U.S. DEPARTMENT OF ENERGY

Barriers to Industrial Energy Efficiency

Report to Congress
May 2015

United States Department of Energy
Washington, DC 20585

Message from the Assistant Secretary

The industrial sector has shown steady progress in improving energy efficiency over the past few decades and energy efficiency improvements are expected to continue. Studies suggest, however, that there is potential to accelerate the rate of adopting energy efficient technologies and practices that could reduce energy consumption in the industrial sector by an additional 15 to 32 percent by 2025. There are barriers that impede the adoption of energy efficient technologies and practices in the industrial sector. This report examines these barriers and identifies successful examples and opportunities to overcome these barriers.

I extend my appreciation to the many stakeholders across industry, non-profit organizations, and the public sector for their support, feedback and strategic interest in industrial energy efficiency. Contributions from these stakeholders helped identify the most serious barriers and helped develop recommendations that can have a large impact on improving energy efficiency in the industrial sector.

This report is being provided to the following Members of Congress:

- **The Honorable John A. Boehner**
  Speaker, House of Representatives

- **The Honorable Joseph R. Biden**
  President of the Senate

- **The Honorable Fred Upton**
  Chairman, House Committee on Energy and Commerce

- **The Honorable Frank Pallone**
  Ranking Member, House Committee on Energy and Commerce

- **The Honorable Lisa Murkowski**
  Chair, Senate Committee on Energy and Natural Resources

- **The Honorable Maria Cantwell**
  Ranking Member, Senate Committee on Energy and Natural Resources

If you have any questions or need additional information, please contact me or Mr. Brad Crowell, Assistant Secretary for Congressional and Intergovernmental Affairs, at (202) 586-5450.

Sincerely,

Dr. David T. Danielson

Executive Summary

The industrial sector accounts for the largest share of energy consumption in the United States, and energy efficiency improvements in this sector can significantly reduce the nation's demand for energy. In 2012, the industrial sector accounted for 32 percent of all energy consumption, and by 2025 this share is expected to exceed 36 percent. In 2012, manufacturers accounted for 74 percent of industrial energy consumption, which represents 24 percent of all energy consumed in the United States.

The industrial sector has shown steady progress in improving energy efficiency over the past few decades, and energy efficiency improvements are expected to continue. Studies suggest, however, that there is potential to accelerate the rate of adopting energy efficient technologies and practices that could reduce energy consumption in the industrial sector by an additional 15 to 32 percent by 2025. This reduction in industrial sector energy consumption is equivalent to a reduction in national energy consumption of 6 to 12 percent by 2025.

There are barriers, however, that impede the adoption of energy efficient technologies and practices in the industrial sector. This report examines these barriers and identifies successful examples and opportunities to overcome these barriers. The report was prepared in response to Section 7 of the American Energy Manufacturing Technical Corrections Act (Act), which directs the Secretary of Energy to conduct a study,[1] in coordination with the industrial sector and other stakeholders, of barriers to the deployment of industrial energy efficiency.

Three groups of energy efficiency technologies and measures were examined:

- Industrial end-use energy efficiency
- Industrial demand response
- Industrial combined heat and power

The conclusions of this collaborative effort, summarized below, demonstrate the important role that industrial energy efficiency has in the U.S. and highlight its potential to continue to assist American industrial sectors with being strong, clean and efficient for decades to come. A total of 42 barriers were identified that affect the deployment of industrial energy efficiency across all three groups, and many examples and opportunities were identified to address these barriers. There may be additional barriers and opportunities not captured in this document, and this list should not be viewed as fully exhaustive.

[1] The study is contained in Appendix A.

This report results from a collaboration of the DOE with nearly 50 experts from industry, combined heat and power operators, environmental stewardship organizations, associations of state governmental agencies, and federal governmental agencies.

BARRIERS TO INDUSTRIAL ENERGY EFFICIENCY

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I. Legislative Language

This report was prepared in response to Section 7 of the American Energy Manufacturing Technical Corrections Act (Public Law 112-210). Section 7 of the Act is titled, "Reducing Barriers to the Deployment of Industrial Energy Efficiency," wherein it is stated:

(a) Definitions – In this section:

1) *Industrial Energy Efficiency – The term "industrial energy efficiency" means the energy efficiency derived from commercial technologies and measures to improve energy efficiency or to generate or transmit electric power and heat, including electric motor efficiency improvements, demand response, direct or indirect combined heat and power, and waste heat recovery.*

2) *Industrial Sector – The term "industrial sector" means any subsector of the manufacturing sector (as defined in North American Industry Classification System codes 31-33 (as in effect on the date of enactment of this Act)) establishments of which have, or could have, thermal host facilities with electricity requirements met in whole, or in part, by onsite electricity generation, including direct and indirect combined heat and power or waste recovery.*

(b) Report on the Deployment of Industrial Energy Efficiency

1) *In General – Not later than 2 years after the date of enactment of this Act, the Secretary shall submit to the Committee on Energy and Commerce of the House of Representatives and the Committee on Energy and Natural Resources of the Senate a report describing:*

   (A) the results of the study conducted under paragraph (2); and

   (B) recommendations and guidance developed under paragraph (3).

2) *Study —The Secretary, in coordination with the industrial sector and other stakeholders, shall conduct a study of the following:*

   (A) The legal, regulatory, and economic barriers to the deployment of industrial energy efficiency in all electricity markets (including organized wholesale electricity markets, and regulated electricity markets), including, as applicable, the following:

      (i) Transmission and distribution interconnection requirements.

      (ii) Standby, back-up, and maintenance fees (including demand ratchets).

      (iii) Exit fees.

      (iv) Life of contract demand ratchets.

      (v) Net metering.

(vi) Calculation of avoided cost rates.

(vii) Power purchase agreements.

(viii) Energy market structures.

(ix) Capacity market structures.

(x) Other barriers as may be identified by the Secretary, in coordination with the industrial sector and other stakeholders.

(B) Examples of—

(i) Successful State and Federal policies that resulted in greater use of industrial energy efficiency;

(ii) successful private initiatives that resulted in greater use of industrial energy efficiency; and

(iii) cost-effective policies used by foreign countries to foster industrial energy efficiency.

(C) The estimated economic benefits to the national economy of providing the industrial sector with Federal energy efficiency matching grants of $5,000,000,000 for 5- and 10-year periods, including benefits relating to—

(i) estimated energy and emission reductions;

(ii) direct and indirect jobs saved or created;

(iii) direct and indirect capital investment;

(iv) the gross domestic product; and

(v) trade balance impacts.

(D) The estimated energy savings available from increased use of recycled material in energy-intensive manufacturing processes.

3) *Recommendations and Guidance —The Secretary, in coordination with the industrial sector and other stakeholders, shall develop policy recommendations regarding the deployment of industrial energy efficiency, including proposed regulatory guidance to States and relevant Federal agencies to address barriers to deployment.*

II. Background

Section 7 of the American Energy Manufacturing Technical Corrections Act directs the U.S. Department of Energy (DOE) to undertake a study "in coordination with the industrial sector and other stakeholders" on barriers to industrial energy efficiency. DOE is directed to "develop policy recommendations regarding the deployment of industrial energy efficiency, including proposed regulatory guidance to States and relevant Federal agencies to address barriers to deployment."

In the Act, the industrial sector is defined to be manufacturing subsectors as described in North American Industry Classification System (NAICS) codes 31–33.[2] The manufacturing sector (NAICS 31–33) is broadly defined to include business establishments that use mechanical, physical, or chemical processes to create new products. Business establishments in the manufacturing sector are frequently called plants, factories, or mills, and cover a wide size of operations, ranging from small bakeries to integrated steel mills. The key distinction between manufacturing business establishments (NAICS 31–33) and businesses in other NAICS sectors is that manufacturers transform raw materials into new products.

The manufacturing sector is an important segment of the U.S. economy and is responsible for driving a significant amount of economic activity. Metrics that highlight the importance of manufacturing in the United States include (2013 data unless noted otherwise):

- Contributed $2.08 trillion, or about 12.5 percent, to U.S. gross domestic product.
- Supported more than 17.4 million jobs.
- Created high paying jobs—in 2012, compensation for manufacturing jobs was more than 25 percent higher than the average compensation for all U.S. jobs.

Data from the Energy Information Administration (EIA) shows that the industrial sector accounts for the largest share of energy consumption in the United States. In 2012, the United States consumed approximately 95 quads of energy, with the industrial sector accounting for 30.6 quads, or 32 percent of the total. Of this 32 percent, manufacturers accounted for 74 percent, equal to 22.6 quads of energy or 24 percent of all energy consumed in the United States.

EIA forecasts that total energy consumption will grow to about 102 quads in 2025, with nearly all of the growth coming from the industrial sector. From 2012 to 2025, energy consumption in

[2] EIA's definition of the industrial sector includes agriculture, mining, construction and manufacturing. The Act defines the industrial sector more narrowly to only include manufacturing.

the industrial sector is forecast to increase from 30.6 quads to 37.4 quads – a 22 percent increase. In 2025, energy use in the industrial sector is expected to exceed 36 percent of total energy consumption in the United States.

Given the scale of energy use in the industrial sector, energy efficiency improvements in this sector can significantly reduce the nation's demand for energy. While the industrial sector has shown steady progress in improving energy efficiency over the past few decades, studies suggest that industrial energy efficiency could be accelerated, reducing industrial energy consumption by an additional 15 to 32 percent by 2025 compared to EIA forecasts. This level of energy reduction in the industrial sector translates to a reduction in national energy consumption of 6 to 12 percent by 2025.

There are barriers, however, that impede the adoption of energy efficient technologies and practices in the industrial sector, and these barriers limit opportunities to capture additional energy savings. DOE recognizes that barriers to deployment of industrial energy efficiency involve complex, often controversial, issues. The intent of this report is not to prioritize or make value judgments of the barriers. Rather, the objective is to identify and discuss barriers that impede deployment of energy efficiency in the industrial sector and identify successful examples and opportunities to overcome these barriers.

For this report, industrial energy efficiency is divided into three groups:

- Industrial end-use energy efficiency
- Industrial demand response
- Industrial combined heat and power (CHP)

For each group, barriers are discussed and successful examples are identified to overcome many of these barriers. This study also discusses economic benefits of an energy efficiency grant program and energy savings from increased recycling. These latter two topics are both specified in the legislative language.

This report results from a collaboration of the DOE with nearly 50 experts from industry, combined heat and power operators, environmental stewardship organizations, associations of state governmental agencies, and federal governmental agencies. Contributions from these stakeholders significantly improved the depth and breadth of the report and study.

III. Barriers to Industrial End-Use Energy Efficiency

Industrial end-use energy efficiency includes a broad range of energy-efficient technologies and management practices that can be implemented in the manufacturing sector to reduce energy consumption. Examples that illustrate the diversity of technologies and practices include advanced electric motors and drives, high efficiency boilers, waste heat recovery, energy-efficient lamps and lighting controls, modernization or replacement of process equipment, improved process performance through the use of sensors and controls, and implementation of systematic energy management systems.

Barriers that impede implementing industrial end-use efficiency are summarized in the following categories:

- Economic and financial
- Regulatory
- Informational

Economic and Financial Barriers

- *Internal competition for capital.* Manufacturers often have limited capital available for end-use efficiency projects and frequently require very short payback periods (one to three years).
- *Corporate tax structures.* U.S. tax policies, such as depreciation periods, the treatment of energy bills, and other provisions can be a deterrent.
- *Program planning cycles.* There can be a mismatch between industrial planning cycles and utility and state energy efficiency program cycles, which can hinder industrial sites from moving forward with an energy efficiency project.
- *Split incentives.* Companies often split costs and benefits for energy efficiency projects between business units, which complicates decision-making.
- *Failure to recognize non-energy benefits of efficiency.* Not considering non-energy or co-benefits of an end-use energy efficiency project weakens the business case.
- *Energy price trends.* Volatile energy prices can create uncertainty in investment returns, leading to delayed decisions on energy efficiency projects.

Regulatory Barriers

- *Utility business model.* The structure of utility cost recovery and lost revenue mechanisms can reduce a utility's interest in promoting industrial energy efficiency projects.

- *Industrial participation in ratepayer-funded energy efficiency programs.* Opt-out programs or loosely defined self-direct programs allow industrial customers to not participate in traditional energy efficiency programs.
- *Failure to recognize all energy and non-energy benefits of efficiency.* There can be unrecognized energy benefits and non-energy societal benefits associated with improving energy efficiency. If these benefits are omitted, there can be under-procurement of industrial energy efficiency resources.
- *Energy resource planning.* Not requiring cost-effective energy efficiency to be considered as part of the integrated resource planning process can slow the evolution or expansion of industrial energy efficiency programs.
- *Environmental permitting.* Uncertainty, complexity, and costs associated with permitting processes such as New Source Review can deter facilities from moving forward with energy efficiency projects.

Informational Barriers

- *Adoption of systematic energy management system.* Some manufacturing plants lack information on the benefits of modern energy management systems. These plants fail to capture the value of cost-effective energy savings that can be achieved by these systems.
- *Awareness of incentives and risk.* Lack of knowledge of available Federal, state and utility incentives for end-use efficiency measures can lead to missed opportunities.
- *Metering and energy consumption data.* Lack of disaggregated energy consumption data, such as process unit and equipment-level energy consumption data, and tools to evaluate such data, can prevent identification and evaluation of opportunities.
- *In-house technical expertise.* Lack of in-house technical expertise or the resources to hire outside staff for the development and operation of end-use efficiency projects can hinder deployment.

The barriers listed above are focused on industrial end-use energy efficiency. It is important to note that there is some overlap between barriers as they are applicable to multiple energy efficiency groups. For example, internal competition for capital is discussed as a barrier for both end-use energy efficiency and combined heat and power (see **Table 4** for a list of overlapping barriers). In this report, most barriers are discussed under a single energy efficiency group. The categorization of a particular barrier to a single energy efficiency group is based on factors that include where stakeholders frequently associated the barrier, and how the barrier is frequently discussed in reference material.

IV. Barriers to Industrial Demand Response

Demand response is defined as:[3]

> *Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.*

The definition of demand response includes changes that might involve a reduction in electricity demand, a shift in demand, or even an increase in the demand for electricity. In the past, traditional demand response programs were focused on reducing electricity use during peak time periods (e.g., a hot summer afternoon). In recent years, technology advancements and new electricity market structures have allowed a greater level of communication and interaction between electricity consumers and utilities, and the definition of demand response has evolved from a focus on reductions in electricity demand to now include changes in electricity demand.

Barriers to increased industrial demand response are summarized below.

Economic and Financial Barriers

- *Limited number of customers on time-based rates.* Participation in demand response programs can be limited if customers are not on time-based rates.
- *Lack of sufficient financial incentives.* Some demand response programs may not provide a sufficient financial incentive to encourage participation.
- *Failure to fully account for demand response benefits.* Valuing the benefits of demand response, and determining how to attribute the benefits, can be complex.

Regulatory Barriers

- *Utility cost recovery structure.* The traditional regulatory model can discourage demand response if utility revenue is linked to financial returns derived from building new infrastructure.
- *Program requirements and aggregation.* Some potential participants in demand response programs are deterred due to numerous program requirements and terms that vary significantly, or aggregation rules that limit smaller industrial facilities.

[3] Definition of demand response from FERC, Web link.

- *Lack of standardized measurement and verification.* Absence of standard measurement and verification procedures can negatively impact demand response contract settlement, operational planning, and long-term resource planning.
- *Electricity market structures that limit demand response.* Some electricity markets focus on supply side resources, and demand response may not be allowed to participate in certain markets, or there may be other barriers to participation.
- *Inclusion in state energy efficiency resource standards (EERS).* Not including demand response in EERS programs may limit growth.

Informational Barriers

- *Knowledge and resource availability.* Lack of knowledge of federal, state, and utility incentives for demand response programs and lack of an understanding of programs can result in low participation. In addition, insufficient in-house technical expertise can also hinder participation.
- *Lack of widespread adoption of interoperability and open standards.* Many different devices and systems need to communicate in a robust demand response program. Demand response programs are hindered if technologies from different vendors do not interoperate seamlessly. Several types of interoperability standards have been established such as SEP 2.0, OpenADR, and Green Button, and they are being adopted in the market. However, more widespread use of open standards is necessary to align communication across devices.
- *Administrative burden.* The amount of time and effort required to participate in a demand response program can be a deterrent, especially for smaller industrial companies.

V. Barriers to Industrial Combined Heat and Power

Combined heat and power, also known as cogeneration, is the simultaneous production of electric and thermal energy from a single fuel source. Instead of purchasing power from the grid and then producing thermal energy onsite in a furnace or boiler, a CHP system produces both forms of energy—electricity and useful thermal energy (e.g., hot water or steam).

CHP systems are described as either topping or bottoming cycles. In a conventional topping-cycle system, a fuel (e.g., natural gas) is combusted in a prime mover, such as a gas turbine or reciprocating engine. The prime mover produces mechanical energy in the form of a rotating shaft, and this mechanical energy drives a generator that produces electricity. The thermal energy that is not used to generate electricity (e.g., exhaust heat) is captured from the prime mover and used for an end-use need such as process heating, hot water heating, or space conditioning. In a bottoming cycle, also referred to as waste heat to power (WHP), fuel is combusted to provide thermal input to a furnace or other industrial process and some of the heat rejected from the process is then used for power production.

Within the context of this report, the topic of waste heat recovery is limited to WHP. Most industrial WHP applications are bottoming cycle systems as described in the previous paragraph. Industrial WHP can also include systems in which heat is recovered from the exhaust of an engine or turbine generator and used to generate additional electricity through an organic Rankine cycle or similar technology. This type of system is less common in industrial applications and is not a CHP system, because there is no thermal energy delivered to an end-use. That said, the barriers to implementing non-CHP WHP are similar to those that apply to CHP, such as interconnection and utility rate structures. Therefore, both types of WHP are addressed in conjunction with the discussion of CHP, and both types of WHP are addressed by policy recommendations included in this study.

Barriers to CHP are summarized below.

Economic and Financial Barriers

- *Internal competition for capital.* Payback expectations and capital budget constraints influence CHP investment decisions.
- *Natural gas outlook.* The availability and long-term price forecast for natural gas impacts investments in CHP.

- *Accounting practices.* Emphasis on minimizing upfront capital costs, and the "split-incentive" between capital improvement and operation and maintenance (O&M) budgets.
- *Financial risk.* Industrial facilities may have a hard time finding low-cost financing due to financial risks.
- *Access to favorable tax structures.* Lack of financing instruments such as Master Limited Partnerships or Real Estate Investment Trusts.
- *Sales of excess power.* The inability to sell excess power or access to reasonable sales agreements for excess power.

Regulatory Barriers

- *Utility business model.* The structure of utility cost recovery and lost revenue mechanisms can reduce a utility's interest in promoting industrial CHP projects.
- *Environmental permitting and regulatory issues.* Output-based regulations and New Source Review permitting requirements.
- *Inconsistent interconnection requirements.* Lack of standardized interconnection requirements can impede CHP.
- *Lack of recognition of environmental benefits.* Lack of financial value for the potential emissions benefits of CHP.
- *Failure to recognize the full value of CHP in regulatory evaluations.* Utility procurement and resource plans may omit some value streams provided by CHP.
- *Standby rates.* Structure of standby rates that are not designed to closely preserve the nexus between charges and cost of service.
- *Exclusion from clean energy standards.* CHP's eligibility under CEPS programs.
- *Capacity and ancillary services markets.* Electricity markets and programs may limit CHP's ability to participate.

Informational Barriers

- *Awareness of available incentives.* Insufficient knowledge of federal, state and utility incentives and eligibility requirements for CHP projects.
- *Technical knowledge and resource availability.* Lack of in-house technical expertise or the resources to hire outside staff for the design, development, and operation of a CHP system.

VI. Economic Benefits of Energy Efficiency Grants

The Act requests the development of estimated economic benefits from Federal energy efficiency matching grants:

> *[... shall conduct a study of ...the] estimated economic benefits to the national economy of providing the industrial sector with Federal energy efficiency matching grants of $5,000,000,000 for 5- and 10-year periods, including benefits relating to—*
>
> *i. Estimated energy and emission reductions;*
> *ii. Direct and indirect jobs saved or created;*
> *iii. Direct and indirect capital investment;*
> *iv. The gross domestic product; and*
> *v. Trade balance impacts.*

The economic benefits analysis was completed based on the following key assumptions:

- $5 billion of Federal matching grants allocated equally over 10 years (i.e., $500 million per year).
- Participant cost share is 80 percent for a base case. With this assumption, the total funding pool is $25 billion or $2.5 billion per year.
- 50 percent of funds are allocated for combined heat and power projects, and 50 percent of funds are allocated for energy efficiency and demand response projects.

All funds for this hypothetical grant program are used for deployment of commercially available technologies. In practice, a grant program could be set-up to allocate funds for related activities that complement commercially available technologies and stimulate industrial energy efficiency. For example, a modest percentage of funding could be allocated for marketing and outreach, and also for research and development, while preserving the majority of grant funds for deployment.

The results of the analysis indicate that a $5 billion Federal matching grant program implemented over a 10-year period ($500 million of Federal funding invested each year) will reduce annual energy consumption by 119 to 300 TBtu in Year 5, and 237 to 600 TBtu in Year 10. This reduced energy consumption is expected to save participating manufacturers $3.3 to $3.6 billion per year in Year 5, and $6.7 to $7.1 billion per year in Year 10 (single year savings are $670 to $710 million per year). Annual CO_2 emissions are expected to be reduced by 24 to 38 million metric tons in Year 5, and 48 to 75 million metric tons in Year 10. The grant program is expected to support approximately 9,700 to 11,200 jobs per year, which equates to 3.9 to 4.5

jobs per million dollars of investment. The GDP impact is expected to be in the range of $374 to $452 million per year.

The results shown above correspond to a base case scenario with 80 percent participant cost share. An alternative scenario was evaluated based on 50 percent participant cost share and is described in the study. In general, the economic impacts for the 50 percent cost sharing scenario are not as great as the 80 percent cost sharing scenario because of reduced capital leverage from the Federal funds.

The economic analysis did not consider impacts that might be derived from increased awareness that would be generated as a result of a $5 billion Federal grant program. Based on observations from the American Recovery and Investment Act and other energy efficiency incentive programs, there is frequently a "spillover" effect that creates activity by market participants that do not receive incentive payments. In the case of the hypothetical $5 billion grant program, some manufacturing plants would likely move ahead with industrial energy efficiency projects even though they do not receive grant funds. These plants could decide to move ahead with an energy efficiency project that they would not otherwise consider because of increased awareness and education resulting from the grant program. Due to modeling limitations, this spillover effect was not captured in the analysis completed for this study.

VII. Energy Savings from Increased Recycling

The Act requests an estimate of the energy savings available from increased use of recycled material in energy-intensive manufacturing processes.

EPA defines recycling as collecting and processing materials that would otherwise be thrown away and turning these materials into new products. It excludes the reuse of products (e.g., clothes and furniture donated to charitable organizations for use by others), as well as the use of the waste product as a fuel source. Recycling provides opportunities to reduce energy use, decrease carbon dioxide emissions, and minimize the quantity of waste requiring disposal. While many products are recycled, this report focuses on how energy can be saved by recycling in the following energy-intensive industries:

- Paper
- Aluminum
- Glass
- Steel
- Plastics

These five energy-intensive industries generate substantial waste products. These industries account for 53 percent of total waste products in the municipal solid waste stream. However, the products of these industries are also the most recovered, accounting for 67 percent of total municipal solid waste recovery. Still, substantial amounts of waste products coming from these industries could be recovered, which could in turn yield significant energy savings.

The analysis was limited to primary recycling (also called closed-loop recycling), where recycled products are mechanically reprocessed into a product with properties equivalent to the original product. Further, the analysis evaluated the impacts of increased recycling using only currently deployed technologies. Several studies are referenced in the recycling section, and these studies support the conclusion that adjusting a manufacturing "input" (in this case, recycled materials) can be a critical strategy for increasing the energy efficiency of energy-intensive manufacturers.

The recycling analysis only considered recycling of post-consumer scrap, which is material that has been used by end-users and can no longer be used for its intended purpose. T wo scenarios were evaluated: modest and aggressive. The modest scenario assumed that recycling rates remain well within the boundaries of existing technology and material availability limitations, and the aggressive scenario pushed these boundaries (see appendix A for more information on the scenarios). It is important to note that the recycling rate assumptions for the moderate and

aggressive scenarios are not based on industry data. Rather, the authors of the study considered data on current recycling rates and the technical recycling limits, and developed the recycling rate assumptions for the scenarios within those ranges of data.

The recycling analysis included a breakdown of three types of plastics with a high potential for increased recycling:

- *Polyethylene terephthalate (PET).* PET is used for soft drinks packaging (PET bottles) and synthetic fibers.
- *High-density polyethylene (HDPE).* HDPE is used to make plastic jugs.
- *Low-density polyethylene (LDPE)/linear low-density polyethylene (LLDPE).* LDPE is used for plastic bags, and LLDPE is used for stretch wrap.

The recycling analysis shows that the following three manufacturing sectors have the potential to increase energy savings by more than 10 percent in at least one of the two scenarios:[4]

- Plastics (PET): 32 percent savings in aggressive scenario; 17 percent savings in modest scenario
- Steel: 15 percent savings in aggressive scenario; 6 percent savings in modest scenario
- Aluminum: 12 percent savings in aggressive scenario; 3 percent savings in modest scenario

While PET manufacturing shows the highest energy savings percentage (32 percent in aggressive scenario), the total energy savings are greatest for the steel industry because the amount of energy used for steel production is greater than the amount of energy needed for plastics production. For the steel industry, energy savings are estimated at 118 TBtu for the aggressive scenario, and 43 TBtu under the modest scenario. In terms of total energy savings, the steel industry is followed by paper, plastics (PET, HDPE, and LDPE/LLDPE combined), aluminum, and glass.

[4] The other sectors show energy savings from increased recycling but the savings are below 10 percent.

VIII. Summary of Barriers, Opportunities, and Successful Examples

Table 1, Table 2, and Table 3 summarize barriers for end-use energy efficiency, demand response, and CHP. These tables also show opportunities to address many of the barriers along with successful examples. In some cases, barriers do not have straightforward solutions, and for these barriers no opportunities or examples are provided. In each table, the barriers are divided into three types:

- Economic and financial
- Regulatory
- Informational

Table 1. Opportunities and Successful Examples for End-Use Energy Efficiency

Type of Barrier	Description of Barrier	Opportunities and/or Successful Examples
Economic and Financial	Internal competition for capital	Opportunity: Provide or support alternative financing structures, such as on-bill financing. Examples: • Minnesota Power provides industrial users in northeastern Minnesota with on-bill financing for energy efficiency projects. • Walmart Supplier Energy Efficiency Program – Walmart helps encourage end-use efficiency investments in their supply chain. • Cummins has an internal capital fund devoted to energy efficiency improvements.
	Corporate tax structures	Example: Netherlands adopted the Random Depreciation of Environmental Investments Measure in 1991, which offers accelerated depreciation for certain energy efficient assets.
	Program planning cycles	–
	Split incentives	Example: J.R. Simplot – recognizing the "split incentive problem," the company now trains employees in best practices and has adopted an Energy Champions program.
	Failure to recognize non-energy benefits of efficiency	Opportunities: • Provide guidance describing how energy efficiency can qualify for emissions reductions credits in specific regulatory schemes. • Publish papers on approaches to recognize the non-energy benefits of end-use efficiency. • Pilot explicit consideration of co-benefits as part of the energy efficiency cost calculation.
	Energy price trends	–
Regulatory	Utility business model	Opportunity: Consider, where appropriate, various methods that may align customer and utility incentives to achieve greater savings from energy efficiency.

Type of Barrier	Description of Barrier	Opportunities and/or Successful Examples
	Lack of industrial participation in ratepayer-funded energy efficiency programs	Opportunities: • Consider facilitating collaborations between utilities and their industrial customers, such as strengthening Measurement and Verification (M&V) protocols for self-direct programs, to ensure industrial customer efficiency efforts are documented. For example, using the SEP M&V protocol. • Evaluate industrial customer participation in energy efficiency programs, such as revolving fund programs. • Consider including energy efficiency in Clean Energy Portfolio Standards (CEPS), such as through an Energy Efficiency Resource Standard (EERS), if consistent with state policy goals.
	Failure to recognize all energy and non-energy benefits of efficiency	–
	Energy efficiency not included in energy resource planning	Opportunities: • Include end-use efficiency as part of utility integrated resource plans and state planning. • Independent System Operators/Regional Transmission Organizations can work closely with states and utilities to ensure proper accounting for existing energy efficiency resources. Example: CHP/ WHP and other forms of end-use efficiency are included in Integrated Resource Plans in Massachusetts, Connecticut, and in a few other states.
	Environmental permitting	Opportunities: • Review the New Source Review process to consider ways to encourage end-use efficiency improvements within the legal framework specified under the Clean Air Act and other statutes. • Review the implementation of New Source Review to ensure that U.S. EPA guidance is followed.
Informational	Adoption of systematic energy management system	Example: Nissan worked with the U.S. Energy Department to implement an energy management system that meets all requirements of Superior Energy Performance (SEP) and Independent System Operators 50001 at its vehicle assembly plant in Smyrna, Tennessee.
	Lack of awareness of incentives	Opportunities: • Increase outreach on existing industrial energy efficiency programs. • Develop energy efficiency technical and economic potential studies to show current and future market opportunities resulting from incentives.
	Metering and energy consumption data	Example: Some organizations, such as 3M and PPG Industries, have begun to allocate energy costs to individual business units and/or production lines based on submetered energy data.
	Lack of in-house technical expertise	Opportunities: • Expand technical assistance to industrial facilities through the Better Plants program, and other programs such as the Superior Energy Performance program and Industrial Assessment Centers. • Expand technical assistance to industrial companies through the ENERGY STAR Industrial program. • Expand technical assistance under the Manufacturing Extension Partnership.

Table 2. Opportunities and Successful Examples for Demand Response

Type of Barrier	Description of Barrier	Opportunities and/or Successful Examples
Economic and Financial	Limited number of customers on time-based rates	Opportunity: Ensure that customers have access to market pricing signals. Example: Cement makers praise the Texas demand response program, which links consumer credits or rebates to real time market prices for electricity.
	Lack of sufficient financial incentives	–
	Failure to fully account for demand response benefits	Example: California has developed demand response cost-effectiveness tests, but there are no widespread standards on valuing avoided T&D due to demand response.
Regulatory	Utility cost recovery structure	Opportunity: Consider, where appropriate, various methods that may align customer and utility incentives to achieve greater savings from energy efficiency.
	DR program requirements and aggregation	Opportunity: Consider opportunities to allow for increased participation in demand response programs (i.e. review size thresholds and other requirements).
	Lack of standardized measurement and verification	Opportunity: Consider codifying North American Energy Standards Board guidance when selecting appropriate measurement and verification standards for retail demand response programs.
	Electricity market structures that limit demand response	Example: Studies have shown that implementing a capacity market in the Electricity Reliability Council of Texas that allows for demand response participation could help increase grid reliability and lower electricity costs for consumers.
	Exclusion from state energy efficiency resource standards	Opportunity: Consider the inclusion of demand response as an eligible resource in a state EERS (as a separate target, not comingled with other resources), if consistent with state policy goals. Example: Arizona's EERS program allows for demand response as an eligible activity.
Informational	Lack of knowledge and resource availability	Opportunity: Increase outreach to industrial end-users on demand response opportunities, such as through existing programs and the development of resources explaining participation requirements.
	Lack of interoperability and open standards	Opportunity: Develop a standard platform to enable communication. Example: OpenADR represents an open and standardized way for electricity providers and operators to develop technology to communicate across an existing IP-based communications network such as the Internet.
	Administrative burden	Opportunity: Curtailment Service Providers can work with Regional Transmission Organizations/ Independent System Operators and states to streamline demand response participation requirements. Example: EnerNOC, a CSP, offers a demand response program that provides participants with recurring payments in return for agreeing to reduce electricity consumption.

Table 3. Opportunities and Successful Examples for Combined Heat and Power

Type of Barrier	Description of Barrier	Opportunities and/or Successful Examples
Economic and Financial	Internal competition for capital	Example: Sikorsky Aircraft had competing alternatives for capital expenditures but elected to fund the CHP project, which had an estimated payback of 3.2 years.
	Natural gas outlook	–
	Accounting practices	–
	Financial risk/ Lack of low-cost financing structures	Opportunities: • Consider allowing CHP to qualify for Master Limited Partnership status. • Consider adopting performance-based incentives for CHP if this is consistent with state policy goals.
	Sales of excess power /Lack of access to power markets	Opportunities: • Consider criteria identified by FERC in determining the Public Utility Regulatory Policies Act avoided cost rate. • Consider expanding the ability of industrial customers to sell excess power to third parties in retail markets.
	Lack of tax code support	Opportunities: • Consider extending 5-year capital depreciation to WHP equipment. • Consider allowing Bonus Depreciation for CHP and WHP (50 percent depreciation during the first year). • Consider expanding the existing ITC to include WHP.
Regulatory	Utility business model	Opportunity: Consider, where appropriate, various methods that may align customer and utility incentives to achieve greater savings from CHP.
	Environmental permitting and regulatory barriers	Opportunities: • Consider output-based regulations that recognize thermal energy in federal regulations. • State air agencies can consider output-based regulations that recognize thermal energy. • States can consider offering streamlined air permitting for small-scale CHP systems (15 MW or less).
	Inconsistent interconnection requirements	Opportunity: Consider the use of best practice interconnection standards as a basis for state rulemaking where appropriate. Example: New York modified its interconnection requirements to allow for distributed generation systems up to 2 MW in size to interconnect to both radial and secondary network systems.
	Lack of recognition of environmental benefits	Opportunity: Publish papers on approaches to recognize the non-energy benefits of CHP.
	Failure to recognize the full value of CHP in regulatory evaluations	–
	Utility standby rates	Opportunity: Evaluate standby charges to ensure they accurately reflect the costs and benefits of distributed generation and that they are designed to closely maintain the balance between charges and the cost of service.
	Exclusion from clean energy standards	Opportunity: Consider including CHP in energy efficiency resources standards, if consistent with state policy goals.
	Capacity and ancillary services markets	Example: In ISO-NE, CHP systems with a capacity of 1 MW or larger can participate in capacity and ancillary service markets.

Type of Barrier	Description of Barrier	Opportunities and/or Successful Examples
Informational	Lack of awareness of available incentives	Opportunity: Consider increasing outreach to industrial end-users on the benefits of CHP. Example: The New York State Energy Research and Development Authority's (NYSERDA's) FlexTech program successfully coordinates information on the availability of incentives and technical assistance resources.
	Technical knowledge and resource availability	Examples: • The Database of State Incentives for Renewables & Efficiency (DSIRE) contains information on federal, state, city, utility and other incentive programs and policies to encourage clean energy projects, including CHP. DSIRE serves as an important resource for project developers, policymakers, and state regulators. • DOE's CHP Deployment Program provides stakeholders with resources necessary to identify CHP market opportunities and supports implementation of CHP systems in industrial, commercial, institutional, and other applications.

There is some overlap between barriers and the related successful examples and opportunities across the three types of industrial energy efficiency. In many cases a single action, or group of actions, can address multiple barriers. **Table 4** shows several of these overlapping barriers. The intent of this table is to illustrate how stakeholders can address multiple barriers with a single action (or subset of actions).

Table 4. Overlapping Barriers and Opportunities

Type of Barrier	Description of Barrier	Cross-cutting Categories	Opportunity
Economic and Financial and Regulatory Barriers	Lack of Recognition of Environmental Benefits	• End-use energy efficiency (**Table 1**, *Failure to recognize all energy and non-energy benefits of efficiency*) • CHP (**Table 3**, *Lack of recognition of environmental benefits*)	• Provide guidance that describes how energy efficiency can qualify for emissions reductions credits in specific regulatory schemes, and publish papers on approaches to recognize the non-energy benefits of end-use efficiency and CHP.
Regulatory Barriers	Utility Business Model	• End-use energy efficiency (**Table 1**, *Utility business model*) • Demand Response (**Table 2**, *Utility cost recovery structure*) • CHP (**Table 3**,*Utility business model*)	• Consider, where appropriate, various methods that may align customer and utility incentives to achieve greater savings from end-use energy efficiency, demand response and CHP.
Regulatory Barriers	Exclusion from Clean Energy Portfolio Standards (CEPS)	• Demand Response (**Table 2**, *Exclusion from state energy efficiency resource standards*) • CHP (**Table 3**, *Exclusion from clean energy standards*)	• For states that have a CEPS, state agencies, including state legislatures, can consider the inclusion of demand response and CHP as eligible resources in the CEPS, if consistent with state policy goals.
Informational Barriers	Lack of awareness and knowledge	• End-use energy efficiency (**Table 1**, *Lack of awareness of incentives*) • Demand Response (**Table 2**, *Lack of knowledge and resource availability*) • CHP (**Table 3**, *Lack of awareness of available incentives*)	• Develop technical and economic potential studies for each industrial energy efficiency type to identify market opportunities and the benefits from these opportunities. Agencies can increase outreach to industrial end-users through existing programs and the development of resources explaining participation requirements.
Informational Barriers	Lack of in-house technical expertise	• End-use energy efficiency (**Table 1**, *Lack of in-house technical expertise*) • CHP (**Table 3**, *Technical knowledge and resource availability*)	• Expand technical assistance to industrial facilities through existing programs, such as state energy efficiency programs.

Appendix A: The Study, 'Barriers to Industrial Energy Efficiency'

This appendix contains the study that supports the report to Congress.