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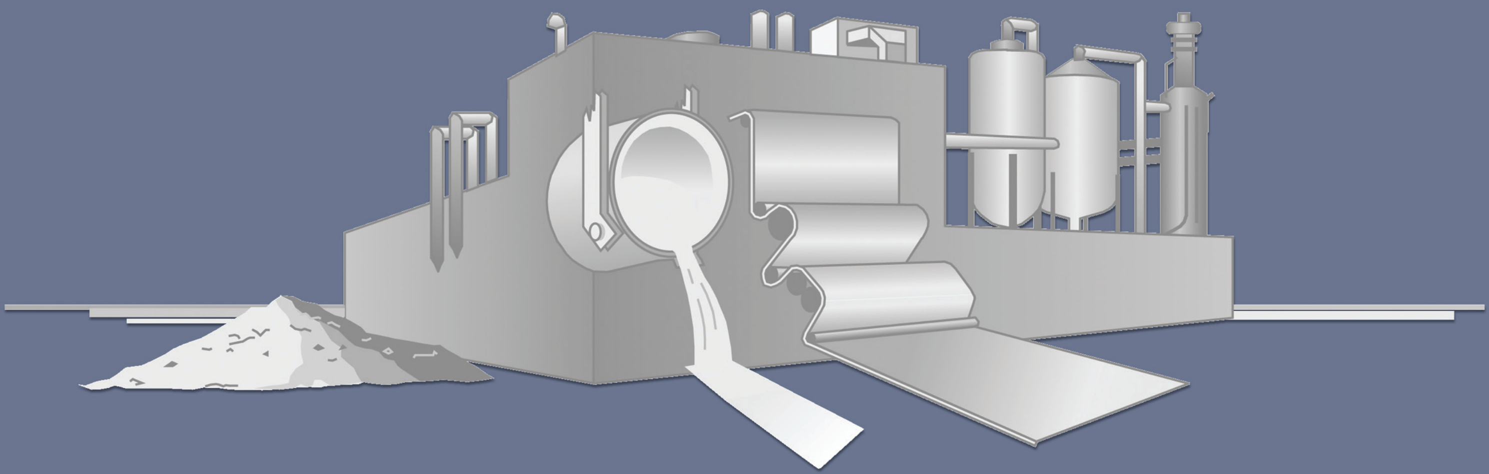
Industrial Technologies Program:
Summary of Program Results for CY 2009

Boosting the Productivity and Competitiveness of U.S. Industry



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Foreword

A robust U.S. industrial sector relies on a secure and affordable energy supply. While all Americans are feeling the pinch of volatile energy prices, project financial-constriction impacts on industry are especially acute. Uncertainty over energy prices, emission regulations, and sources of financing not only hurt industrial competitiveness – together they have the potential to push U.S. manufacturing operations offshore, eliminate jobs that are the lifeline for many American families, and weaken a sector of the economy that serves as the backbone of U.S. gross domestic product.

The Industrial Technologies Program (ITP) is actively working through public-private partnerships to address the enormous energy challenges now facing America and its industrial sector. ITP has an established track record for moving innovative technologies through commercialization and onto the floors of industrial plants, where they are at work today saving energy and reducing carbon emissions. For the period 1992 - 2010, ITP-sponsored projects have resulted in 50 R&D 100 awards and 265 issued patents. Also notable are the significant savings identified this year through the plant energy savings assessments conducted as part of ITP's Save Energy Now Initiative.

The daunting challenges confronting U.S. industry and the rapidly evolving energy supply situation prompted a re-examination of ITP strategies for technology development and delivery. A number of practical opportunities were identified to build on ITP strengths, expand into promising new areas, and boost program impacts to support critical national goals. ITP operates under the guidance of the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE). To learn more about the current ITP program and new directions see the ITP website at http://www1.eere.energy.gov/industry/.

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Working in partnership with industry, the U.S. Department of Energy's (DOE's) Industrial Technologies Program (ITP) is helping reduce industrial energy use, carbon emissions, and waste while boosting productivity and economic competitiveness. Operating within the Office of Energy Efficiency and Renewable Energy (EERE), ITP conducts research, development, and demonstration (RD&D) projects and technology transfer activities that are producing substantial benefits to industry and helping the nation to address some of its biggest challenges in the areas of energy security and environmental performance. This document summarizes some of the impacts of ITP's programs through 2009. The selection of 2009 as the timeframe for this report recognizes the fact that it takes at least two years to gain a full perspective on program performance and to assess the results of commercialization efforts for the technologies and practices at issue.

Industry is the largest and most diverse energy-consuming sector in the U.S. economy. In recent years, the industrial sector has used one-third of the energy consumed in the nation, produced about 1,670 MMT of CO_2 per year, contributed 12% to the overall U.S. gross domestic product, and provided nearly 12 million manufacturing jobs. These statistics – combined with the convergence of concerns surrounding energy security, climate change, and global competitiveness – emphasize the strategic role that improved industrial energy efficiency can play in responding to some of the nation's most pressing energy, economic, and environmental challenges.

Over the past 30 years, ITP has supported more than 600 separate RD&D projects that have produced over 250 commercialized technologies. In 2009 alone, 95 commercialized technologies in use saved 53.1 trillion Btu in measured savings. While these energy savings are impressive, industry has reaped even greater benefits from improved productivity, reduced resource consumption, decreased emissions, and enhanced product quality associated with these technological advances. For the period 1992 - 2010, ITP-sponsored projects have resulted in 50 R&D 100 awards and 265 issued patents. Also, many ITP-supported projects have significantly expanded knowledge about complex industrial processes and have laid the foundation for future energy-efficient technologies.

In addition to its RD&D projects, one of ITP's major efforts is the Save Energy Now Initiative (formerly the BestPractices Program)– a highly successful national initiative. Save Energy Now has developed a robust suite of energy-savings tools and services that ITP provides for partnering with industry to improve energy efficiency. For example, as of September 2009 the Save Energy Now Initiative has completed over 2,300 assessments. More than 1,500 industrial facilities have implemented the assessment recommendations, achieving $218 million, 35 trillion Btu, and 2.3 MMT of CO_2 savings each year. In 2009, ITP recognized 140 companies for their energy savings.

ITP is also working with U.S. industry to support the development of an emerging set of energy management standards and a related certification program anchored to a viable business case. Energy standards are considered by many to be the most effective and least costly approach to energy demand management. Similar to environmental or quality management systems in industry, changing how energy is managed will yield substantial energy efficiency improvements. A new energy management standard, ISO 50001, will provide a method for integrating energy efficiency into existing industrial or commercial management systems for continuous improvement. Once completed, ISO 50001 promises to create a framework for all of industry to manage energy and improve cost savings. To facilitate the transition to the ISO standard, the forthcoming industry-designed American National Standards Institute (ANSI)-accredited plant-certification program–known as Superior Energy Performance–will include provisions for conforming to the ISO 50001 energy management standard, as well as achieving a defined level of annual energy intensity performance improvement. A total of 50 countries are participating in developing this international standard. The International Organization for Standardization intends to release ISO 50001 in 2011.

An additional product of the Save Energy Now Initiative is an effort by ITP to aggressively drive progress on energy efficiency throughout the supply chain. As supply chains for companies have grown increasingly complex, understanding and managing energy waste within these chains can reduce energy prices and regulatory risk, while simultaneously increasing a firm's competitive advantage. Not only can it improve security in a company's operations, it can enhance their suppliers' businesses, as well as provide mentoring and support for these suppliers' energy and emissions management systems.

Many energy-intensive industries, including aluminum and steel, are limited in the choice of fuels and feedstocks used in their processes. As a result, many opportunities for energy-efficiency improvements are very process- and industry-specific. However, other important energy applications, such as motor drives, boilers, and compressed air systems, are common across the industrial sector, thereby creating crosscutting energy-efficiency opportunities.

Summary

Industrial Distributed Energy, a crosscutting activity within ITP, builds on activities conducted by DOE's Office of Industrial Technologies during the 1980s and 1990s and DOE's Distributed Energy Resources program since 2000. Since 1990, the use of distributed energy within the United States, primarily combined heat and power (CHP), has increased significantly. CHP generation capacity additions between 1990 and 2009 totaled 57.1 GW, according to the CHP Installation Database maintained by ICF International for DOE through a contract with Oak Ridge National Laboratory (ORNL). According to a report prepared by ORNL, if CHP generation capacity were to increase from the current 3% to 20% by 2030, more than 5.3 quad of energy would be saved, and CO_2 emissions would be reduced by 848 MMT. This represents 60% of the projected greenhouse gas emissions production from 2006 to 2030.

Through current and expanded funding from the *American Reinvestment and Recovery Act*, ITP is advancing CHP as one of the more promising efficient energy solutions to help revitalize the American economy, enhance the nation's energy security, and reduce carbon emissions. CHP can achieve efficiencies of as much as 80% compared with roughly 45% for conventional heat and power production.

One of ITP's primary roles is to invest in high-risk, high-value RD&D that will reduce industry's energy requirements while stimulating economic productivity and growth. Because energy is an important input for many of the nation's key manufacturing industries, reducing energy requirements will also reduce energy costs, greenhouse gases, and other emissions and will improve productivity per unit of output. As a federal program, ITP invests in advanced technologies that are anticipated to produce dramatic energy and environmental benefits for the nation. Investments focus on technologies and practices that will provide clear public benefit but have market barriers preventing adequate private-sector investment. ITP partners with manufacturers to help them overcome these barriers so that the benefits of energy-efficient innovation can be unleashed.

ITP has developed a ten-part strategy to achieve its goals:

1) Investigate cross-cutting R&D to save energy in the top energy-consuming processes used across industry.

2) Exploit fuel and feedstock flexibility to give manufacturers options for responding to energy price and supply pressures. For more information, see www1.eere.energy.gov/industry/fuelflexibility.

3) Invest in "next-generation" technologies that are adaptable to processes throughout industry and that could dramatically change the way products are manufactured.

4) Strengthen planning and analysis to identify opportunities with the greatest potential for energy savings and develop a robust market transformation strategy.

5) Institute rigorous stage-gate project and portfolio management procedures to ensure sound project management and funding decisions.

6) Emphasize commercialization planning throughout the R&D life cycle.

7) Encourage private investment in energy efficiency through new partnerships and strategies to reach industry.

8) Drive ambitious reductions in industrial energy intensity through the Save Energy Now Initiative. For information on Save Energy Now, see www1.eere.energy.gov/industry/saveenergynow/.

9) Promote energy-efficiency improvements throughout the supply chain. ITP is collaborating with manufacturers and suppliers to develop a practical approach for corporate leadership to encourage and support energy management across supply chains.

10) Help drive the development of energy management standards and the Superior Energy Performance certification program to provide a clear roadmap for continual improvement in energy efficiency. For information on the U.S. Council for Energy-Efficient Manufacturing, see www.superiorenergyperformance.net.

In addition to tracking current and cumulative energy savings, ITP monitors other benefits associated with the successfully commercialized technologies resulting from its research partnerships. These benefits include cumulative reductions of various air pollutants including particulates, volatile organic compounds, nitrogen oxides, sulfur oxides, carbon, and most recently, jobs created or saved. In 2009, ITP programs were instrumental in saving industry 733 trillion Btu, equivalent to the 2008 energy consumption for the entire state of New Mexico, or $4.59 billion. Over ITP's entire history, these cumulative net benefits are about 10.0 quadrillion Btu, equivalent to the 2008 energy consumption for all of California or $50.55 billion (in 2009 dollars).

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The bulk of this document consists of seven appendices. Appendix 1 describes the 95 ITP-supported technologies currently available commercially and their applications and benefits. Appendix 2 describes the 132 ITP-supported emerging technologies likely to be commercialized within two or three years. Appendix 3 describes 128 ITP-supported technologies used in past commercial applications, the current benefits of which are no longer counted in this report. Appendices 4 and 5 summarize the benefits of two ITP technical assistance activities: the Industrial Assessment Centers and the Save Energy Now initiative. Appendix 6 summarizes the benefits of CHP systems attributed to DOE activities. Finally, Appendix 7 describes the methodology used to assess and track ITP-supported technologies.

ITP Program Impacts

Industrial Energy Use

Industry is the largest and most diverse energy-consuming sector of the U.S. economy. In recent years, the industrial sector has used one-third of the energy consumed in the nation, produced about 1,670 MMT of CO_2 per year, contributed 12% to the overall U.S. gross domestic product (GDP), and provided nearly 12 million manufacturing jobs. These statistics – combined with the convergence of concerns surrounding energy security, climate change, and global competitiveness – emphasize the strategic role that improved industrial energy efficiency can play in responding to some of the nation's most pressing energy, economic, and environmental challenges.

In 2009, the industrial sector used 28.20 quad of all types of energy including losses associated with electricity transmission of 6.44 quad (see Figure 1). Petroleum (7.78 quad), natural gas (7.58 quad), and electricity (3.01 quad delivered) are the three fuels most used by industry, with coal and biomass providing another 3.39 quad combined. The industrial sector consumed a total of 21.76 quad, of which 18.36 quad were consumed by manufacturing industries.

Of that 18.36 quad, energy-intensive industries consumed 15.17 quad. The non-energy-intensive industries (3.19 quad) and non-manufacturing industries (agriculture, mining, and construction – 3.40 quad combined) accounted for the remaining energy consumption. Industry used 6.80 quad of the fossil fuels for feedstocks – raw materials for plastics and chemicals – rather than as fuels. Energy expenditures in the manufacturing sector are approximately $104 billion annually.

Energy-intensive industries such as forest products, chemicals, petroleum refining, nonmetallic minerals (glass and cement, especially), and primary metals account for about 83% of all manufacturing energy use. Many of the energy-intensive industries are limited in their choice of fuels because the technologies currently used in specific processes require a certain fuel. For example, aluminum production requires large amounts of electricity to reduce the alumina to metal. Paper pulping leaves a large residual of wood lignin that can be reprocessed for its chemical content and consequently supplies the industry with half of its primary energy. Therefore, the wide variety of fuels (and feedstocks) used in the industrial sector partially reflects the specific

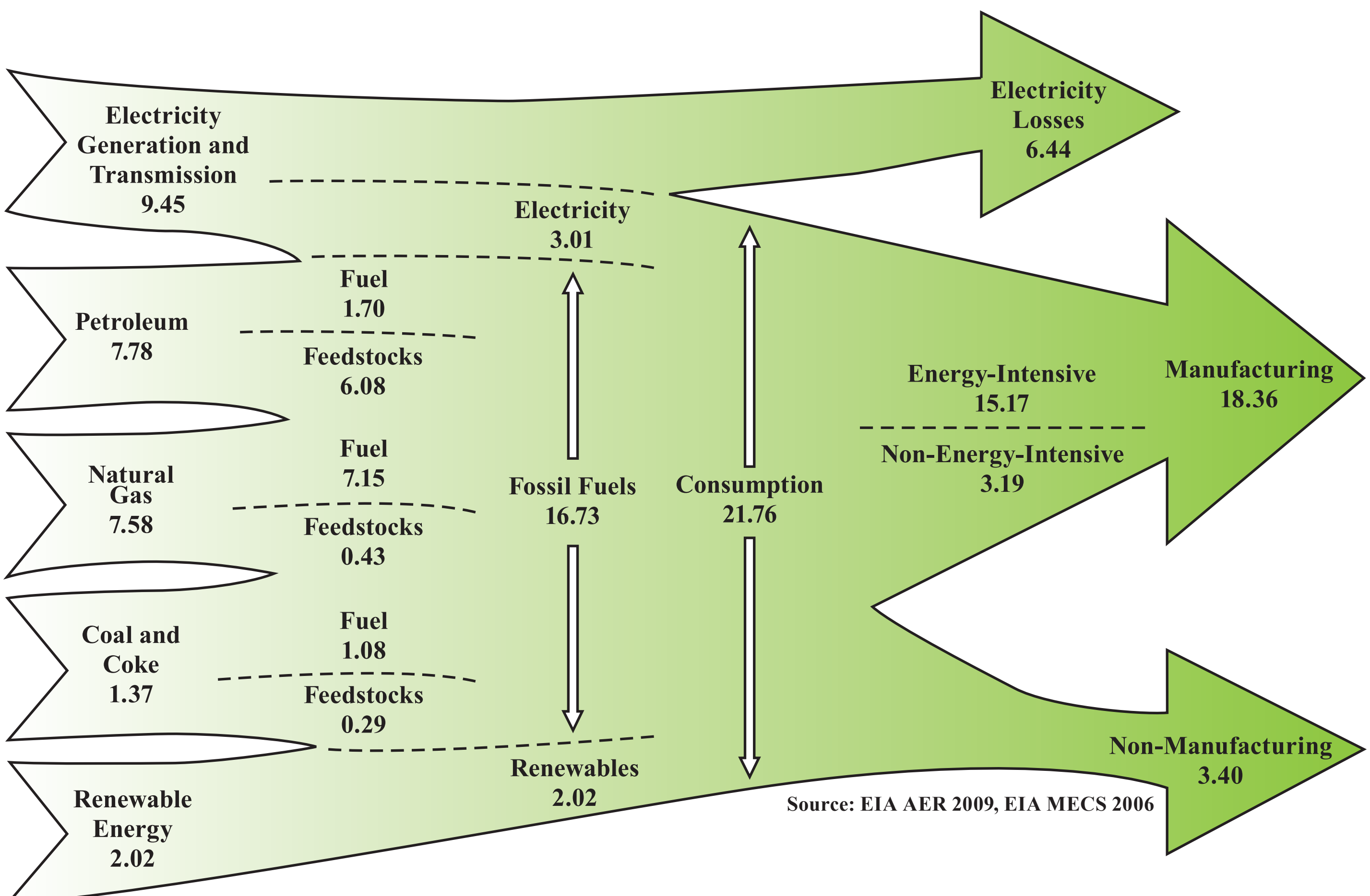

Figure 1. Industrial Energy Flows (Quad), 2009

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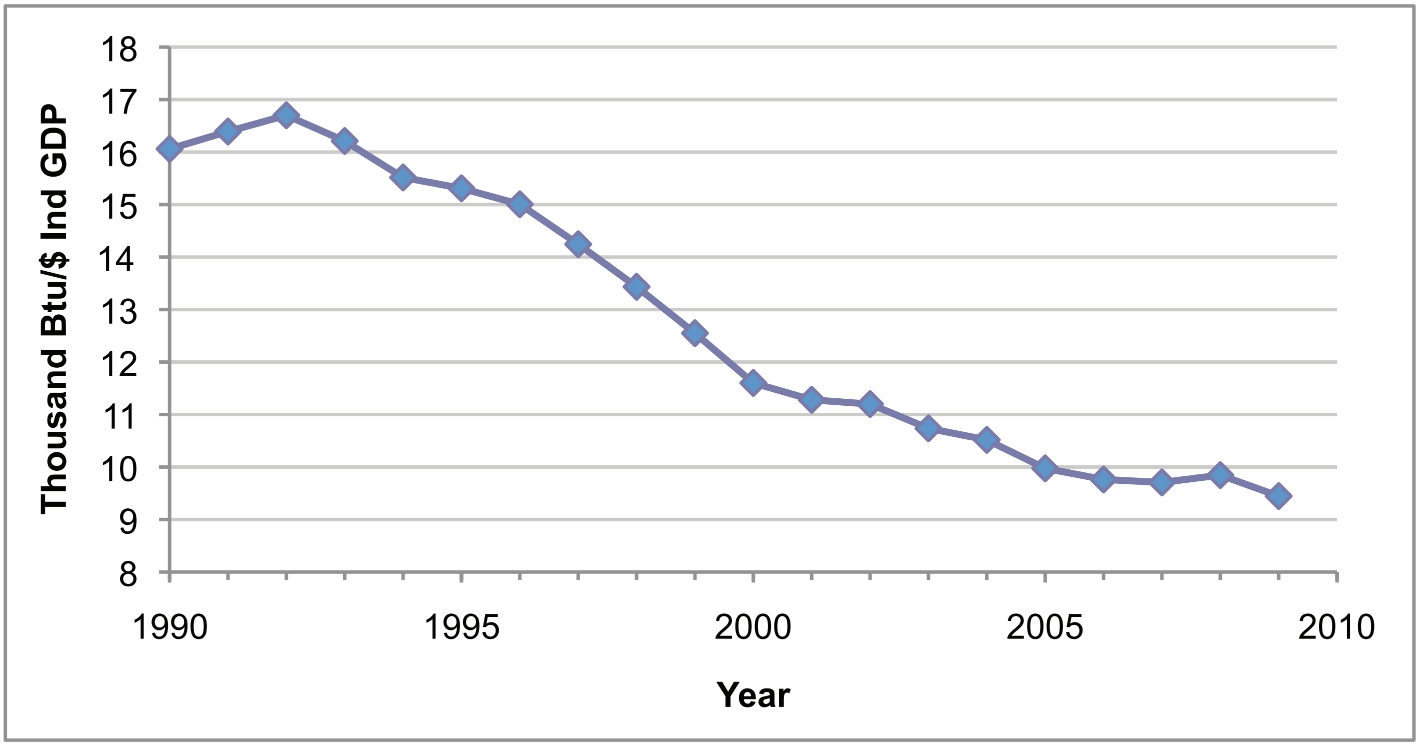
requirements of the processes used to make particular goods or commodities. Because of these energy requirements, the industrial sector offers a wide variety of opportunities for energy-efficiency improvements that are specific to particular industries or that crosscut many industries (i.e., are common to many industries or are needed by many process-specific technologies).

The energy intensity of the industrial sector has been declining over the past decade, in part because of investments in the development of energy-efficient technologies by the Industrial Technologies Program (ITP), previously the Office of Industrial Technologies (OIT). Since its peak in 1992, industrial sector energy intensity has declined more than 40%, from 16,700 Btu/dollar of real industrial GDP to 9,450 Btu/dollar of real industrial GDP in 2009 (see Figure 2).



Sources: EIA Annual Energy Review, 2009, Table 2.1d and BEA, Value Added for Industry, 1990-1997 and 1998-2009, *(Constant $2005)*

Figure 2. Historical Industrial Energy Intensity

ITP Program Impacts

The Industrial Technologies Program Office

ITP leads the federal government's efforts to improve industrial energy efficiency and environmental performance. The program is part of the Office of Energy Efficiency and Renewable Energy (EERE) and contributes to its efforts to provide reliable, affordable, and environmentally sound energy for the nation's future.

Large opportunities to save energy still exist in U.S. industry. Putting current knowledge to use and continuing research can make a difference. American industry can increase the nation's resilience in the face of current and future energy challenges. Advances in energy efficiency, fuel flexibility, and innovative technologies can enhance energy security, economic growth, and environmental quality. Potential areas for further reducing industry's energy consumption and reliance on oil and natural gas include the following:

- **Development of Next-Generation Technology.** Progress toward long-term national goals for energy and the environment rely on continuous technological innovation. The technologies required to address today's challenges can take a decade or more to progress from basic science to commercialization.
- **More Efficient Operating and Maintenance Practices.** Improved operating practices can be adopted rapidly at negligible cost to enhance both near- and mid-term operating efficiency in manufacturing facilities.
- **Increased Adoption of State-of-the-Art Technology.** Energy efficiency can be improved in the near- and mid-term by increasing industries' adoption of currently available advanced technologies. For example, waste heat recovery, combined heat and power (CHP), and advanced boiler technologies offer huge energy-saving opportunities.
- **Increased Fuel and Feedstock Flexibility.** Manufacturers need the flexibility to adapt to dynamic energy prices and supply issues. Much of industry's natural gas is used for boilers and process heaters, which present primary fuel switching opportunities.

National energy security will require widespread industry adoption of innovative technologies and practices that reduce energy demand. ITP leads federal efforts to expedite novel technology research and accelerate market introduction of dramatically more efficient industrial technologies and practices. Over the next few years, ITP will build on accumulated knowledge and strategic partnerships to take full advantage of new opportunities to accelerate and broaden impacts on industrial energy use. New challenges call for innovative solutions. The development of energy-efficient technologies ready to enter the market in the near term must be accelerated; at the same time, groundbreaking research must be conducted on revolutionary technologies for the future. ITP's focus on applied research and development (R&D) effectively turns knowledge and concepts initiated by others into real-world energy solutions. In addition, novel strategies to expand ITP's partner base will boost program impacts by expediting technology commercialization and adoption of efficient energy management practices. ITP is currently evaluating a number of strategies to help industry respond to energy challenges today and tomorrow, including:

- Investigate cross-cutting R&D to save energy in the top energy-consuming processes used across industry. ITP is focusing on a small number of widely used technology areas that could achieve large energy benefits throughout the manufacturing supply chain.
- Exploit fuel and feedstock flexibility to give manufacturers options for responding to energy price and supply pressures. ITP is seeking to develop alternative fuel and feedstock technologies to replace oil and natural gas in the long term while supporting near-term deployment activities to reduce the impacts of fuel price hikes. By increasing the range of fuel options available to industry, ITP will foster energy independence and economic resilience. For more information, see www1.eere.energy.gov/industry/fuelflexibility.
- Invest in "next-generation" technologies that are adaptable to processes throughout industry and that could dramatically change the way products are manufactured. ITP is funding research in nanomanufacturing, information and communications technology, and energy intensive processes that could bring new, cost-competitive options to American industry.
- Strengthen planning and analysis to identify opportunities with the greatest potential for energy savings and develop a robust market transformation strategy. ITP is conducting a thorough analysis of industry market barriers and challenges that will allow more effective investment decisions with higher impacts.
- Institute rigorous stage-gate project and portfolio management procedures to ensure sound project management and funding decisions. ITP has developed its own program management guidelines based on the conventional Stage-Gate Management™ concept of R.G. Cooper and Associates (see Figure 3). ITP is examining projects at critical gates throughout the R&D cycle based on carefully defined technical and business criteria. This program management tool provides ITP managers with a straightforward pathway for evaluating progress and

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imposes discipline in project management, raising the potential for commercial success of ITP's R&D portfolio.

- Emphasize commercialization planning throughout the R&D life cycle. ITP will work with its R&D partners to develop robust commercialization strategies and provide other support to ensure the market success of promising new technologies.

- Encourage private investment in energy efficiency through new partnerships and strategies to reach industry. ITP will expand its alliance with equipment manufacturers who are well positioned to drive new technology to the market and publicize it to their customers. Private industry will also be challenged to increase their investment in advanced technologies, energy management and best operating practices, and the replacement of older, inefficient equipment.

- Drive ambitious reductions in industrial energy intensity through the Save Energy Now Initiative (formerly the BestPractices program). For information on Save Energy Now, see www1.eere.energy.gov/industry/saveenergynow/.

- Promote energy-efficiency improvements throughout the supply chain.

- Help drive the development of energy management standards and the Superior Energy Performance certification program to provide a clear roadmap for continual improvement in energy efficiency. For information on the U.S. Council for Energy-Efficient Manufacturing, see www.superiorenergyperformance.net.

In addition to these strategies, ITP partners with other program areas within EERE and performs ongoing program evaluation, including assessing past programs and the benefits that have accrued from investments.

ITP's website (http://www1.eere.energy.gov/industry) provides a wealth of information about the program, and the EERE Information Center (1-877-337-3463, eereic@ ee. doe.gov) fields questions and facilitates access to ITP resources for industrial customers.

One of ITP's major efforts is the Save Energy Now Initiative – a highly successful national initiative. Save Energy Now has developed a robust suite of energy-savings tools and services that ITP provides for partnering with industry to improve energy efficiency. As of September 2009 the Save Energy Now Initiative has completed over 2,300 assessments. More than 1,500 industrial facilities have implemented the assessment recommendations, achieving $218 million, 35 trillion Btu, and 2.3 MMT of CO_2 savings each year. In 2009, ITP recognized 140 companies for their energy savings.

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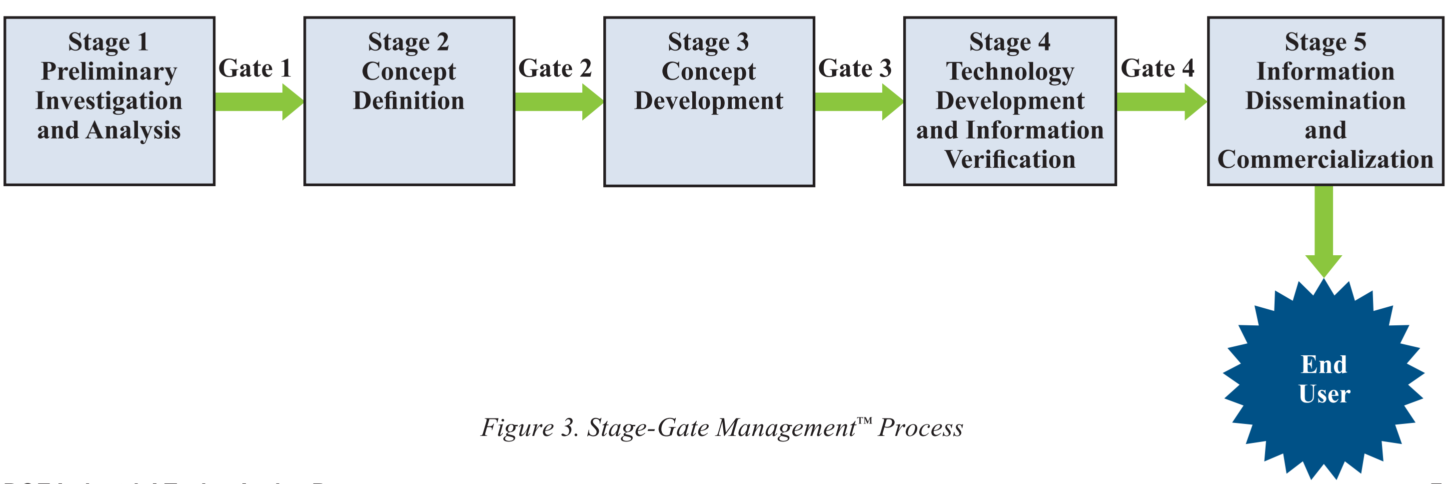

Figure 3. Stage-Gate Management™ Process

for continuous improvement. Once completed, ISO 50001 promises to create a framework for all of industry to manage energy and improve cost savings. To facilitate the transition to the ISO standards the forthcoming industry-designed American National Standards Institute (ANSI)-accredited plant-certification program–known as Superior Energy Performance–will include provisions for conforming to the ISO 50001 energy management standard, as well as achieving a defined level of annual energy intensity performance improvement. A total of 50 countries are participating in developing this international standard. The International Organization for Standardization intends to release ISO 50001 in 2011.

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This report also quantifies the benefits of projects in the EERE portfolio now managed through other program offices but initiated in ITP. For example, partnerships with an emerging bio-based products industry, now managed through the Biomass Program, bring expertise and technology from several industries – agriculture, forest products, and chemicals – to create plastics, chemicals, and composite materials from renewable resources. Also, projects are included that were funded by the discontinued Inventions and Innovation (I&I) Program that provided grants to individual inventors and small companies for conducting early development through to prototyping for innovative energy-saving ideas. In addition, projects are included that were funded by the discontinued NICE[3] (National Industrial Competitiveness through Energy, Environment, and Economics) Program that developed and demonstrated advances in energy efficiency and clean production technologies.

Tracking Program Impacts

ITP has assessed the progress of the technologies supported by its research programs for more than 20 years. ITP program managers recognize the importance of developing accurate data on the impacts of their programs. Such data are essential for assessing ITP's past performance and guiding the direction of future research programs.

Pacific Northwest National Laboratory (PNNL) estimates energy savings associated with specific technologies using a process for tracking and managing data. When a technology's full-scale commercial unit is operational in a commercial setting, that technology is considered commercially successful and is placed on the active tracking list. When a commercially successful technology unit has been in operation for about 10 years, that particular unit is then considered a mature technology and typically is no longer actively tracked. The active tracking process involves collecting technical and market data on each commercially successful technology, including details on the following:

- Number of units sold, installed, and operating in the United States and abroad (including size and location)
- Units decommissioned since the previous year
- Energy saved
- Environmental benefits
- Improvements in quality and productivity achieved
- Other impacts, such as employment and effects on health and safety
- Marketing issues and barriers.

Information on technologies is gathered through direct contact with either the technology's vendors or end users. These contacts provide the data needed to calculate the technology's unit energy savings, as well as the number of operating units. Therefore, unit energy savings are calculated in a unique way for each technology. Technology manufacturers or end users usually provide unit energy savings or at least enough data for a typical unit energy savings to be calculated. The total number of operating units is equal to the number of units installed minus the number of units decommissioned or classified as mature in a given year – information usually determined from sales data or end-user input. Operating units and unit energy savings can then be used to calculate total annual energy savings for the technology.

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The cumulative energy savings measure includes the accumulated energy saved for all units actively tracked. These energy savings include the earlier savings from now mature and decommissioned units.

Once cumulative energy savings have been determined, long-term impacts on the environment are calculated by estimating the associated reduction of air pollutants. This calculation is based on the type of fuel saved and the pollutants typically associated with combustion of that fuel and uses assumed average emission factors.

Several factors make the tracking task challenging. Personnel turnover at developing organizations and user companies makes it difficult to identify applications. Small companies that develop a successful technology may be bought by larger firms or may assign the technology rights to a third party. As time goes on, the technologies may be incorporated into new products, applied in new industries, or even replaced by newer technologies that are derivative of the developed technology.

Program benefits documented by PNNL are conservative estimates based on technology users' and developers' testimonies. These estimates do not include either derivative effects, resulting from other new technologies that spin off of ITP technologies, or the secondary benefits of the energy and cost savings accrued in the basic manufacturing industries downstream of the new technologies. Therefore, actual benefits are likely to be much higher than the numbers reported here. Nonetheless, the benefits-tracking process provides a wealth of information on the program's successes. The process of tracking these benefits is shown in Figure 4.

Over the past 30 years, ITP has supported more than 600 separate R&D projects that have produced over 250 technologies in commercial use. In 2009, there were 95 technologies that were in commercial use and yielding benefits. Appendix 1 presents fact sheets on these 95 technologies. The fact sheets include applications data, both technical and commercial, that may enable industry organizations to identify significant opportunities for adapting technologies to their particular practices. Table 1, on pages 12 and 13, provides information on the 95 currently tracked technologies. This table shows energy savings in 2009, as well as cumulative energy savings and pollution reductions. Note that for some technologies, energy savings values are unavailable, very small, or too difficult to quantify. The 95 commercial technologies in use during 2009 saved 53.1 trillion Btu that year. Cumulatively, these technologies have saved 1,319 trillion Btu.

Technologies that are likely to be commercialized within two or three years are identified in Appendix 2. Some of these 132 emerging technologies have already yielded scientific information that has improved current industrial processes.

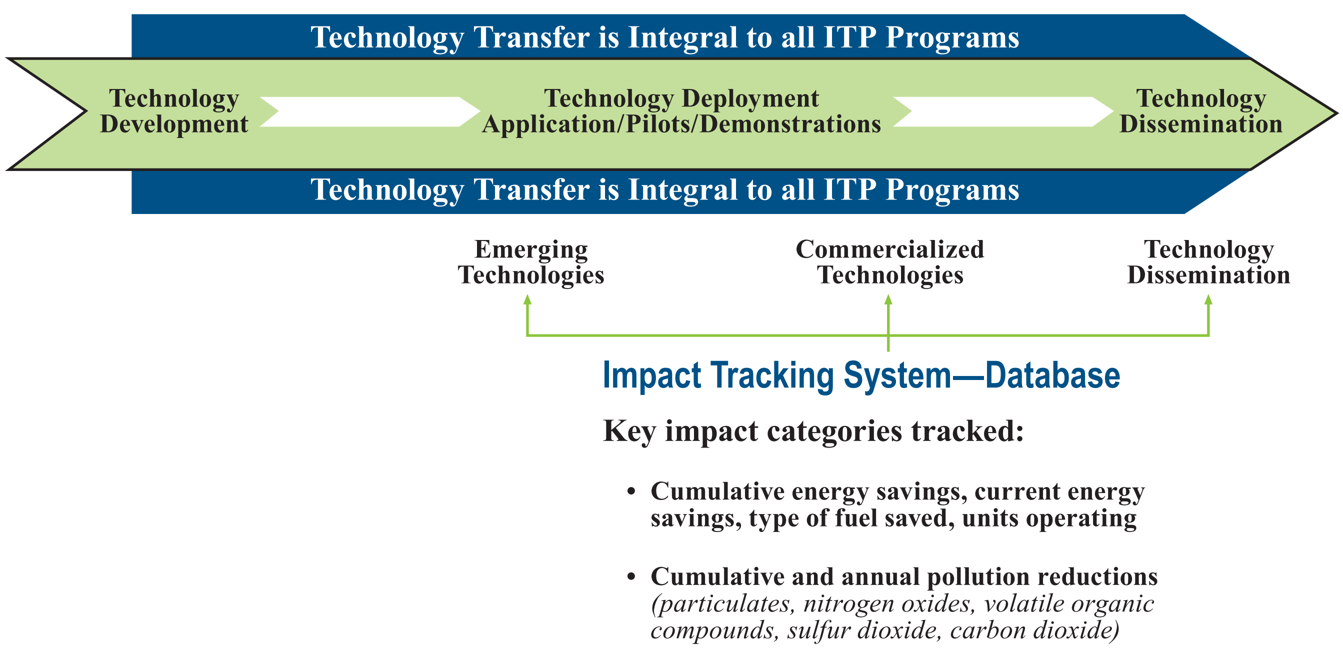

Figure 4. Technology Tracking Process

ITP Program Impacts

After a commercial technology has contributed to energy and cost savings for about ten years, the technology is considered historical and presumed to be supplanted by newer, more effective technologies. Appendix 3 describes the 128 historical technologies that have been used in commercial applications in the past. The technologies in this category are no longer tracked. While some may still be in use, new applications of the technologies are unlikely. During the time they were tracked, these technologies yielded benefits that are counted in the cumulative tallies shown in Table 1. The 128 historical technologies cumulatively saved 2,367 trillion Btu.

The method of calculating the results for the Industrial Assessment Centers (IACs) and the resulting benefits are described in Appendix 4. As Table 1 shows, the centers saved 246 trillion Btu in 2009 and cumulatively saved 2,203 trillion Btu since the activity's inception in 1977. The method of calculating the results for the Save Energy Now Initiative and the resulting benefits are described in Appendix 5. As shown in Table 1, Save Energy Now saved 224 trillion Btu in 2009 and has cumulatively saved 1,365 trillion Btu since its inception in 1998. The method of calculating the results attributable to DOE's combined heat and power (CHP) activities and the resulting benefits are described in Appendix 6. As shown in Table 1, CHP activities saved 210 trillion Btu in 2009 and have cumulatively saved 2,748 trillion Btu since 1990.

The determination of the net economic benefits of ITP programs is discussed in Appendix 7. Using the energy savings from the technologies as well as the IACs, Save Energy Now, and CHP activities, the cost savings are determined annually for the fuels saved. The annual energy savings by fuel type is multiplied by the fuel's price, with prices adjusted to reflect the fuel's current costs. The sum of all energy saved times the average energy price yields an estimate of the annual savings in that particular year. To arrive at the net economic benefits, the cumulative energy savings are reduced by the appropriation allocated by the government for ITP programs and by the cost of the industry of adopting the new technologies. Details of this methodology are provided in Appendix 7. In 2009, ITP programs were instrumental in saving industry 733 trillion Btu, equivalent to the 2008 energy consumption for the entire state of New Mexico, or $4.59 billion. Over ITP's entire history, these cumulative net benefits are about 10.0 quad, equivalent to the 2008 energy consumption for all of California or $50.55 billion (in 2009 dollars). In addition, the ITP programs have cumulatively reduced emissions of carbon by 221 million tons, of nitrogen oxides by 1.88 million tons, and of sulfur dioxides by 4.01 million tons, as Table 1 shows.

Table 1. Technology Program Impacts

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Technologies Commercially Available	Cumulative Energy Savings (10^{12} Btu)	2009 Energy Savings (10^{12} Btu)	Cumulative Pollution Reductions (Thousand Tons)				
			Particulates	VOCs	SO_X	NO_X	Carbon
ALUMINUM							
Aluminum Reclaimer for Foundry Applications	0.004	0.001	-	0.000	-	0.000	0.063
Isothermal Melting	0.011	0.001	0.000	0.000	0.002	0.002	0.213
CHEMICALS							
Cavity-Enhanced Gas Analyzer for Process Control	-	-	-	-	-	-	-
Hollow-Fiber Membrane Compressed Air Drying System	0.020	0.009	0.000	0.000	0.004	0.003	0.400
Improved Methods for the Production of Polyurethane Foam	0.296	0.103	0.001	0.001	0.031	0.041	5.25
Low-Cost, Robust Ceramic Membranes for Gas Separation	0.043	0.016	-	0.000	-	0.005	0.683
Low-Frequency Sonic Mixing Technology	-	-	-	-	-	-	-
Membranes for Reverse-Organic Air Separations	0.274	0.150	0.002	0.001	0.159	0.042	5.96
Mixed Solvent Electrolyte Model	-	-	-	-	-	-	-
Nylon Carpet Recycling	1.32	0.428	-	0.005	-	0.155	21.0
Pressure Swing Adsorption for Product Recovery	0.626	0.111	-	0.002	-	0.073	9.93
Process Heater for Stoichiometric Combustion Control	2.45	0.411	0.002	0.009	0.144	0.302	40.6
Titania-Activated Silica System for Emission Control	-	-	-	-	-	-	-
Total Cost Assessment Tool	-	-	-	-	-	-	-
TruePeak Process Laser Analyzer	-	-	-	-	-	-	-
FOREST PRODUCTS							
Advanced Quality Control (AQC) Solution for Thermo-Mechanical Pulping	1.27	0.192	0.006	0.004	0.274	0.204	24.9
Biological Air Emissions Control	1.53	0.829	0.000	0.005	0.005	0.180	24.4
Borate Autocausticizing	0.035	-	0.000	0.000	0.020	0.005	0.766
Continuous Digester Control Technology	9.00	-	-	0.032	-	1.05	143
Detection and Control of Deposition on Pendant Tubes in Kraft Chemical Recovery Boilers	7.18	1.75	0.054	0.032	4.17	1.11	156
MultiWave™ Automated Sorting System for Efficient Recycling	-	-	-	-	-	-	-
Screenable Pressure-Sensitive Adhesives	-	-	-	-	-	-	-
Thermodyne™ Evaporator – A Molded Pulp Products Dryer	0.476	0.068	-	0.002	-	0.056	7.56
GLASS							
High Luminosity, Low-NO_X Burner	-	-	-	-	-	-	-
High Throughput Vacuum Processing for Producing Innovative Glass/Photovoltaic Solar Cells	-	-	-	-	-	-	-
Process for Converting Waste Glass Fiber into Value-Added Products	0.385	0.140	-	0.001	-	0.045	6.11
METAL CASTING							
CFD Modeling for Lost Foam White Side	-	-	-	-	-	-	-
Die Casting Copper Motor Rotors	0.389	0.152	0.002	0.001	0.084	0.063	7.65
Improved Magnesium Molding Process (Thixomolding)	0.223	0.075	-	0.001	-	0.026	3.54
Improvement of the Lost Foam Casting Process	2.28	0.163	0.004	0.008	0.212	0.310	39.9
Low Permeability Components for Aluminum Melting and Casting	-	-	-	-	-	-	-
Rapid Heat Treatment of Cast Aluminum Parts	-	-	-	-	-	-	-
Titanium Matrix Composite Tooling Material for Aluminum Die Castings	0.068	0.018	-	0.000	-	0.008	1.09
MINING							
Belt Vision Inspection System	-	-	-	-	-	-	-
Fibrous Monoliths as Wear-Resistant Components	-	-	-	-	-	-	-
Horizon Sensor™	0.251	-	0.001	0.001	0.054	0.040	4.93
Imaging Ahead of Mining	7.14	0.351	0.032	0.025	1.54	1.15	140
Lower-pH Copper Flotation Reagent System	4.87	0.973	0.022	0.017	1.05	0.783	95.6
STEEL							
Aluminum Bronze Alloys to Improve Furnace Component Life	0.074	0.010	-	0.000	-	0.009	1.18
Automated Steel Cleanliness Analysis Tool (ASCAT)	-	-	-	-	-	-	-
Electrochemical Dezincing of Steel Scrap	0.370	0.087	0.005	0.000	0.232	0.104	10.4
H-Series Cast Austenitic Stainless Steels	0.001	0.000	-	0.000	-	0.000	0.009
HotEye® Steel Surface Inspection System	8.29	-	-	0.029	-	0.970	132
Laser Contouring System for Refractory Lining Measurements	-	-	-	-	-	-	-
Life Improvement of Pot Hardware in Continuous Hot Dipping Processes	-	-	-	-	-	-	-
Low-Temperature Colossal Supersaturation of Stainless Steels	-	-	-	-	-	-	-
Microstructure Engineering for Hot Strip Mills	-	-	-	-	-	-	-
Shorter Spherodizing Annealing Time for Tube/Pipe Manufacturing	0.138	0.008	-	0.000	-	0.016	2.19
Vanadium Carbide Coating Process	0.000	-	-	0.000	-	0.000	0.000

Table 1. Technology Program Impacts

IMPACTS

Technologies Commercially Available	Cumulative Energy Savings (10^{12} Btu)	2009 Energy Savings (10^{12} Btu)	Cumulative Pollution Reductions (Thousand Tons)				
			Particulates	VOCs	SO_X	NO_X	Carbon
CROSSCUTTING							
Adjustable-Speed Drives for 500 to 4000 Horsepower Industrial Applications	1.65	0.551	0.007	0.006	0.357	0.266	32.4
Advanced Aerodynamic Technologies for Improving Fuel Economy in Ground Vehicles	0.093	0.052	0.001	0.000	0.054	0.014	2.02
Advanced Reciprocating Engine Systems (ARES)	-	-	-	-	-	-	-
Aerogel-Based Insulation for Industrial Steam Distribution Systems	0.163	0.132	-	0.001	-	0.019	2.59
Autotherm® Energy Recovery System	0.137	0.037	0.001	0.001	0.080	0.021	2.99
Barracuda® Computational Particle Fluid Dynamics (CPFD®) Software	-	-	-	-	-	-	-
Callidus Ultra- (CUBL) Burner	95.1	26.4	-	0.333	-	11.1	1,510
Catalytic Combustion	-	-	-	-	-	-	-
Composite-Reinforced Aluminum Conductor	-	-	-	-	-	-	-
Cromer Cycle Air Conditioner	1.13	0.458	0.005	0.004	0.243	0.181	22.1
Electrochromic Windows - Advanced Processing Technology	0.002	0.001	0.000	0.000	0.000	0.000	0.044
Energy-Conserving Tool for Combustion-Dependent Industries	0.022	0.006	0.000	0.000	0.005	0.004	0.428
Fiber-Optic Sensor for Industrial Process Measurement and Control	-	-	-	-	-	-	-
Fiber Sizing Sensor and Controller	-	-	-	-	-	-	-
Force Modulation System for Vehicle Manufacturing	0.017	0.017	0.000	0.000	0.005	0.003	0.357
Freight Wing™ Aerodynamic Fairings	0.711	0.493	0.005	0.003	0.413	0.110	15.5
Functionally Graded Materials for Manufacturing Tools and Dies	-	-	-	-	-	-	-
Ice Bear® Storage Module	0.003	0.001	0.000	0.000	0.001	0.000	0.053
Improved Diesel Engines	1,160	16.3	8.70	5.22	674	179	25,300
In-Situ, Real Time Measurement of Elemental Constituents	0.927	-	-	0.003	-	0.108	14.7
Materials and Process Design for High-Temperature Carburizing	-	-	-	-	-	-	-
Mobile Zone Optimized Control System for Energy-Efficient Surface-Coating	0.059	0.007	0.000	0.000	0.005	0.008	1.02
Nanocoatings for High-Efficiency Industrial Hydraulic and Tooling Systems	-	-	-	-	-	-	-
Portable Parallel Beam X-Ray Diffraction System	-	-	-	-	-	-	-
Predicting Corrosion of Advanced Materials and Fabricated Components	-	-	-	-	-	-	-
Process Particle Counter	-	-	-	-	-	-	-
Pulsed Laser Imager for Detecting Hydrocarbon and VOC Emissions	1.77	0.360	-	0.006	-	0.207	28.0
Simple Control for Single-Phase AC Induction Motors	-	-	-	-	-	-	-
Solid-State Sensors for Monitoring Hydrogen	-	-	-	-	-	-	-
SpyroCor™ Radiant Tube Heater Inserts	7.46	2.24	-	0.026	-	0.873	118
Three-Phase Rotary Separator Turbine	0.036	-	0.000	0.000	0.008	0.006	0.704
Ultra-Low NO_X Premixed Industrial Burner	-	-	-	-	-	-	-
Ultrananocrystalline Diamond (UNCD) Seal Faces	-	-	-	-	-	-	-
Uniform Droplet Process for Production of Alloy Spheres	-	-	-	-	-	-	-
Uniformly Drying Materials Using Microwave Energy	0.211	0.024	0.000	0.001	0.008	0.026	3.49
Vibration Power Harvesting	-	-	-	-	-	-	-
Wear Resistant Composite Structure of Vitreous Carbon Containing Convoluted Fibers	0.007	0.002	0.000	0.000	0.004	0.001	0.156
Wireless Sensors for Condition Monitoring of Essential Assets	-	-	-	-	-	-	-
Wireless Sensors for Process Stream Sampling and Analysis	-	-	-	-	-	-	-
OTHER INDUSTRIES							
Advanced Membrane Devices for Natural Gas Cleaning	-	-	-	-	-	-	-
Clean Energy from Biosolids	-	-	-	-	-	-	-
Deep Discharge Zinc-Bromine Battery Module	-	-	-	-	-	-	-
High-Intensity Silicon Vertical Multi-Junction Solar Cells	-	-	-	-	-	-	-
Long Wavelength Catalytic Infrared Drying System	0.012	0.003	-	0.000	-	0.001	0.185
Plant Phenotype Characterization System	-	-	-	-	-	-	-
Plastics or Fibers from Bio-Based Polymers	0.124	0.018	0.001	0.001	0.072	0.019	2.69
Commercial Technologies Total	1,319	53.1	8.85	5.78	683	199	27,900
IAC Total	2,203	246	10.6	8.07	700	337	43,700
Save Energy Now Total	1,365	224	6.56	5.05	437	208	27,100
CHP Total	2,748	210	35.3	3.03	1,717	759	76,400
Historical Technologies Total	2,367	N/A	9.05	17.0	468	378	45,800
GRAND TOTAL	**10,002**	**733**	**70.4**	**38.9**	**4,005**	**1,881**	**220,900**