15th DEER Conference

New Directions in Engines and Fuels

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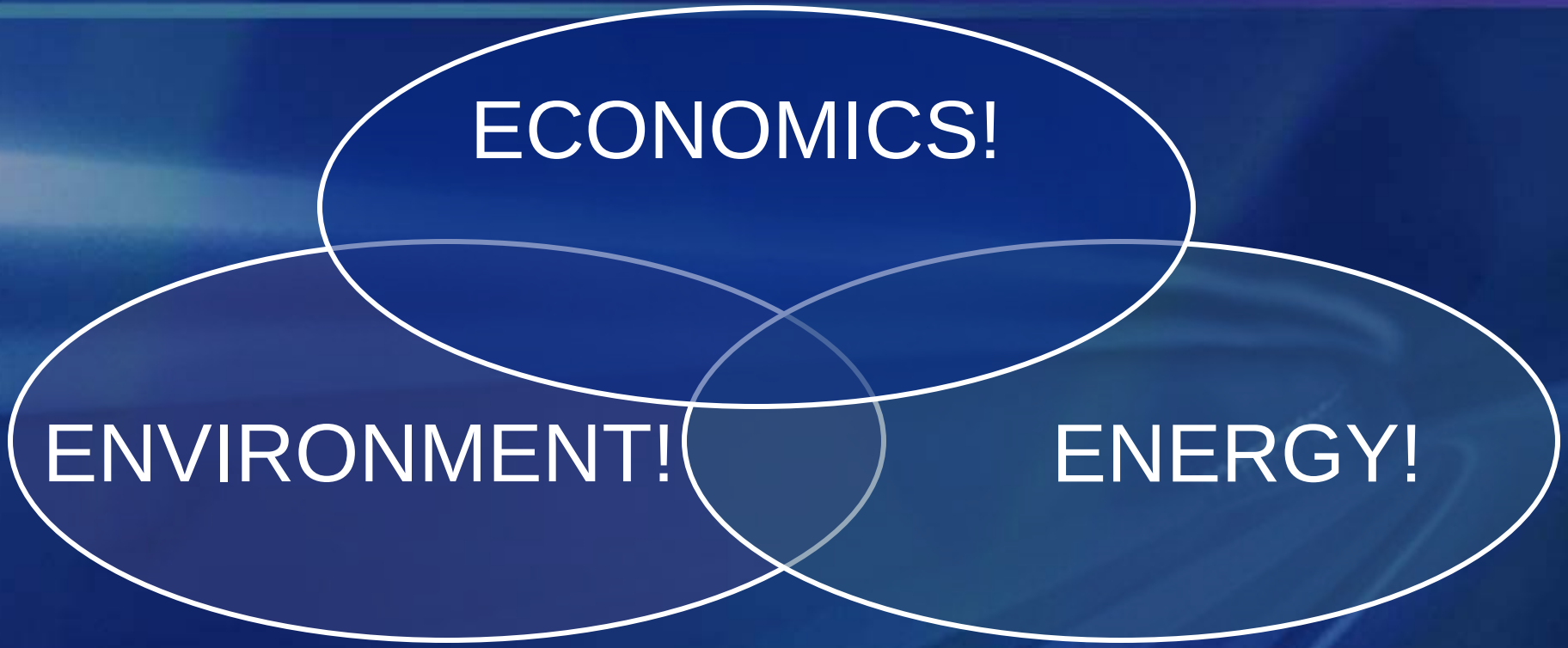
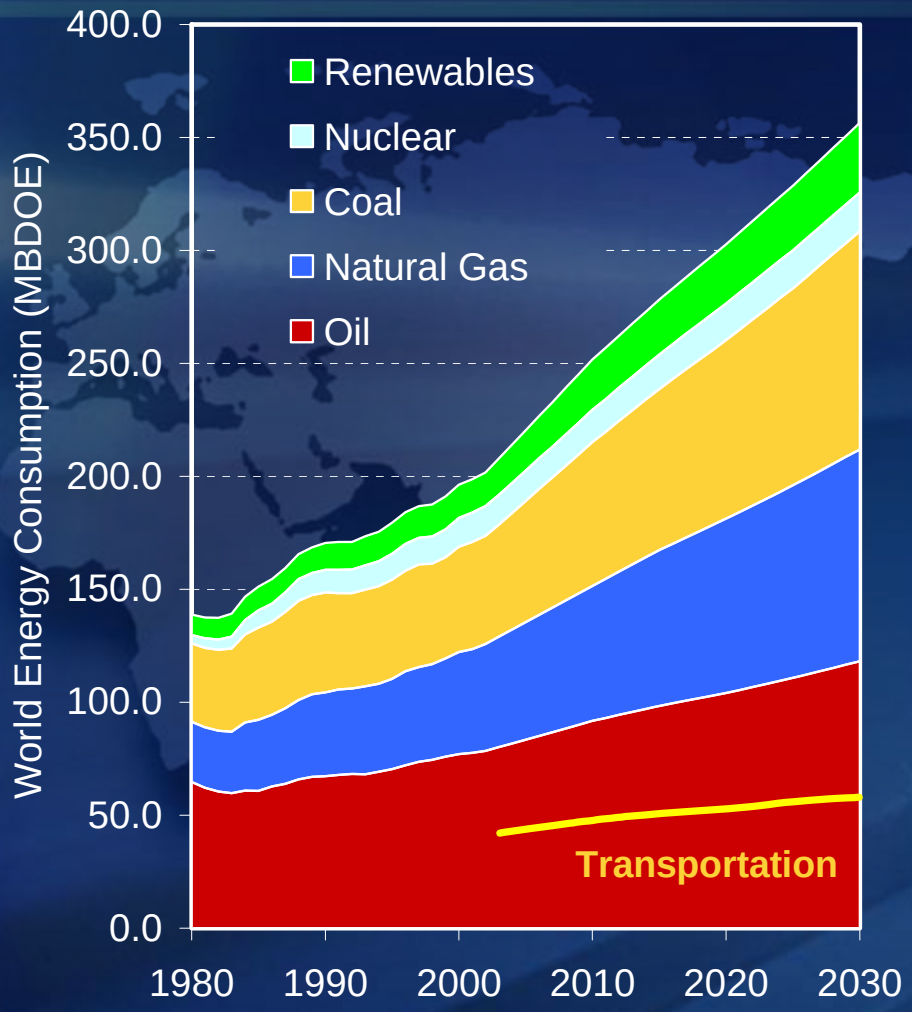
Our Industry is in a State of Transformation!



The 3 Es: SUSTAINABILITY

Global Energy Consumption to 2030 -The projections in 2006

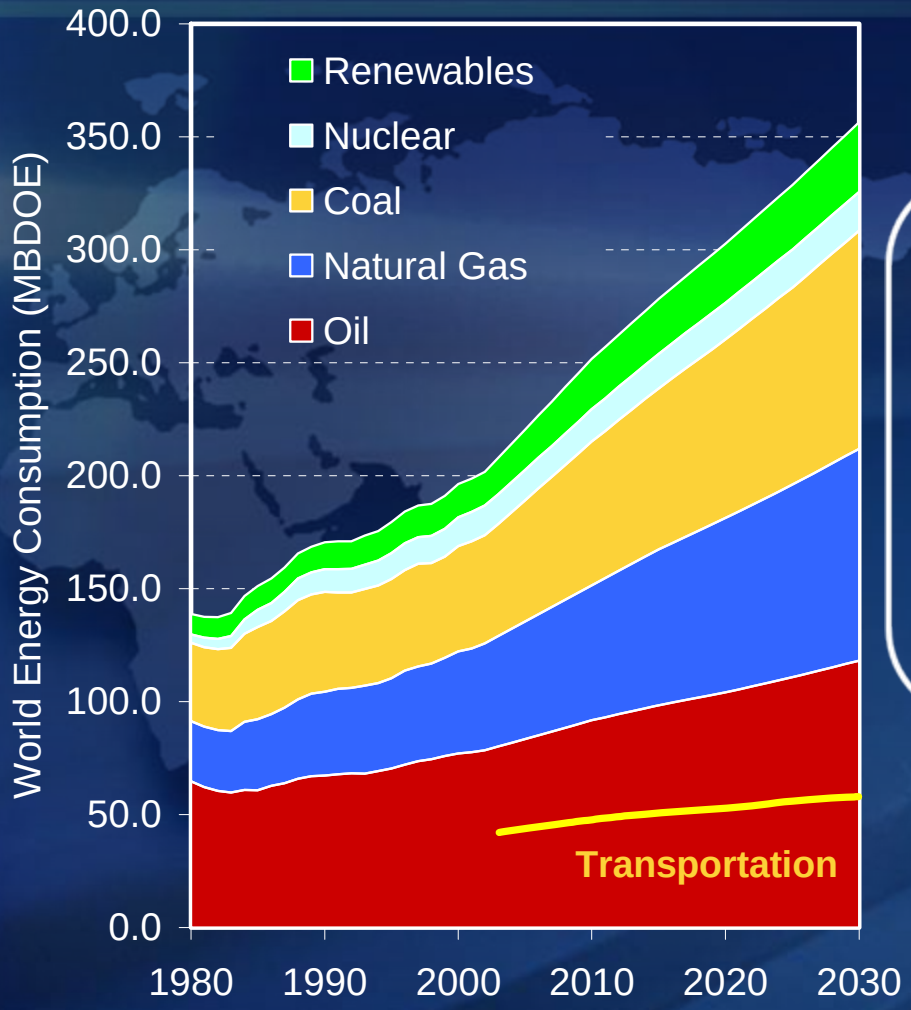


Oil

- 2006: 85MBD
  1,000 barrels/second !
- 2030: 120 MBD projected
- 50% used for transportation
- Transportation is 96% dependent on petroleum

Source: DOE-EIA 2006

Global Energy Consumption to 2030 -The projections in 2006



2008 Update (IEA)

- 2008: 86MBD
- 2030: 106MBD projected

Source: DOE-EIA 2006

World Oil Demand at Different Oil Intensities

Oil Intensity *Barrels/Person/Year*	Global Oil Demand at this Oil Intensity *Million Barrels Per Day (MBD)*		
	In 2010	In 2020	In 2030
25.2 (US 2007)	455	524	572
14.3 (Japan 2007)	259	300	325
10	181	210	227
6	109	125	136
4.76 (World 2007)	86	99	108

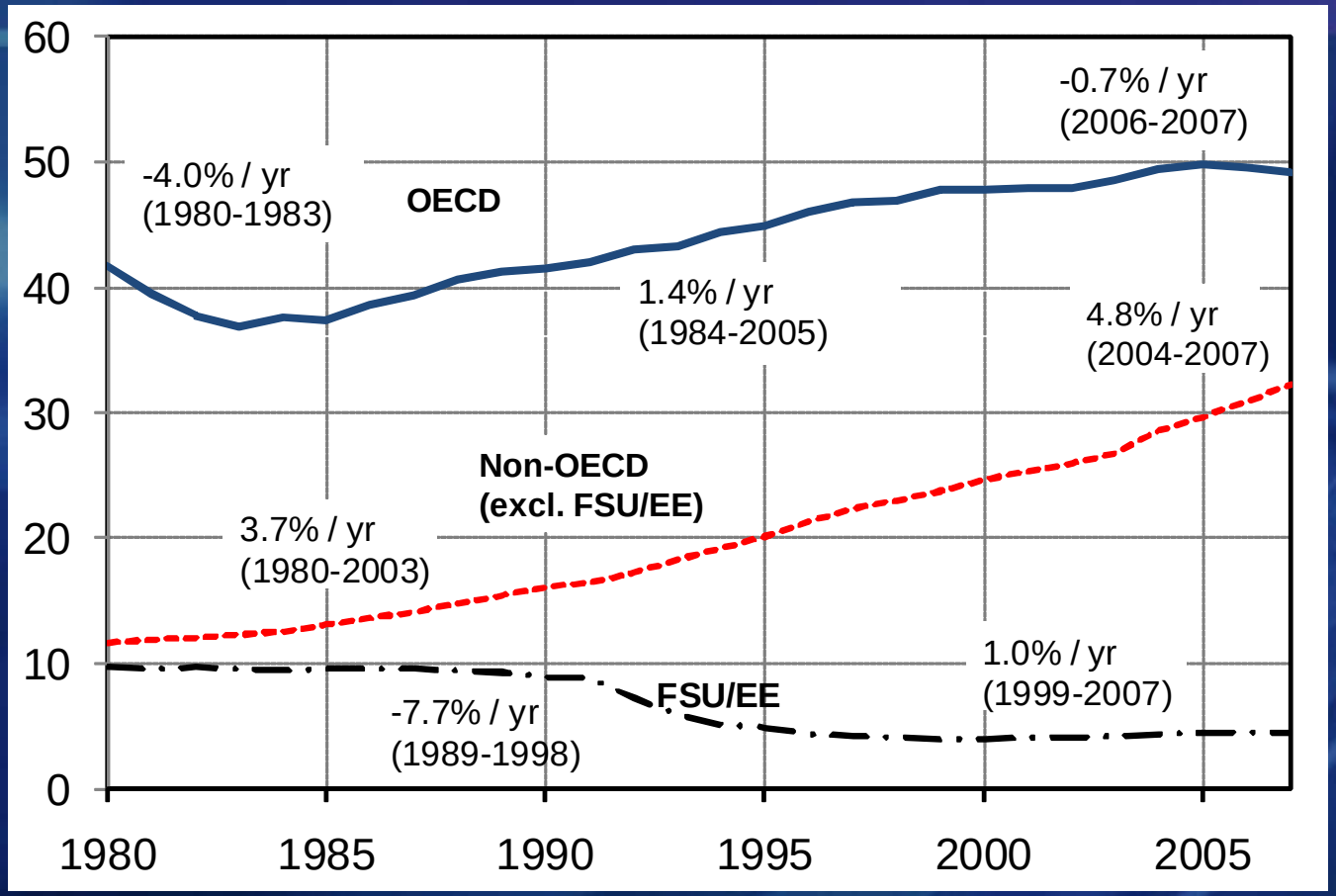
→ Economic Development

→ Population Growth

Source: Historical data from IEA and US Bureau of the Census data

Oil Demand Growth from 1980 to 2007

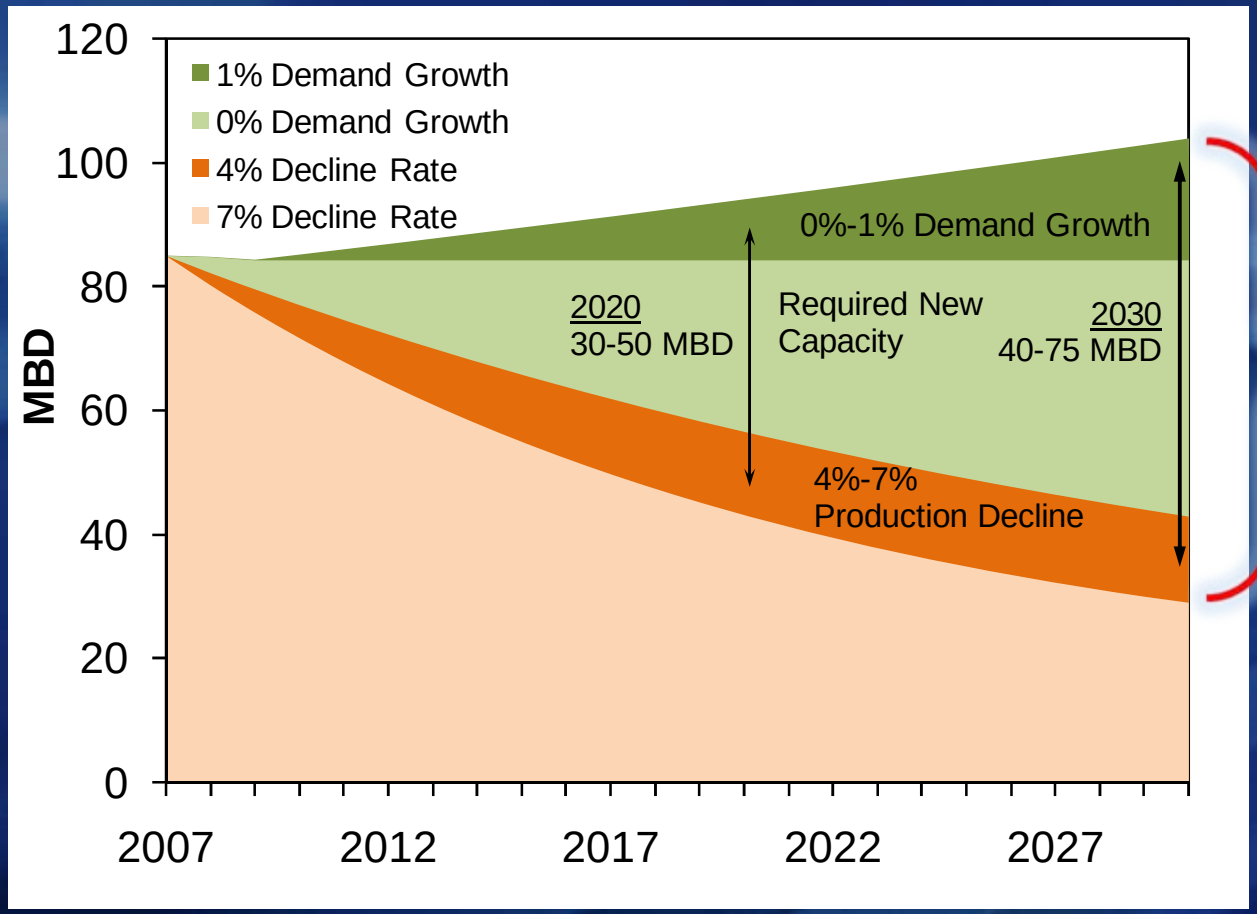
(million barrels per day)



OECD: Organization for Economic Cooperation and Development
FSU: Former Soviet Union
EE: Eastern Europe

Source: Data from EIA

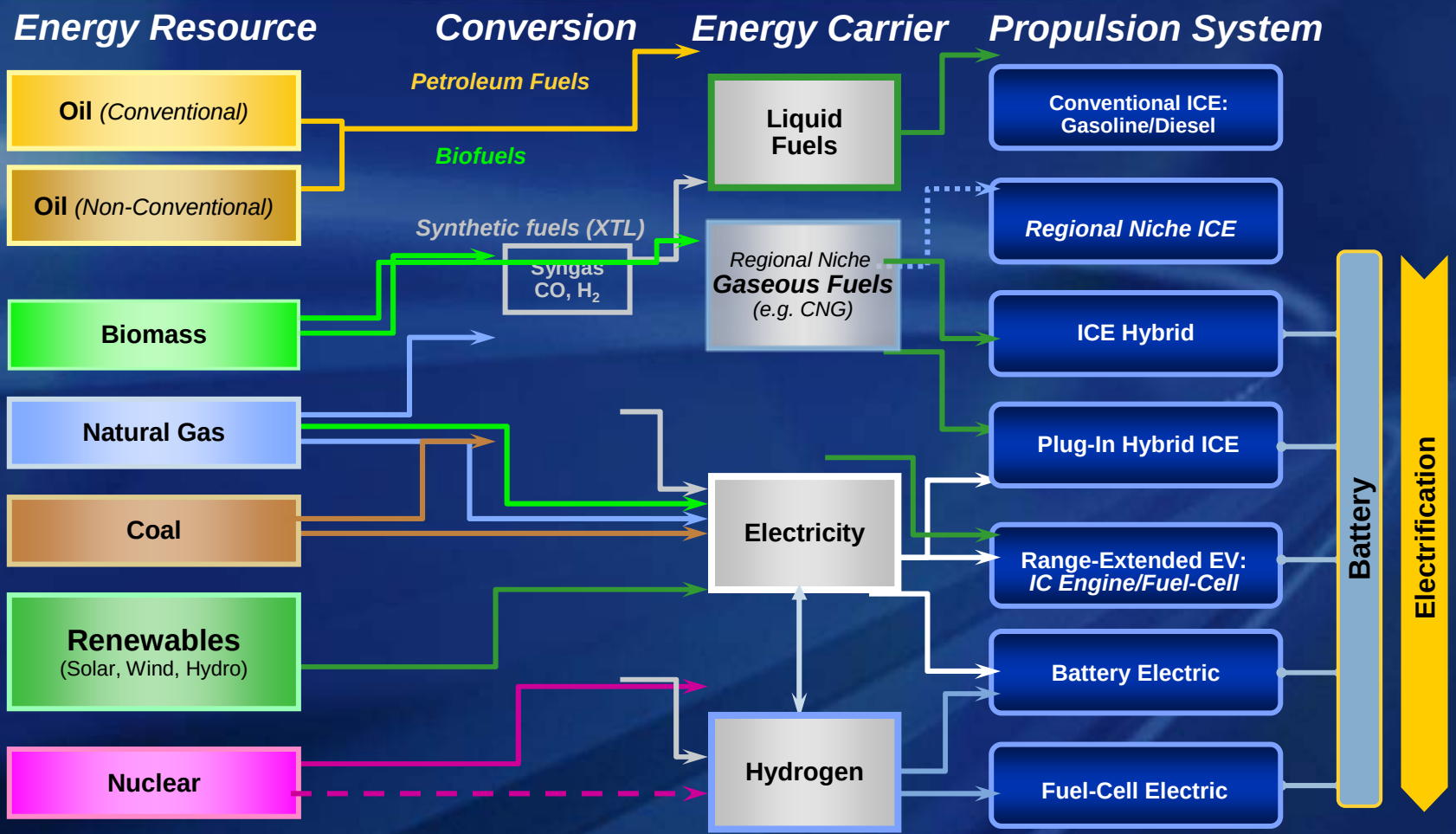
Significant new Capacity is Required to make up for Declines in Existing Capacity!



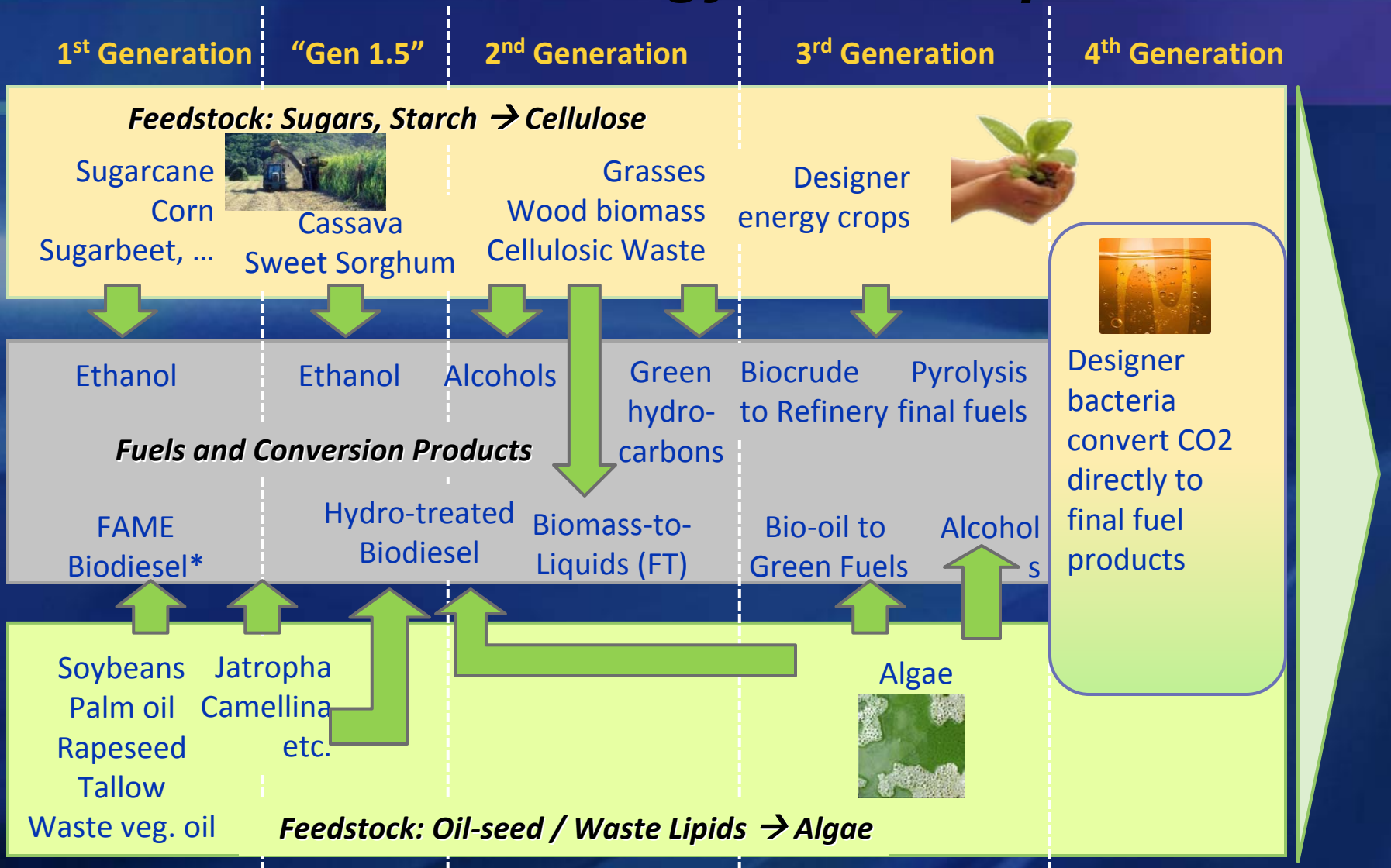
"Needing 6 new Saudi Arabias by 2030"!

Source: IEA World Energy outlook, 2008

Energy Diversity & Key Energy Supply Chains



Biofuels Technology Roadmap



- GM is committed to the rapid commercialization of “The Next Generation of Ethanol”
- GM has strategic alliances with two leading cellulosic ethanol start-ups, Coskata and Mascoma, that cover the biothermal and biochemical spectrum in advanced biofuel technology
- Partnership is about accelerating putting next generation of cellulosic ethanol on the market

GM Sandia 90-Billion Gallon Biofuel Deployment Study

Joint project conducted by GM and Sandia National Laboratories is the first true value-chain approach to future large-scale biofuels

Can Large-Scale Biofuels Provide a Real and Sustainable Solution to Reducing Petroleum Dependence?

1. What must happen to grow ethanol production to 90B gal by 2030?
2. What is required for cellulosic ethanol to be cost competitive with gasoline?
3. What are the associated greenhouse gas, energy, and water footprints?
4. What risks could impact cellulosic ethanol's production and competitiveness goals and how can we mitigate these?

GM

Sandia National Laboratories

Biomass for 90 billion gallons of ethanol can be produced largely without reducing current active cropland

2030 land use

44 M acres cropland as pasture and idle cropland

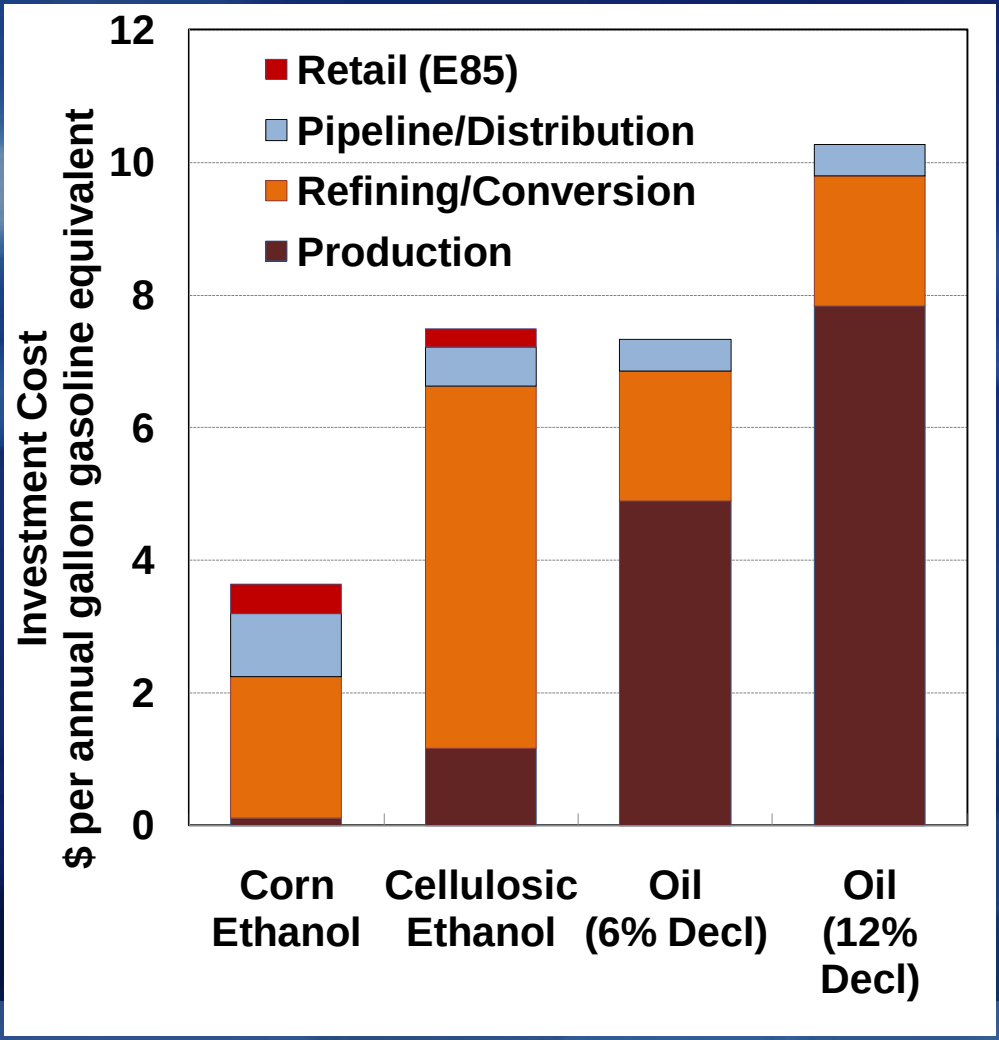
40 M acres non-grazed forest land

No land use change for residues

equals 2006 corn ethanol acreage

SRWC: Short Rotation Woody Crop

Petroleum or Ethanol: Capital Costs Are Quite Similar



- Actual costs to sustain petroleum production over a 25-year period in the Gulf of Mexico vs. same energy production via ethanol
- Ethanol CAPEX is dominated by the cost of building cellulosic biorefineries. Efforts to reduce the installed per gallon cost have significant payoff.
- The retail infrastructure for E85 is a comparatively small cost.
- Petroleum CAPEX is dominated exploration and production; existing refineries can be used but will require upgrading and maintenance over time.
- New production in the Gulf of Mexico assumes 6% or 12% decline in field over a 25-year period: requires ongoing investment in oil field production and bringing online new wells.

Biomass Energy Potential by Continent from Abandoned Agricultural Land

*** Ethanol chosen as example liquid fuel. 1 US gal = 3.78 liter.*

Continent	Abandoned Land (Mha)	Biomass Productivity (ton C/ha/yr)	Mean Productivity (ton C/ha/yr)	Biofuels Potential (EJ/yr)	Mean (EJ)	Ethanol Volume (B gal)**
Asia	67-83	1.2-1.7	1.4	1.6-2.8	2.1	26
North America	34-39	3.5-3.7	3.6	2.4-2.9	2.6	33
Europe	15-17	3.5-5.0	4.3	1.0-1.7	1.4	18
Africa	51-66	3.1-4.6	3.8	3.1-6.0	4.5	56
South America	49-56	4.5-5.6	5.0	4.4-6.3	5.3	66
Oceania	0-1	7.0-9.5	8.2	0.1-0.1	0.1	1
Australia	61-65	3.0-4.3	3.6	3.7-5.6	4.6	58

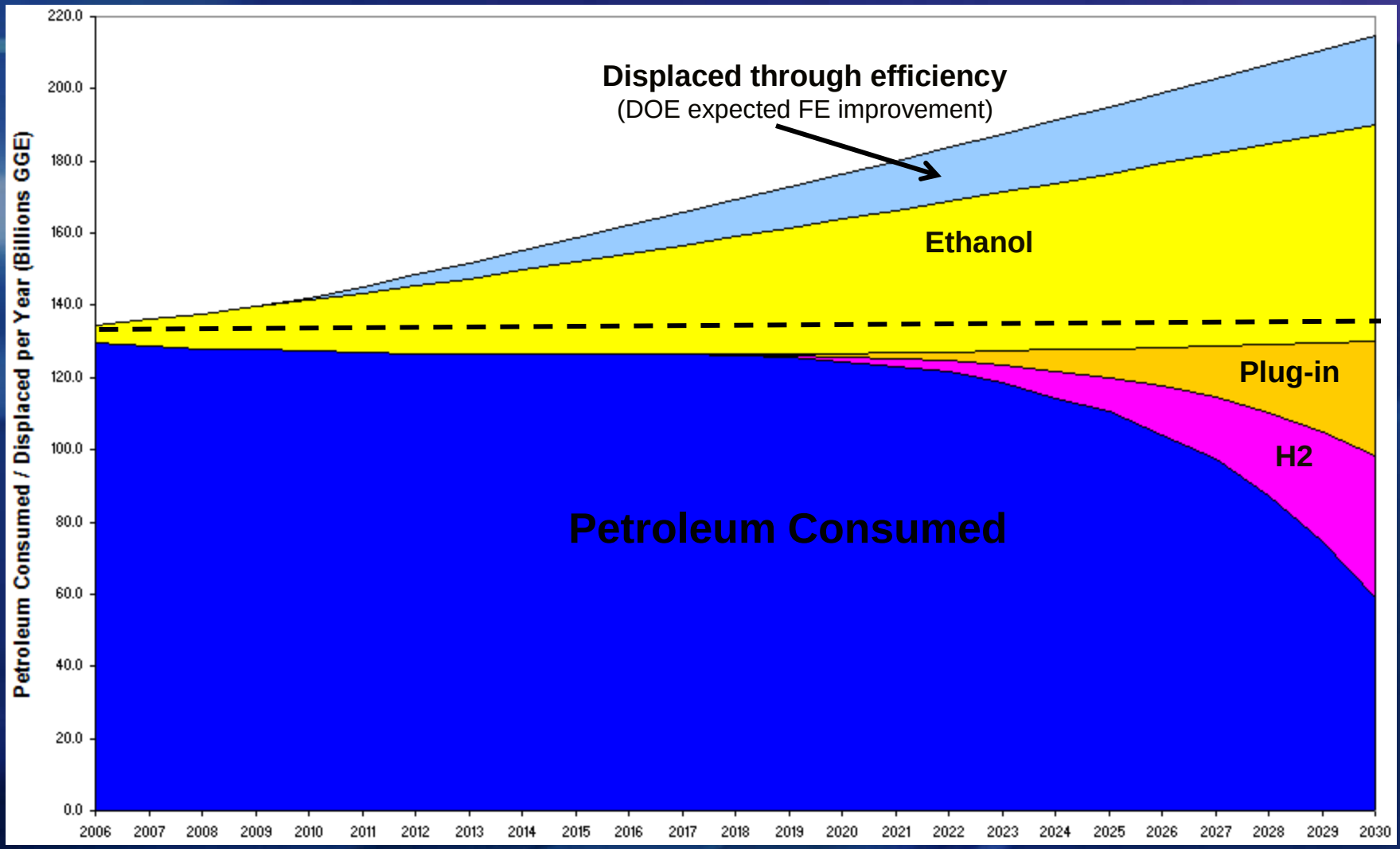
Campbell, J. E., D. B. Lobell, R. C. Genova, and C. B. Field: The global potential of bioenergy on abandoned agriculture lands. Environmental Science & Technology, online June 25, 2008 edition.

Field, C. B., J. E. Campbell, and D. B. Lobell: Biomass energy: the scale of the potential resource, Trends in Ecology & Evolution 23:65-72, 2008.

Electricity as a Transportation Fuel

Composite Effect of New Technologies – Example Scenario

(Efficiency improvements, ethanol, plug-ins, and FCEVs)



Mobility based predominately on Petroleum faces Severe and Imminent constraints

- **Petroleum production and deliverability** are inadequate to supply an economically developing world
  - Even slight increases in petroleum intensity per person, coupled with global population growth requires production well beyond capability in the next two decades
  - The current global recession is a temporary lull that must be used wisely
- **GM remains committed** to an energy strategy that displaces petroleum through efficiency improvements and diversification of energy carriers
- **Biofuels** present a strategic opportunity in the drive for energy and environmental sustainability
- **Electrification** of the vehicle will continue to provide efficiency improvements (hybrids) and give access to the widest range of energy resources (Plug In Hybrids, E-REVs. BEVs & Fuel Cells)
- **A collective will** and constancy of purpose are required with the end in mind (Auto, Energy, Governments and Society)


GM
Thank You for your Attention