progress; rather, it affords us the time we need to ensure we progress in socially, economically, and environmentally just ways. In the face of uncertainty and the potential for serious harm, synthetic biology will often require risk analysis. We do not yet know what the full environmental or socio-economic risks of synthetic biology are, nor has our regulatory system evolved to keep up with the science. That is why we need a precautionary approach.

Precedent exists within the executive branch to support the use of precaution. The President's Cancer Panel released a report in April 2010 on reducing environmental cancer risks, recommending that:

> *"A precautionary, prevention-oriented approach should replace current reactionary approaches to environmental contaminants in which human harm must be proven before action is taken to reduce or eliminate exposure. Though not applicable in every instance, this approach should be the cornerstone of a new national cancer prevention strategy that emphasizes primary prevention, redirects accordingly both research and policy agendas, and sets tangible goals for reducing or eliminating toxic environmental exposures implicated in cancer causation... "*[ii]

This should be a guiding precept for the Presidential Commission for the Study of Bioethical Issues.

In October 2010 at the United Nations Convention on Biological Diversity (CBD), 193 nations unanimously agreed to apply the precautionary principle to the introduction and use of synthetic organisms. The CBD also recognized this technology to be a potential environmental threat in need of further review -- particularly as it is applied to biofuels production.[iii] This was the first time the United Nations addressed the issue of synthetic biology; ignoring this important decision would be negligent.

Lack of Environmental Risk Assessment

The Commission's lack of attention to ecological harms posed by synthetic biology is irresponsible and dangerous. The only ecologist to speak to the Commission, Dr. Allison Snow, raised serious concerns about the environmental risks of synthetic biology -- but none of these concerns are reflected in the recommendations.

In her testimony, Dr. Snow presented four cautionary precepts to keep in mind about the ecological risks of synthetic biology and novel genetically engineered organisms (GEO):

1) *"We need to be very careful whenever novel, self-replicating organisms are let loose in the environment (intentionally or by accident). Many will do no harm out in the environment, but important exceptions could occur, especially if the GEO can multiply and become more abundant.*
2) *Novel GEOs that seem innocuous or weak might evolve to become more successful when they start reproducing. Even if they are highly domesticated, mutations or unexpected properties might allow them to multiply in some environments.*
3) *Once these organisms are released into the environment, novel GEOs cannot be taken back.*
4) *Predicting which new organisms might cause irreversible harm can be extremely challenging. . . we have little or no experience with cultivating microalgae and bacteria outdoors, let alone new life forms that are entirely synthetic."*[iv]

These points are mostly ignored in the guidelines.

The potential environmental impacts of the commercial use of organisms with synthetic DNA must also be examined. Many commercial applications of synthetic biology will undoubtedly lead to the environmental release of synthetic organisms - since it is impossible to prevent organisms from escaping from unsecured operations conducting activities described by some synthetic biology proponents as "akin to brewing beer."[v] More study also is needed on the risks of introducing synthetic organisms into the human body for biomedical and health-related applications, as well as on the risks posed by uses of synthetic organisms in agriculture. Since this technology is already being used to replicate pathogens, serious study of biosecurity risks is also necessary.

Even more troubling is the impact that synthetic biology could have on ecosystems and communities in the global South. A new "bioeconomy," in which any type of biomass can be used as feedstock for tailored synthetic microbes, is being enabled by synthetic biology. Biomass to feed synthetic microbes will be grown mostly in the global South, disrupting fragile ecosystems and exacerbating environmental damage from industrial crop production. Further pressure will be placed on land and water, which already are in short supply for food production, to produce fuels and chemicals that will be consumed mainly by wealthier nations. The Commission ignores these socio-economic and environmental harms despite the fact that already countries such as Brazil have felt their effects.

Unfounded Reliance on "Suicide Genes"

Despite the fact that "suicide genes" were explicitly described as having uncertain efficacy in Dr. Snow's testimony, the Commission relies solely on these and other types of self-destruction modalities as the main form of mitigating potential environmental harm. In fact, one of the main studies cited by the Commission in support of using methods to create "suicide genes" is still in an early development stage and has not been field tested.

Scientists who have studied "terminator technologies" in seeds have concluded that the process is never completely effective. They found that frequently occurring mutations allow organisms to overcome the intended sterilization thereby allowing those organisms to remain viable. Specifically, "suicide genes" and other genetic use restriction technologies (GURTs) represent an evolutionary disadvantage; selective pressures will lead organisms to overcome intended biological constraints.[vi] Biological containment of synthetic organisms – which reproduce quickly, escape confinement, and cannot be recalled – is impossible.

Importantly, the UN Convention on Biological Diversity has mandated an international moratorium on the use of "terminator technologies" such as "suicide genes," and other GURTS that has been in place for the past decade. Reliance on an unproven technology that has been deemed unacceptable by 193 nations as the main method to "contain" synthetic organisms is irresponsible.

Reliance on a technology that will not guarantee biosafety or biosecurity and that has been prohibited by the international community is not a solution. Synthetic biology requires the strictest levels of physical, biological, and geographic containment as well as independent environmental risk assessment for each proposed activity or product.

Self-Regulation Amounts to No Regulation and Undercuts the Rights of Workers and the Public

Self-regulation cannot be a substitute for real and accountable regulatory oversight. Some synthetic biologists already have made several unsuccessful attempts at self-regulation. The second annual synthetic biology conference in May 2006, SynBio 2.0, was portrayed by proponents as "Asilomar 2.0," in reference to the 1975 meeting that proposed voluntary guidelines on recombinant DNA. At the 2006 meeting, synthetic biologists attempted to write a set of self-regulations intended to protect the environment and promote the field. This conference failed to produce serious results. Synthetic biologists were too concerned about promoting research and development to agree on even weak attempts at self-regulation.

The lack of open dialogue with concerned parties also contributed to the failure of the industry's attempt at self-governance. Civil society and the public, blocked from participating in these discussions of self-governance, issued an open letter to the conference participants. Signed by 38 organizations working in 60 countries, this letter called on synthetic biologists to abandon their proposals for self-governance and to engage in an inclusive process of global debate on the implications of their work.[vii]

The current state of "self-governance" permits students to create synthetic organisms on campuses; and stretches of synthetic DNA may be purchased online, allowing laypeople to create organisms in their garages where, with no oversight, life forms not previously found in nature may be dumped down drains and flow, freely, into the environment.

The J. Craig Venter Institute and the Massachusetts Institute of Technology also attempted to draft self-regulations the following year in their report, *Synthetic Genomics: Options for Governance*. This report was limited in scope to biosecurity and biosafety in laboratory settings, focused solely on the U.S., and, importantly, completely avoided the topic of environmental safety. These experiences reinforce the need for real oversight to ensure that the real threats synthetic biology poses are never actualized.

The support of the Presidential Commission for the Study of Bioethical Issues for self-regulation undercuts the fledgling efforts of the Occupational Safety and Health Administration (OSHA) to put new safety requirements in place to protect workers using biologically engineered materials, nanomaterials, and novel organisms. The Commission's support for self-regulation undercuts the ability of workers to speak out and protect themselves. Becky McClain, a former Pfizer scientist, recently won the first lawsuit regarding a worker's right to discuss publicly the health and safety issues of the genetic engineering laboratory.[viii] The Commission's failure to support lab scientists' basic right to know which synthetic organisms they may have been exposed to means those workers could become ill without being able to inform their doctors of the potential causes of their illness. There is nothing "ethical" about this kind of self-regulation.

Conclusion

The Commission's recommendations fall short of what is necessary to protect the environment, workers' health, public health, and the public's right to know.

We repeat our call for a moratorium on the release and commercial use of synthetic organisms until we have a better understanding of the implications and hazards of this field and until we have properly updated and effectively implemented public regulation of synthetic biology.

The time for precaution and the regulation of synthetic biology is now.

Sincerely,

African Biodiversity Network (Kenya)
African Centre for Biosafety (South Africa)
Alliance for Humane Biotechnology
Amberwaves
Asociación para la Promoción y el Desarrollo de la Comunidad CEIBA / Friends of the Earth Guatemala
Associação para do Desenvolvimento da Agroecologia (Brazil)
Biofuelswatch
Center for Environmental Health
Center for Food Safety
Center for Genetics and Society
Centro Ecológico (Brazil)
COECOCEIBA-Friends of the Earth Costa Rica (Costa Rica)
Columban Center for Advocacy and Outreach
Columban (Missionaries) Justice, Peace, and Integrity of Creation Office (Australia)
Development Fund (Norway)
Ecumenical Ecojustice Network
Edmonds Institute
Environmental Rights Action/Friends of the Earth Nigeria
ETC Group (Canada)
Food & Water Watch
Friends of the Earth Australia
Friends of the Earth England Wales and Northern Ireland
Friends of the Earth Canada
Friends of the Earth Cyprus
Friends of the Earth Spain
Friends of the Earth Uganda
Friends of the Earth U.S.
GE Free New Zealand
Gene Ethics, Australia
GeneWatch UK
GLOBAL 2000/Friends of the Earth Austria
Groundwork/ Friends of the Earth South Africa

Human Genetics Alert (UK)
Institute for Agriculture and Trade Policy
Institute for Social Ecology
Institute for Sustainable Development (Ethiopia)
International Center for Technology Assessment
Loka Institute
Lok Sanjh Foundation (Pakistan)
MADGE Australia Inc.
Maudesco/ Friends of the Earth Mauritius
Movimiento Madre Tierra (Honduras)
National Association of Professional Environmentalists (Friends of the Earth Uganda)
National Toxics Network (Australia)
Natural Capital Institute
Natural Justice (South Africa)
Oregon Physicians for Social Responsibility
Our Bodies, Ourselves
PENGON (Friends of the Earth Palestine)
Pureharvest (Australia)
RAFI-USA
Research Foundation for Science, Technology and Ecology and Vandana Shiva (India)
Safe Alternatives for our Forest Environment (SAFE)
Say No To GMOs!
Sempreviva Organização Feminista (Brazil)
South Australia Genetic Food Information Network (SAGFIN)
TestBiotech (Germany)
Washington Biotechnology Action Council

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[i] "The Wingspread Consensus Statement on the Precautionary Principle." Science & Environmental Health Network, 26 Jan. 1998. <http://www.sehn.org/wing.html>.

[ii] *Reducing Environmental Cancer Risk: What We Can Do Now*. President's Cancer Panel, Apr. 2010. <http://deainfo.nci.nih.gov/advisory/pcp/annualReports/pcp08-09rpt/PCP_Report_08-09_508.pdf>

[iii] "COP 10 Outcomes." *United Nations Convention on Biological Diversity*. 2 Nov. 2010. <http://www.cbd.int/nagoya/outcomes/>.

[iv] Snow, Allison A. "Transcript: Benefits and Risks of Synthetic Biology." *The Presidential Commission for the Study of Bioethical Issues*. 8 July 2010. Web. <http://www.bioethics.gov/transcripts/synthetic-biology/070810/benefits-and-risks-of-synthetic-biology.html>.

[v] Keasling, Jay. Amyris Biotechnologies. Testimony to the House Committee on Energy and Commerce hearing on Developments in Synthetic Genomics and Implications for Health and Security. May 27, 2010. < http://energycommerce.house.gov/documents/20100527/Keasling.Testimony.05.27.2010.pdf>

[vi] Steinbrecher, Ricarda A. *V-GURTs (Terminator) as a Biological Containment Tool?* Rep. EcoNexus, June 2005. <http://www.econexus.info/sites/econexus/files/ENx_V-GURTs_brief_2005.pdf>.

[vii] ETC Group. *Global Coalition Sounds the Alarm on Synthetic Biology, Demands Oversight and Societal Debate*. 19 May 2006. <http://www.etcgroup.org/upload/publication/8/01/nr_synthetic_bio_19th_may_2006.pdf>.

[viii] Pollack, Andrew and Duff Wilson, "Pfizer Whistle Blower Awarded $1.4 million," New York Times, 2 April 2010. < http://www.nytimes.com/2010/04/03/business/03pfizer.html>

PUBLIC SUBMISSION

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Received: March 07, 2011
Status: Posted
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Tracking No. 80c0267e
Comments Due: March 07, 2011
Submission Type: Web

Docket: DOE-HQ-2010-0002
Rulemaking to Amend 10 CFR Part 1021: National Environmental Policy Act Implementing Procedures

Comment On: DOE-HQ-2010-0002-0032
Re-opening of public comment period - National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0036
Comment on FR Doc # 2011-03981

Submitter Information

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Department of the Interior
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Government Agency Type: Federal
Government Agency: DOI

General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0036.1: Comment on FR Doc # 2011-03981

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
1849 C Street, NW – MS 2462-MIB
Washington, D.C. 20240

March 7, 2011

9043.1
PEP/NRM
IN REPLY REFER TO:
ER11/11

Electronically Filed

Ms. Carol Borgstrom
Director
NEPA Rulemaking Comments
Office of NEPA Policy and Compliance (GC–54)
U.S. Department of Energy
1000 Independence Avenue, SW.
Washington, DC 20585

Re: **COMMENTS – Review of Department of Energy (DOE) National Environmental Policy Act Implementing Procedures**

Dear Ms. Borgstrom,

The Department of the Interior (Department) has reviewed the Federal Register Notice of Monday, January 3, 2011, under Proposed Rules, and we offer the following comments regarding U.S. Department of Energy proposed amendments to its existing regulations governing compliance with the National Environmental Policy Act (NEPA). The Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) provided the comments contained within this letter.

GENERAL COMMENTS

DOE cites several former Minerals Management Service (now BOEMRE) categorical exclusions as substantiation for their revised categorical exclusion for research activities (B3.16). The Department is in the process of reviewing BOEMRE's categorical exclusions and some of the existing categorical exclusions may be deleted or revised (see 75 FR 62418).

Specific Comments

Appendix B to Subpart D of Part 1021—Categorical Exclusions Applicable to Specific Agency Actions; B. Conditions That Are Integral Elements of the Classes of Actions in Appendix B

1. Specific text in **B.3.16** (p. 227) **B.5.25** (p. 233) is not appropriate in un-surveyed areas.

   B.3.16 (p. 227) *Research Activities in Salt Water and Freshwater Environments,* Includes the statement: "…none of the above activities would occur within the boundary of…a recognized area of high biological sensitivity, or outside those areas if the activities would have the potential to cause significant impacts within these areas."

   B.5.25 (p. 233) *Small-Scale Renewable Energy Research and Development and Pilot Projects in Salt Water and Freshwater Environments*: Includes the statement: "…none of the above activities would occur (1) within areas of hazardous natural bottom conditions…."

   If data does not exist describing what is on the seafloor, a determination cannot be made regarding whether the area has high biological sensitivity, hazardous natural bottom conditions, or sensitive and non-renewable cultural resources. Therefore, before a determination to use a Categorical Exclusions could be made, an assessment of survey data within the APE, or an assessment of potential seafloor impacts from the proposed activities needs to be completed and any deficiencies need to be corrected.

2. Also regarding **B5.25** (pages 233 and 247) *Small-Scale Renewable Energy Research and Development and Pilot Projects in Salt Water and Freshwater Environments:*

   There should be some discussion or consideration of impacts surrounding the decommissioning of authorized temporary structures/devices. Both planned decommissioning and unplanned "cessation of operation" or failure (such as when the Finavera wave buoy sunk off Oregon in 2007) should be addressed.

   The situations in which a small-scale renewable energy research and development and pilot project would qualify for categorical exclusion are unclear. There are many conditions that "limit the scope and location" of the activity, but there is a lack of clarity and distinct definition as to what was meant by "limit the scope".

If a condition applies, then a review for making a CE does not apply? One condition that should be defined more clearly is "the construction of permanent devices". This should also be defined similarly between our departmental agencies and FERC.

3. **B 5.15** (Page 246) *Small Scale Renewable Energy Research and Development and Pilot Projects*

   Includes the statement, "Small-scale renewable energy research and development projects and small-scale pilot projects located within a previously disturbed or developed area".

   - The term "small-scale" needs a definition.

   - Please clarify if it is intended that all research projects must only be proposed in previously disturbed areas, or if this restriction applies to only pilot projects. Perhaps it could be restated, "This refers to small scale projects located in a previously disturbed area and includes both research and development projects and pilot projects."

4. **B5.18** (P. 246) *Wind Turbines*

   Includes the statement, "The installation, modification, operation, and removal of commercially available small wind turbines, with a total height generally less than 200 feet".

   - Provide more information supporting the proposal that wind turbines smaller than 200 feet need less review. While it appears that this threshold is provided based on FAA requirements, it does not appear to consider visual, biological, or other potential impacts. Please provide a reference where it was determined that factors related to turbines larger than 200 feet are more of a problem than, for example, 175 foot-tall turbines. Please describe any restriction on the scope, i.e., the number of turbines to be installed in a given proposal. If it is limited to one or two short turbines in a previously disturbed area, then it seems like it fits the definition. Attachments included prior EAs, with FONSIs, for shorter turbines to demonstrate that they did not have a significant impact. However, each were for one or two wind turbines, not a group or wind farm.

   - Describe how the determination made that a significant number of birds or bats would not be affected. Is this tiered off another study? If an ESA consultation is required, would that negate the CER and require an EA?

Questions or requests for clarification regarding any of the BOEMRE comments contained herein may be directed to Mr. Eric Wolvovsky, [Eric.Wolvovsky@boemre.gov], telephone number (703-787-1719). Any policy questions related to the Departmental application of categorical exclusion may be directed to Lisa Treichel [Lisa_Treichel@ios.doi.gov], telephone number (202-208-7116).

We appreciate the opportunity to comment.

Sincerely,

Mary Josie Blanchard

for Willie R. Taylor
Director, Office of Environmental
Policy and Compliance

PUBLIC SUBMISSION

As of: March 08, 2011
Received: March 07, 2011
Status: Posted
Posted: March 08, 2011
Tracking No. 80c02d9c
Comments Due: March 07, 2011
Submission Type: Web

Docket: DOE-HQ-2010-0002
Rulemaking to Amend 10 CFR Part 1021: National Environmental Policy Act Implementing Procedures

Comment On: DOE-HQ-2010-0002-0032
Re-opening of public comment period - National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0037
Comment on FR Doc # 2011-03981

Submitter Information

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Email: jhanson@icta.org
Submitter's Representative: Jaydee Hanson
Organization: International Center for Technology Assessment

General Comment

Dear Department of Energy:

RE: Enviromental Risk of GMO Algae

We are very concerned that your funding of genetically engineered algae research and synthetic biology research on algae has not been well considered in terms of the potential environmental effects of these unique forms of algae.

We have been working with David Haberman and the Friends of the Earth to educate the environmental community as to why we do not believe that genetically modified and synthetic biology engineered algae should be released into the environment. In another posting to this docket we have joined the Center for Food Safety and the Friends of the Earth in a critique of the DOE approach to this algae research, but with David Haberman's permission, I am posting here the power point slides he developed for a talk to one of our briefings.

Attachments

DOE-HQ-2010-0002-0037.1: Comment on FR Doc # 2011-03981

Risk Assessment Of Genetically Modified Algae

Presented To:
Friends Of The Earth

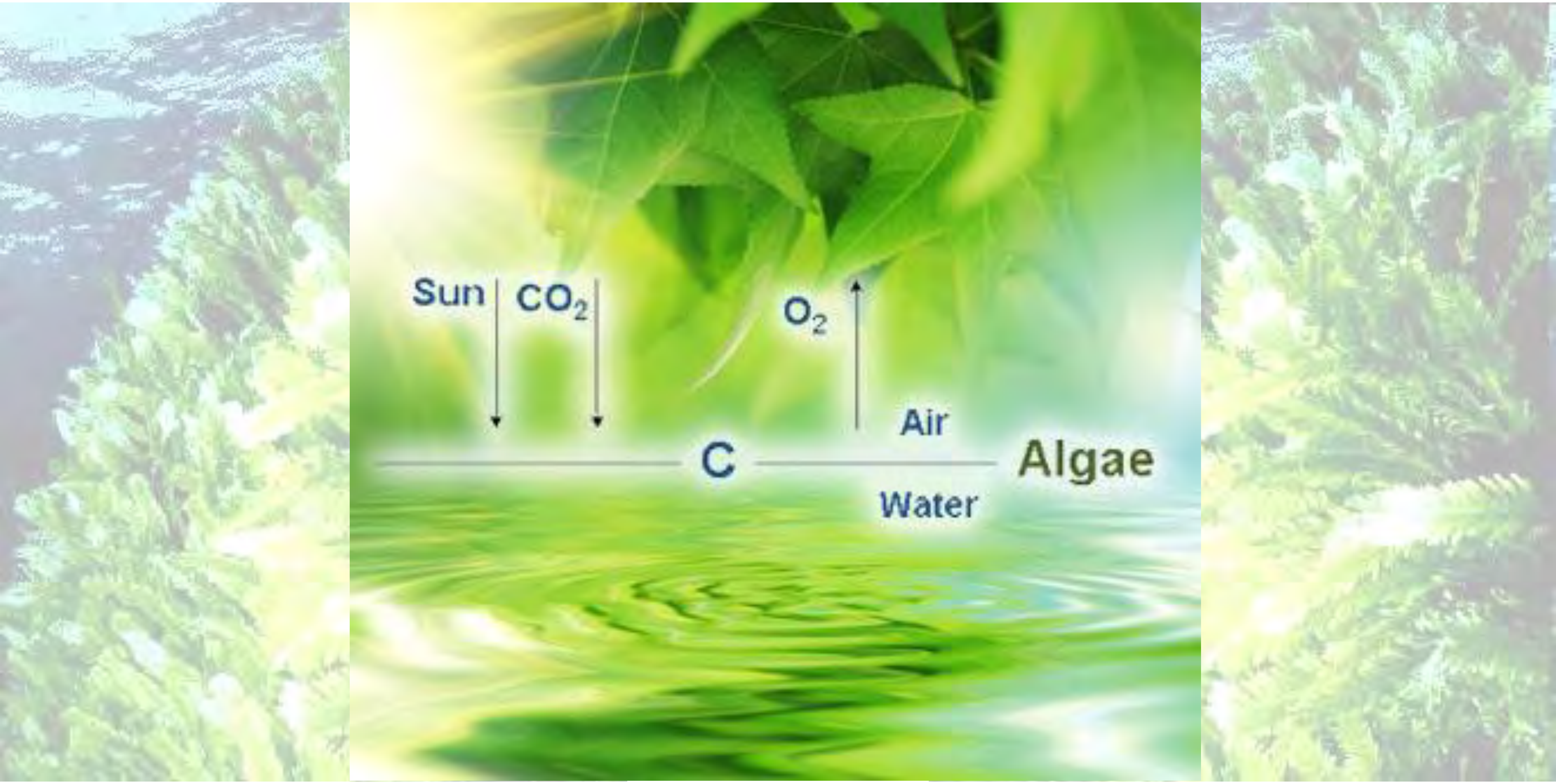
David Haberman
IF, LLC

Washington, DC
August 20, 2010

Abstract

A proposition to support a Government funded risk assessment of the genetic modification of algae will be presented. A risk inventory is derived from an examination of publically available information on the activities of the Government and companies funded by the Government. The algae value chain as applied to the production of biomass derived fuels has great potential. There have been multiple successes in operating algae (using naturally available species) systems optimized for carbon capture as well as systems optimized for biofuel production. These successes are undermined by the combined risks (economic, environmental, public health & safety as well as national security) which are intrinsic in the development and deployment of genetically modified algae. An independent risk assessment of genetically modified algae which applies engineering risk management methodology, including a failure mode effects criticality analysis is necessary to understand the real applications consequences, severity and probabilities.

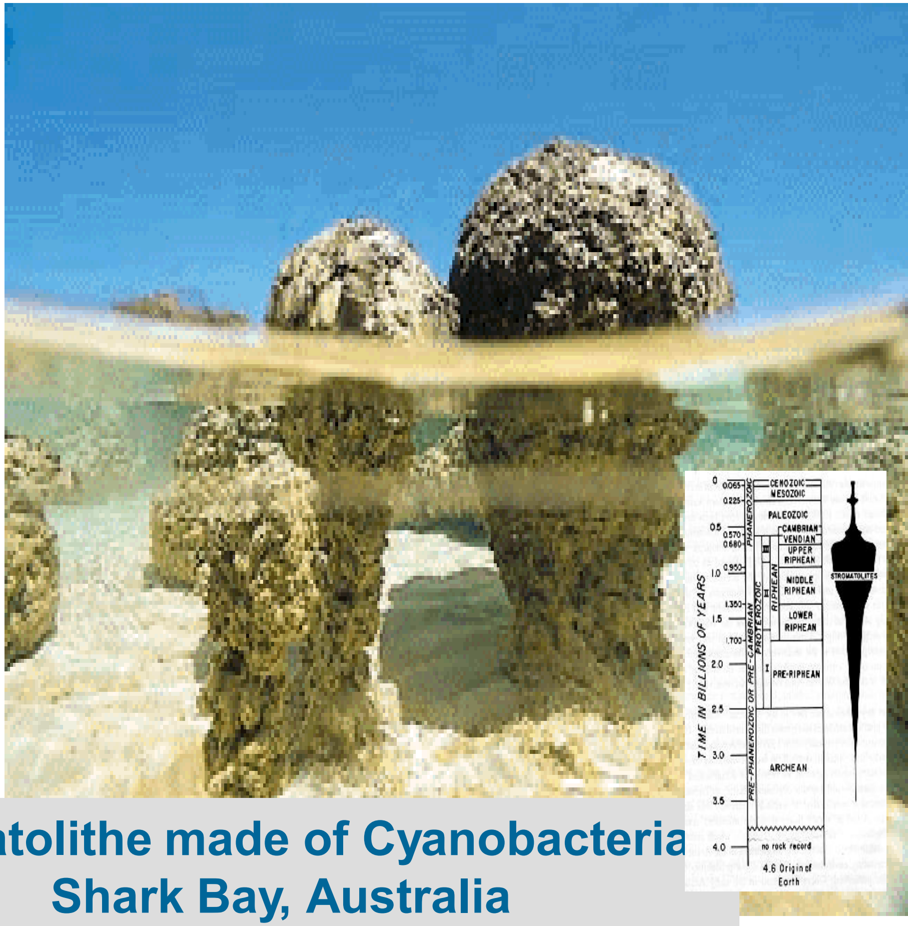
Algae Plays a Special Role in the Environment



Exists In Every Biosphere

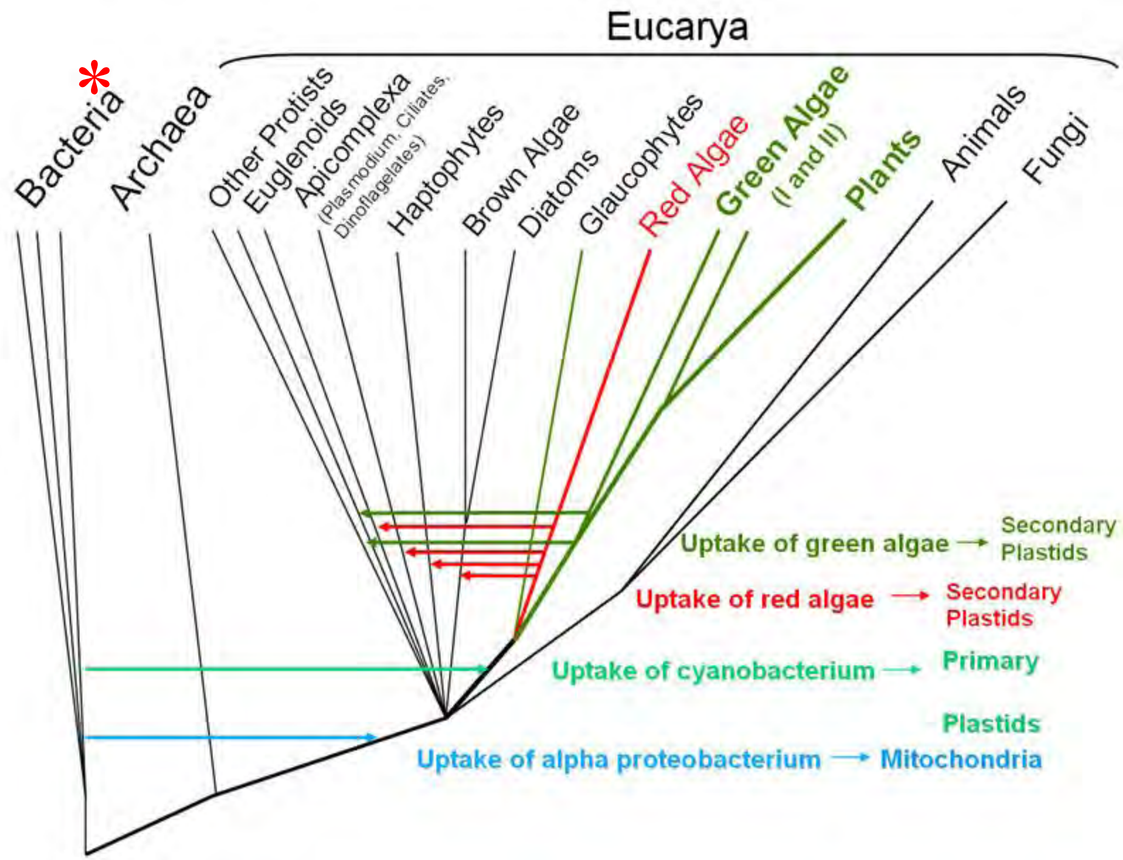
Introduction

- Algae is photosynthetic organism
- Algae exists throughout the environment
- Algae produces at least 50% of the O_2 in the atmosphere
- Algae are the bases of innumerable food chains
- Not all the species have been identified
- Algae's roles in nature are not fully understood



Stromatolithe made of Cyanobacteria
Shark Bay, Australia

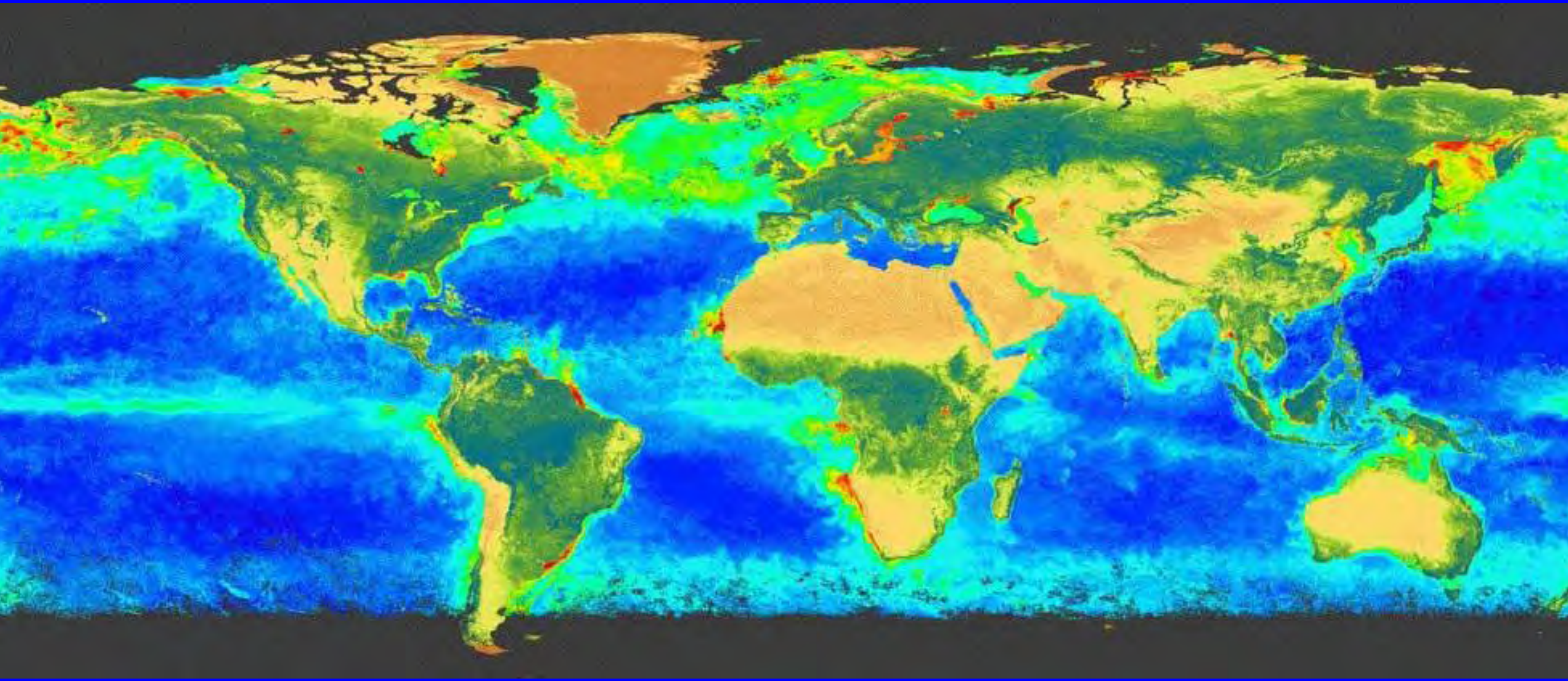
Evolutionary relationship of photosynthetic bacteria, algae, and higher plants



* Includes Cyanobacteria

Chloroplasts in algae and all higher plants were originally derived by capture of a photosynthetic bacterium by a eukaryotic organism. DNA in chloroplasts is similar to bacterial DNA

Global Biosphere from NASA SeaWiFS



Algae produce 50% of O_2 but are less than 1% of total plant biomass on Earth

Efficient: they do not waste energy creating huge mass of cellulose!

Algae Based Products

- Algae contains lipids (oil), proteins and carbohydrates
- There is an established worldwide market for algae based products
- People consume algae both directly & indirectly and inhale it everyday
- There is an established human dependency on algae based products

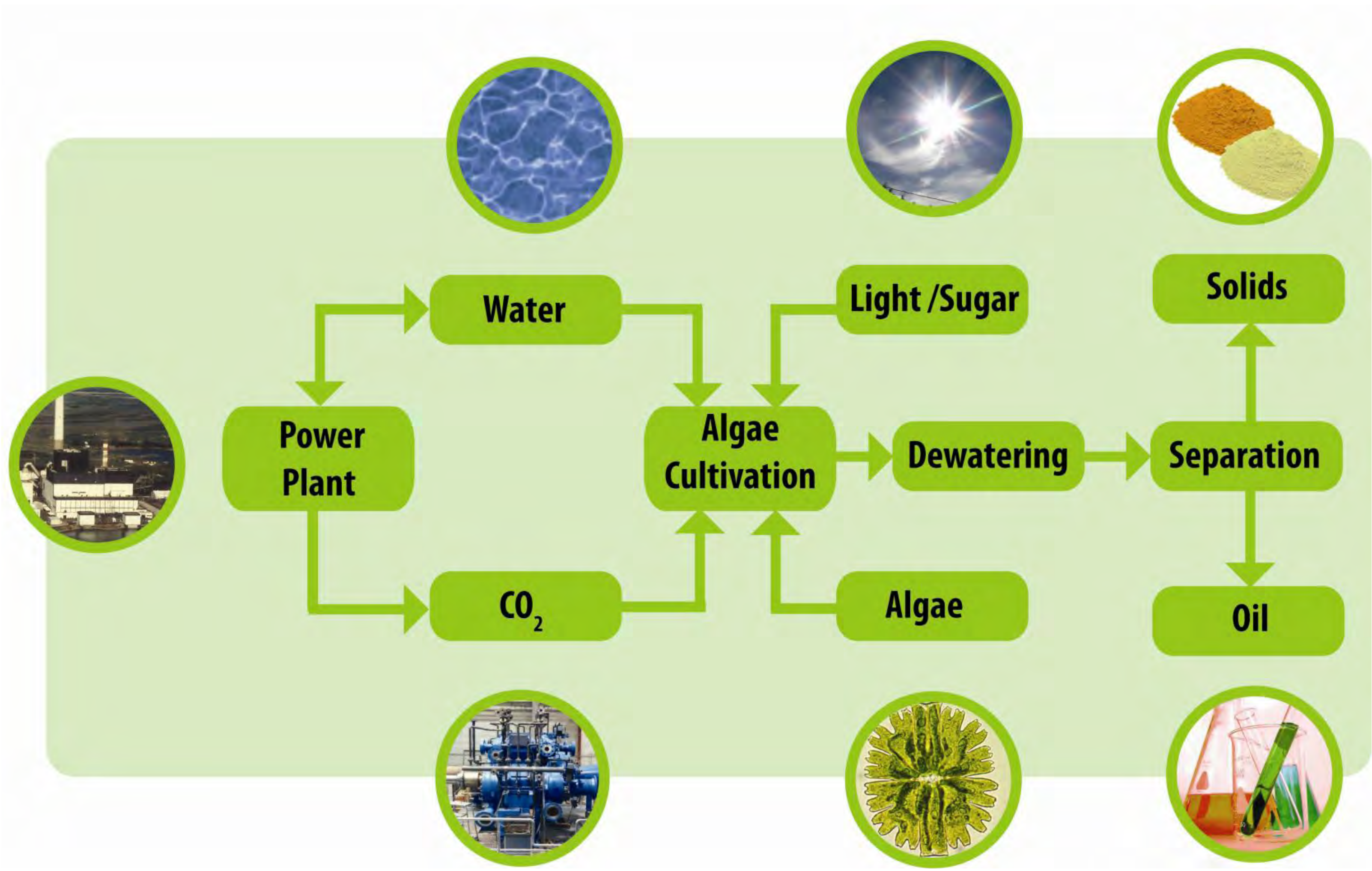

Gong Bi Microalgae,
Taiwan, 2005
Open Pond System for marine farming

Algae Enables Opportunity

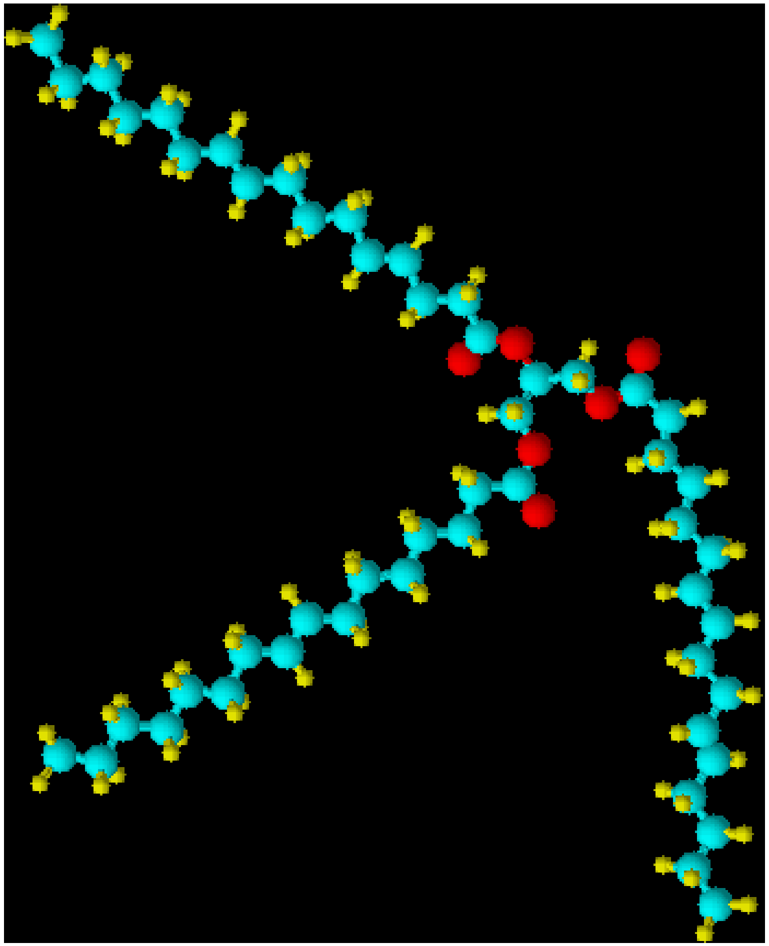
- Food vs. Fuel Debate Favors Algae
- Government Recognition Of Potential
- Energy Sector Investing In Positioning
- Field Success At Arizona Public Service / NETL
- Compares Favorably With Cellulosic Biomass
- Carbon Recycling Optimization Demonstrated

Crop	Oil gal/Acre
Algae	*1600 – 12,550*
Corn	*13*
Soy	*47*
Safflower	*83*
Sunflower	*102*
Castor	*150*
Rapeseed	*171*
Jatropha	*192*
Jojoba	*192*
Coconut	*290*
Palm	*640*

Algae Value Chain

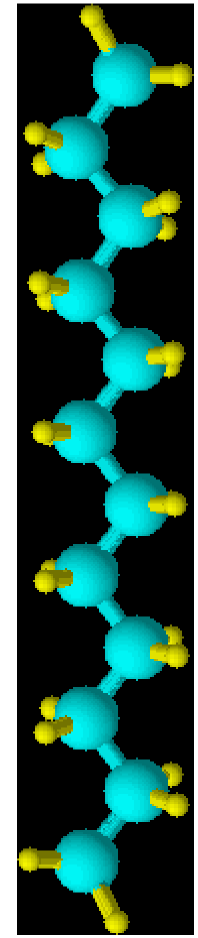


Fuel Based On Algae Oil



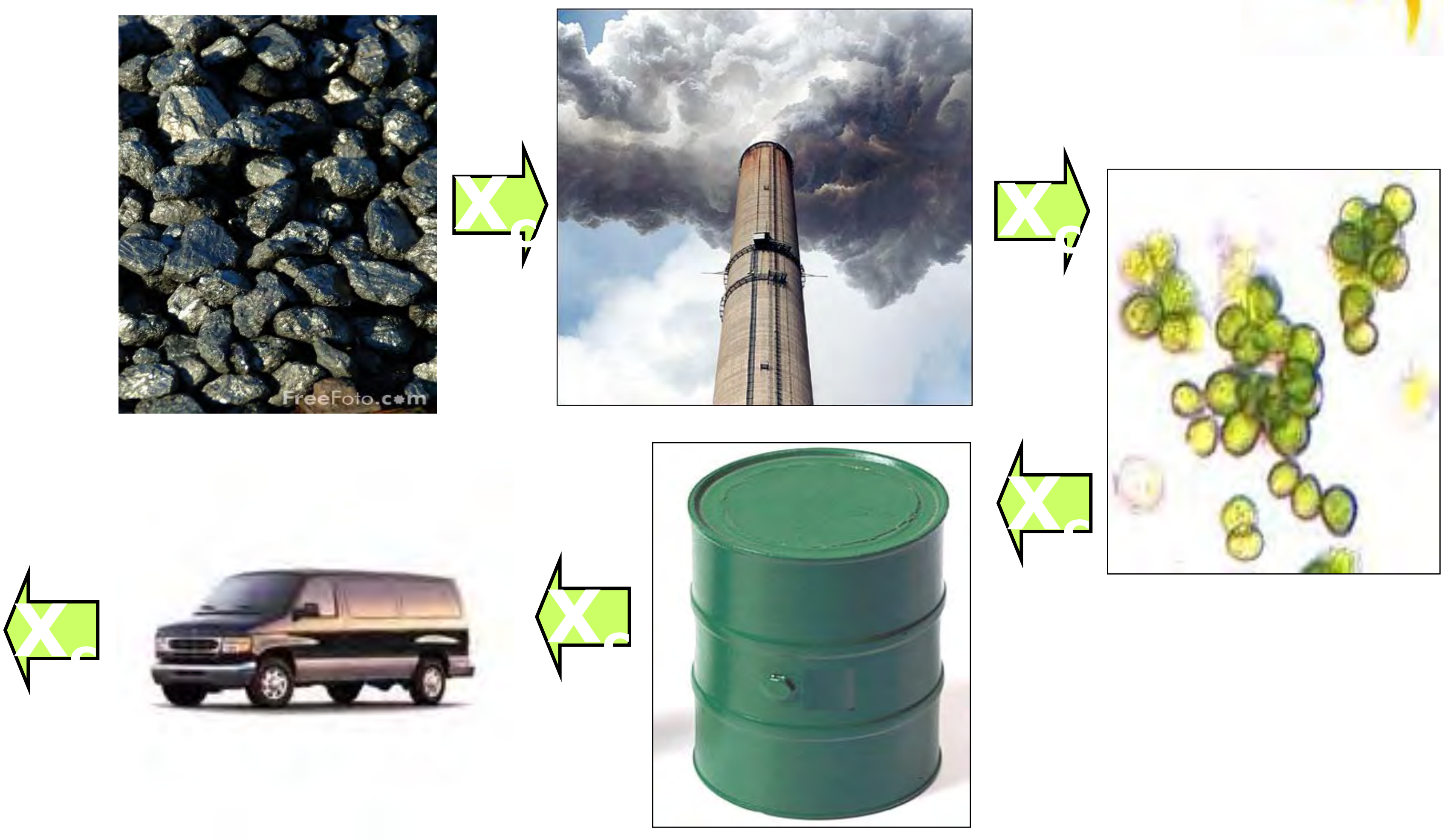
Triglyceride

Substitution
Of Feedstock
For Fuels
Manufacture



Hydrocarbon

Carbon Recycling



2005-2007: APS Redhawk, AZ
1,060MW (Gas)

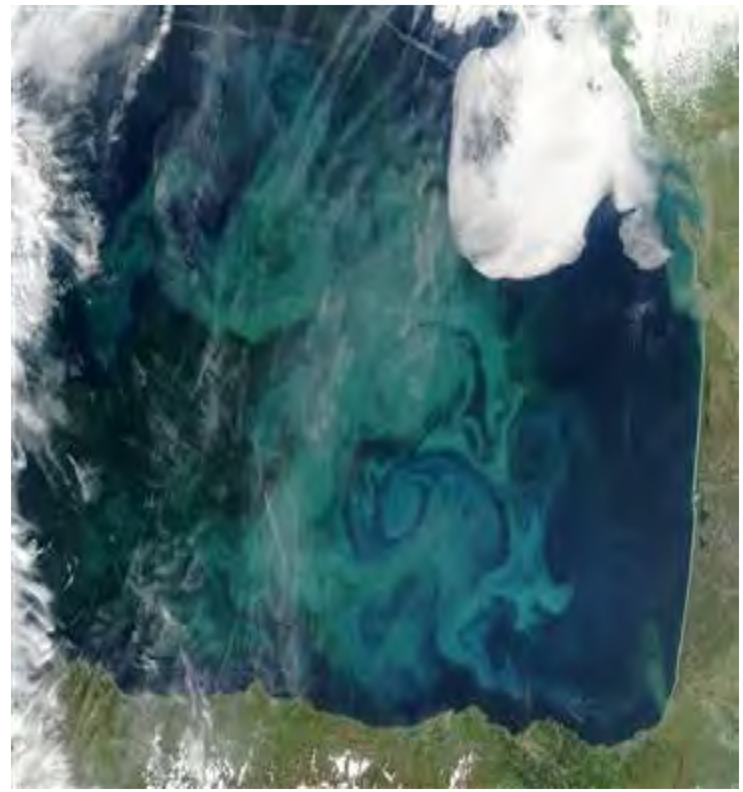
Carbon Recycling With Algae Demonstrated Successfully

Risks

1. Genetically Modified Algae Escapes Into Environment
2. Genetically Modified Algae Is Transferred Overseas To Avoid Regulations
3. Genetically Modified Algae Is Intentionally Deployed Into Environment
4. Genetically Modified Algae Is Stolen
5. Genetically Modified Algae Developed With Government Financing Under Weak Regulations Is “Grandfathered” In Avoidance Of Improved Oversight
6. Genetically Modified Algae Is Used In Human Food Or Nutriceuticals
7. Release Of Genetically Modified Algae Is Hidden

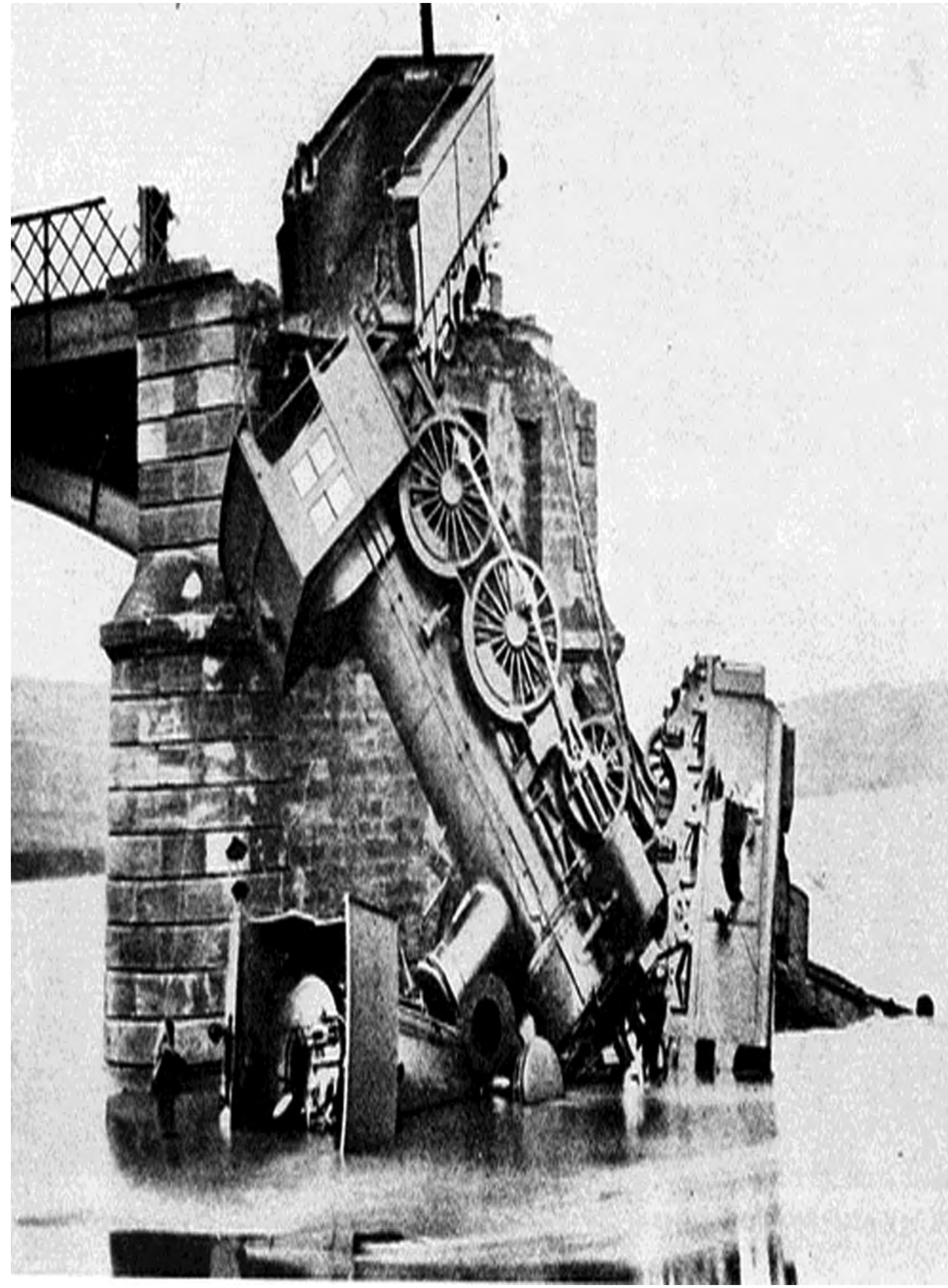
Attributes That Do Not Contribute To GMO Algae Profitability

- Oxygen
- Nutrition
- Degradation
- Optical
- Olfactory
- Adhesion
- Bouyancy



Consequences

1. Oxygen Production By Algae Falls
2. GMO Algae Replaces Natural Algae
3. Innumerable Food Chains Negatively Impacted
4. GMO Algae Interferes With Other Natural Processes
5. Human Health Is Effected Via Inhalation & Allergic Reactions
6. GMO Algae Is Weaponized
7. Lack Of Notification, Inspection Or Early Warning Results In Lack Of Timely Response
8. Lack Of Mitigation & Repair Strategies Amplify Damage
9. Destruction Of Value Proposition For Algae Applications – Including Existing Worldwide Uses
10. Wildlife Migration Patterns Change

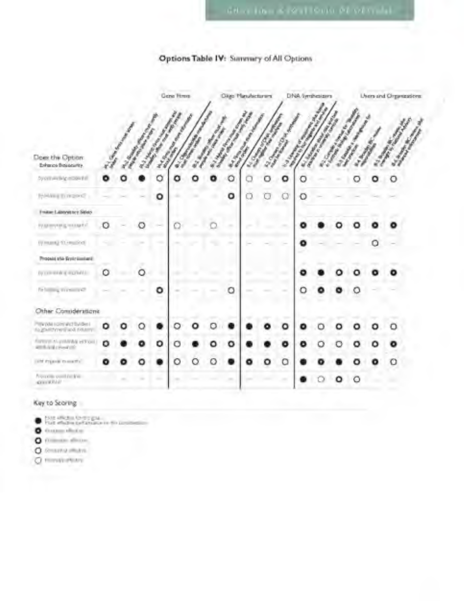


Locations Of GMO Algae Developers

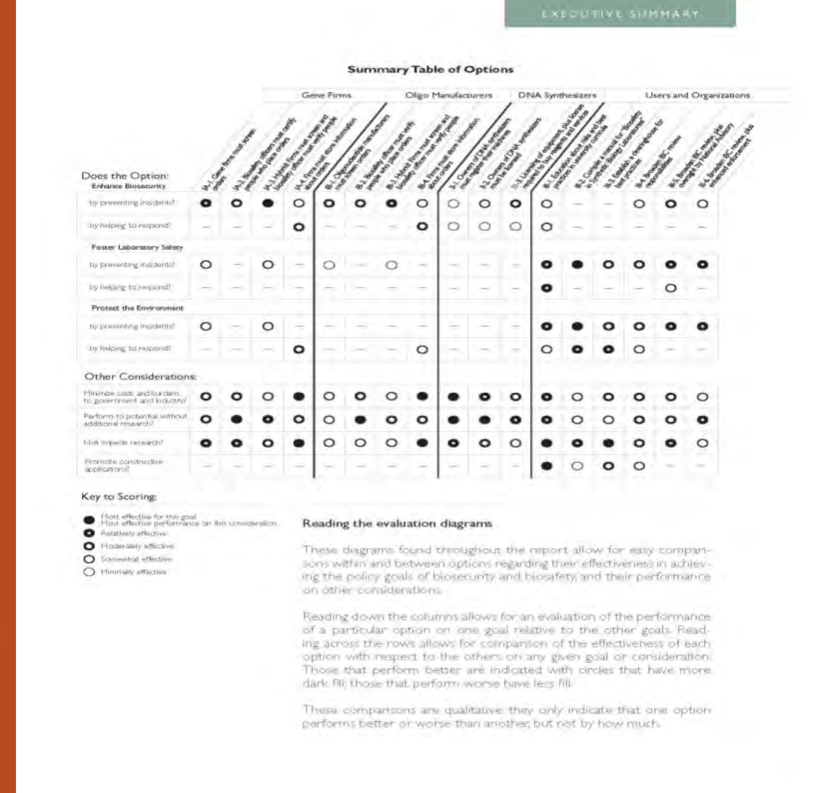
- National Renewable Energy Laboratory In Golden, Colorado
- Midwest Research Institute In Kansas City w/ NREL
- Sapphire In Las Cruces, New Mexico w/ USDA
- DOW in Texas w/ DOE
- Battelle Memorial Institute In Ohio w/ NREL
- Los Alamos National Laboratory In New Mexico
- Chevron In California w/ NREL
- Exxon In New Jersey and Virginia
- Synthetic Genomics In San Diego, California w/ Exxon and BP

Independent Risk Analysis Imperative

- Question Justifications For Government Funding GMO Algae
- Investigate Both Government & Industry Activities To Date
- Empower Experts (That Are Not Conflicted) To Conduct Comprehensive Hazardous Operations Review Procedures & Failure Mode Effects Criticality Analysis
- Conduct Study On Use Of GMO Algae As A Biological Weapon



SYNTHETIC GENOMICS | *Options for Governance*



No Independent Oversight

Industry Defines Terms Of Regulation Without Admitting Real Risks

Michele S. Garfinkel, *The J. Craig Venter Institute, Rockville, Maryland,* **Drew Endy,** *Massachusetts Institute of Technology, Cambridge, Massachusetts,* **Gerald L. Epstein,** *Center for Strategic and International Studies, Washington, District of Columbia and* **Robert M. Friedman,** *The J. Craig Venter Institute, Rockville, Maryland*

October 2007

J. Craig Venter INSTITUTE   CSIS   MIT

NREL Went Into Business With Chevron On September 12, 2007 To Develop GMO Algae (CRADA 07-208)

Purpose: Develop Biofuels by performing cutting edge genomics, proteomics and metabolic engineering

5 Years + $50M Budget

NREL Is Operated By Midwest Research Institute & Battelle Memorial Institute – Both Organizations Lobby Intensely To Avoid Any Reporting

NREL Was Awarded An Additional $38M By DOE-OBP In 2009

NREL
National Renewable Energy Laboratory

National Renewable Energy Laboratory

Cooperative Research and Development Agreement

STEVENSON-WYDLER (15 USC 3710)
COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT
(hereinafter "CRADA") No. CRD-07-208

between

Midwest Research Institute, Operator of
The National Renewable Energy Laboratory
under its U.S. Department of Energy Contract No. DE-AC36-99GO10337,
1617 Cole Blvd., Golden, CO 80401 (hereinafter "Contractor")

and

Chevron Technology Ventures, a division of Chevron U.S.A.. Inc.
3901 Briarpark Drive
Houston, TX 77042
(hereinafter referred to as the "Participant")

The Participant and the National Renewable Energy Laboratory are hereinafter jointly referred to as the "Parties" and individually as a "Party".

ARTICLE 1. Definitions:

A. "Government" means the Federal Government of the United States of America and agencies thereof.

B. "DOE" means the Department of Energy, an agency of the Federal Government.

C. "Contracting Officer" means the DOE employee administering the Contractor's DOE contract.

D. "Generated Information" means information produced in the performance of this CRADA.

E. "Proprietary Information" means information which embodies (i) trade secrets or (ii) commercial or financial information which is privileged or confidential under the Freedom of Information Act (5 USC 552 (b)(4)), either of which is developed at private expense outside of this CRADA and is marked as Proprietary Information.

Released By FOIA – NREL Guards Its Secrets

No Mention Of GMO Risks !

No Mention Of NREL's Conflicts Of Interest !

" A greater understanding of the underlying principles is necessary before commercial scale-up
Is feasible"
" A significant amount of research and a number of breakthroughs are needed to make algal biofuels a commercial reality"

- Scale-up Unproven
- Economic Feasibility Unknown
- NREL's BioProcessing Pilot Plant has a critical role to play

Report to Congress

Microalgae Feedstocks for Biofuels Production
(EISA 2007 – Section 228)

March 14, 2008

U.S. Department of Energy

Written By NREL

DOE-NREL Ignored Many Expressions Of Concern Regarding GMO Algae

IDC HERZLIYA | Lauder School of Government, Diplomacy & Strategy

16 Oct. 2008

National Renewable Energy Laboratory

1617 Cole Blvd.

Golden CO 80401-3393

Attn: Dan Arvizu, Laboratory Director

Dear Dr. Arvizu,

The purpose of this letter is to express strong objections to the National Renewable Energy Laboratory's (NREL) championing of the development and use of genetically modified algae. There are extreme potential risks to the environment and the public's health from genetic modification (GMO) of a highly adaptable, fast producing species of algae. These risks include:

1. Destabilizing existing eco-systems
2. Destroying food chains and killing dependent life
3. Killing beneficial species of natural algae
4. Destroying existing uses of algae for food, pharmaceuticals and fertilizer
5. Creating toxic GMO species that can directly harm people
6. Undermining current efforts to adapt algae for use in energy
7. Leaving us in the dark since there is little ability to assess or repair GMO damage to the environment

In 1998 NREL published a close out report on algae that recommended GMO. As you know, that report was widely condemned by algae experts as erroneous and short-sighted. NREL took little action in the algae area since that report was published but has recently become expressive of new ambitions to investigate algae. These new ambitions include alliances with developers of GMO. NREL's current plan to control algae application pathways is potentially flawed and has not been inclusive of dissenting experts.

Interdisciplinary Center (IDC) Herzliya | Lauder School of Government, Diplomacy and Strategy
Public Benefit Company P O Box 167 Herzliya 46150. Israel | www.idc.ac.il | Tel: +972 54 2520 345 | Fax: +972 9 9527377 |
iberzin@idc.ac.il

ISRAEL CELEBRATES 60

EERC Energy & Environmental Research Center

UNIVERSITY OF NORTH DAKOTA
15 North 23rd Street — Stop 9018 / Grand Forks, ND 58202-9018 / Phone: (701) 777-5000 Fax: 777-5181
Web Site: www.undeerc.org

October 23, 2008

The Honorable Byron Dorgan
United States Senate
322 Hart Senate Office Building
Washington, DC 20510-3405

Dear Byron:

I am writing for the purpose of sharing with you the Energy & Environmental Research Center's (EERC's) concerns regarding the National Renewable Energy Laboratory's (NREL's) position and actions regarding genetically modified (GMO) algae as a biomass feedstock for alternative fuels. Our concerns follow point-for-point with those expressed in a letter to NREL by Dr. Isaac Berzin, Director, Institute for Alternative Energy Policy, Lauder School of Government, Diplomacy & Strategy, IDC-Herzliya, Israel (see enclosed). NREL refuses to even admit receiving this letter.

Dr. Berzin hosted our delegation during our trip to Israel last May. Dr. Berzin is a world-renowned algae scientist and was recognized by Time Magazine in May 2008 as one of the 100 most influential people in the world for his work with algae.

As you know, the EERC has been extensively involved in U.S. Department of Defense (DOD)- and U.S. Department of Energy (DOE)-funded research focused on the use of naturally produced algae in various strategic energy production protocols.

Algae are a ubiquitous lifeform with many thousands of species that live in water, clouds, and even ice. The extent of algal interaction with the environment is not fully understood; therefore, changing this interaction through genetic modification creates unknown consequences. Genetic modification of algae is encumbered with an expanded set of risks because of algae's photosynthetic efficiency. The tremendous rate of growth translates to the geometric spread of any mistake. A significant number of industrial and

Kiplinger's Biofuels Market Alert
Vol. 2, No. 21 • October 29, 2008 www.Kiplinger.com

Technology

Battle Brewing over Genetically Modified Algae

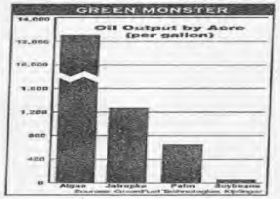
A brouhaha is erupting over the propriety of using genetic engineering to develop a "super" algae, one that would be perhaps even more ideal as a feedstock for making biofuels than the naturally occurring stuff.

The controversy stems from a public-private partnership between the Department of Energy's National Renewable Energy Laboratory (NREL) and oil giant Chevron [CVX]. Its goal is to develop an algae species that could produce lipid oils at an even faster rate than Mother Nature. Lipid oils contain properties that are remarkably similar to high-grade crude oil.

Of course, nature is itself no slouch at producing algae at a rapid clip. In fact, the marine organisms reproduce so fast that an entirely new species of algae can be produced naturally in less than one year.

The little green microbes—and their potential for providing enormous amounts of transportation fuel—have caught the eye of many investors. *(See "Algae: Little Green Microbes to the Rescue," KBMA, Sept. 17, 2008, Page 1.)* The yield per acre exceeds that of any other oil crop by far.

GREEN MONSTER



Most investments are in projects pursuing natural selection strategies for developing the best possible algae feedstock. Development of a super genetically engineered microbe could pose a large potential risk to such investments.

Opponents of the NREL/Chevron project mostly fret about the environmental impact of genetically modified algae, should they be released into the environment, which is highly likely.

In a letter to Sen. Byron Dorgan (D-ND), Gerald Groenewold, director of the Univ. of North Dakota's Energy & Environmental Research Center—a leading alt-fuels research institution—points out that "genetic modification of algae is encumbered with an expanded set of risks because of algae's photosynthetic efficiency." Dorgan is chairman of the Senate Appropriations Committee's energy and water development panel, which funds DOE.

Because algae reproduce so quickly, Groenewold writes, "[the risk] translates to the geometric spread of any mistake." Moreover, he adds, "there is no environmental assessment protocol for GMO (genetically modified organism) algae."

Groenewold charges NREL with letting its "efforts to monetize intellectual property run ahead of the national mission," adding that "[key stakeholders] have all been shut out of the NREL process." A road mapping meeting hosted by the Department of Energy this December leaves out key players in the field, including the National Energy Technology Laboratory, also a DOE laboratory.

According to Isaac Berzin, a leading algae researcher and director of the Institute for Alternative Energy Policy at Lauder School of Government, Diplomacy & Strategy in Israel, there are several risks associated with genetically modified algae. Berzin says they could destabilize existing

continued on page 2

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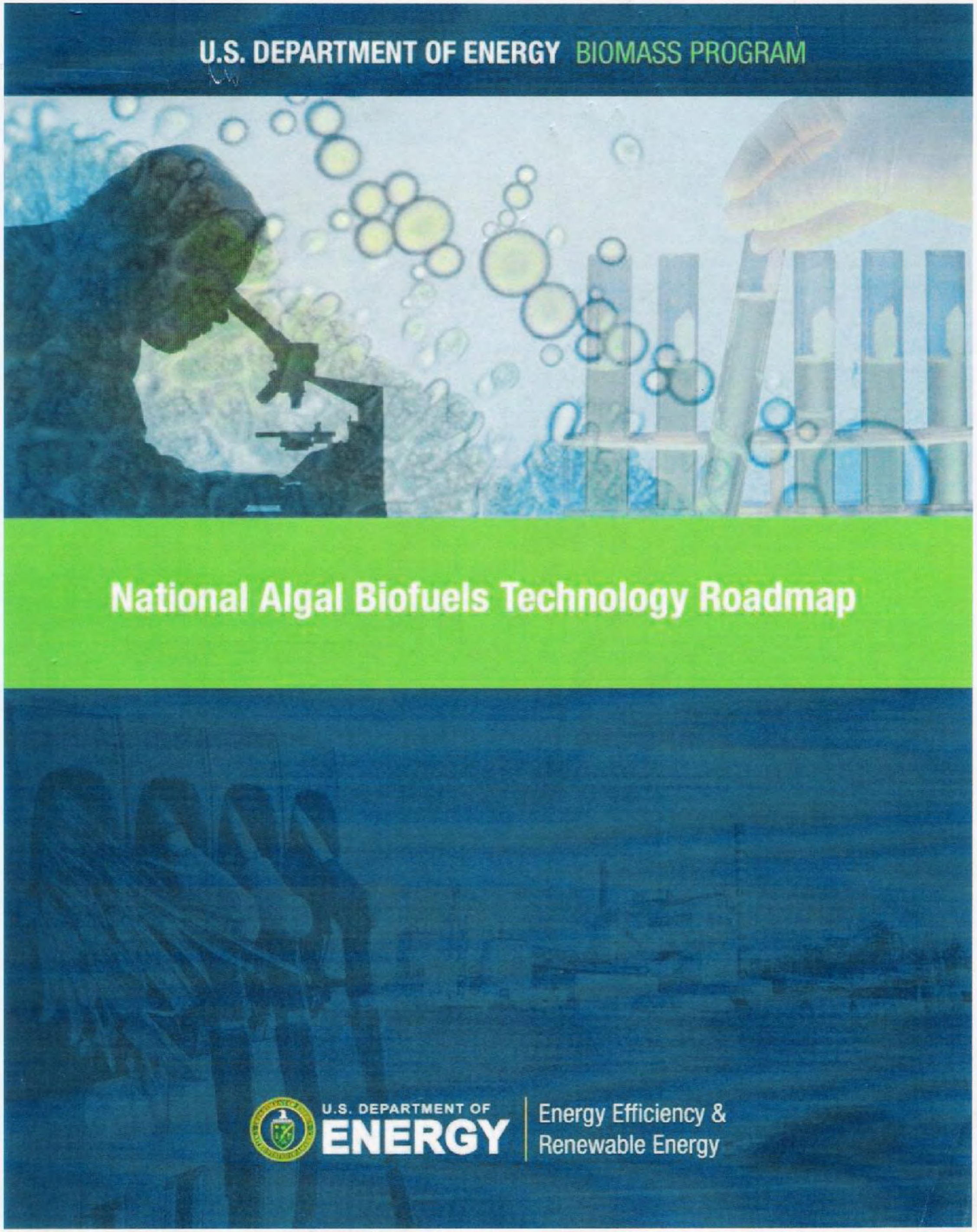
DOE's Office of Biomass & NREL Hold Invitation Only Meeting On Dec. 9-10, 2008

Roadmap Fails To:

- Recognize Risks Of GMO
- Identify Who Was Favored To Be Included By DOE In Roadmapping
- Clarify Which DOE Labs Have Monetary Interests In Algae
- Recognize Weakness In NEPA Process Regarding GMO Algae
- Define Editorial Process
- NREL COI Covered Up
- Offer A Timely Commitment To Regulation



Rubber Stamp Approval

USDA Rural Development

United States Department of Agriculture
Rural Development

Subject: Finding of No Significant Environmental Impact and Necessary Environmental Findings for the Sapphire Energy, Inc.'s Integrated Algal Biorefinery (IABR) Facility in Columbus, New Mexico

To: Project File

The attached environmental assessment for the subject proposal has been prepared and reviewed by the appropriate Rural Development officials. After reviewing the assessment and the supporting materials attached to it, I find that the subject proposal will not significantly affect the quality of the human environment. Therefore, the preparation of an environmental impact statement is not necessary.

Mitigative measures which will be employed for this project include the following:

1) The USFWS recommends that in order to minimize the likelihood of adverse impacts to all birds protected under the Migratory Bird Treaty Act (MBTA), construction activities should occur outside the general migratory bird nesting season of March through August, or that areas proposed for construction during nesting season be surveyed, and when occupied, avoided until nesting is completed.
2) The applicant should coordinate with the USFWS and NMDGF in order to minimize potential impacts to any burrowing owls located on the site if present as outlined in the ""“Guidelines and Recommendations for Burrowing Owl Surveys and Mitigation” (July 2007). "
3) The approval of this project is conditional upon receipt of the USACE Jurisdictional Determination confirming that there are no jurisdictional wetlands or waterways located on the property.
4) The approval of this project is conditional upon receipt of all other required permits and approvals (air quality, water rights, NPDES, Discharge) as stated in the EA.

I also find that the assessment properly documents the proposal's status of compliance with the environmental laws and requirements listed therein.

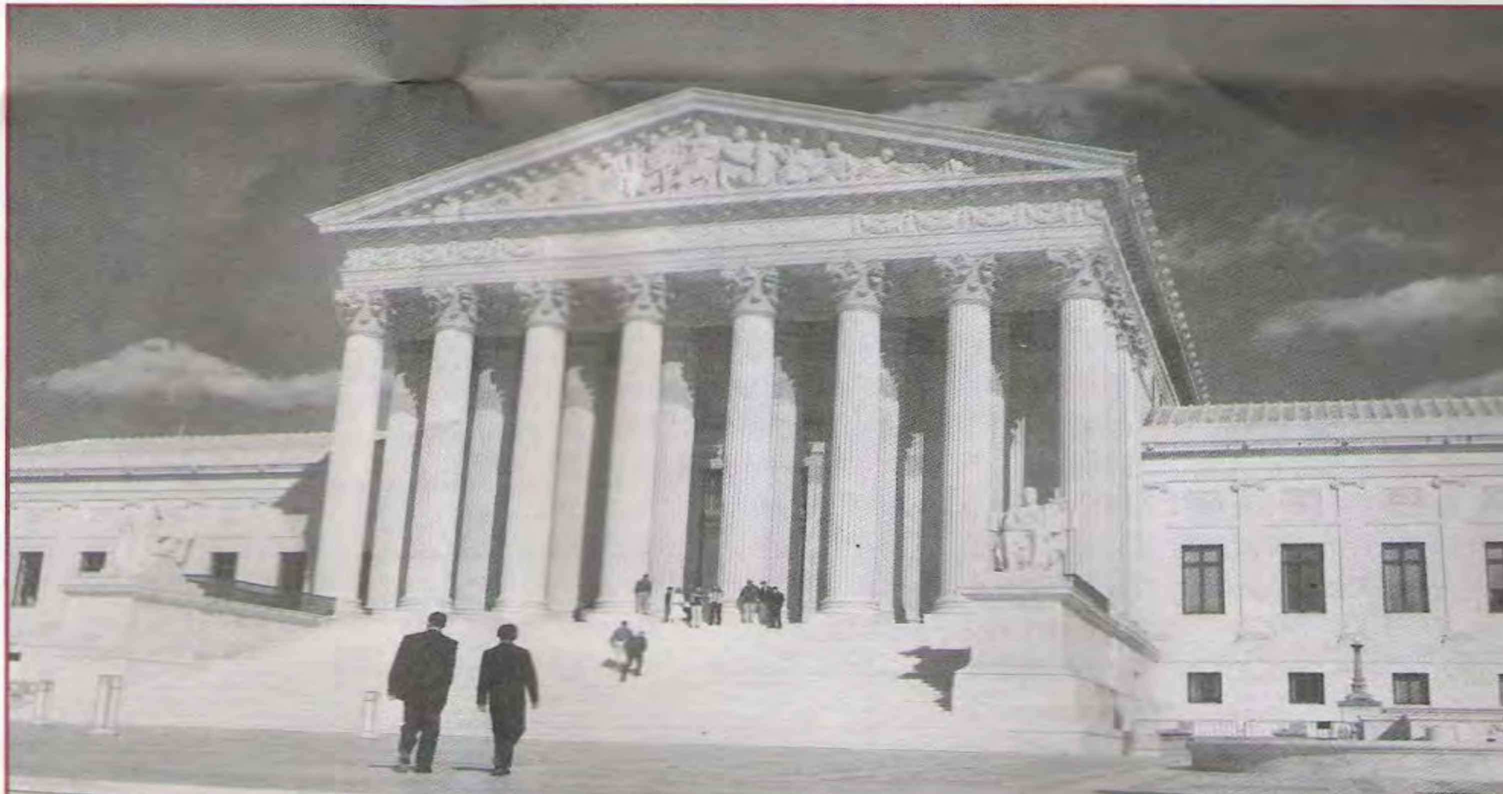
Judith A. Canales

JUDITH A. CANALES
Administrator
Rural Business and Cooperative Service

9/21/09
Date

Monsanto Challenges Center for Food Safety in the U.S. Supreme Court

DOE & USDA Ignore Legal Finding



ON JANUARY 15, 2010, the U.S. Supreme Court decided to hear its first-ever case involving the risks of genetically engineered crops. Named *Monsanto v. Geertson Seed Farms*, No. 09-475, the case before the high court will be yet another step in an ongoing battle waged by the Center for Food Safety (CFS) to protect consumers, farmers, and the environment from the potentially harmful effects of genetically engineered (GE) crops.

GMO Algae Developer Strategy

- Absorb Biofuel Funding Now
- Taint Investor Community Against Non-GMO Algae Potential
- Stonewall Environmental Regulations
- Use Patent Claims To Threaten Non-GMO Algae Developers
- Quickly Monetize Patent Applications (Claims)
- Set Up Off-Shore To Avoid Regulations, Liabilities & Accountability To US Investors
- Syndicate Misleading Public Messaging
- Lobby & Litigate Against Public Release Of Environmental Representations
- Pursue “Grandfather” Strategy By Abbreviating NEPA’s

Recommendations

- Initiate An Independent Risk Assessment Of GMO Algae Reporting To Congress
- Shut Down Government Funding For Development Of GMO Algae Until Congressional Review Of Risk Assessment
- Secure All Sites, Experiments And GMO Algae To Assure Protection
- Issue Notifications To All Government Funded GMO Operations To Inventory & Secure All GMO Algae
- Create An Intra-Department Safety Oversight Panel, Including EPA, FDA, USDA, DOD, DOE, NOAA, OSHA, DHS, DOT To Review Results Of Risk Assessment
- Instruct Patent Office To Turnover All GMO Algae Patent Applications To Safety Oversight Panel
- Instruct EPA to undertake an open comment period for changes to the section 5 of the Toxic Substances Control Act (TSCA) which is found in the in the Code of Federal Regulations at 40 C.F.R. Part 725 And Associated Points Of Consideration
- Instruct FDA to initiate sampling & site inspections of all algae developers and cultivators
- Instruct OSHA to initiate reviews of safety & health training at all gmo algae developers’ sites and to develop a protocol for inhalation hazards
- Instruct NOAA in coordination with EPA to initiate an algae sampling effort in open bodies of water in proximity to locations of developers
- Issue Instructions to Post Office, DHS and DOT that transport of gmo algae is a health and safety risk and should require a special procedure that includes pre-approvals, packaging, labeling and bonding
- Require an environmental protection bond of Exxon, Shell, BP and Chevron to address the costs of emergency response to gmo algae release

Risks To United States

- American-Made Biological Weapon Technology Transferred Offshore & Sold (Legally) Offshore
- Human Respiratory Health Threatened
- Food Nutritional Levels Compromised
- Thousands Of Food Chains Broken
- Most American Algae (Non-GMO) Enterprises Destroyed By Investor Retreat
- Public Acceptance Of Biofuels Undermined
- Ecosystems Degraded

Nation Will Benefit From Independent Risk Assessment

- Investor Confidence
- Regulatory Clarity
- Liability Boundaries Illuminated
- Level Playing Field For Non-GMO Algae
- Avoid Public & Policy Backlash
- Protect Environment
- Protect Public Health
- Preserve Industry In United States

Thank You !

Mr. Haberman has seven years of experience working on the development of carbon recycling systems which are enabled by algae.

I welcome feedback on this presentation.

David Haberman
(561) 733-7350
ifdhllc@aol.com

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Rulemaking to Amend 10 CFR Part 1021: National Environmental Policy Act Implementing Procedures

Comment On: DOE-HQ-2010-0002-0032
Re-opening of public comment period - National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0038
Comment on FR Doc # 2011-03981

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General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0038.1: Comment on FR Doc # 2011-03981

NATIONAL WILDLIFE FEDERATION®
901 E. St. NW, # 400
Washington, DC 20004
(202) 797-6800
NWF's mission is to inspire Americans to protect wildlife for our children's future.

March 7, 2011

Docket ID: DOE–HQ–2010–0002

Office of NEPA Policy and Compliance
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

Re: DOE NEPA Implementing Procedures, RIN 1990–AA34

Dear Sir or Madam:

On behalf of the National Wildlife Federation (NWF) and its four million members and supporters, I submit these comments on the National Environmental Policy Act (NEPA) Implementing Procedures regarding the proposed establishment and modification of new and existing categorical exclusions. We thank the agency for allowing us an extension to enable us to respond.

NWF applauds the Department of Energy's goals of removing barriers towards the adoption of new and innovative research on renewable energy. While we thank the agency for its commitment to the development of renewable energy technologies and support many of the new and revised categorical exclusions of categories such as B3.9 (projects to reduce emissions and waste generation) and B5.23 (electric vehicle charging stations), we are concerned that not all of the proposed categories meet the criteria of not having significant environmental impacts, individually or cumulatively. We are also concerned that the definition of "previously disturbed or developed area" is too vague. Our concerns are outlined below:

B3.6 Small-Scale Research and Development, Laboratory Operations, and Pilot Projects

DOE's rule proposes to change the phrases ''indoor bench-scale research,'' ''small-scale research and development,'' and ''demonstration actions'' to ''actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment. Demonstration actions frequently follow research and development and pilot projects that are directed at establishing proof of concept." This exemption from NEPA requirements could allow projects such as open-pond algae farms to move forward without a review of environmental risks. The Department of Energy has already supported a number of algae farm projects, including the 300-acre open pond algae farm in New Mexico operated by

Sapphire Energy with a $50 million loan guarantee. Many companies, including Sapphire Energy, are experimenting with genetically engineered or other non-native algae species. The FONSI for Sapphire Energy's project stated that, "If, during the DOE project period, Sapphire proposes to use any microorganisms that are defined as GMOs, DOE will conduct a supplemental environmental review of those activities." By allowing algae farms to be categorically excluded from the environmental assessment requirement, there would be no requirement for DOE conduct a review should Sapphire or other companies receiving funds for "actions taken on a small scale" use potentially invasive species.

Categorical exclusions from NEPA are meant only for categories which do not "individually or cumulatively have a significant impact on the human environment and for which, therefore, neither an EA nor an EIS is required." Because algae can be easily aerosolized and blown away with a breeze, there are significant risks associated with establishing an algae farm with non-native or genetically engineered species. Should these species enter the local ecosystem, they could wreak havoc on native populations. Even in a closed system, algae could still enter a local ecosystem through discharge of wastewater. According to a 2009 analysis of the potential environmental concerns associated with harvesting algae for bioenergy, "exotic and potentially invasive algal species from engineered cultivation systems may threaten the integrity of local and regional ecosystems, including those downstream from cultivation pond runoff (and harvesting discharge)."[i]

B3.8 Outdoor Terrestrial Ecological and Environmental Research

DOE proposes to exempt "small test plots for energy-related biomass or biofuels research (including the use of genetically engineered plants) are within the scope of this categorical exclusion." The fact that these plots are small-scale does not automatically mean that there will be no environmental impacts associated with them. As explained in the comments for B3.6, even closed production systems for algae may still present risks to native biodiversity should a non-native or genetically engineered strain with invasive qualities get into a local waterway- via wastewater or other routes. Because harvesting algae for biomass is still such a new field, little is known about potential contamination routes and risks to native species. This is precisely why a complete environmental assessment must be performed prior to these pilot facilities getting funding.

Beyond algae research facilities, NWF is concerned about exemptions for projects that involve potentially invasive species, including both non-native species and genetically engineered varieties of species that may have invasive qualities. Bioenergy research plots using seeded varieties of miscanthus or *Arundo donax* (giant reed), for example, may pose a significant threat to local ecosystems. Therefore, NWF recommends that for non-algae research projects using plants, DOE allow categorical exclusions only for projects using feedstocks that successfully pass an established weed risk assessment test such as the Australian Weed Risk Assessment.

Finally, the proposed rule states that an environmental assessment is not necessary because genetically modified crops are already being regulated by the U.S. Department of Agriculture. The fact that the U.S. Department of Agriculture has approved a genetically engineered crop does not guarantee environmental safety. It would be irresponsible for the DOE to not conduct its own environmental review of genetically engineered crops, especially if their intended use is different than that analyzed by the USDA (i.e. biofuels production instead of food production).

B5.15 Small-Scale Renewable Energy Research and Development and Pilot Projects

As with sections B3.6 and B3.8, NWF is opposed to categorical exclusions from NEPA for projects to harvest algae biomass for energy, given the risks posed by using non-native species and the high potential for algae strains to contaminate local ecosystems. For non-algae research projects using plants, DOE should allow categorical exclusions only for projects using feedstocks that successfully pass an established weed risk assessment test. On the other hand, NWF supports the use of this categorical exclusion for lower-risk types of renewable energy research and development pilot projects, such as small-scale wind and solar projects. NWF believes further clarification is necessary in the definition of a “previously disturbed or developed area”, as described below in section B6.0.

B5.16 Solar Photovoltaic Systems

The actions listed in categorical exclusion B5.16 apply to the installation, modification, operation, and removal of commercially available solar photovoltaic systems located on a building or other existing structure, or on land generally comprising less than 10 acres within a previously disturbed or developed area. NWF believes further clarification is necessary in the definition of a “previously disturbed or developed area”, as described below in section B6.0.

B5.18 Wind Turbines

DOE proposes a new categorical exclusion for the installation, modification, operation, and removal of small (200 feet in height or less), commercially available wind turbines, when located within previously disturbed or developed areas and in a set buffer zone from aviation aids or weather radar. NWF believes further clarification is necessary in the definition of a “previously disturbed or developed area”, as described below in section B6.0.

B5.18 requires that turbines ‘not have the potential to cause significant impacts to bird or bat species’. NWF believes this clause is too vague to provide a useful limit on siting of wind installations authorized by DOE. NWF suggests the availability of a categorical exclusion be linked at minimum to a municipal, state, or federal wind turbine siting guideline, such as the recently released Fish and Wildlife Service Draft Land-based Wind Turbine Siting Guidelines.

While B5.18 states that activities under this categorical exclusion would not have the potential to cause significant impacts because they, among other reasons, ‘generally involve no more than minor changes to an existing footprint’, that does not take into consideration the non-footprint related impacts of up to 200 foot structures on bird, bat, and wildlife behavior, nor the potential cumulative impacts of multiple structures in an important migration corridor or other essential habitat.

B5.20 Biomass Power Plants

DOE's proposal includes a new categorical exclusion relating to the installation, modification, operation, and removal of small-scale biomass power plants. This exemption would mean that there would be no environmental review of biomass sourcing for DOE-funded small-scale biomass power plants. NWF believes that DOE should not be categorically excluding biomass power plants from environmental review unless there are clear indications that the biomass will be sustainably sourced, such as through a credible sustainability certification system like the Forest Stewardship Council or Council for Sustainable Biomass Production. While many small scale facilities are able to source enough biomass through residues, thinning, and waste wood, depending on where the facility is sited and how many nearby facilities there are, this may not always be possible. Without any type of environmental review process, DOE's categorical exclusion would allow for funded biomass facilities to source biomass through the conversion land from natural forests to a dedicated, fast growing energy supply such as short rotation monoculture tree plantations, which would be represent a significant loss of local wildlife habitat.

B5.25 Small-Scale Renewable Energy Research and Development and Pilot Projects in Salt Water and Freshwater Environments

NWF is extremely concerned about DOE's proposal to categorically exempt projects that harvest algae for biomass in salt water and freshwater environments from the environmental review process. As mentioned in NWF's comments on sections B3.6 and B3.8, the risks of non-native and potentially invasive strains of algae entering a local ecosystem are quite high, especially for a pilot project within a freshwater or saltwater environment. While NWF applauds the fact that the agency has excluded certain areas with high wildlife value such as marine sanctuaries and wildlife refuges, we believe that it would be irresponsible of the agency to allow pilot projects using algae for bioenergy to be given the green light without an environmental review process. Little is known about the potential ecological and environmental impacts of algae biomass facilities. Should these projects use non-native species, including genetically modified species that may have invasive qualities, the likelihood of these species disrupting the delicate balance of the native ecosystem and entering into nearby ecosystems is unknown. Without proper research and an understanding of potential effects on biodiversity, DOE should not allow a categorical exemption for algal production for biomass.

With consideration of the wildlife resource screens mentioned above, NWF does support the use of a categorical exclusion for small scale research, development, and pilot demonstration of deepwater floating offshore wind energy technology, as well as wave and tidal energy projects. With siting screens, research and demonstration projects in these technologies will not have significant impacts, and NWF strongly supports removing unnecessary barriers to the commercialization of deepwater offshore wind technology in particular. The ability to support larger turbines farther offshore on a floating platform could reduce impacts of offshore wind to marine mammals and migratory birds, reduce potential visual resource and navigation conflicts, and make offshore clean energy generation available in the many states otherwise lack ideal depth conditions for offshore wind generation off their coasts.

B6.0 Previously Disturbed or Developed Area

DOE proposes to allow numerous activities[ii] on or contiguous to "previously disturbed or developed areas" based upon categorical exclusions. These activities range in scope from drop-off sites for recycled materials (B1.35) to 200-foot high wind turbines (B5.18) to construction of up to twenty miles of new transmission lines (B4.12; C4). The preamble defines previously disturbed areas as "land that has been changed such that the former state of the area and its functioning ecological processes have been altered." NWF agrees that new development in places that are already industrialized often results in reduced impacts on environmental resources. However, the definition offered in the preamble is a too vague to provide a useful limit on the siting of new projects authorized by DOE and, therefore, support the agency's use of categorical exclusions. In truth, it would be difficult to identify many locations in this country or the world where "functioning ecological processes" have not been altered by man's activities. The current science on climate change amply demonstrates that fact.

If the goal of this provision of the proposed rules is to encourage siting of new facilities in areas that are already heavily impacted by other human activity, NWF suggests that the availability of a categorical exclusion be tied at minimum to the fact that infrastructure similar in scope and intensity already exists on or immediately adjacent to the proposed location for the new facility. Additionally, NWF suggests specific mention of the many brownfield, superfund, and abandoned mine locations that through collaboration with DOE, the Environmental Protection Agency's Repowering America program has identified as having strong renewable energy generation potential and some degree of existing infrastructure.

We thank you for the opportunity to provide these comments. Please do not hesitate to contact me at (202) 797-6616 if you require any further information or clarification of our comments.

Aviva Glaser

Agriculture Program Coordinator
National Wildlife Federation

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[i] Ryan, Caitlin. 2009. Cultivating Clean Energy: The Promise of Algae Biofuels. Natural Resources Defense Council and Terrapin Bright Green.

[ii] The list includes: B1.31 Installation or Relocation of Machinery and Equipment; B1.35 Drop-off, Collection and Transfer Facilities for Recyclable Materials; B2.1 Workplace Enhancements; B3.6 Small-Scale Research and Development, Laboratory Operations, and Pilot Projects; B3.10 Particle Acelerators; B3.12 Microbiological and Biomedical Facilities; B3.14 Small-Scale Educational Facilities; B3.15 Small-Scale Indoor Research and Development Projects Using Nanoscale Materials; B4.6 Additions and Modifications to Transmission Facilities; B4.7 Fiber Optic Cable; B4.8 Electricity Transmission Agreements; B4.12 Construction of Transmission Lines; B5.1 Actions To Conserve Energy or Water; B5.5 Short Pipeline Segments; B5.8 Import or Export Natural Gas, With New Cogeneration Powerplant; B5.15 Small-Scale Renewable Energy Research and Development and Pilot Projects; B5.16 Solar Photovoltaic Systems; B5.17 Solar Thermal Systems; B5.18 Wind Turbines; B5.19 Ground Source Heat Pumps; B5.20 Biomass Power Plants; B5.21 Methane Gas Recovery and Utilization Systems; B5.22 Alternative Fuel Vehicle Fueling Stations; B5.23 Electric Vehicle Charging Stations; B6.10 Upgraded or Replacement Waste Storage Facilities; C4 Upgrading, Rebuilding, or Construction of Electric Transmission Lines; C11 Particle Acceleration Facilities.

PUBLIC SUBMISSION

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Rulemaking to Amend 10 CFR Part 1021: National Environmental Policy Act Implementing Procedures

Comment On: DOE-HQ-2010-0002-0032
Re-opening of public comment period - National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0039
Comment on FR Doc # 2011-03981

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Submitter's Representative: Daniel Hirsch
Organization: Committee to Bridge the Gap

General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0039.1: Comment on FR Doc # 2011-03981

NRDC
THE EARTH'S BEST DEFENSE

COMMITTEE TO BRIDGE THE GAP
BRIDGING THE GAP BETWEEN NUCLEAR DANGERS & A SAFE, SUSTAINABLE FUTURE

Via Electronic Mail

March 7, 2011

U.S. Department of Energy
Office of NEPA Policy and Compliance (GC–54)
1000 Independence Avenue, SW
Washington, DC 20585

Subject: DOE–HQ–2010–0002, DOE NEPA Implementing Procedures, RIN 1990–AA34

Dear Sir or Madam,

We write to comment briefly on the Department of Energy's (DOE) suggested expansions of particular categories under "Categorical Exclusions" from the National Environmental Policy Act, (NEPA) 42 U.S.C. § 4321 et seq.

Specifically, in Section B1.24 regarding Property Transfers, the proposed language runs counter to a key purpose of NEPA. NEPA requires an environmental analysis to determine if there is a potential for significant impact on the environment. DOE proposes to categorically exclude from environmental analysis any transfer action the agency asserts that may be covered under the provision: "that under reasonably foreseeable land uses there would be no potential for release of substances at a level, or in a form, that could pose a threat to public health or the environment and the covered actions would not have the potential to cause a significant change in impacts from before the transfer, lease, disposition, or acquisition of interests."

In contrast to this conclusory language, an environmental analysis is generally needed precisely to determine such matters – such as what is the reasonably foreseeable land use, whether under such use there is potential for releases of substances that could pose a threat to health or the environment, and whether the action would have the potential to cause a significant change in impacts. Terms like "a threat to public health or the environment" can be defined in the eye of the beholder and at least a minimum level of scrutiny provided by NEPA review could do away with later controversy. For example, if particular cancer risk levels could be increased, what specific risk level is sufficient to for the DOE to designate "a threat to public health?" We note that DOE has resisted radiation standards that would protect the public at levels within the risk range deemed acceptable by U.S. Environmental Protection Agency and instead allows exposures orders of magnitude above what EPA finds acceptable.

In short, land transfers prior to full cleanup can have significant adverse impacts on cleanup, sometimes stopping cleanup entirely and therefore could potentially lead to increased public exposures. This particular Categorical Exclusion should be revised to only permit transfers to be categorically excluded that involve transfers of non-contaminated land. The Federal Register notice indicated that reference to contamination was being removed. Instead, the agency should not, especially in light of the cleanup of the weapons complex, allow for Categorical Exclusions that would allow for land transfers of contaminated land.

Thank you for your consideration and do not hesitate to contact us at the numbers below if you have any questions.

Sincerely,

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Natural Resources Defense Council
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Daniel Hirsch
President
Committee to Bridge the Gap
(831) 336-8003

PUBLIC SUBMISSION

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Comment On: DOE-HQ-2010-0002-0032
Re-opening of public comment period - National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0040
Comment on FR Doc # 2011-03981

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General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0040.1: Comment on FR Doc # 2011-03981

3 March 2011

Comments concerning Appendix A actions.

I recall that in 1993 DOE issued a rule-making related to revising their categorical exclusions. There was a statement in the rulemaking that the administrative actions included in Appendix A were there so that no one would think that they needed to do an EA if the action wasn't shown as excluded from further NEPA documentation. I find that environmental checklists that refer to these Appendix A criteria are applied by at least one DOE office to cover routine everyday activities, which is inherent to any office. I had hoped that these routine office actions would have been set aside at this time as examples of when NEPA is not required – not to continue this waste of time and resources documenting that in fact yes, research is being conducted, that yes, documents are prepared, or yes, we will hire a summer intern. It seems to me that either you need to provide some level of scale for when these apply, or, you surely have forgotten why the NEPA was passed – it certainly was not so that an office could award a $2,000 contract for a cultural resource survey or to hire a summer intern. I would have thought that before a contract was awarded at the higher level (by HQ) to a national contractor to provide support to DOE that HQ would have prepared an EA or EIS that evaluated why this multi-million dollar contract was being awarded and what kind of actions it would cover – which surely would cover awarding small contracts, doing a literature search and preparing a document.

I think if DOE feels that this is a correct interpretation of NEPA, then these types of actions should also be posted to let the American public know how their money is being spent. This type of action undermines NEPA and has nothing to do with the letter and spirit of NEPA. Under what circumstance can you compare a categorical exclusion criteria evaluation for a 10 million dollar short-term clean-up action to hiring someone or doing research?

Appendix B Actions

B (4). (Introduction to this section) 'Have the potential to cause 'significant impacts' on environmentally sensitive resources.' By changing the original wording of *adverse* to *significant* you have left the degree of impact open to interpretation and I disagree strongly with this approach. The word significant historically has been associated with environmental impact statements and authors avoid using this term for that reason. However, I am more concerned that you can adversely affect a protected resource but not consider this a significant impact. Those authors who are being pressured to get a ground-disturbing action approved may not consider a 40 % loss of a protected species significant, but they would formerly need to consider this an adverse impact. This distinction is lost and it would appear that reducing the scope of what is under consideration is the intent of this change.

B1.3 a- including these actions as a maintenance activity should be limited to large or high expense projects. If someone changes a light bulb fixture or air filter, they require a NEPA documentation under this checklist criteria. It would seem more appropriate to limit the scale of this criteria to something that might actually result in an impact, rather than a daily activity.

B1.3 k – erosion and soil stability should be expanded to include use of other options besides reseeding or vegetation. The use of gabions or grading for positive drainage could appropriately be included as an example. Seeding often does include grading to replace original contours, etc. This criterion could also be more specific to include reclamation after any activity.

B1.11 Fencing: Replacing *adversely* by *significant* minimizes the loss of migratory routes used by wildlife that cannot cross a fence. The result is a loss of the specific wildlife on both sides of the fence that it affects as well as the habitat on both sides; there is a known relationship between habitat and wildlife. The use of significant is again open to interpretation, whereas, an adverse impact clearly states the problem.

B1.14: Refueling of nuclear reactors: where are you addressing the end state of the fuel that is being removed? The way this criterion is stated only applies to the actual act of refueling and does not include disposition of spent rods – where is this covered?

B1.24 Transfer of properties. The problem with this criterion is that when DOE transfers a real property to GSA, who will often transfer the property to the Park Service (Land to Parks Program), the end use is most often unknown and it is actually in error to suggest that the change in use would not have the potential to cause a significant change in impacts from prior uses (vacant?) before, when you can't predict what the change in use will be. An excess property is perhaps lying vacant, or has been cleaned up – the end use may actually cause some type of impact, but the end use is unknown at the time of transfer. I think that perhaps GSA or NPS owns the NEPA and for DOE, it is simply a change in title. GSA will know what is happening to the property. If this criterion is specific to office buildings that are being sold as an office building, perhaps more specificity is appropriate.

B3.1 a – suggest bounding what is covered under this criterion – what is an example of a large scale refraction reflection survey? Saying something is 'large scale' is too subject to interpretation without a qualifying statement as to what you are expecting to be covered.

B5.13 Experimental wells for injection of carbon dioxide…I strongly feel that this should be evaluated at the EA level – is this tested technology? Have multiple EAs already been done on all different levels of scale?

B5.18 (4). Wind turbines and *significant* impacts to bird and bat species. I would like to see something added to this line that requires agreement by the US Fish and Wildlife Service for the size and location. If there are no significant impacts, then this requirement would not be troublesome. You also don't identify the scale – is this a 40 acre project or a 200 acre project? Previously disturbed areas can cover a lot of different scenarios – I think this also needs to be bounded.

B5.25 small scale-pilot or research projects – I feel that this warrants an EA level of analysis. Our marine areas are too fragile for a variety of projects that could include use of chemicals, invasive work, etc. Perhaps there is some way to bound the scale of the project that would allow truly small projects in very specific areas.

B6.1 – cleanup actions – is 10 million dollars still characteristic of a small-scale project? I realize that the cost of a small clean-up has escalated since this was first suggested in around 1993, however, would like to see some way of bounding the action so that it is really a small-scale project.

C8 protection of wildlife, fish, and cultural resources – can the change in scope from the criteria that is a CX be explained? When is something large scale?

Misc. comments:

1. Many of the renewable energy criteria refer to location on a previously disturbed or developed property. Please bound this by adding a time line. One project I worked on considered disturbance related to an action that happened 50 years ago as applicable, even though an entirely different use occurred over the intervening years. Fifty years ago NEPA did not exist and no environmental evaluation was completed. In addition, technology has changed significantly and any potential impacts that might have been

considered 50 years ago would not be similar to the impacts related to new technology. For example, to say that the impacts related to logging that was done with the available technology in the 1950's would be applicable to impacts related to logging, if logging were to occur 50 years later, after reclamation and re-growth has occurred, does not begin to characterize the impacts related to current day logging practices. Is adding an applicability statement along the lines of: area previously disturbed within the past (e.g.,) 5 years appropriate? If an intervening use has occurred, it would seem that a return to an original use would create impacts

2. The difference in scale between many criteria (not just appendix A to B) is obvious and warrants consideration. NEPA is all about ground-disturbing actions – not routine activities such as painting a building, installing a window, or surveying a water level or doing a ground survey. As an example, if a checklist was completed on installing one new shallow well that would be put in using a Geoprobe rig and no protected resources are present, here is an example of the criteria that would apply:
   A2; A8; A9; B1.2k, n, p; B1.13;and B3.1a,b,c,f,j. Is this really your intent?

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Re-opening of public comment period - National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0041
Comment on FR Doc # 2011-03981

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General Comment

Re: DOE NEPA Implementing Procedures, RIN 1990-AA34
Docket ID: DOE-HQ-2010-0002
10 CFR Part 1021

On behalf of the Blue Ridge Environmental Defense League, I submit the following comments on the above referenced matter. In brief, we oppose the addition of categorical exclusions to implementation of the National Environmental Policy Act.

Attachments

DOE-HQ-2010-0002-0041.1: Comment on FR Doc # 2011-03981

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March 7, 2011

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Re: DOE NEPA Implementing Procedures, RIN 1990-AA34
Docket ID: DOE-HQ-2010-0002
10 CFR Part 1021

On behalf of the Blue Ridge Environmental Defense League, I submit the following comments on the above referenced matter. In brief, we oppose the addition of categorical exclusions to implementation of the National Environmental Policy Act. Although some of the proposed changes may indeed be minor and worthy of further consideration, we oppose exclusions which would themselves have negative environmental impacts, would lead to further categorical exclusions, or would actually undermine the technology thus exempted.

Of particular concern to us are new categorical exclusions in the following areas:

B5.13 Experimental Wells for Injection of Small Quantities of Carbon Dioxide
B5.16 Solar Photovoltaic Systems
B5.17 Solar Thermal Systems
B5.18 Wind Turbines
B5.19 Ground Source Heat Pumps
B5.20 Biomass Power Plants
B5.21 Methane Gas Recovery and Utilization Systems
B5.24 Drop-in Hydroelectric Systems

The above list is a mix of energy facilities, some of which are truly beneficial, others of which are not. For example, solar voltaic, solar thermal, and wind turbines I believe are generally beneficial. On the other hand, biomass power plants and landfill methane are either negative themselves or associated with other negative impacts.

The beneficial energy sources listed could be undermined by the proposed categorical exclusions because the affected public would see them as loopholes. The negative energy sources simply should not enjoy categorical exclusions. The conventional approach to biomass energy sources which labels them as “carbon neutral” is a mistaken concept without scientific basis; biomass energy source impacts are large and should not enjoy any categorical exclusion.

Thank you for the opportunity to submit these remarks.

Louis Zeller
Science Director

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Document: DOE-HQ-2010-0002-0042
Comment on FR Doc # 2010-32316

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General Comment

Please find attached comments submitted by Friends of the Earth, the International Center for Technology Assessment, the Center for Food Safety and the Center for Biological Diversity.

Attachments

DOE-HQ-2010-0002-0042.1: Comment on FR Doc # 2010-32316

March 7, 2011

Ms. Carol Borgstrom, Director NEPA Rulemaking Comments
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CC: submitted to http://www.regulations.gov
DOE NEPA Implementing Procedures, RIN 1990–AA34
Docket No. DOE–HQ–2010–0002.

Comments on DOE NEPA Implementing Procedures, RIN 1990-AA34

Friends of the Earth, the International Center for Technology Assessment, the Center for Food Safety and the Center for Biological Diversity are opposed to many of the proposed categorical exclusion provisions to the U.S. Department of Energy's NEPA Implementing Procedures. The National Environmental Policy Act (NEPA) requires federal agencies to integrate environmental values into their decision making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. The below proposed categorical exclusions to NEPA should be rejected and permanently disallowed by the DOE:

B3.6 Small-Scale Research and Development, Laboratory Operations, and Pilot Projects
B3.8 Outdoor Terrestrial Ecological and Environmental Research
B3.12 Microbiological and Biomedical Facilities
B3.15 Small-Scale Indoor Research and Development Projects Using Nanoscale Materials
B5.20 Biomass Power Plants
B5.25 Small-Scale Renewable Energy Research and Development and Pilot Projects in Salt Water and Freshwater Environments

NEPA mandates that all major Federal actions significantly affecting the quality of the human environment must be evaluated for their potential environmental impacts. Categorical exclusions are available for actions that would not have the potential to cause significant environmental impacts. The above provisions, in many instances, could in fact cause significant environmental impacts and therefore would be illegal to exclude from NEPA compliance.

In addition to comments on the noted proposed categorical exclusions we are also submitting a few documents to the docket. First is a report published by Friends of the Earth on the use of synthetic biology for biofuels production. Second is a letter submitted to the Presidential Commission for the Study of Bioethical Issues in response to their report on synthetic biology. Third is written comments submitted to the House of Representatives Energy and Commerce Committee during their hearing on synthetic biology. Finally, we are also submitting our report on nanotechnology and energy production as well as the Principles for the Oversight of Nanotechnologies and Nanomaterials. Many of the proposed rule changes under discussion (B3.6, B3.8, B3.12, B5.20, B5.25) will directly impact the use of biotechnology, synthetic biology and nanotechnology for biofuels production and the risks these emerging technologies pose cannot be ignored by a categorical exclusion from NEPA.

According to a study conducted by the Woodrow Wilson International Center for Scholars, the Department of Energy funds by far the largest amount of synthetic biology projects of any other agency in the Federal government. Since 2006, DOE has spent over $700 million on synthetic biology research (a conservative estimate since the Department did not making its funding information public). Only four percent of these funds were allocated to examine the ethical, legal and social implications of synthetic biology and the DOE did not release any funding information on research conducted to study the potential environmental impacts of this research.[i] This amounts to a programmatic research program, worthy of its own Environmental Impact Statement; rather, the DOE is attempting to segment the potential environmental impacts of this research by seeking categorical exemptions from NEPA for each separate part.

These documents, along with the below comments, highlight the concerns around the environmental impact of synthetic biology and why these categorical exemptions would be an irresponsible attempt to skirt NEPA requirements.

Environmental Risks of Synthetic Biology and Genetically Engineered Organisms

genetically engineered crops or organisms, such as algae or yeast, for biofuels production pose serious threats to the environment. Since the widespread use of genetically engineered (GE) crops, we have seen that GE plants have the ability to share genes across species, [ii] evolve and mutate over time [iii], and drastically affect entire ecosystems. [iv] GE crops generally use genes that have been in the environment, but some of these new synthetic biology creations are using DNA that are human-made and not found in nature. While other types of pollution such as synthetic chemicals break down over time and do not breed, synthetic biological creations are designed to self-replicate and once released into the environment they would be impossible to stop and could wipe out entire species. This type of pollution, known as genetic pollution, can be devastating since it cannot be cleaned up. Once it has escaped, it can never be removed from the environment.

Dr. Allison Snow, an ecologist at Ohio State University, explained at the Presidential Commission for the Study of Bioethical Issues meeting in 2010 what this scenario might actually look like: “As a hypothetical example of a worst case scenario, a newly engineered type of high-yielding blue-green algae (cyanobacteria) could be grown in thousands of acres of outdoor ponds for biofuels. Algae grown in open ponds will be engineered to be very hardy and they could be more competitive than native strains. The new type of engineered algae might spread to natural habitats—to lakes, rivers, and estuaries, where it might flourish and displace other species. In some cases, this could result in algal blooms that suffocate fish and release toxic chemicals into the environment. So it would be a bad decision to go ahead with this kind of application.”[v] Unfortunately, it is projects such as this that the DOE is hoping will receive a categorical exemption from NEPA and will undergo no serious analysis of the risks these projects pose to the environment or public health. Even if a project is small in scale and still at the research stage, it can have dramatic effects on the environment. The gypsy moths ravaging the oak forests of the eastern United States are the descendants of a failed experiment to use the moths to produce silk. The experiment failed, but we are still dealing with the moths that it accidentally released.

Experts in the field agree that there is no way to contain synthetic or genetically engineered organisms—particularly algae. According to Lissa Morganthaler-Jones, CEO and co-founder of Livefuels Inc., a small number of genetically engineered algae have already leaked from the lab into the environment. "They have been carried out on skin, on hair and all sorts of other ways, like being blown on a breeze out the air conditioning system," she said.[vi] Isaac Berzin, founder of GreenFuel Technologies Corp., the first algae-to-biofuels company, believes that a leak hasn't happened yet but that it is inevitable. "Of course it's going to leak, because people make mistakes," said Berzin. [vii]

Synthetic biologists like to talk about designing in a "kill-switch" or "suicide genes," that could be used to stop any organisms from getting out of control if they are released into the environment. Craig Venter has described how his team of researchers "will be able to engineer synthetic bacterial cells so they cannot live outside of the lab or other production environments. This is done, for example, by ensuring that these organisms have built in dependencies for certain nutrients without which they cannot survive. They can also be engineered with so called 'suicide genes' that kick in to prevent the organism from living outside of the lab or the environment in which they were grown."[viii] Other examples include algae designed without swimming flagella or an inability to absorb the low levels of carbon dioxide found in seawater. [ix]

Unfortunately, ecology has shown that one cannot just engineer safety into synthetic organisms. Even if the novel organisms are domesticated and seem innocuous, argues Dr. Snow, "mutations or unexpected properties might allow them to multiply in some environments. Physical or biological confinement (which could be based on engineered suicide genes or chemical dependencies) may not work forever or in all cases because mutations, human error, or unexpected events might allow [genetically engineered organisms] (GEOs) to escape and reproduce." Dr. Snow continues, "It would take only a few survivors to propagate and spread if biological confinement breaks down. The potential for rapid evolutionary change is especially high in microbes. Some will die out but others may thrive and evolve. GEOs that can exchange genes with related lineages or other species could evolve even faster—allowing synthetic genes to persist in hybrid descendants. So, we cannot assume that all domesticated or supposedly 'suicidal' GEOs are unable to persist in the environment."[x] Isaac Berzin agrees: "You know where you start…but you don't know where you are ending. Algae adapt to their environment. Once you release it into the environment, guess what? They change. They get used to the worst toxins known to man…We live on a small planet, so it doesn't matter if disaster comes from Africa or China or New York. We are all going to be affected when it happens."[xi]

Once a synthetic organism enters the environment, either through intentional or unintentional release, the ways in which these organisms will interact with the natural environment is unpredictable, potentially devastating, and permanent. A synthetic organism designed for a specific task, such as biofuels production, could interact with naturally occurring organisms and adversely harm the environment. The synthetic organism could displace existing organisms or interfere with the existing ecosystem. Once it found an ecological niche in which to survive, it would be difficult if not impossible to eradicate.[xii]

B3.6 Small-Scale Research and Development, Laboratory Operations, and Pilot Projects

DOE proposes to change the phrases "indoor bench-scale research," "small-scale research and development," and "demonstration actions" to "actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment. Demonstration actions frequently follow research and development and pilot projects that are directed at establishing proof of concept." It is unclear exactly what scale would be necessary to prove a technology, a point that must be analyzed through an Environmental Assessment or an Environmental Impact Statement, since different operations and different scales bring varying levels of environmental impact.

This exemption would allow projects such as large-scale open-pond algae farms using genetically engineered and synthetic engineered algae to move forward without any review of the related environmental risks. The Department of Energy and the U.S. Department of Agriculture are already supporting a 300-acre open-pond algae farm in New Mexico operated by Sapphire Energy with a $50 million loan guarantee. While the Environmental Assessment for that project said that the company is using only natural algae, much of the company's own information (including information provided later in the EA) admits that they will in fact use genetically engineered algae in their operation. The risks of GE or synthetic algae escaping from an open-pond algae farm are enormous and cannot be ignored through a categorical exclusion. This is especially true in open-pond operations since algae is an aerosol that can be blown away with the slightest breeze and enter the ecosystem.

B3.8 Outdoor Terrestrial Ecological and Environmental Research

DOE states explicitly in this rule "that small test plots for energy-related biomass or biofuels research (including the use of genetically engineered plants) are within the scope of this categorical exclusion. The fact that the U.S. Department of Agriculture has approved a genetically engineered crop does not guarantee environmental safety. USDA has been sued repeatedly for deregulating GE crops without conducting an Environmental Impact Statement. Lower courts have affirmed numerous times (GE sugar beets and GE alfalfa) the need for USDA to conduct an EIS prior to full deregulation of genetically engineered crops. The U.S. Supreme Court even upheld the ban on Monsanto's Roundup Ready Alfalfa until and unless future deregulation occurs contingent on a full EIS. It would be irresponsible for the DOE to not conduct its own environmental review of GE crops, especially is their intended use is different than that analyzed by the USDA (i.e. biofuels production instead of food production). Different uses of GE crops bring different risks to the environment, each of which need their own analysis.

These "small test plots" should not be used for any GE or synthetic organism, whether it's a crop, algae, microbe, or other self-replicating organism. As mentioned above in point B3.6, much of the outdoor research in biofuels and biomass research involves operations like open-pond algae farms that raise serious environmental concerns that must be reviewed under NEPA.

B3.12 Microbiological and Biomedical Facilities

The siting, construction, modification, operation, and decommissioning of microbiological and biomedical diagnostic, treatment and research facilities must not be excluded from NEPA review. The creation and use of facilities intended to house genetically engineered and synthetic organisms for the production of biofuels raises real risks to the local environment and ecosystem. A full EIS looking at the potential risks of intentional or unintentional release of GE or synthetic organisms, as well as alternatives to using these biotechnologies must be conducted before any microbiological or biomedical facilities are constructed, modified for different uses, or operated. Plans must also be in place if such facilities decommissioned for the safe disposal of any remaining self-replicating organisms that were housed in the facility.

B3.15 Small-Scale Indoor Research and Development Projects Using Nanoscale Materials

The Department of Energy's (DOE) research and development projects that make use of nanoscale materials must not be excluded from NEPA, as outlined in B3.15 of Docket DOE–HQ–2010–0002. There is a growing body of research demonstrating that some nanomaterials used in energy generation, storage and efficiency applications can pose health and environmental risks. For example, carbon nanotubes are touted for use in electronics, energy applications, and specialty car and plane parts; however, early research shows that some forms of nanotubes can cause mesothelioma, the deadly cancer associated with asbestos exposure. [xiii] The release of nanomaterials to the environment could also result in accelerated generation of potent greenhouse gas emissions.

Nanotechnology is a powerful technology that has the potential to deliver novel approaches to the methods by which we harness, use, and store energy. Nevertheless, Friends of the Earth warns that overall, this technology will come at a huge energy and broader environmental cost. Nanotechnology may ultimately facilitate the next wave of expansion of the global economy, deepening our reliance on fossil fuels and existing hazardous chemicals, while introducing a new generation of hazards. Further, it may transform and integrate ever-more parts of nature into our systems of production and consumption. A precautionary approach to nanotechnology is essential for all classes of nanoproducts. Without government action a whole new generation of more energy intensive nanoproducts will flood the market; we need regulations to evaluate not only safety but energy and greenhouse gas (GHG) implications of nanotechnologies. All nanomaterials must be subject to new safety assessments as new substances, even where the properties of larger scale counterparts are well known. All manufactured nanomaterials must also be subject to nano-specific health and environmental impact assessment and must be demonstrated to be safe prior to approval for commercial use.

B5.20 Biomass Power Plants

This proposed exclusion would be for the "installation, modification, operation, and removal of small-scale biomass power plants…using commercially available technology." This would ignore the serious risks biomass for energy use pose to the environment and access to land, water, and inputs for the production of biomass.

Combusting materials to make electricity is inherently polluting, and burning biomass is no exception. Burning biomass (including wood, grasses, garbage, manure, and other materials) for electricity causes significant air pollution, including particulate matter, volatile organic compounds, carbon monoxide, sulfur dioxide and nitrogen oxides, and lead. Emissions of some of these pollutants from biomass can be even higher than from coal combustion and are harmful to local populations because they can cause respiratory impairment, cancer and other health impacts. Science shows that burning biomass can emit almost 1.5 times as much global warming pollution per unit of energy as coal. Converting land from natural forests to monoculture tree plantations for bioenergy production greatly reduces the carbon sequestering capacity found in natural and undisturbed forests. Additional global warming pollution is associated with the harvest and transport of biomass. Energy mandates and incentives that include biomass and do not include protections for natural ecosystems from biomass harvesting could result in widespread forest destruction and soil degradation. Clean energy does not come out of a smokestack: biomass burning for electricity is dirty energy. Additionally, much of the biomass and bioenergy research currently being conducted involves the use of genetically engineered or synthetic organisms tailored to break down specific types of biomass into fuels and other materials, such as industrial chemicals and bio-plastics.

Any new biomass plant using these biotechnologies, regardless of size, must look at the potential environmental impacts such an operation would have. Additionally, NEPA would require that the full scale of environmental impacts – including impact on land and water use – be analyzed. These risks cannot be skimmed over by a categorical exclusion, as proposed in this rule.

B5.25 Small-Scale Renewable Energy Research and Development and Pilot Projects in Salt Water and Freshwater Environments

As already mentioned, algal production for biofuels - especially when it is genetically engineered or engineered with synthetic DNA - raises serious environmental concerns. DOE proposes to exclude the construction of these small-scale facilities for "the growth and harvest of algae as biomass" that are "(1) within areas of hazardous natural bottom conditions, or (2) within the boundary of an established marine sanctuary or wildlife refuge, a governmentally proposed marine sanctuary or wildlife refuge, or a recognized area of high biological sensitivity, or outside those areas if the activities would have the potential to cause significant impacts within those areas."

Unfortunately, algae are a natural aerosol and can easily escape into local ecosystems, waterways, soils, and even the human body through inhalation. Any operation planning to use GE or synthetic algae must undergo thorough environmental review to ensure the proposed action will not significantly impact the human environment. These operations using algae must not be categorically exempt from proper NEPA review since the conditions being proposed for exemption are far from a guarantee of environmental safety.

Conclusion

Thank you for this opportunity to submit comments to the Office of the General Council of the U.S. Department of Energy regarding the proposed rule changes under Docket ID: DOE–HQ–2010–0002. We hope that the above items will not be considered for categorical exemption from NEPA review since those major federal actions would raise potential risks to the human environment and must not be ignored in the name of streamlining the Department's regulations.

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[vi] Maron, Dina Fine. "The Race to Make Fuel Out of Algae Poses Risks as Well as Benefits" *The New York Times*. 22 July 2010. <http://www.nytimes.com/cwire/2010/07/22/22climatewire-the-race-to-make-fuel-out-of-algae-poses-ris-80037.html?pagewanted=1>.
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[viii] Venter, J. Craig. Testimony at Hearing on Developments in Synthetic Genomics and Implications for Health and Energy. House of Representatives, Washington, DC. 27 May 2010.

[ix] Maron, Dina Fine. "The Race to Make Fuel Out of Algae Poses Risks as Well as Benefits"
[x] Snow, Allison. "Risks of Environmental Releases of Synthetic GEOs."
[xi] Maron, Dina Fine. "The Race to Make Fuel Out of Algae Poses Risks as Well as Benefits"
[xii] Ibid.
[xiii]Poland, C.,. et al Carbon nanotubes introduced into the abdominal cavity of mice show asbestos-like pathogenicity in a pilot study. Nature Nanotechnology 3, 423 - 428 (2008) Published online: 20 May 2008

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General Comment

See attached file(s)

Attachments

DOE-HQ-2010-0002-0043.1: Comment on FR Doc # 2010-32316

Comments to DOE-HQ-2010-0002-0014 due 3.7.2011

You paint too broad a brush.

In California with active environmental groups and with CEQA, the categorical exclusions beg for civil lawsuits.

Why do this?

Most energy projects are major. Earthquake issues are critical, as are flooding issues.

Water is valuable and use of it without source recognition is a major factor.

You propose to limit "use of the categorical exclusion to situations where there is low potential for seismicity, subsidence, and contamination of freshwater aquifers and where the actions are otherwise consistent with best practices and DOE protocols, including those that protect against uncontrolled releases of harmful materials."

Just how is that defined? In California, it would warrant an Initial Study and an Environmental Impact Report.

Injection wells are dangerous. Though an experimental well may have been chosen carefully, the policy makers with money making ideas and no sense of danger wish to multiply the potential revenue.

That is never taken into consideration at this level of NEPA.

Stormwater control is another potential money maker for local policymakers. The danger is high.

This approach in this document is unacceptable. Public health and safety should be a consideration first and foremost.

Saltwater intrusion and destruction of wetlands and aquifers have always been major problems. Again, civil suits are filed. It appears you wish the Federal courts to handle the issue also.

Education and its facilities is a State matter. This appears to be placed for university consideration, but that is not confined only to private universities. The education market is not a Federal issue and Executive Order 13132 should apply.

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Comment on FR Doc # 2010-32316

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General Comment

See attached file(s)

Attachments

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March 7, 2011

Ms. Carol Borgstrom
NEPA Rulemaking Comments
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U.S. Department of Energy
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Re: DOE NEPA Implementing Procedures, RIN 1990–AA34

Dear Ms. Borgstrom:

Thank you for the opportunity to comment on the Department of Energy (DOE) Notice of Proposed Rulemaking on the National Environmental Policy Act (NEPA) Implementing Procedures regarding the proposed establishment and modification of new and existing categorical exclusions. These comments are submitted on behalf of Defenders of Wildlife (Defenders), a non-profit public interest conservation organization with over 500,000 members nationally.

As we transition toward a clean energy future, it is imperative for our future and the future of our wild places and wildlife that we strike a balance between addressing the near-term impact of large scale solar development with the long-term impacts of climate change on our biological diversity, fish and wildlife habitat, and natural landscapes. To ensure that the proper balance is achieved, we need smart planning for renewable power that avoids and minimizes adverse impacts on wildlife and wild lands. These projects should be placed in the least harmful locations, near existing transmission lines and on already disturbed lands.

We applaud the Department of Energy's goals of removing barriers towards the adoption of new and innovative research on renewable energy. While we thank the agency for its commitment to the development of renewable energy technologies, we are concerned that sufficient criteria have not been established to ensure that actions "do not, absent extraordinary circumstances, individually or cumulatively have a significant impact on the human environment and for which, therefore, neither an EA nor an EIS is required. *See* 40 C.F.R. 1508.4.

Comments:

1. B6.0 Previously Disturbed or Developed Area.

DOE proposes to allow numerous activities[i] on or contiguous to "previously disturbed or developed areas" based upon categorical exclusions. The preamble defines previously disturbed areas as "land that has been changed such that the former state of the area and its functioning ecological processes have been altered." Defenders agrees that siting projects in already disturbed areas will often result in reduced impacts on natural resources. Unfortunately, the definition offered in the preamble is too vague to provide an understanding of the areas identified by DOE and, therefore, support the agency's use of categorical exclusions.

If the goal of this provision of the proposed rules is to encourage siting of new facilities in areas that are already developed, Defenders suggests specific mention of the many brownfield, superfund, and abandoned mine locations that have been identified through the Environmental Protection Agency's Repowering America program, in partnership with the DOE.

2. B5.15 Small-Scale Renewable Energy Research and Development and Pilot Projects.

B5.15 is a proposed CE for small-scale renewable energy research and development projects and small-scale pilot projects. Such projects shall be limited to "those in previously disturbed and developed areas" and will be developed "in accordance with applicable requirements and incorporate appropriate controls and practices."

Recent utility-scale solar development on western public lands has included projects as large as 5,000 or more acres. In this context, a small-scale renewable energy project could easily encompass tens or hundreds of acres, and site-specific ecological and wildlife impacts may be significant even at these reduced scales. Additionally, while we firmly support the establishment of renewable energy on previously disturbed or developed lands, these lands may also contain important ecological resources. Therefore, we recommend that the "appropriate controls and practices" for siting and implementing small-scale renewable energy projects include the following:

- Pre-development surveys for endangered and threatened species and other sensitive ecological resources. Projects that will or have the potential to adversely affect endangered and threatened species or other sensitive ecological resources are not eligible for this CE.

- Appropriate mitigation measures designed to insure that projects compensate for impacts to ecological resources, such as biological diversity and water resources.
- Continued monitoring of environmental impacts to guide future application of the CE.
- Decommissioning/reclamation plans to restore impacted lands.

3. B5.16 Solar Photovoltaic Systems.

B5.16 is a proposed CE for the installation and operation of commercially available solar photovoltaic systems on existing building and structures or on lands "generally comprising less than 10 acres with a previously disturbed or developed area." Projects must comply with local zoning and "incorporate appropriate control technologies and best management practices."

We applaud the DOE for providing a mechanism to accelerate the development of distributed solar systems for existing buildings and structures under this proposed CE. However, the extension of the proposed CE to "land generally comprising less than 10 acres" increases the likelihood of adverse impacts to ecological resources. Therefore, we recommend that the best management practices for siting and implementing solar photovoltaic systems include the following:

- Pre-development surveys for endangered and threatened species and other sensitive ecological resources. Projects that will or have the potential to adversely affect endangered and threatened species or other sensitive ecological resources are not eligible for this CE.
- Appropriate mitigation measures designed to insure that projects compensate for impacts to ecological resources, such as biological diversity and water resources.
- Continued monitoring of environmental impacts to guide future application of the CE.
- Decommissioning/reclamation plans to restore impacted lands.

4. B5.17 Solar Thermal Systems.

B5.17 is a proposed CE for the installation and operation of "commercially available small-scale solar thermal systems (e.g. solar hot water systems) at an existing facility or on land generally comprising less than 10 acres within a previously disturbed or developed area." Projects must comply with local zoning and "incorporate appropriate control technologies and best management practices."

We applaud the DOE for providing a mechanism to accelerate the development of solar thermal systems for existing buildings and structures under this proposed CE. However, the extension of the proposed CE to “land generally comprising less than 10 acres” increases the likelihood of adverse impacts to ecological resources. Therefore, we recommend that the best management practices for siting and implementing solar thermal systems include the following:

- Pre-development surveys for endangered and threatened species and other sensitive ecological resources. Projects that will or have the potential to adversely affect endangered and threatened species or other sensitive ecological resources are not eligible for this CE.
- Appropriate mitigation measures designed to insure that projects compensate for impacts to ecological resources, such as biological diversity and water resources.
- Continued monitoring of environmental impacts to guide future application of the CE.
- Decommissioning/reclamation plans to restore impacted lands.

5. B5.18 Wind turbines.

B5.18 is a proposed CE for the installation and operation of “commercially available small wind turbines, with a total height generally less than 200 feet.” Turbines shall be located within a previously disturbed or developed area and be sited so as to not have “potential to cause significant impacts on bird or bat species.” Projects must comply with local zoning and “incorporate appropriate control technologies and best management practices.”

We understand this categorical exclusion to apply to the installation of a single wind turbine at residential or facility scale. A CE would not be appropriate for the installation of small-scale wind farms which include multiple turbines. Wind turbines, regardless of their size, have the potential to adversely affect bird and bat species depending on their location. Therefore, we recommend that the best management practices for siting and implementing wind turbines include the following:

- Limit project size available for this CE to a single wind turbine supporting an existing or proposed facility.
- Pre-development surveys for bird and bat species, with a special emphasis on endangered and threatened species and other sensitive species. Projects that will or have the potential to adversely affect endangered and threatened species or other sensitive species are not eligible for this CE.

- Continued monitoring of environmental impacts to guide future application of the CE. Should impacts to birds or bat be discovered, project plans shall include appropriate operational changes to ameliorate impacts.

6. B5.25 Small-Scale Renewable Energy Research and Development and Pilot Projects in Salt Water and Freshwater Environments.

B5.25 is a proposed CE for the installation and operation of "small-scale renewable energy research and development projects and small-scale pilot projects located in salt water and freshwater environments." Project activities would be in accordance with approved spill prevention, control, and response plans and incorporate "appropriate control technologies and best management practices." Additionally, projects would not be installed in certain ecologically sensitive environments, i.e. wildlife refuges, etc., and not be permanent installations.

The siting of renewable energy development projects in salt and freshwater environments has the potential to adversely affect ecological resources. We recommend that the best management practices for siting and implementing small-scale renewable energy research and development and pilot projects in salt water and fresh water environments include the following:

- Pre-development surveys for endangered and threatened species and other sensitive ecological resources. Projects that will or have the potential to adversely affect endangered and threatened species or other sensitive ecological resources are not eligible for this CE.
- Appropriate mitigation measures designed to insure that projects compensate for impacts to ecological resources, such as biological diversity and water resources.
- Continued monitoring of environmental impacts to guide future application of the CE.
- Decommissioning/reclamation plans to restore impacted lands and waters.

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[i] The list includes: B1.31 Installation or Relocation of Machinery and Equipment; B1.35 Drop-off, Collection and Transfer Facilities for Recyclable Materials; B2.1 Workplace Enhancements; B3.6 Small-Scale Research and Development, Laboratory Operations, and Pilot Projects; B3.10 Particle Acelerators; B3.12 Microbiological and Biomedical Facilities; B3.14 Small-Scale Educational Facilities; B3.15 Small-Scale Indoor Research and Development Projects Using Nanoscale Materials; B4.6 Additions and Modifications to Transmission Facilities; B4.7 Fiber Optic Cable; B4.8 Electricity Transmission Agreements; B4.12 Construction of Transmission Lines; B5.1 Actions To Conserve Energy or Water; B5.5 Short Pipeline Segments; B5.8 Import or Export Natural Gas, With New Cogeneration Powerplant; B5.15 Small-Scale Renewable Energy Research and Development and Pilot Projects; B5.16 Solar Photovoltaic Systems; B5.17 Solar Thermal Systems; B5.18 Wind Turbines; B5.19 Ground Source Heat Pumps; B5.20 Biomass Power Plants; B5.21 Methane Gas Recovery and Utilization Systems; B5.22

Alternative Fuel Vehicle Fueling Stations; B5.23 Electric Vehicle Charging Stations; B6.10 Upgraded or Replacement Waste Storage Facilities; C4 Upgrading, Rebuilding, or Construction of Electric Transmission Lines; C11 Particle Acceleration Facilities.

We thank you for the opportunity to provide these comments. Please do not hesitate to contact Erin Lieberman at (202) 772-3273 or elieberman@defenders.org if you require any further information or clarification of our comments.

Erin Lieberman
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PUBLIC SUBMISSION

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Docket: DOE-HQ-2010-0002
Rulemaking to Amend 10 CFR Part 1021: National Environmental Policy Act Implementing Procedures

Comment On: DOE-HQ-2010-0002-0032
Re-opening of public comment period - National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0045
Comment on FR Doc #2010-32316

Submitter Information

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Organization: Kaibab Band of Paiute Indians

General Comment

Attachments

DOE-HQ-2010-0002-0045.1: Comment on FR Doc #2010-32316

From: Leann [mailto:kptenv@scinternet.net]
Sent: Monday, March 07, 2011 6:48 PM
To: askNEPA
Subject: Comment on Proposed Additional Categorical Exclusions

We wish to make a comment on this. As the Gulf oil spill pointed out, it is important that we make decisions prudently and not use categorical exclusions to facilitate experimental or unproved techniques, or proven techniques employed in extreme situations, that may easily backfire.

We do not support the use of categorical exclusions in the NEPA process for experimental and R&D projects because their nature is inherently unpredictable and must be fully vetted by the analysis used in EAs and EISs.

LeAnn Skrzynski;
Environmental Program Director
Kaibab Band of Paiute Indians

PUBLIC SUBMISSION

As of: 3/14/11 1:52 PM
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Comments Due: March 07, 2011

Docket: DOE-HQ-2010-0002
Rulemaking to Amend 10 CFR Part 1021: National Environmental Policy Act Implementing Procedures

Comment On: DOE-HQ-2010-0002-0032
Re-opening of public comment period - National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0046
Comment on FR Doc #2011-03981

Submitter Information

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General Comment

Attachments

DOE-HQ-2010-0002-0046.1 Comment on FR Doc #2011-03981

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 1 7 2011

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

Office of NEPA Policy and Compliance
(GC-54)
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, DC 20585

Dear Sir/Madam:

In accordance with our responsibilities under Section 309 of the Clean Air Act, the Environmental Protection Agency (EPA) has reviewed the proposed rulemaking for the Department of Energy's (DOE) National Environmental Policy Act (NEPA) Implementing Procedures.

The Council on Environmental Quality's NEPA implementing regulations require federal agencies to adopt procedures to supplement its regulations. These procedures shall include specific criteria for and identification of those typical classes of actions which normally: 1) require environmental impacts statements (EISs); 2) require environmental assessments (EAs) but not necessarily EISs and; 3) do not require either an EA or EIS but instead, categorical exclusions (CATEXs). DOE has promulgated such procedures, which were last updated in 1996.

Since that time, the range of activities in which DOE is involved has changed and expanded. Several of these changes are the result of the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, and the American Recovery and Reinvestment Act of 2009. DOE has also experienced changes due to the growth and development of new technologies in the private and public sectors, including energy efficient and renewable energy technologies. As a result, DOE is proposing revisions to its NEPA procedures. Specifically, DOE is proposing to establish one new EA category and two new EIS categories. It is also proposing to establish 20 new CATEXs, and to remove two CATEX categories. EPA believes that these proposed changes will enhance the efficiency of DOE's environmental review process while maintaining appropriate consideration of environmental effects pursuant to NEPA. Accordingly, we do not object to the proposed rulemaking.

We appreciate the opportunity to review this proposed rulemaking. If you have any further questions you may contact me at (202) 564-5400. You may also call my staff point of contact, Marthea Rountree. She can be reached at (202) 564-7141.

Sincerely,

Susan E. Bromm

Susan E. Bromm
Director
Office of Federal Activities

PUBLIC SUBMISSION

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Comment On: DOE-HQ-2010-0002-0032
Re-opening of public comment period - National Environmental Policy Act Implementing Procedures

Document: DOE-HQ-2010-0002-0047
Late Comment submitted by Edison Electric Institute on FR Doc #2011-03981

Submitter Information

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Organization: Edison Electric Institute (EEI)

General Comment

Attachments

DOE-HQ-2010-0002-0047.1: Late Comment submitted by Edison Electric Institute on FR Doc #2011-03981

March 14, 2011
Ms. Carol Borgstrom, Director
Office of NEPA Policy and Compliance (GC-54)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Submitted via: US Postal Service

Re: **NEPA Rulemaking Comments, Docket ID: DOE-HQ-2010-0002, RIN 1990-AA34, 76 Fed. Reg. 214 (Jan. 3, 2011)**

Dear Ms. Borgstrom:

The Edison Electric Institute (EEI) is submitting these comments in response to the U.S. Department of Energy's (DOE's) above- referenced notice of proposed rulemaking (NOPR) to amend DOE regulations governing compliance with the National Environmental Policy Act (NEPA).

EEI is the association of shareholder-owned electric utilities in the United States, international affiliates, and industry associates worldwide. Our members serve 95 percent of the ultimate customers in the shareholder-owned segment of the industry, they and represent approximately 70 percent of the U.S. electric power industry.

EEI members engage in various electricity generation, transmission, distribution, sales, and related activities that can involve efficiency, funding, planning, and resource decisions by DOE. In these contexts, NEPA may apply, and EEI members can be directly impacted by the process that DOE undertakes to comply with NEPA as well as the outcome of that process. Therefore, EEI and our members have a direct interest in the NOPR.

EEI commends DOE for taking steps to update the agency's NEPA regulations, which DOE last updated in 1996. As DOE observes in the NOPR, the agency has gained substantial experience in the past 15 years – and so have other federal agencies – making such an update appropriate. By updating the regulations, DOE is striving to fine-tune them to ensure that NEPA review is done efficiently without wasting limited public and private resources on unnecessary reviews. This is entirely appropriate.

EEI thus supports efforts by DOE to clarify and amend the list of types of projects that are appropriate for categorical exclusion under 10 CFR Part 1021 Subpart D appendices

A and B. By identifying activities appropriate to treat as categorical exclusions, DOE is properly avoiding the need for case-by-case environmental assessments and environmental impact statements that would reach the same conclusion. This avoids wasting limited DOE and other public and private resources and ensures that those resources can be put to more productive use.

Though EEI is not commenting on each individual proposed change in the NOPR, we believe that DOE has done a careful job of identifying types of actions that will not have a significant effect on the human environment and so qualify as categorical exclusions under Council on Environmental Quality (CEQ) regulations at 40 C.F.R. §§ 1507.3 and 1508.4. We also commend DOE for consulting with CEQ in undertaking the update to the DOE NEPA regulations, as required by § 1507.3, thus giving further assurance that the changes proposed by DOE are appropriate.

EEI appreciates that DOE has included updates to its NEPA regulations relating to power resources (appendix B, section 4) and conservation, fossil, and renewable energy activities, including electric vehicle charging stations (appendix B, section 5). We support DOE updating the list of electricity generation and delivery activities that qualify as categorical exclusions. We encourage DOE to continue to identify and to refine the list over time, to avoid unnecessary case-by-case NEPA reviews.

In section IV.B of the NOPR preamble, DOE proposes to change terminology in its NEPA regulations from "electric powerlines" to "electric transmission lines." EEI recommends that DOE consider modifying the proposed new phrase to read "electric transmission and distribution lines and related facilities" (using "or" instead of "and" as appropriate in context) to ensure that the relevant categorical exclusions are not limited just to transmission lines but apply to energy delivery facilities more generally.

In section IV.E of the NOPR preamble, DOE proposes changes to appendix B, which covers specific types of actions that qualify as categorical exclusions. EEI would offer a few observations about these provisions:

- At B1.7, DOE proposes to add smart grid technology as an example of the "electronic equipment" categorical exclusion. EEI supports this change.
- At B1.19, DOE proposes to cover the life cycle of microwave, meteorological, and radio towers as a categorical exclusion. EEI encourages DOE to add individual electric transmission towers and distribution poles to this list, as their footprints are of the same nature as these other facilities.
- At B1.25, DOE proposes to provide that property transfers for cultural resource protection, habitat preservation, and wildlife management are categorically exempted. EEI encourages DOE to stipulate that any permit holders and owners of facilities on land involved in the transfers must be given advance notice so they can protect their rights.
- At B3.9, DOE proposes to expand the categorical exclusion for projects to reduce emissions and waste generation to cover a wider array of fuels, including

coal, natural gas, and biomass. EEI agrees with including such fuels and encourages DOE to consider removing a fuel constraint altogether.

- At B4.9, DOE proposes to specify that natural gas pipelines, communication cables, and roads are examples of multiple uses of transmission line rights-of-way that are categorically excluded. [EEI agrees, but] DOE should specify that such multiple uses need to accommodate technical and other concerns that may be raised by the owners of the transmission facilities involved.
- [At B4.10, DOE proposes to include abandonment and restoration of rights-of-way to the "removal of electric transmission lines and substations" categorical exclusion. EEI agrees, but again DOE should stipulate that any permit holders and owners of facilities affected by the abandonment must be given advance notice so they can protect their rights.]

Again, EEI is not commenting on the details of each of DOE's proposals. But we do support DOE taking steps to identify activities that qualify for categorical exclusion from case-by-case NEPA review, to ensure that DOE, other agency, public, and private resources are put to more productive use than NEPA review of activities with no significant environmental effect.

If you have any questions, please contact Henri Bartholomot (202/508-5622, hbartholomot@eei.org), Rick Loughery (202/508-5647, rloughery@eei.org), or Meg Hunt (202/508-5634, mhunt@eei.org).

Sincerely,

Richard M. Loughery
Director, Environmental Activities

Submitted Via Electronic Mail to asknepa@hq.doe.gov

BIOTECHNOLOGY
INDUSTRY ORGANIZATION

May 17, 2011

Docket No. DOE-HQ-2010-0002

Office of NEPA Policy and Compliance
Attn: Carol Borgstrom (GC-54)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Re: DOE NEPA Implementing Procedures, RIN 1990-AA34

Ms. Borgstrom:

The Biotechnology Industry Organization (BIO) submits these comments in response to the January 3, 2011 notice of proposed rulemaking (NOPR) by the United States Department of Energy (DOE) regarding the proposed amendments to existing regulations governing algal biomass production and compliance with the National Environmental Policy Act (NEPA). The existing regulatory framework for algal biomass sufficiently protects human health and the environment; making categorical exclusions for small-scale research, laboratory, or pilot (demonstration) projects appropriate in future rulemakings. Though the formal comment period has closed, BIO is pleased to offer these comments on the DOE's proposed actions that affect renewable energy projects involving genetically enhanced algal biomass for renewable energy production. BIO appreciates the opportunity to be involved in this important process on behalf of its member companies.

BIO is the world's largest biotechnology organization, providing advocacy, business development, and communications services for more than 1,100 member companies worldwide. BIO represents leading technology companies in the production of conventional and advanced biofuels and other sustainable solutions to energy and climate change. Some of BIO's members are involved in research and development associated with algal biomass production, providing BIO with a nexus to the proposed rulemaking. BIO also represents companies working to develop new crop technologies for food, feed, fiber, and fuel.

BIO applauds the DOE's goals of removing barriers toward the adoption of new and innovative research on renewable energy. The DOE proposals to expedite its environmental review of renewable energy projects will accelerate research and development by public and private institutions, while continuing to protect the natural and human environments.

BIO strongly supports science-based regulation of innovative technologies that focuses on reducing and eliminating actual risks to the natural and human environment. BIO shares the fundamental desire for regulation and oversight that ensures the fulfillment of legitimate objectives such as the protection of safety, health, and the environment while also supporting innovation in this important and emerging area of biotechnology. BIO member companies therefore seek the assurance of well-reasoned, well-balanced, and predictable regulations. Clear regulations and consistent oversight are essential elements to an economy that will enable BIO's members to secure capital investment needed to bring leading-edge technologies to market. Accordingly, BIO urges the DOE to adopt regulations that respect the principles for regulation and oversight delineated in the Coordinated Framework for the Regulation of Biotechnology[1] and as articulated by the White House Emerging Technologies Interagency Policy Coordination Committee.[2]

Federal regulatory statutes affecting this nascent industry are already considerable, sufficient, and effective. Therefore, the DOE's proposed categorical exclusions for small-scale research and development and pilot-scale algal projects are adequate to ensure safety to humans and the environment.

[1] 51 Fed. Reg. 23302 (June 26, 1986).
[2] The White House Emerging Technologies Interagency Policy Coordination Committee, *Memorandum for the Heads of Executive Departments and Agencies*, (March 11, 2011), *available at* http://www.whitehouse.gov/sites/default/files/microsites/ostp/etipc-memo-3-11-2011.pdf.

BIO strongly supports the DOE's proposals for categorical exclusion for the following actions that apply to algal biomass for renewable energy: (1) research activities in salt water and freshwater environments (B3.16), (2) for small-scale renewable energy research and development and pilot projects (B5.15), and, (3) for small-scale renewable energy research and development and pilot projects in salt water and freshwater environments (B5.25). BIO believes these proposals are well-reasoned and appropriate in their scope and conformance to conditions for categorical exclusions permitted in the DOE's implementing regulations.[3]

BIO member companies are developing new algal biomass technologies for renewable energy in a variety of closed systems and open-ponds. These companies diligently follow routine steps to ensure compliance with regulatory requirements and guard against any environmental, health, and safety risks. Organism characterization enables companies conducting algae projects to assess and avoid potential plant pest characteristics and potential environmental and health risks. Existing law requires a comprehensive and scientific characterization of an algal species is required for advanced development and, in the case of genetically enhanced micro-organisms (GEMs), an understanding of the specific genetic modification and its expression in the algal organism is required.

Laboratory research involving genetically enhanced organisms is routinely conducted in accordance with biosafety and containment guidelines established by the National Institutes of Health (NIH).[4] These guidelines define control technologies and best management practices for laboratory research, which are tiered to risk characteristics of the subject organism. Compliance with NIH guidelines is mandatory for research at institutions receiving NIH funding, including research with NIH funds on genetically enhanced algae.

Under the Coordinated Framework for the Regulation of Biotechnology, research involving genetically enhanced algae may be subject to regulation by the US Department of Agriculture (USDA) under the Plant Protection Act[5] and/or the Environmental Protection Agency (EPA)

[3] 10 CFR §§ 1021.100-410, *available at* http://nepa.energy.gov/documents/nepa1021_rev.pdf.
[4] The Nat'l Inst. of Health, Office of Biotechnology Activities, *Guidelines for Research Involving Recombinant DNA Molecules*, (Jan. 2011), *available at* http://oba.od.nih.gov/oba/rac/Guidelines/NIH_Guidelines_prn.pdf.
[5] 7 U.S.C. §§ 7701 et seq.

under the Toxic Substances Control Act (TSCA).[6] These statutes provide clear regulatory procedures for containing genetically enhanced algae and require entities working with genetically enhanced algae to follow these procedures unless the algae is specifically approved for release into the environment.[7] An unintentional release of regulated genetically enhanced algae from a research facility or other containment structure may be subject to enforcement action by the USDA[8] or the EPA[9] for failing to properly contain the organisms.[10] The USDA, EPA, or both of these Agencies must evaluate and then approve the intentional release of genetically enhanced algae into the environment. Moreover, decisions by these Agencies must conform to NEPA standards and the respective agency's regulations implementing NEPA.

The three proposed DOE categorical exclusions identified in the NOPR include a common condition for covered actions. Under each exclusion, research and development would be conducted in accordance with an approved spill prevention, control, and response plan, and would incorporate appropriate control technologies and best management practices.[11] BIO supports the inclusion of those elements as a condition for covered actions to qualify for categorical exclusions under DOE implementing regulations. BIO offers the following as examples of control technologies and management practices that member companies currently implement in small-scale research and development or pilot projects involving algae biomass for renewable energy.

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[6] 15 U.S.C. §§ 2604(a).

[7] The USDA Animal and Plant Health Inspection Service (APHIS) is responsible for regulating GE organisms and plants under the plant pest authorities in the Plant Protection Act of 2000, as amended (7 USC § 7701 et seq.) to ensure that they do not pose a plant pest risk to the environment. The importation, interstate movement and environmental release of genetically engineered organisms are regulated through permitting, notifications, and deregulation if the donor organism, recipient organism, or vector or vector agent belongs to any genera or taxa designated by USDA as a plant pest and meets the plant pest definition, or is (i) an unclassified organism and/or an organism whose classification is unknown, (ii) any product which contains such an organism, or (iii) any other organism or product which USDA determines is a plant pest or has reason to believe is a plant pest (i.e., regulated article). Under APHIS regulations, no person shall introduce any regulated article unless APHIS is notified of the introduction in accordance with §340.3, or such introduction is authorized by permit in accordance with §340.4, or such introduction is conditionally exempt from permit requirements under §340.2(b); and such introduction is in conformity with all other applicable restrictions in this part. APHIS must consider the potential environment impacts of its decisions in accordance with NEPA regulations (40 CFR Parts 1500-1508) and the USDA and APHIS NEPA implementing regulations and procedures (7 CFR Part 1b, and 7 CFR Part 372).

[8] The Animal and Plant Health Inspection Service, *Introduction of Organism and Products Altered or Produced Through Genetic Engineering Which Are Plant Pests or Which There is Reason to Believe Are Plant Pests.* 7 CFR § 340 (1987).

[9] Microbial Products of Biotechnology: Final Rule. 40 CFR § 725 (1997).

[10] The U.S. Env. Protection Agency, *EPA Compliance with NEPA*, available at http://epa.gov/enforcement/nepa/epacompliance/index.html. *See also* 40 CFR § 725.235. Any manufacturer, importer, or processor required to report activities under TSCA must file a notification with EPA, unless the activity is eligible for a specific exemption under the regulation. The intentional environmental release of a new intergeneric microorganism requires prior notification to EPA and EPA authorization. Research and development activities conducted inside a structure is exempt from prior notification provided certain conditions are met. EPA is legally required to comply with the procedural requirements of NEPA. Courts have consistently recognized that EPA procedures or environmental reviews under enabling legislation are functionally equivalent to the NEPA process and thus exempt from procedural requirements in NEPA.

[11] *See* 76 Fed. Reg. 214 at pages 226 (Exclusion B3.16), 230 (Exclusion B5.15), and 233 (Exclusion B5.25).

Small-Scale Outdoor Closed Systems:

Small-scale outdoor closed systems for algal biomass production employ redundant containment structures for algal cultures. Primary containment vessels fully enclose the algal cultures while allowing the introduction of nutrient media and gases as well as the removal of mature algal cultures and exhaust gases through flexible fittings and rigid piping. Primary containment vessels are surrounded by secondary vessels capable of containing the entire volume of primary vessels in the event of a sudden or catastrophic breach of the primary containment. The liquid in the secondary vessels is monitored for the unintended presence of algae and is chemically disinfected as necessary. Liquid handling and ancillary equipment (hoses, pumps, tanks, heaters, and coolers) are routinely monitored for leakage. Process and wastewater is chemically disinfected before discharge into sanitary sewers or other authorized waste discharge streams. The disinfection procedures are designed to reduce viable microbial populations by at least 6 logs in liquid and solid wastes.[12] Algal biomass is harvested and processed within a secondary containment structure to prevent release into the environment. Containment vessels and liquid handling and ancillary equipment are chemically disinfected as necessary to maintain proper operating conditions. Moreover, TSCA requires a written spill prevention and control plan to be implemented for routine operations and to address any emergency spills.

Small-Scale Open Pond Systems:

Small-scale open pond systems utilized in photosynthetic algal biomass production also employ redundant containment structures. The primary containment vessels used in pond systems are waterproof and chemical-resistant liners. Secondary containment measures consist of berms surrounding the entire pond system, which are deep and large enough to contain everything in the primary vessels in the event of a sudden or catastrophic breach of primary containment measures.

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[12] Log reduction is a mathematical term used to show the relative number of live microbes eliminated from a surface by disinfecting or cleaning. For example, a 6-log reduction means lowering the number of microorganisms by 1,000,000-fold; that is, if a surface has 1,000,000 microbes on it, a 6-log reduction would reduce the number of microorganisms to one.

Primary containment vessels are regularly monitored for leaks and liner damage. The soil, water, air, and vegetation surrounding open pond systems are also regularly monitored for the presence of algae. Evaporation ponds, which are essential in the use of brackish and salt-water systems, are also monitored for the presence of algal organisms, and render additional chemical treatment of wastewater unnecessary. Liquid handling and ancillary equipment are also routinely monitored to prevent leakage.

These control technologies and management practices have proven to be sufficient to protect against inadvertent risks to environmental and human safety from small-scale research and development, and pilot projects involving algal biomass for renewable energy. BIO appreciates the opportunity to comment on the DOE's proposed rulemaking. We would be pleased to provide additional information on this matter as requested.

Very truly yours,

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