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Energy efficiency: A compelling global resource

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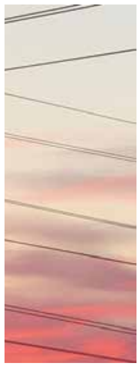
Introduction

Globally, energy efficiency represents about 40 percent of the greenhouse gas reduction potential that can be realized at a cost of less than €60 per metric ton of carbon dioxide equivalent (tCO_2e).[1] In many cases, it is an extremely attractive upfront investment that pays for itself over time, while providing the added benefits of reducing the cost of energy and increasing the energy productivity of the economy. It is not surprising, then, that many governments have emphasized energy-efficiency opportunities during the current economic downturn as a way to stimulate their faltering economies. By focusing funding on energy-efficiency initiatives, governments hope not only to save or create jobs—the primary goal of the spending—but also to reduce domestic dependence on foreign energy supplies and reduce carbon emissions associated with energy use.

Interest in energy efficiency is not new. Companies, governments, and consumer groups have sought for years to power more economic activity and residential demand with less energy. While innumerable barriers across sectors have hampered many efforts, there have been some clear successes, such as the growing adoption of energy-saving appliances in many developed markets. In recent years, increased awareness of these pockets of success—along with spiking oil costs, growing national competition for global energy supplies, environmental issues, and the increased stress of growing demand on an aging energy infrastructure—have prompted renewed interest in energy efficiency in many quarters, public and private. The large infusions of public investment in energy efficiency over the past year have only added to the momentum.

This anthology of articles looks at the energy-efficiency opportunity and how to capture it in nations and companies over the next few years. The opportunity to lower energy costs substantially is compelling. The United States, for instance, could realize more than a trillion dollars in energy savings by 2020 if comprehensive efforts are put in place to overcome barriers and improve energy efficiency across the economy. As Hannah Choi Granade, Jon Creyts, Philip Farese, and Ken Ostrowski report in, "Energy efficiency: Unlocking the US opportunity," the efficiency potential is highly fragmented across more than a hundred million residential, commercial, and industrial buildings, and billions of devices. Capturing the full value will require investment—about $50 billion more a year for the next decade—and a holistic approach involving information and education, incentives, new codes and standards, and third-party solutions.

1 "Pathways to a Low-Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve," at globalghgcostcurve.bymckinsey.com.



Governments will play a decisive role in boosting energy efficiency. By refocusing energy policies, developing nations could dramatically reduce the growth of energy demand over the next 12 years without impairing economic growth. In their article “Promoting energy efficiency in the developing world,” Diana Farrell and Jaana Remes observe that reducing energy subsidies, introducing incentives for energy efficiency, and implementing and enforcing new efficiency standards are the three most important elements of a successful energy-efficiency agenda in the developing world.

Industry also will both contribute to and benefit from greater energy efficiency. In their article, “Capturing the lean energy-efficiency opportunity in industrial and manufacturing operations,” Nicole Roettmer, Erik Schaefer, and Ken Somers demonstrate how companies that incorporate a focus on improving energy efficiency in their lean efforts can achieve significant operating cost reductions. And still more savings are to be found in better managing corporate IT assets, as William Forrest, James Kaplan, and Noah Kinder show in their article, “Data centers: How to cut carbon emissions and costs.”

Similar to the case for industry, energy efficiency can also provide a competitive advantage on a national scale. A new study of the impact of energy efficiency in the German economy reveals that German businesses, particularly in energy-intensive sectors, could gain cost advantages against global competitors if energy productivity improves across the economy. Kalle Greven, Anja Hartmann, and Florian Jaeger provide a summary of this significant study in their article, “The energy advantage.”

Similar thinking needs to be done across sectors. This compendium offers some early perspectives on what we believe will be one of the most important economic shifts in modern times—a transition to a more energy-efficient, low-carbon economy. This is just the beginning of a wave of insights and thinking about how leaders successfully steer their organizations and economies into this new era.

Shannon Bouton
Jon Creyts
John Livingston
Tomas Nauclér

Energy efficiency: Unlocking the US opportunity

By Hannah Choi Granade, Jon Creyts, Philip Farese, and Ken Ostrowski

The central conclusion of our work: Energy efficiency offers a vast, low-cost energy resource for the US economy—but only if the nation can craft a comprehensive and innovative approach to unlock it. Significant and persistent barriers will need to be addressed at multiple levels to stimulate demand for energy efficiency and manage its delivery across more than 100 million buildings and billions of devices. If executed at scale, a holistic approach would yield gross energy savings worth more than $1.2 trillion, well above the $520 billion needed for upfront investment in efficiency measures (not including program costs). Such a program is estimated to reduce end-use energy consumption in 2020 by 9.1 quadrillion BTUs, roughly 23 percent of projected demand, potentially abating up to 1.1 gigatons of greenhouse gases annually.

A more efficient use of energy has been the goal of many initiatives within the United States over the past several decades. While specific efforts have had different degrees of success, the trend is clear: the US economy has steadily improved its ability to produce more with less energy. Yet this improvement has emerged unevenly and incompletely within the economy. As a result, net efficiency gains are falling short of their full potential as positive net present value (NPV) investments. Concerns about energy affordability, energy security, and greenhouse gas emissions have heightened interest in the potential for energy efficiency to help address these important issues.

Despite numerous studies on energy efficiency, two issues remain unclear: the magnitude of the NPV-positive opportunity and the practical steps necessary to unlock its full potential. What appears needed is an integrated analysis of energy-efficiency opportunities that simultaneously identifies the barriers and reviews possible solution strategies. Such an analysis would ideally link efficiency opportunities and their barriers with practical and comprehensive approaches for capturing the billions of dollars of savings potential that exist across the economy.

To contribute to these efforts, McKinsey is engaged in ongoing research into opportunities for greater efficiency in energy use in the United States, the barriers to achieving that potential, and possible solutions. This article summarizes the findings from one significant stream of this research,

conducted by McKinsey, along with leading companies, industry experts, government agencies, and environmental NGOs (nongovernmental organizations).[1]

Compelling nationwide opportunity

Our research for this study indicates that by 2020, the United States could reduce annual energy consumption by 23 percent from a business-as-usual (BAU)[2] baseline projection by deploying an array of NPV-positive efficiency measures. As a result the United States could save 9.1 quadrillion BTUs of end-use[3] energy (18.4 quadrillion BTUs in primary energy). This potential exists because significant barriers impede the deployment of energy-efficient practices and technologies. It will be helpful to begin by clarifying the size and nature of this opportunity. Then we will describe the case for taking action to address the barriers and unlock the energy-efficiency potential.

Capturing the full potential over the next decade would decrease the end-use energy consumption this report analyzed[4] from 36.9 quadrillion BTUs in 2008 to 30.8 quadrillion BTUs in 2020 (Exhibit 1), with potentially profound implications for existing utility business models.[5] The residential sector accounts for 35 percent of the end-use efficiency potential (33 percent of primary-energy potential), the industrial sector 40 percent (32 percent in primary energy), and the commercial sector 25 percent (35 percent in primary energy). (The differences between primary and end-use potentials are attributable to conversion, transmission, distribution, and transportation losses. We present both numbers throughout because each is relevant to specific issues considered.)

This change represents an absolute decline of 6.1 quadrillion end-use BTUs from 2008 levels and an even greater reduction of 9.1 quadrillion end-use BTUs from the energy consumption level projected for 2020. If this entire potential is captured, despite the absolute decline in consumption, construction of new power plants, gas pipelines, and other energy infrastructure will be required to address selected pockets of growth, retirement of economically or environmentally obsolete energy infrastructure, and introduction of unaccounted-for consumption such as from electric vehicles. However, energy efficiency could measurably reduce the total new-infrastructure investment required during this period.

1 The full report on the conclusions of this research initiative is titled *Unlocking Energy Efficiency in the U.S. Economy* (July 2009) and is available on mckinsey.com.

2 The Energy Information Administration's *Annual Energy Outlook 2008* (AEO 2008) was used for McKinsey's business-as-usual projection; we use the 81 percent of nontransportation energy with consumption that we were able to attribute to specific end uses (see footnote 3).

3 End-use, or "site," energy refers to energy consumed in industrial, business, and residential settings, which includes providing light, heating and cooling spaces, running motors and electronic devices, and powering industrial processes. By contrast, primary, or "source," energy represents energy in the form in which it is first accounted (such as BTUs of coal, oil, or natural gas) before transformation to secondary or tertiary forms (such as electricity). From the end-use viewpoint, primary energy is lost during transformation to other forms and in transmission, distribution, and transport to end-users; these losses are an important energy-saving opportunity but one that is outside the scope of this report. Unless explicitly defined as primary energy, energy usage and savings values in this report refer to end-use energy.

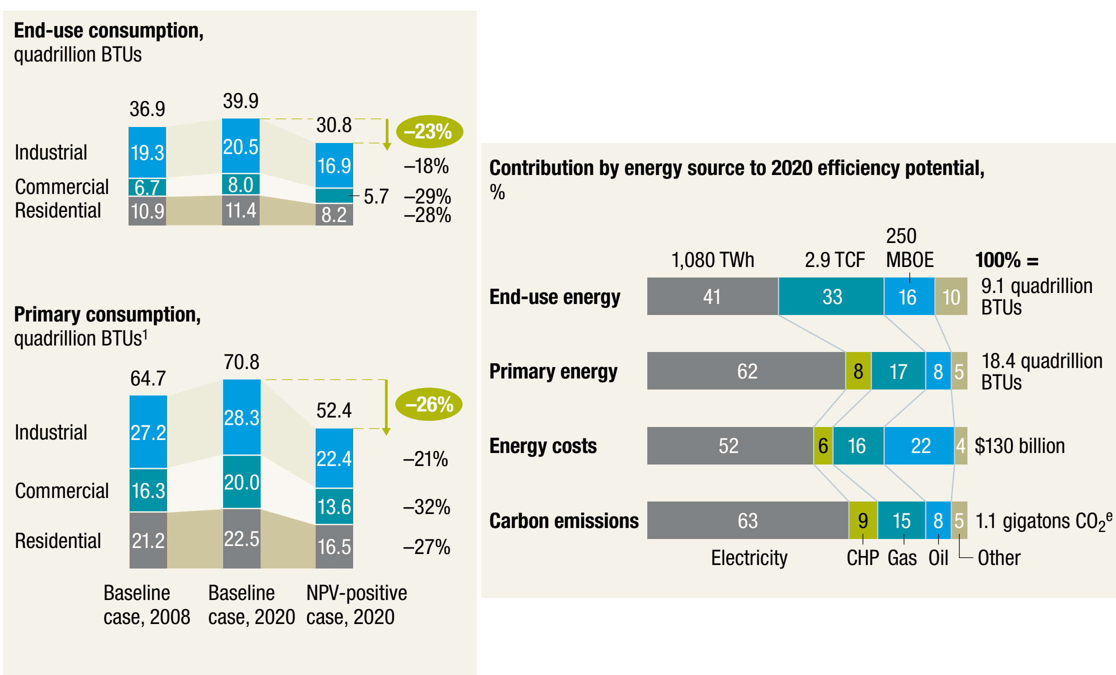
4 The scope of our analysis was the 81 percent of nontransportation energy in the *Annual Energy Outlook 2008* with end-uses that we were able to attribute.

5 We examine implications for utility company business models in Chapter 5 of the full report.

Beyond the economics, efficiency represents an emissions-free energy resource. If captured at full potential, energy efficiency would abate approximately 1.1 gigatons CO_2e of greenhouse gas emissions per year in 2020 relative to BAU projections and could serve as an important bridge to an era of advanced low-carbon supply-side energy options.

Exhibit 1

Significant energy-efficiency potential in the US economy



[1] Includes primary savings from CHP.

Source: EIA AEO 2008, McKinsey analysis

In modeling the national potential for greater energy efficiency, we focused our analysis on identifying what we call the "NPV-positive" potential for energy efficiency. In calculating the NPV-positive potential,[6] we considered direct life-cycle energy, operating, and maintenance cost savings, net of equipment and installation costs, regardless of who invests in the efficiency measure or receives the benefit. We used industrial retail rates as a proxy for the value of energy savings in our calculations,[7]

6 See Appendix B in the full report for more details on this calculation methodology.

7 Industrial retail rates represent an approximate value of the energy saved as they include generation, transmission, capacity, and distribution costs in regulated and restructured markets. The bulk of the rate is composed of generation cost, with minor contribution from transmission and capacity, and negligible contribution from distribution. The rate represents a slightly conservative estimate of the value of the energy savings because the load factor underestimates the national average, but the other components are closer to probable savings from the realizing of significant energy efficiency. We also computed the avoided cost of gas using an industrial retail rate, which likewise is close to the wholesale cost of gas plus a small amount of transport cost. A more detailed discussion of the avoided cost of energy is available in Appendix B of the full report.

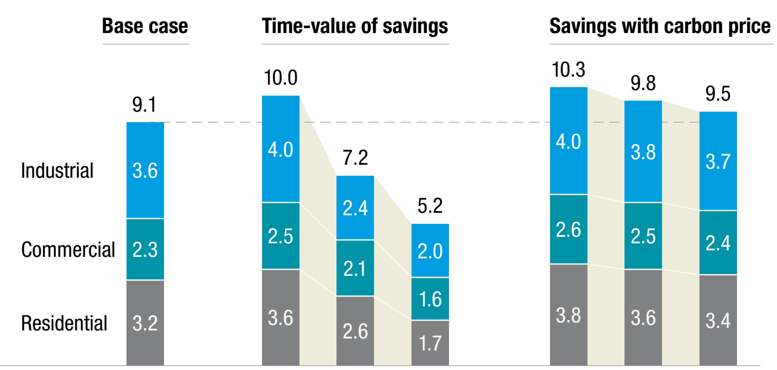
applied a 7 percent discount factor as the cost of capital, and assumed no price on carbon. This methodology provides a relatively conservative representation of the potential for NPV-positive energy efficiency from the perspective of policy makers and business leaders who must make decisions in the broad interests of society. This is in contrast to some studies that report on technical potential, which applies the most efficient technology regardless of cost, and differs from reports that project achievable potential given historical performance of efficiency programs under an implied set of constraints.

We also acknowledge, however, that there are different views of future scenarios, societal discount rates, and what constitutes "NPV-positive" from the perspective of individual economic actors. Thus we tested the resiliency of the NPV-positive opportunities by adjusting the discount rate (expected payback period), possible carbon price ($0, $15, $30, and $50 per ton CO_2e), and the value of energy savings (customer-specific retail prices and marginal long-term energy savings). We found the potential to remain quite significant across all of these sensitivity tests (Exhibit 2). Introducing a carbon price as high as $50 per ton CO_2e from the national perspective increases the potential by 13 percent. Applying a discount rate of 40 percent, using customer-class-specific retail rates, and assuming no future cost of carbon reduces the NPV-positive potential from 9.1 quadrillion to 5.2 quadrillion BTUs. This would mean a reduced but still significant potential that would more than offset projected increases in BAU energy consumption through 2020.

Exhibit 2

Sensitivity of NPV-positive energy-efficiency potential

Quadrillion BTUs, end-use energy



		Base case	Time-value of savings			Savings with carbon price		
Energy price	Industrial retail[1]	✔	✔			✔	✔	✔
	Customer retail			✔	✔			
Discount factor, %		7	4	20	40	7	7	7
Carbon price, $ per ton CO_2e		0	0	0	0	50	30	15

[1] AEO 2008 industrial energy prices by census division (national average weighted across all fuels: $13.80/MMBTU) are used as a proxy.

Source: EIA AEO 2008, McKinsey analysis

Our methodology provided a more granular examination of the economics of efficiency potential and the barriers to its capture than has been publicly reported. Using the Energy Information Administration's National Energy Modeling System (NEMS) and its *Annual Energy Outlook 2008* (AEO 2008) as a foundation, for each census division and building type we developed a set of business-as-usual choices for end-use technology through 2020. Then, to identify meaningful opportunities at this level of detail, we modeled deployment of 675 energy-saving measures to select those with the lowest total cost of ownership, replacing existing equipment and building stock over time whenever doing so was NPV-positive.[8] We disaggregated national data on energy consumption using some 60 demographic and usage attributes, creating roughly 20,000 consumption microsegments across which we could analyze the potential.

By linking our models with usage surveys and research on user-related barriers and consumption patterns we were able to reaggregate the microsegments as 14 clusters of efficiency potential according to sets of shared barriers and usage characteristics. The resulting clusters, as shown in Exhibit 3, are sufficiently homogeneous to suggest a set of targeted, actionable policy solutions and business models.

While not all actions that decrease the consumption of energy represent NPV-positive investments relative to alternatives, as defined by our methodology all the energy-efficiency actions included in this report represent attractive investments. The upfront deployment cost of these NPV-positive efficiency measures ranges upward from $0.40 per MMBTU (million BTUs) saved, averaging $4.40 per MMBTU of end-use energy saved (not including program costs). The average is 68 percent below the AEO 2008 business-as-usual forecast price of saved energy in 2020, $13.80 per MMBTU weighted average across all fuel types (Exhibit 4), and 27 percent below the forecast lowest delivered natural-gas price in the United States in 2020. Furthermore, the energy and operational savings from greater efficiency total some $1.2 trillion in present value to the US economy: unlocking this value would require an initial upfront investment of approximately $520 billion (not including program costs).[9] Even the most expensive opportunities selected in this study are NPV-positive over the lifetime of the measure and represent the least expensive way to provide for future energy requirements.

Significant barriers to overcome

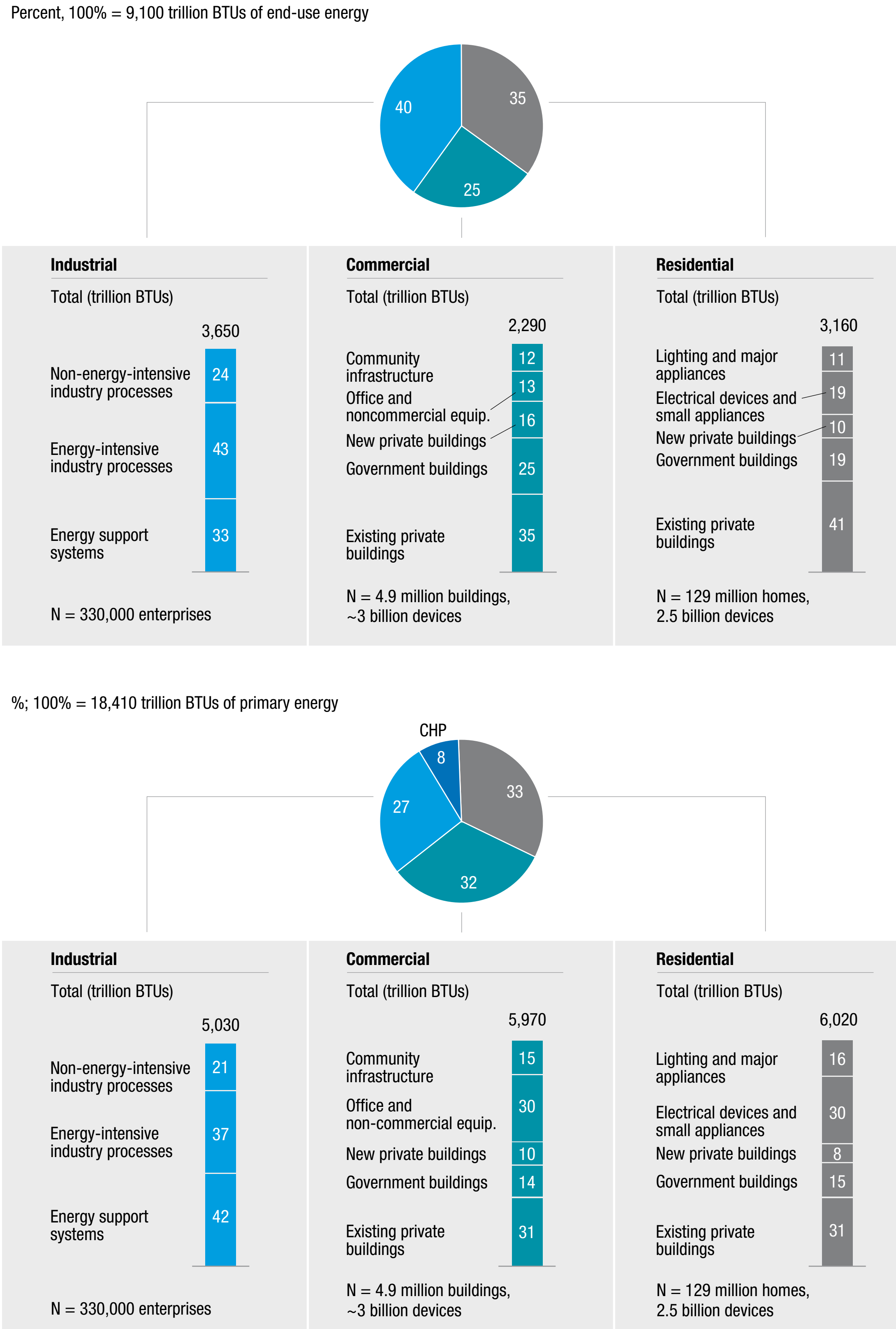
The highly compelling nature of energy efficiency raises the question of why we have not already captured this potential, since it is so large and attractive. In fact, much progress has been made over the past few decades throughout the United States, with significantly greater-than-average results in selected regions and segments. Since 1980, energy consumption per unit of floor space has decreased 11 percent in residential and 21 percent in commercial sectors, while energy consumption per real dollar of gross domestic product (GDP) has decreased 41 percent. Although these numbers do not incorporate structural changes, many studies indicate that efficiency plays a role in these reductions. As an indicator of this success, recent BAU forecasts have incorporated expectations of greater energy efficiency. For example, the Energy Information Administration's 20-year consumption forecast shows a 5 percent improvement in commercial energy intensity

8 We modeled the energy savings potential of combined heat and power installations in the commercial and industrial sectors separately from these replacement measures.

9 The net present value of this investment therefore would be $1.2 trillion minus $520 billion, or $680 billion.

Exhibit 3

Clusters of efficiency potential in stationary uses of energy—2020

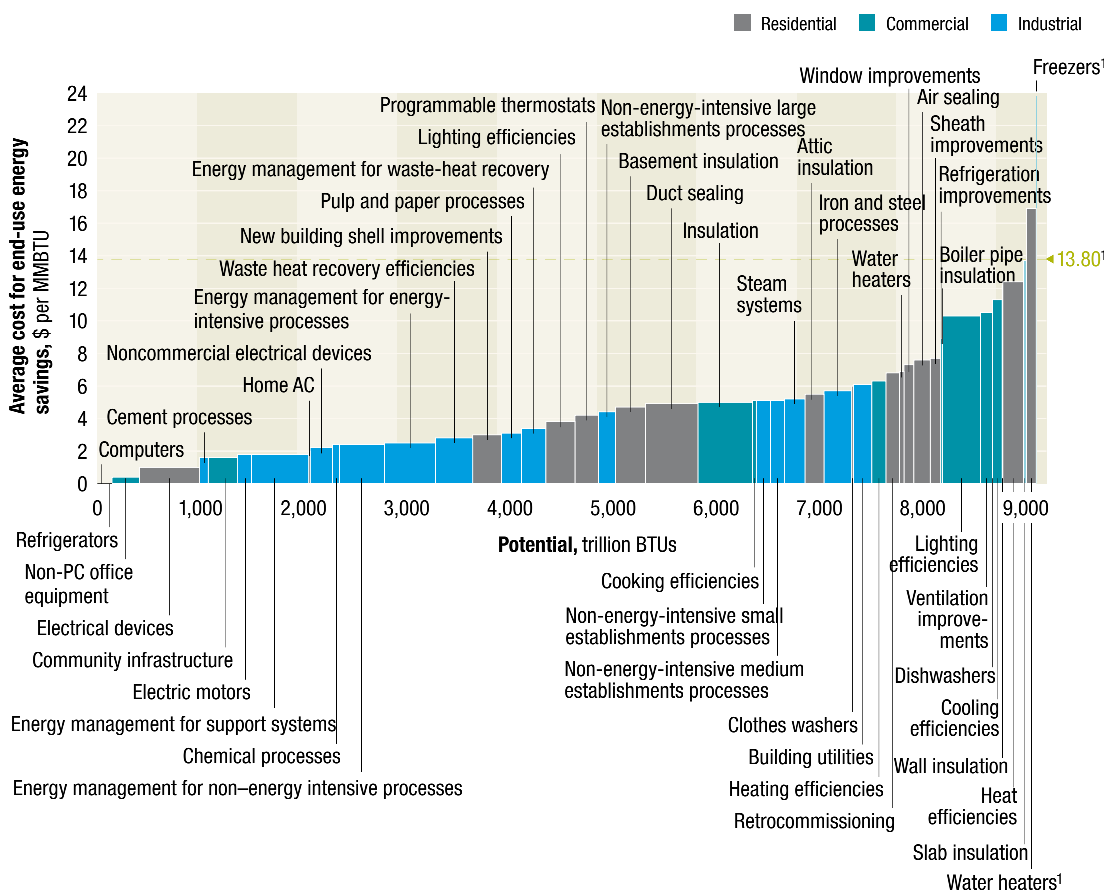


Source: EIA AEO 2008, McKinsey analysis

(the amount of energy consumed per unit produced) and a 10 percent improvement in residential energy intensity compared with its projections of four years ago.[10]

Exhibit 4

US energy-efficiency supply curve—2020



[1]Average price of avoided energy consumption at the industrial price; $35.60/MMBTU represents the highest regional electricity price used; new build cost based on AEO 2008 future construction costs.

Source: EIA AEO 2008, McKinsey analysis

As impressive as the gains have been, however, an even greater potential remains because of the fundamental nature of energy efficiency and the presence of multiple, persistent barriers at both the individual opportunity level and overall system level. By their nature, energy-efficiency measures typically require a substantial upfront investment in exchange for savings that accrue over the

10 AEO 2004 and 2008.

lifetime of the deployed measures. Additionally, efficiency potential is highly fragmented, spread across more than 100 million locations and billions of devices used in residential, commercial, and industrial settings. This dispersion virtually ensures that efficiency captures only limited mind-share—it is rarely the highest priority for anyone. Finally, measuring and verifying energy not consumed is by its nature difficult.

These attributes of energy efficiency give rise to opportunity-specific barriers that require opportunity-level solution strategies and suggest components of an overarching strategy (Exhibit 5).

Exhibit 5

Multiple challenges associated with pursuing energy efficiency

Fundamental attributes of energy efficiency

- **Requires outlay:** Full capture would require initial outlay of approximately $520 billion, plus program costs
- **Fragmented:** Potential is spread across more than 100 million locations and billions of devices
- **Low mind-share:** Improving efficiency is rarely the primary focus of any in the economy
- **Difficult to measure:** Evaluating, measuring, and verifying savings, are more difficult than measuring consumption, impairing investor confidence

Opportunity-specific barriers

Structural

- **Agency:** Incentives split between parties, impeding capture of potential
- **Ownership transfer issue:** Owner expects to leave before payback time
- **Transaction barriers:** Unquantifiable incidental costs of deployment[1]
- **Pricing distortions:** Regulatory, tax, or other distortions

Behavioral

- **Risk and uncertainty:** Regarding ability to capture benefit of the investment
- **Lack of awareness/information:** About product efficiency and own consumption behavior
- **Custom and habit:** Practices that prevent capture of potential
- **Elevated hurdle rate:** Similar options treated differently

Availability

- **Adverse bundling:** Combining efficiency savings with costly options
- **Capital constraints:** Inability to finance initial outlay
- **Product availability:** Insufficient supply or channels to market
- **Installation and use:** Improperly installed and/or operated

Opportunity-specific solution strategies

- **Information and education**
- **Incentives and financing**
- **Codes and standards**
- **Third-party involvement**

Components of an overarching strategy

- **Recognize energy efficiency as an important energy resource** while the nation concurrently develops new energy sources
- **Launch an integrated portfolio** of proven, piloted, and emerging approaches
- Identify methods to **provide upfront funding**
- **Forge greater alignment** among stakeholders
- **Foster development** of next-generation energy-efficient technologies

[1] Financial transaction barriers and actual quality trade-offs are factored into the initial NPV-positive potential calculation as real costs.

Source: McKinsey analysis

Our research suggests that unlocking the full potential of a given opportunity requires addressing all barriers in a holistic rather than piecemeal fashion. To simplify the discussion, we have grouped individual opportunity barriers into three broad categories: structural, behavioral, and availability. Structural barriers prevent an end-user from having the choice to capture what would otherwise be attractive efficiency potential; for example, tenants in an apartment building customarily have little choice about the efficiency of the HVAC system, even though they pay the utility bills.[11] This type of agency barrier affects some 9 percent of the end-use energy-efficiency potential. Behavioral barriers include situations in which lack of awareness or end-user inertia block pursuit of an opportunity; for example, a facility manager, lacking awareness of energy consumption differences, might replace a broken pump with a model having the lowest upfront cost rather than a more energy-efficient model with lower total ownership cost. Availability barriers include situations in which an end-user interested in and willing to pursue a measure cannot access it in an acceptable form; for example, a lack of access to capital might prevent the upgrade to a new heating system, or the bundling of premium features with energy-efficiency measures in a dishwasher might dissuade an end-user from purchasing a more efficient model.

Solutions available to address the barriers

Experience over the past several decades reveals a large array of tools to address the barriers that impede capture of attractive efficiency potential. Some of these have been proven on a national scale, some have been piloted in select geographic areas or at certain times on a city scale, and others are emerging and merit trial but are not yet thoroughly tested. The array of proven, piloted, and emerging solutions falls into four broad categories:

- **Information and education.** Increasing awareness of energy use and knowledge about specific energy-saving opportunities would enable end-users to act more swiftly in their own financial interest. Options include providing more information on utility bills or use of in-building displays, voluntary standards, additional device- and building-labeling schemes, audits and assessments, and awareness campaigns.

- **Incentives and financing.** Given the large upfront investment needed to capture efficiency potential, various approaches could reduce financial hurdles that end-users face. Options include traditional and creative financing vehicles (such as on-bill financing), monetary incentives and grants, including tax and cash incentives, and price signals, such as tiered pricing and externality pricing (carbon price, for example).

- **Codes and standards.** In certain clusters, some form of mandate may be warranted to expedite the process of capturing potential, particularly where end-user or manufacturer awareness and attention are low. Options include mandatory audits and assessments, equipment standards, and building codes, including improving code enforcement.

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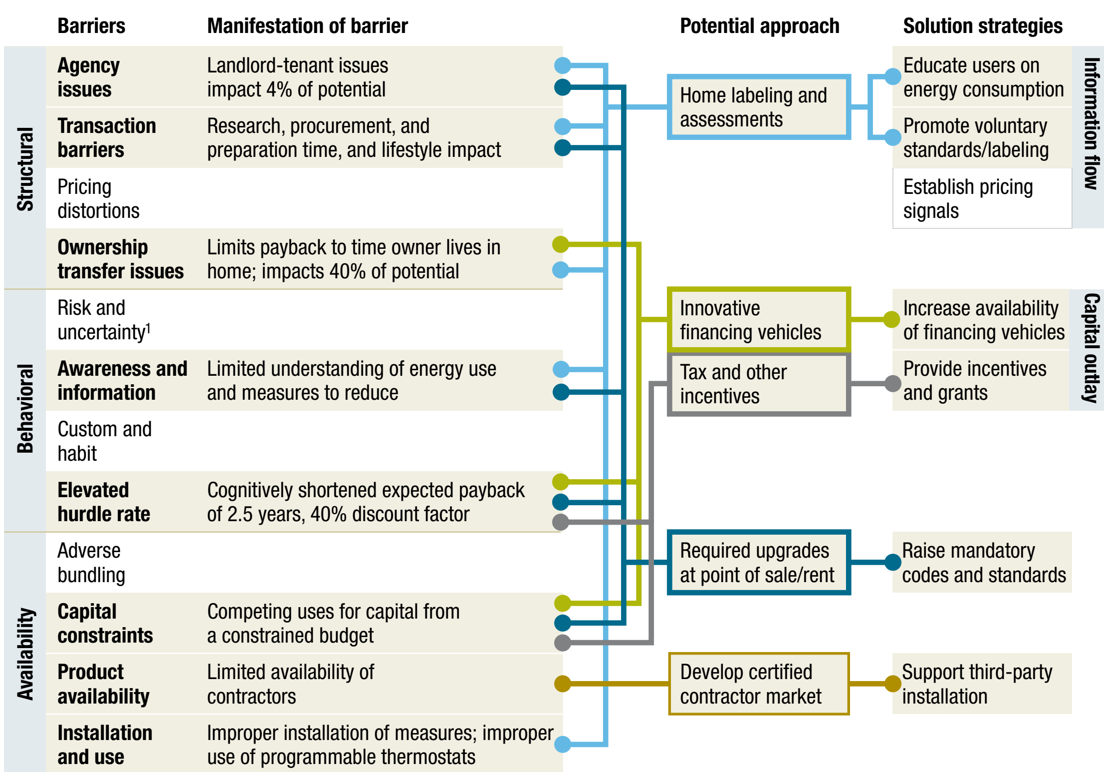
11 We refer to space conditioning systems generically as HVAC systems (heating, ventilation, and air conditioning), whether a building has a heating system, a cooling system, an air exchanger, or all three systems.

- **Third-party involvement.** A private company, utility, or government agency could support a "do-it-for-me" model for energy end-users by providing the operational engine to deploy measures, thereby addressing most noncapital barriers. When coupled with monetary incentives, this solution strategy could address the majority of barriers, though some number of end-users might decline the opportunity to receive the efficiency upgrade, preventing capture of the full potential.

For most opportunities a comprehensive approach will require multiple solutions to address the entire set of barriers facing a cluster of efficiency potential. Through an extensive review of the literature on energy efficiency and interviews with experts in this and related fields, we have attempted to define solutions that can address the various barriers under a variety of conditions. Exhibit 6 illustrates how we mapped alternative solutions against the barriers for a cluster; Chapter 1 explains this approach in detail.

Exhibit 6

Addressing barriers in existing non-low-income homes



[1] Represents a minor barrier.

Source: McKinsey analysis

Elements of a holistic implementation strategy

Capturing the full efficiency potential identified in this study would require an additional investment of $50 billion per year, four to five times 2008 levels of investment, sustained over a decade. Even the fastest-moving technologies of the past century that achieved widespread adoption, such as cellular telephones, microwaves, or radio, took 10 to 15 years to scale up at similar rates. Without an increase in national commitment it will remain challenging to unlock the full potential of energy efficiency. As noted previously, there are five important aspects to incorporate into the nation's approach to scaling up and capturing the full potential of energy efficiency. An overarching strategy would need to:

1. **Recognize energy efficiency as an important energy resource that can help meet future energy needs, while the nation concurrently develops new no- and low-carbon energy sources.** Energy efficiency is an important resource that is critical in the overall portfolio of energy solutions. Likewise, as indicated in our prior greenhouse gas abatement work,[12] new sources of no- and low-carbon generation are also important components of the portfolio. While it may initially seem counterintuitive given the magnitude of the energy-efficiency potential available over the next decade, there are important reasons for continuing to develop new no- and low-carbon options for energy supply. First, as described in our original report on US greenhouse gas abatement (Exhibit 7), energy efficiency in stationary uses of energy represents less than half of the potential abatement available to meet any future reduction targets. Additionally, some areas of the country will continue to experience growth, and some may need to retire and replace aging assets. Although it is uncertain, the growth of electric vehicles could add to these requirements. Finally, pursuing energy efficiency at the scale of the opportunity identified will present a set of risks related to the timing and magnitude of potential capture. As such there remains a strong rationale to diversify risk across supply and demand resources.

2. **Formulate and launch at both national and regional levels an integrated portfolio of proven, piloted, and emerging approaches to unlock the full potential of energy efficiency.** There are multiple combinations of approaches the nation could take to help scale up the capture of energy efficiency. In addition to seeking the impact of national efforts, this portfolio should effectively and fairly reflect regional differences in energy-efficiency potential. Any approach would need to make the following three determinations:

   — The extent to which government should mandate energy efficiency through the expansion and enforcement of codes and standards

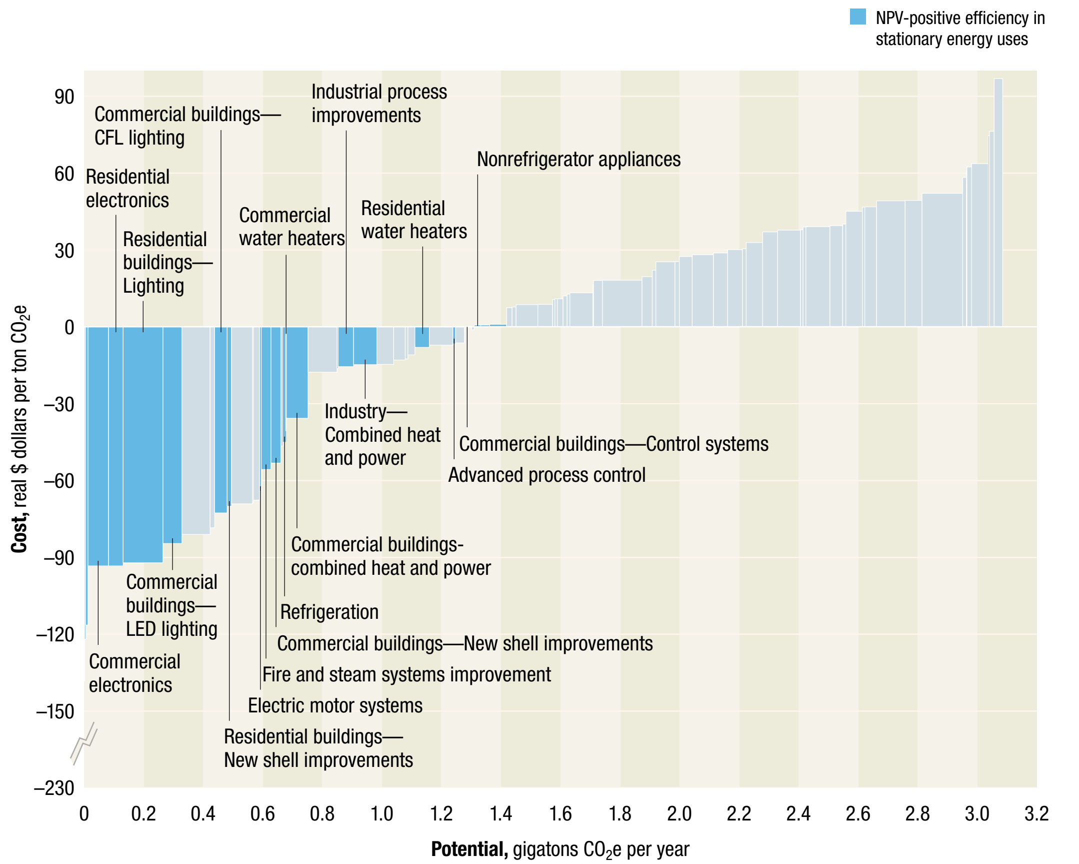
   — Beyond codes and standards, the extent to which government (or other publicly funded third parties) should directly deploy energy efficiency

   — The best methods by which to stimulate demand further and enable capture of the remaining energy-efficiency potential

12 "Reducing US Greenhouse Gas Emissions: How Much at What Cost?" on www2.mckinsey.com/clientservice/ccsi/costcurves.

Exhibit 7

US mid-range greenhouse gas abatement curve—2030

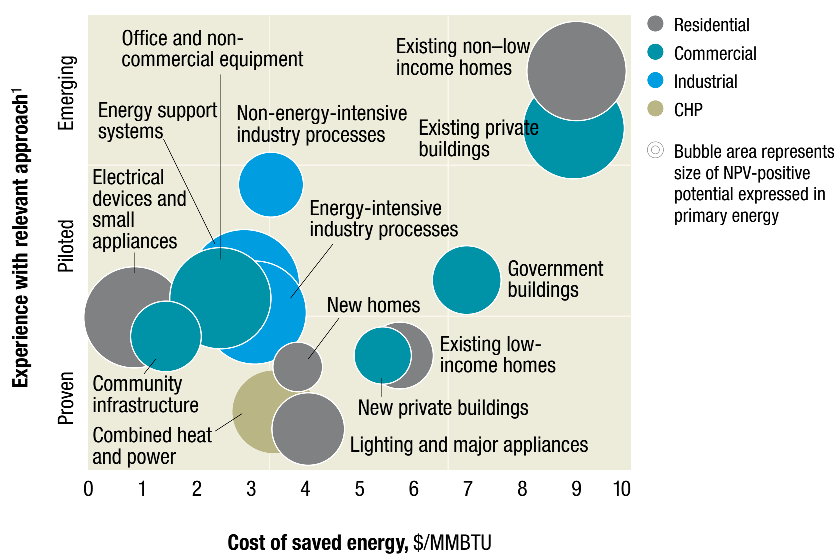


Source: McKinsey analysis

Exhibit 8 illustrates one example of a portfolio of solution strategies focusing on those that have so far proven most successful. Such a tool facilitates evaluation of a portfolio against the relevant parameters of cost, risk (experience), and return (size of the potential).

Exhibit 8

Portfolio representing cost, experience, and potential of clusters possible with specified solution strategies



[1] Drawing an analogy to our work with business transformation; piloted solutions represent those tried on the scale of a state or major city (ie, over 1 million points of consumption), emerging are untested at that level, and proven have broad success at a national scale.

Source: EIA AEO 2008, McKinsey analysis

3. **Identify methods to provide the significant upfront funding required by any plan to capture energy efficiency.** End-user funding by consumers has proved difficult. Partial monetary incentives and supportive codes and standards increase direct funding by end-users: the former by reducing initial outlays and raising awareness, the latter by essentially forcing participation. Enhanced performance contracting or loan guarantees are relatively untested but could facilitate end-user funding. Alternatively, the entire national upfront investment of $520 billion (not including program costs) could be recovered through a system-benefit charge on energy on the order of $0.0059 per kilowatt-hour of electricity and $1.12 per MMBTU of other fuels over 10 years. This would represent an increase in average customer energy cost of 10 percent that would be more than offset by the eventual average bill savings of 27 percent. Different solution strategies and policies would result in different administrative cost structures. For example, codes and standards have been typically shown to incur less than 10 percent program cost, whereas low-income weatherization programs have averaged from 20 to 30 percent.[13] Federal energy legislation under

13 Further discussion of program costs is included in Chapter 5 of the report.

discussion at the time of this report's publication will likely offer flexibility in the level of energy efficiency each state and energy provider may pursue. It will therefore be incumbent on states and local energy providers to undertake a rigorous analysis to assess the role of efficiency in the context of their overall regional energy strategy.

4. **Forge greater alignment across utilities, regulators, government agencies, manufacturers, and energy consumers.** Designing and executing a scaled-up national energy-efficiency program will require collaboration among many stakeholders. Three tasks in particular will need to be addressed to achieve the necessary level of collaboration. First, aligning utility regulation with the goal of greater energy efficiency is a prerequisite for utilities to support fully the pursuit of efficiency opportunities while continuing to meet the demands of their public or private owners. Second, setting customer expectations that energy efficiency will reduce energy bills, but not necessarily rates, will be important to securing customer support. Finally, measuring energy efficiency requires effective evaluation, measurement, and verification to provide assurance to stakeholders that programs and projects are achieving the savings claimed for them. Rather than attempting to provide "perfect" information, such programs can provide "sufficient" assurance by focusing on consistency, simplicity of design, and addressing both inputs and impact.

5. **Foster innovation in the development and deployment of next-generation energy-efficiency technologies to ensure ongoing productivity gains.** With the launch of a significant national campaign to pursue energy efficiency, the country should also have a strategy to sustain the innovation required to secure future productivity gains. By design, technology development plays a minor role in the potential identified in this report, given its near-term focus. However, we expect that innovative and cost-effective energy-saving technology will continue to emerge. Ongoing funding and support of energy-efficiency research and development can help keep the United States on a trajectory to even greater productivity gains than those presented in this report.

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In the nation's pursuit of energy affordability, climate change mitigation, and energy security, energy efficiency stands out as perhaps the single most promising resource. In the course of this work, we have highlighted the significant barriers to overcome, but have also provided evidence that none are insurmountable. We hope the information in this report further enriches the national debate and gives policy makers and business executives the added confidence and courage needed to take bold steps to formulate constructive ways to unlock the full potential of energy efficiency.

The energy advantage: How Germany can benefit

By Kalle Greven, Anja Hartmann, and Florian Jaeger

Energy has become a strategic factor for many global businesses today. The volatile price of fossil fuels, along with increasing demand for energy to support economic growth and the prospect of government-led efforts to reduce carbon emissions, suggests that energy will be of increasing relevance to companies' cost structures and operating models in the years ahead. Energy considerations influence companies' customers (businesses and consumers), as they demand more energy-efficient products and services. Energy-efficient process design could become a new wave in process reengineering. In the energy industry itself, the demand for innovative, climate-friendly technologies to produce heat and power is also growing.

Executives will focus on two perspectives about energy which, when combined, will be fundamental to developing strategic insights on the role of energy as a competitive factor in their sectors: 1) identifying the products and markets that are arising from new energy trends and the key capabilities required to succeed in these markets; and 2) pinpointing the energy-saving opportunities their own organization can capture through economically viable measures.

To get a better understanding of the strategic implications of energy, we looked closely at energy opportunities and costs in a single developed economy—Germany. While the issues of energy and sustainability matter around the globe, it is especially relevant for Germany. By our analysis, energy influences competitive advantage in roughly 44 percent of the German economy. This share is significantly higher than for all other Western industrialized countries. In looking closely at Germany the implications and dynamics become very clear; extrapolated, the implications apply globally, as well.[1]

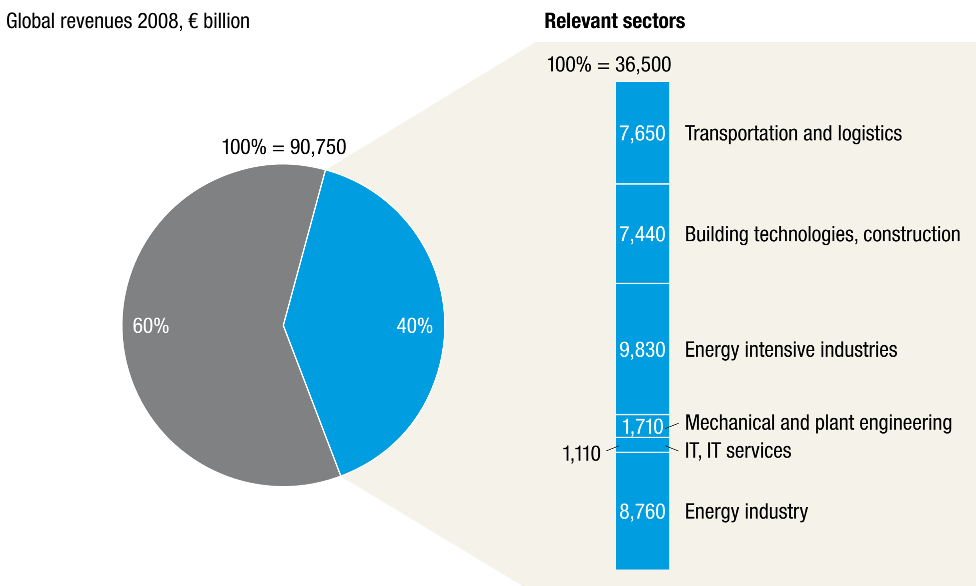
Energy: A competitive factor for 40 percent of the global economy

In 2008, economic activity generated total estimated revenue of €90,750 billion worldwide. About 40 percent of the total—some €36,500 billion—is attributable to companies for which it is of strategic importance to manage the type, quantity, and cost of the energy used in their products and production processes. This share is likely to remain constant through 2020 (Exhibit 1). These sectors are:

1 This article only captures highlights of the full analysis. The complete report, "Energy: A key to competitive advantage," can be obtained from McKinsey & Company, Germany.

Exhibit 1

Energy: A key to competitive advantage—relevant sectors



Source: *World Industry Monitor*, February 2009, IHS Global Insight; McKinsey analysis

- *Transportation and logistics (€7,650 billion)*: Manufacturers of automobiles, trains, aircraft, and ships, and their suppliers, as well as transportation service providers (rail companies, airlines, logistics providers)
- *Building technologies and construction (€7,440 billion)*: Companies that provide materials and services for the construction and renovation of buildings (including household electronics)
- *Energy-intensive industries (€9,830 billion)*: Companies in sectors where energy costs account for more than 5 percent of the production value (particularly steel, nonferrous metals, chemicals, and pulp and paper)
- *Mechanical and plant engineering (€1,710 billion)*: Manufacturers that supply companies in other industrial sectors with plant and machinery (such as motor systems or automation and control technology)
- *Information technology and IT services (€1,110 billion)*: Companies that develop and supply IT solutions, especially software programming and associated services such as installation, maintenance, and consulting
- *Energy industry (€8,760 billion)*: Companies that extract fuel (for example, coal mining, and oil and gas drilling) and/or process and transport fuel, as well as those that generate and transmit electricity; also industry segments that supply relevant plant and machinery (such as turbines, pipelines, and compressors).

Energy: A less important role for the remaining 60 percent of the global economy

For example, energy does not represent a significant share of the cost base for the health care sector (€3,300 billion), the education sector (€2,200 billion), or the insurance industry (€1,100 billion). Within the retail sector, energy does not play a significant role for a substantial number of players—notably standard retailers not vertically integrated in the supply chains of the products they sell. While a few of the products they might sell—for instance, apples from New Zealand—will carry energy costs, energy as a whole does not amount to a significant share of operating expenditure.

In Germany, the share of industries in which energy plays a potentially strategic role is larger than in any other Western industrialized nation. In 2008, these industries generated more than 44 percent of German revenue—€2,380 billion. Japan is a close second at around 43 percent—in other economies, this share is significantly lower, e.g. at 30 percent in the US and at 31 percent in the UK. The relevant industry sectors contribute nearly 32 percent of Germany's gross domestic product (GDP). Close to 12.4 million people work for companies that have to include energy as an important factor in their strategic planning. Additionally, like many other industrial countries, Germany is heavily dependent on imported energy. In 2006, Germany covered more than 60 percent of its primary energy requirements with imports, mainly of oil and gas.

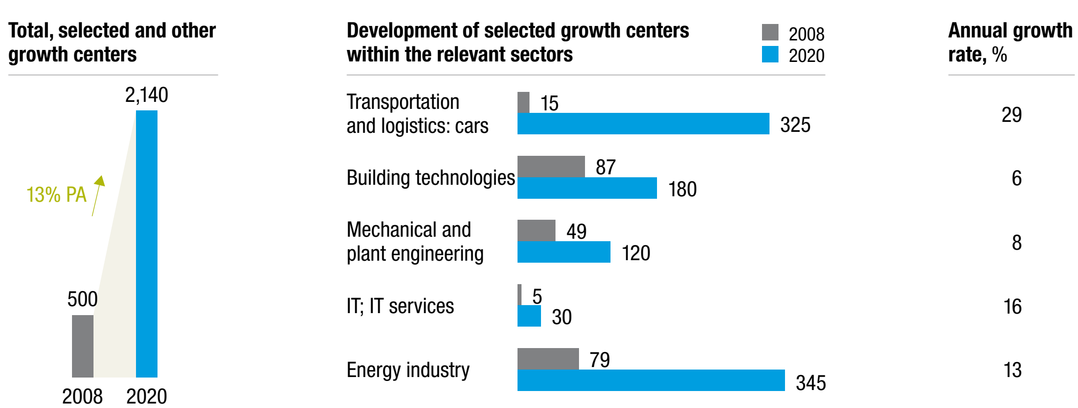
New products and markets

As a whole, the sectors in which energy plays a strategic role are expected to see global growth rise only slightly faster than global GDP to 2020, for instance, at rates of 3.1 percent per year (versus 2.9 percent per year for GDP). However, more granular analysis shows that these sectors each contain segments that are growing much faster and are therefore of critical importance for the sector as a whole. These segments, which we call "growth centers," contain innovative solutions to cut energy consumption or improve conversion efficiency. They are projected to generate annual revenue of €2,140 billion by 2020 (Exhibit 2).

Exhibit 2

Global market potential in growth centers

Global revenues, € billion per annum (PA)



Looking more closely at some of these growth centers, we find:

- **More efficient low-emission passenger car technologies** could grow by 29 percent a year and generate annual revenues of €325 billion by 2020. There are three primary technologies to consider here: first, hybrid vehicles (combustion engine as main propulsion system supported by an electric motor) could account for as much as 16 percent of global market share in 2020 (€270 billion per year), assuming an oil price of $60 per barrel. Second, we estimate that electric cars and plug-in hybrid vehicles could account for 1 percent of all new vehicles sold globally in 2020 (€20 billion). But, third, combustion engines—albeit with significantly higher efficiency—will remain the dominant technology in 2020, despite the fast growth of alternatives. Germany's global share for more efficient low-emission passenger car technologies has the potential to be 15 percent by 2020.

- **Efficient technologies for buildings** could grow by 6 percent a year and generate annual revenues of €180 billion by 2020. Heating accounts for around 80 percent of the world's energy consumption in the buildings sector. Therefore, key levers for improving efficiency—and thus also important technology markets—are heating system construction (including decentralized combined heat and power generation), insulation, and the technical solutions for the reduction of heat consumption, particularly in regions with rough weather conditions. The share of electric power, at just under 20 percent of global energy consumption in the household sector, is small compared with that of heating. Nevertheless, it is the main driver of increased energy consumption in buildings due to the growing number of domestic electric appliances, especially in emerging economies, leading to a rise in the share of electric power in household energy consumption to almost 30 percent by 2020. Key growth centers include white goods (for example, refrigerators and washing machines), energy-efficient lighting technology, compact fluorescent lamps (CFLs), and smart-home solutions (intelligent technologies regulating a household's or company's energy system and appliances). Germany's global share for building technologies has the potential to be 7 percent.

- **Products for discrete and process production** could grow by 8 percent a year and generate annual revenues of €120 billion by 2020. Together with industry-specific solutions, four submarkets are of special importance: automation and control technology, industrial motor systems and drives, more efficient IT infrastructure, and heat recovery. To take advantage of these opportunities, companies will need deep insight into customer preferences. Enhancing the economic value of energy-efficient products for industrial customers and consumers—and making this value transparent to them—will require expertise in design-to-value and value selling, as well as innovative financing solutions and new operating models. Germany's global share for mechanical and plant engineering technologies has the potential to be 5 percent by 2020.

- **Renewable energy, nuclear power, and carbon dioxide capture and storage technologies** could grow by 13 percent a year and generate annual revenues of €345 billion by 2020. New markets will develop from the global push to reduce greenhouse gas emissions, particularly in the field of power generation. The key technology trends in large-scale power generation include the expansion of renewable energy (solar, wind, and biomass), the increasing use of nuclear energy, and—even if only for a transition period—the development of technologies for carbon capture and storage (CCS). Germany's global share of these technologies has the potential to be 16 percent by 2020.

- **Innovative IT systems in energy management technologies** could grow by 16 percent a year and generate annual revenues of €30 billion by 2020. Customized IT solutions and associated services play a key role in increasing energy efficiency across industries. They help to reduce both energy costs and greenhouse gas emissions. In our context, three applications are especially important: IT-based traffic management systems, IT solutions for centralized energy management, and smart grid solutions. (Smart grids optimize the distribution of electric power by effectively connecting different and decentralized power generation facilities to the network, and on the user side, provide technological solutions for measuring and controlling consumption, known as smart metering.) Germany's global share of these technologies has the potential to be 5 percent by 2020.

The overall revenue potential in these growth centers as of 2020 amounts to around €1,000 billion per year, assuming annual growth rates of just under 13 percent. Similar potential can also be expected in other transportation technologies, such as aircraft, truck, and ship construction, in electrical equipment and devices, and in segments of the chemical industry. Thus the cumulative potential growth would represent a market of about €2,140 billion for all growth centers analyzed.

Germany already has a certain edge in these growth centers, adding ten percent annually to their combined global value (versus six percent across all industries). If Germany can maintain its share in these more dynamic market segments, it can add 850,000 new jobs, increasing employment in the segments from 260,000 people today to more than 1.1 million by 2020.[2] Even greater employment growth is possible if German companies succeed in taking the global lead in these growth centers early on and continually enlarge their market shares.

Greater energy productivity

Companies could gain a lasting cost advantage by optimizing the energy efficiency of their products and processes, and consumers, too, would lower their energy costs by applying the technologies described above. If German companies and households pull all the economic levers known today

2 Our estimate is meant to help size the new sectors by expressing them in terms of the potential employment pool. This estimate covers the full range of jobs in the delivery value chain, including sales and installation and it does not take into account the full labor market implications from replaced workers or future productivity growth in these or other segments.

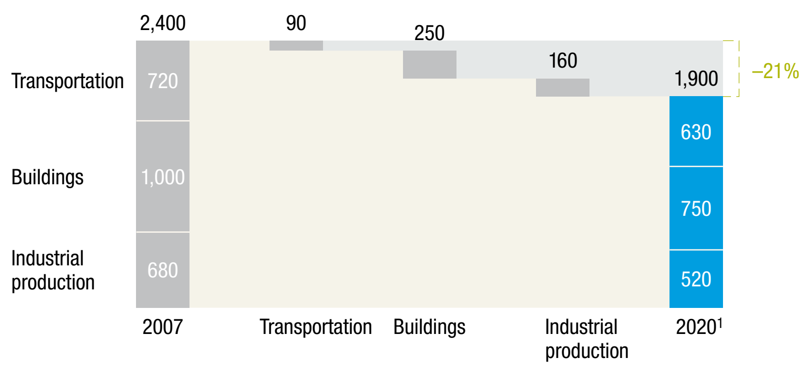
to increase energy productivity, they can reduce their energy costs by €53 billion a year as of 2020. By doing so, Germany could safeguard its international competitiveness, and—as a direct result—secure many domestic jobs.

Germany's energy consumption accounted for 2,400 terawatt hours (TWh) in 2007—around three percent of global consumption. Energy consumption and greenhouse gas emissions in Germany would largely remain stable through 2020 if appliances and equipment were replaced at the end of their life cycles by products that meet current energy-efficiency standards. However, our analysis of energy efficiency in Germany suggests that companies and households could reduce their consumption by 21 percent by 2020, saving 500 TWh of energy annually, if they systematically apply the products and solutions described above and design energy-efficient processes in line with these solutions (Exhibit 3).

Exhibit 3

Potential for reducing energy consumption and costs—German companies and households

Final energy consumption in Germany, terawatt hours (tWh) per annum (PA)



	Transportation	Buildings	Industrial production	2020
Energy savings, € billion PA	13	21	7	**41**
Additional savings of German companies abroad	9	0	3	**12**

Total savings potential as of 2020: €53 billion PA

[1] To give a better illustration of the savings potential, the same usage patterns and economic performance as in 2007 were assumed.

The biggest savings potential is in the *buildings sector*. We estimate Germany can reduce energy used in buildings by 250 TWh (€21 billion) per year—a 25 percent reduction from 2008 levels. (Energy consumption in the buildings sector in Germany currently totals around 1,000 TWh a year.) Of this, 85 percent is for heat and 15 percent for electric power. Residential buildings account for about two-thirds (620 TWh), commercial and public buildings for the remaining one-third (380 TWh). Improvements in the efficiency of electrical usage come from more systematic adoption of energy-efficient white goods, lighting, and smart-home solutions. Insulation and smart-home options for controlling building temperatures, among other solutions, improve heating efficiency. The energy-efficient refurbishment of buildings has already made far more inroads in the commercial and public sectors in Germany than in the fragmented household sector because profitable operator models, such as energy contracting, are easier to implement in these fields. Removing some of the regulatory and legal hurdles to implementation, structurally optimizing the subsidies offered, and intensifying effective energy counseling would be important enablers for the residential sector.

Systematic improvement of energy efficiency in *industrial production* could yield savings of 160 TWh (€7 billion) a year. Many companies in Germany use lean approaches to optimize their production systems, and these efforts indirectly contribute to reducing energy costs as well, frequently by streamlining and preventing waste (such as overproduction or scrap). These companies could gain substantial additional energy savings with initiatives specifically geared to reducing energy consumption. We estimate that these initiatives could generate energy cost savings of from 20 to 30 percent for discrete production, and from 25 to 35 percent in process industries (where the savings can even rise to 50 percent if combined with a conventional lean program). In energy-intensive industries such as cement, lime, and aluminum, introducing energy-optimized production systems could more than double the margin depending on the baseline. To realize savings of this magnitude, companies must anchor energy efficiency centrally in the production system (for instance, the guidelines, principles, and levers of manufacturing). Key actions include minimizing energy waste and applying energy-saving technologies. It is only when companies combine improvements to technologies and processes with positive changes in people's mind-sets and behaviors that they succeed in achieving sustainable energy savings.

Transportation and logistics can contribute 75 TWh (€11 billion) per year in energy savings and *traffic management systems* 15 TWh (€2 billion) annually. Two-thirds of Germany's energy consumption in transportation and logistics (automobiles, trains, aircraft, and ships) involve private transportation —mainly cars—and one-third the transportation of goods. Smaller vehicles, low-consumption combustion engines, and a higher share of electric cars and hybrid vehicles in the fleet could reduce energy use in private transport. Optimizing global supply chains, changing freight transport modes (for instance, from air to sea) or other transport variables—such as route selection or speeds—can reduce energy expended in the movement of goods. Smart traffic management solutions that prevent the buildup of traffic jams using techniques such as traffic management systems that switch and activate freeway lanes can help reduce transportation energy use generally.

Finally, additional savings could be achieved by improving energy used in the foreign facilities of German companies or in international logistics. We estimate the savings potential at €3 billion and €9 billion, respectively, in these efforts.

All together, this adds up to potential savings of €53 billion per year as of 2020. These energy savings would raise Germany's energy productivity from today's €5,500 per toe (ton[3] of oil equivalent) to around €7,000 per toe, putting Germany almost on a par with Japan—despite the much higher share of industry in the German economy. Germany's dependence on imported energy would also fall, increasing the stability of its energy supply. In addition, annual greenhouse gas emissions would drop by more than 200 million tons of CO_2e by 2020.

3 Metric ton: 2,205 pounds.

□ □ □

All in all, unlocking this kind of value in energy savings could provide a significant cost advantage for German companies competing globally. Add to this the strategic potential to profit from developing and selling new energy-efficient products and services, or to reap substantial returns from the right new energy investments, and the case for energy as a new factor in winning competitive advantage is clear.

What is true for Germany is also true elsewhere. Business and political leaders in nearly any nation could accept the challenge and find creative ways to quickly create a competitive advantage in relevant energy-efficiency markets. In many cases, this will require unusual alliances across industries—and often across national borders as well, since global cooperation and coordination is a key to success in many energy growth centers.

Promoting energy efficiency in the developing world

By Diana Farrell and Jaana Remes

Developing economies have a huge opportunity to strengthen their economic prospects by boosting their energy productivity.

Big gains await developing countries if they raise their energy productivity, research by the McKinsey Global Institute (MGI) has found: they could slow the growth of their energy demand by more than half over the next 12 years—to 1.4 percent a year, from 3.4—which would leave demand some 25 percent lower in 2020 than it would otherwise have been (Exhibit 1). That is a reduction larger than total energy consumption in China today.

Policy makers and businesses in developing regions must not be deterred from boosting energy productivity (the output they achieve from the energy they consume) because of the present weakening economic environment and falling oil prices; these do not affect the long-term projections in the study.[1] Time is of the essence: developing economies will install half or more of the capital stock that will be in place in 2020 between now and then. Every building or industrial plant constructed without optimal energy efficiency represents a lost opportunity to lock in lower energy consumption for decades.

Just by using existing technologies that would pay for themselves in future energy savings, consumers and businesses could save some $600 billion a year by 2020. Companies that pioneer energy efficiency in their home markets will be well placed to carve out a leading position in the global market for "green" products and services before it matures. Indeed, 65 percent of available positive-return opportunities to boost energy productivity are located in developing regions (Exhibit 2).

1 The study—conducted before the economic slowdown in late 2008—assumes, among other things, global GDP growth of 3.2 percent annually to 2020 (including, for example, 6.4 percent annual growth in China) and an average oil price of $50 a barrel. A fresh review of the data and underlying assumptions indicates that slowing worldwide economic growth in the near term will have minimal effects on the long-term projections in this article.

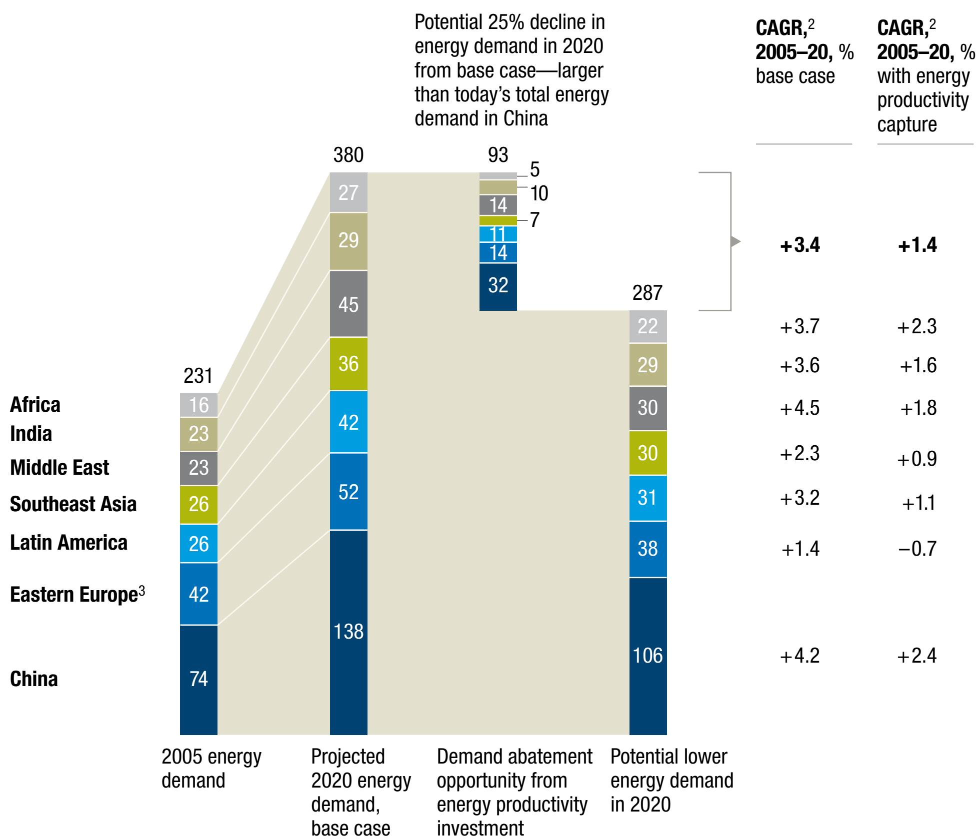
The benefits of higher energy efficiency are achievable with an investment of $90 billion annually over the next 12 years—only about half of what these economies would otherwise need to spend on their energy supply infrastructure to keep pace with higher consumption. Indeed, because of lower labor costs, the price tag for investing in energy productivity is on average 35 percent lower in developing economies than in advanced ones.

At present, a range of market failures and information barriers discourage developing countries from increasing their energy productivity, even with high energy prices. Capital constraints, particularly for low-income households, are a major hurdle. Consumers also tend to lack the information they need to make the right choices. Many companies, insulated from the true price of energy, have relatively little incentive to identify and invest in the fragmented energy savings opportunities that are available. And today's tighter credit markets are squeezing the financing of all investments—even less risky ones, such as those in energy efficiency.

Exhibit 1

Higher energy productivity

End-use energy demand by region,[1] quadrillion British thermal units (QBTUs)



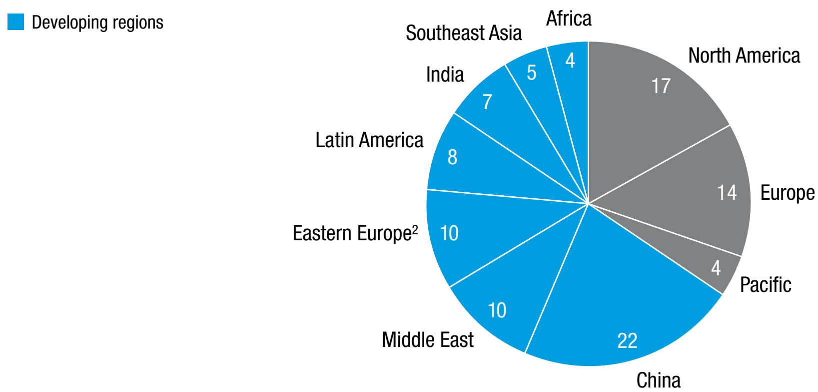
[1]Figures may not sum to totals, because of rounding.
[2]Compound annual growth rate.
[3]Includes Belarus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Russia, and Slovakia.

Source: McKinsey Global Institute analysis

Exhibit 2

Where the opportunities are

End-use energy demand abatement in 2020 by region,[1] %
100% = 143 quadrillion British thermal units (QBTUs)



[1]Figures do not sum to 100%, because of rounding.
[2]Includes Belarus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Russia, and Slovakia.
Source: McKinsey Global Institute analysis

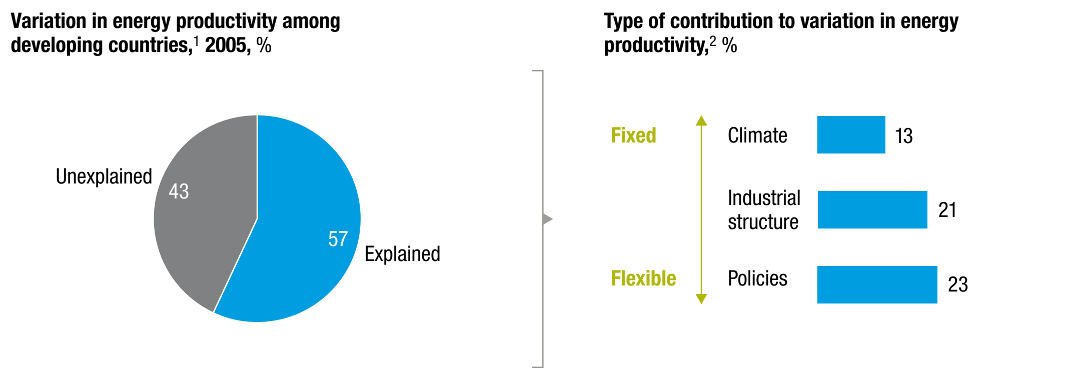
MGI calculates that somewhat more than half of the current variation in energy productivity among developing countries can be explained by climate, industry structure, and energy policies (Exhibit 3). Climatic extremes that require the use of heating and cooling systems unavoidably increase energy consumption in relation to GDP in some regions. Heavy industrialization is a consideration because countries with large manufacturing sectors tend to consume more energy and have lower energy productivity. But for energy policy, there are adjustments that developing countries can make. MGI identifies *four priority areas*.

The first is to reduce energy subsidies, as they tend to lower energy productivity. The International Energy Agency (IEA) estimates that in 2005, these subsidies totaled more than $250 billion a year in developing countries—more than the annual investment needed to build their electricity supply infrastructure. Protecting the poor from the stress of high energy prices is a legitimate goal. But there are other ways to achieve this and similar welfare goals at a lower cost. For example, in Latin America and elsewhere, governments have tried to reduce poverty by using conditional cash-transfer programs, which can also help compensate low-income households for high energy costs. To ease the transition to more efficient energy use, governments should consider providing finance for upgrades to more efficient equipment and use some of the savings from lower energy consumption to assist poor segments of the population.

Second, governments should provide incentives for utilities to improve energy efficiency and encourage their customers to do the same. Policy options include revenue incentives and certification programs that measure and reward progress toward achieving efficiency targets and also encourage the adoption of technologies such as smart metering that help households better manage their energy use.

Exhibit 3

Variation in energy productivity



[1]Data covers 27 developing countries (defined as those with a 2007 average per capita income of less than $11,000, adjusted for purchasing-power parity).
[2]Climate is based on hot/cold days; industrial structure reflects the manufacturing and nonmanufacturing subsectors of the economy, combined with level of per capita income; policies include gas subsidies and gas taxes, as well as an index of corruption.

Source: Global Insight; International Energy Agency (IEA); national sources; McKinsey Global Institute analysis

Implementing and enforcing energy efficiency standards is a third area for action. Such standards boost production of more efficient appliances and equipment and reduce their cost. Indonesia has recently adopted the UN technical regulation on auto energy efficiency, for example, and Ghana has pioneered standards for household appliances in Africa.

A fourth priority is encouraging public–private partnerships, such as collaborations between governments, energy service companies, utilities, and mortgage companies, to finance higher energy efficiency in buildings. China, which manufactures 70 percent of the world's lightbulbs, now has very large subsidies in place to promote the uptake of energy-efficient bulbs.

If developing countries and their businesses seize the initiative on energy productivity, they will cut their energy costs, insulate themselves from future energy shocks, and secure a more sustainable development path—benefits that are all the more desirable given the current global financial turmoil.

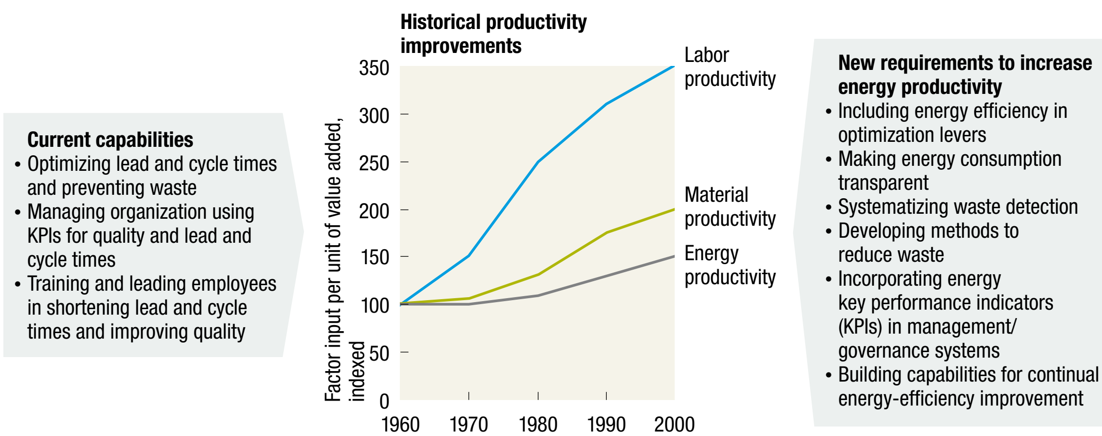
Capturing the lean energy-efficiency opportunity in industrial and manufacturing operations

By Nicole Roettmer, Erik Schaefer, and Ken Somers

Between 1990 and 2009, many industrial and manufacturing companies boosted corporate performance by adopting lean production methods to optimize material and labor productivity. Indeed, a multiyear study of how well thousands of manufacturing companies in North America, Europe, and Asia adopted management best practices (including lean), highlighted just how important these practices are to a company's economic success (Exhibit 1). [1]

Exhibit 1

An analysis of the development of energy productivity over time reveals substantial improvement potential



Source: BMU 2007a, McKinsey

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1 The study, conducted from 2005 to 2008 by McKinsey and the London School of Economics, looked closely at how well manufacturing companies adopted proven best practices, such as lean, and at the relationship between these efforts and financial results. An early view on the research, published in February 2006, is available at mckinseyquarterly.com: Stephen J. Dorgan, John J. Dowdy, and Thomas M. Rippin, "The link between management and productivity."

But most companies that have adopted lean techniques have not incorporated, or only partly adopted, new tools for increasing energy efficiency. Until now, most companies did not pay much attention to cutting energy costs for three main reasons. First, the cost of oil, though rising since 2002, has been relatively inexpensive for years. Second, through 2008, companies focused the majority of their improvement efforts on growth and increasing capacity. And third, companies struggled to track their energy efficiency, which is often highly dependent upon production rates and product mix, in a meaningful way. As a consequence, for many years companies typically found it easier to focus their lean continuous improvement projects on cutting costs or increasing output, which yielded higher returns per project, than on efforts to increase energy efficiency.

With the rise in oil prices in 2007 and 2008, however, companies realized that reducing waste in energy use could have a significant impact on the bottom line. Currently the price of oil is still twice or more what it was during much of the 1990s, and though it has fallen from its highs of 2008, most analysts expect it to rise again as the global economy rebounds. Energy costs for European chemical companies on average rose from 4.8 percent of total costs in 2002 to 11.6 percent in 2006. Because of the run-up in energy costs, the return on efforts to optimize energy usage at many companies was generally three times greater in 2006 than in the 1990s, when oil traded for $25 per barrel on average (corrected for inflation).

In both our research and our experience working with a number of manufacturing companies across several sectors, we have found that most companies can reduce the overall energy efficiency of their operations by 10 percent or better with relatively small investments and by up to 35 percent when making substantially larger ones. Savings vary by sector, of course. Typical savings among integrated steel players in Europe or the United States can be 10 to 15 percent or more, and among chemical companies 10 to 20 percent. What's more, all of these savings can be achieved with limited investment and simple payback periods of less than two years. One European company, for instance, estimates that it can shave 6 percent off its energy costs without any capex investments and an additional 5 percent with capex expenses of less than $20 million.

This is not to say that companies have ignored energy inefficiencies. Most of them have taken a variety of steps to lower their energy intensity (the amount of energy consumed per unit produced)—from launching "green" awareness programs among employees to substituting variable for fixed drives in electric motors to reduce the energy consumed. Traditional lean programs also typically identify savings gained by improving every aspect of a manufacturing step, frequently including energy savings. But in our experience, traditional lean programs enable companies to realize only about one-sixth of their potential energy savings—leaving the rest on the table. Why? Few companies are making systematic efforts to holistically map out energy consumption at each step in their operating processes or to identify specific energy waste in their production systems and then to focus on opportunities to reduce it. They have not been setting concrete goals for improvement—the way they have in other areas where they have applied lean tools and thinking. As a result, few are realizing anything near their energy-savings potential.

Companies can realize greater gains by incorporating energy-efficiency analyses and techniques into their existing lean approaches in three ways. First, they can focus specifically on energy consumption (rather than on energy as an input to a process), and systematically identify waste as they would in any other lean program. Teams focused on improving energy efficiency, for instance, might use such lean approaches as value-added identification to determine the energy required to make the product and the amount of energy wasted, which can be more than 40 percent in process industries (Exhibit 2).

Exhibit 2

Energy efficiency is included in the lean methodology—the "8 kinds of waste" for energy

8 kinds of waste	Definition	Example
1 Overproduction	Producing excess energy (input energy that is unused)	Venting excess steam
2 Waiting	Consuming energy while production is stopped	Laser welding line on standby still consumes 40% of maximum energy
3 Transportation	Inefficient transportation of energy	Leaks and heat radiation in steam network
4 Overspecification	Process energy consumption (deliberately) higher than necessary	Blast furnace operating at 1,100° C instead of the required 1,000° C
5 Inventory	Stored goods use/lose energy	Crude steel cools in storage, is then reheated for rolling
6 Rework/scrap	Insufficient reintegration in upstream process when quality is inadequate	Re-drying polymer lines that did not get coagulated in drying process
7 Motion (inefficient processes)	Energy-inefficient processes	Excess oxygen in steam boiler
8 Employee potential/intellect	Failure to use people's potential to identify and prevent energy waste	Employees not involved in developing energy saving initiatives

A European automaker, for example, over the years made many improvements in its paint-shop operations through lean processes. More recently, it focused specifically on reducing energy usage in the paint shop. In one process, a fixed amount of wax is stored and heated to 135 degrees centigrade for use in sealing auto body cavities before painting. The shop stored about 20 tons of wax on site, and heating the wax consumed about 1,400 kilowatts of electricity. Intent upon reducing energy, the automaker redesigned the process to keep only 8 tons of wax in inventory, lessening to 200 kilowatts the amount of energy needed for heating it. This represented an 85 percent reduction in energy use and annual savings of €260,000.

A second way companies can extend their lean programs to improve energy efficiency is by optimizing energy integration in heating and cooling operations. A chemical company changed its process to release heat more quickly during polymerization, allowing evaporation to start sooner and saving energy in the subsequent drying stage. The total savings for both steps amounted to ten percent and brought the production line close to the industry cost benchmark.

A third way companies can achieve greater gains is by adopting more energy-efficient technologies. A South American steel player, for instance, developed a boiler optimization model that allowed it to reduce the energy losses within its boilers to 3 percent below those of its competitors.

To ensure that the gains are sustainable, companies need to put into place a performance management system for energy efficiency that will provide an objective basis for discussion. One company, for instance, annually spent about $300 million on energy, but the chief operating officer's team had not discussed key performance indicators (KPIs) for energy in two years because it had little sense of how KPIs would change in response to actual operating decisions. A performance management system for energy must correct for such factors as price fluctuations, product mix, and throughput that play a part in classical energy consumption.

To capture these improvements companies will need to:

- **Lead visibly from the top.** Companies must signal the importance of energy cost reduction to employees and communicate the opportunity to reduce energy costs in the existing language of lean. For instance, they should emphasize the importance of low-or-no-capex ideas generated through structured frontline engagement, cross-functional problem solving, and changes in mind-sets and behaviors.

- **Show teams how to win.** Many of the leading players in energy efficiency have invested in developing coaches trained in the discovery of energy waste, which is often invisible and tends to be spread across an entire plant. Identifying that waste requires specific technical knowledge, such as steam production network economics or pinch analysis. A Chinese company, for instance, using the wrong valuation for its steam, decided to increase steam production to generate electricity—and destroyed $3 million in value. In addition to technical knowledge, coaches must possess the ability to tap into frontline knowledge in order to identify solutions and mobilize personnel to capture savings in a manner similar to typical lean programs.

- **Apply an opportunity-based mind-set to identifying energy opportunities.** In our experience, the most successful companies have forced their managers to move from a benchmarking mind-set to one focused instead on opportunities and closing gaps to technical limits for energy savings. This stretches the organization's aspirations on the energy savings that can be achieved with the existing asset configuration and product requirements. Given the extreme product mix- and site-specificity of energy production, transport, and consumption, a benchmarking discussion will quickly devolve into an analysis of variance that leads only to incremental changes. Focusing instead on theoretically achievable energy efficiencies and on the identification of specific types of losses between actual and theoretical positions enables a far more fruitful discussion on potential improvement levers. Such a conversation will generate strong insights in the type and size of losses, and forms a clearly quantified basis for a relentless focus on loss reduction.

- **Set up the right metrics.** Frequently, the challenge for low-cost improvement starts with insufficient energy-consumption metering and energy-generation cost allocation. Improving these enables companies to identify operating changes that lower energy usage, such as reducing standby times. Better information about consumption and cost allocation also helps in developing meaningful KPIs. With a combination of energy-efficiency planning and employee training, low-cost, sustainable savings can be achieved. Relevant metrics would then include a clear correction for product mix, quality losses, and throughput variation.

Energy efficiency in the auto sector

Even in relatively low-energy-consuming industries such as automotive manufacturing, energy usage per product is high enough to be worth addressing. For example, energy costs for the production of the average German car currently stand at only about €70. Even on the small consumption base in this sector, energy-efficiency improvements can amount to 5 percent per year with minor investment.

Making supply chains energy efficient

By Heiko Bette, Tobias Meyer, and Martin Stuchtey

Cheap oil helped to underwrite an ever-expanding globalization of production systems and procurement in many sectors over the last 30 years. Whole industries benefited by taking advantage of low regional factor costs and specialization—made possible by the low cost of fueling the movement of goods by land, sea, and air.

Circumstances have changed. The price of oil has risen steadily since 2002, hitting historic highs in 2007 and 2008. The price of crude oil at its peak—$146 per barrel in July 2008—was 13 times higher than at its trough, $11 per barrel in November 2001. In early 2009—in the midst of a global recession—oil was trading at around $50 per barrel, still about double the average price of $25 per barrel observed over the period of 1990–2005. As expected, the price of oil did rise again when the economy showed signs of a rebound and demand for energy was once again expected to grow.[1] Some analysts see signs that the foundation for the next spike has already been laid.[2] Many shippers expect that oil will trade in a range of $60 to $100 for at least the next ten years.

Today, transportation of goods consumes some 15 million barrels of oil each day, close to a fifth of total world production (Exhibit 1). For the trucks, cargo planes, and ships that account for most of this consumption in global trade, there are few, and in some cases no, alternative fuels available. At $50 per barrel of oil, the spend on fuel to keep modern supply chains humming is $750 million per day. The opportunities to reduce energy usage and related carbon emissions throughout a global industrial supply chain—from shippers to freight carriers—are significant. Our research shows that sectors as varied as high tech, fashion, and automotive can save as much as half the energy that globally dispersed supply chains consume without adding net cost.

Energy-saving activities include shifting production steps closer to end-user markets, reducing packing volume, switching to less energy-intensive[3] modes of transporting select goods, managing ship speed at sea, and adopting traffic guidance systems on land.

1 For more information, see the McKinsey Global Institute report, "Averting the next energy crisis: The demand challenge," March 2009, available on mckinsey.com/mgi.

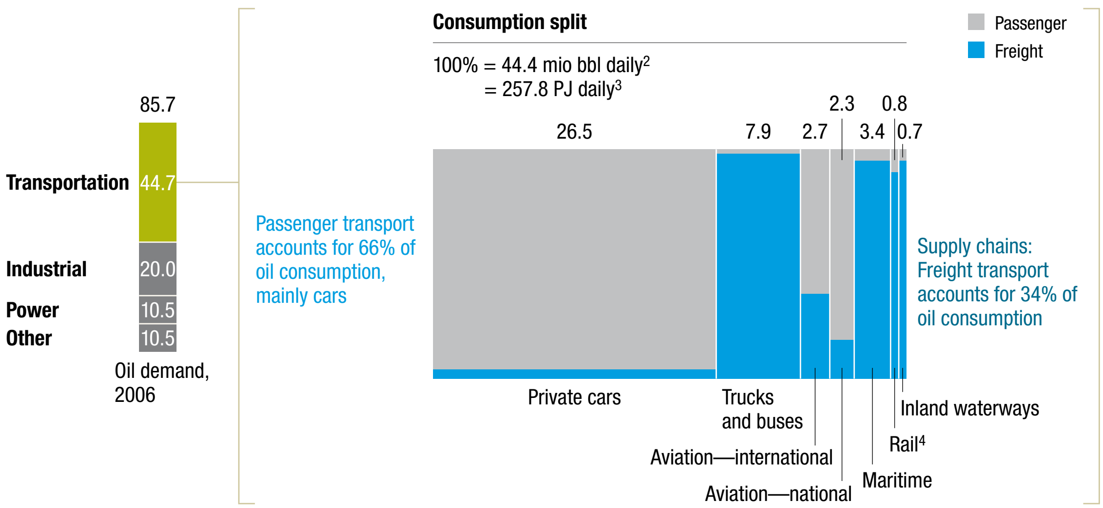
2 See, for instance, Steve Gelsi, "Energy-spending cutbacks spark price-spike talk," *MarketWatch*, April 8, 2009.

3 Defined as the amount of oil consumed by the respective transportation asset per ton-kilometer of goods transported. A ton-kilometer is a generally recognized measure of road freight production, which takes into account both the weight of the shipment and the distance shipped per hour worked. Metric ton: 2,205 pounds.

Exhibit 1

Freight transportation drives a significant and growing share of world oil demand

Millions of barrels of oil per day[1]



[1] 1 barrel (bbl) = 159 liter.
[2] Excluding 0.3 mio bbl daily for pipeline transport and nonenergy use of oil (eg, lubricants).
[3] Based on specific Joule/liter for each fuel type; 1 PJ = 1 Peta Joule = 10^{15} Joule.
[4] Does not include electric rail.

Source: US International Energy Agency; McKinsey analysis

Achieving these savings will be challenging, however. It will require a concerted effort by all stakeholders involved in a supply chain, substantial investments in upgrading infrastructure and transportation assets, and major shifts in consumer mindsets and behavior. But it can be done. It starts with a clear understanding of the economics of the opportunity to unlock substantial value by improving energy productivity in supply chains.

The prize: Reducing energy intensity

In our study of energy usage in global supply chains, we analyzed six broad levers across the flow of goods to reduce energy intensity. We studied a variety of commodities, supply chains, and transportation assets across several sectors to see how each of the levers applies. Generally, shippers—by which we mean the manufacturers, wholesalers, and retailers that represent the lion's share of transport demand—can influence three of these levers. They are:

- Increasing the value density of shipped products (the value of the product relative to its physical or volumetric weight). This can, for instance, be achieved by reducing product weight, size, or packaging.
- Reducing the average distance that products travel from source to end user.
- Changing the mix of transport modes employed to move products—for example, shipping by sea rather than by air.

Companies in transportation businesses—including carriers, third-party logistics providers, equipment manufacturers, and infrastructure companies—chiefly influence three other levers affecting the energy efficiency of transport assets. Governments and transport regulators also can have an impact on these levers, as decisions they make about various kinds of transport infrastructure influence how effective transportation assets will be. The levers are:

- Improving the energy efficiency of transportation assets (including ships, aircraft, and trucks) through advances in technology and improvements in design.
- Achieving more efficient use of transportation capacity by individual players in a supply chain—for example, by increasing load factors and reducing average shipping speed.
- Improving the collective use of transportation assets and infrastructure, for example by implementing smart traffic management systems to help trucks avoid traffic jams and unnecessary detours.

We calculated the impact of these levers on reducing energy consumption within the context of three different oil-price scenarios: $40, $100, and $250 per barrel. The conclusions were astounding. Without adding net cost, players can lower energy intensity by 38 percent in the $100-per-barrel price scenario, and by 51 percent in the $250-per-barrel scenario. This reduction assumes a transition period until 2020, which would be required to make the necessary investments and replace old assets with more energy-efficient equipment. Based on 2008 volumes, this could reduce global oil consumption by as much as eight million barrels a day—nearly 10 percent of total global oil demand. Remarkably, even with the oil price as low as $40 per barrel, nearly half of this global potential, four million barrels a day, can be realized cost effectively for consumers and companies (Exhibit 2).

These conclusions come from a comprehensive analysis of each of the six levers and a careful review of the full potential across the levers to avoid inconsistencies and double counting. To develop the analyses, we reviewed shipment data of transportation companies, comparing specified gross and net weight of products; studied options for redesigning product packaging to lower weight and volume while maintaining the functionality; modeled scenarios for optimizing both production and sourcing locations as well as the mix of transportation modes under realistic assumptions (such as taking into account lead-time restrictions, inventory cost, customs duties, and so on); and drew on analysis of the energy-efficiency potential of different technologies, and of traffic management systems and other technologies to reduce congestion and allow for more efficient vehicle and aircraft routing.[4]

4 A more detailed presentation of our research findings is available in interactive form on mckinseyquarterly.com/ghost.aspx?ID=/Increasing_the_energy_efficiency_of_supply_chains_2414.

Exhibit 2

Energy-efficient supply chains—impact of levers

Reduction of energy intensity, %

Scenarios: A ($40/bbl) B ($100/bbl) C ($250/bbl)

Reduction in energy intensity assuming rationale and informed behavior of shippers, providers, investors, consumers, and government, 10-year horizon

	1 Value density[1]	2 Average distance[1]	3 Modal mix[1]	4 Asset technology	5 Individual usage	6 Collective usage[2]
Impact per lever per scenario vs 2007 base	–2 –3 –3	–1 –4 –15	–3 –4 –7	–10 –20 –22	–7 –12 –17	–1 –2 –3
Lever description/ example	• Reduce packing volume • High potential lever for modes that are 'cubed out,' eg, trucks • Large lever for FMCG and electronics companies • Low relevance for bulk commodities	• Shift of production process steps closer to market, eg, local packaging • In scenario C, shift of raw material processing to source, eg, steel making	• Shift from air to ocean for lower value parts, eg, power cables • Investment in rail to allow shift from road	• Significant windfall efficiency gain (scale, propulsion) even at lower oil prices	• Reduction of vessel speed esp. for container • Load factor optimization (all modes)	• Traffic guidance systems to avoid jams, braking • Reduction of turnaround times (use of saved time for reduction of speed)

Total impact by scenario

–23 –38 –51

[1] Based on fuel consumption after pulling levers 4, 5, and 6.
[2] Small impact, as mainly enabler for scale.

Let's look in more detail at the opportunities for reducing energy intensity through each of these levers.

Actions for shippers

The levers shippers can influence could trigger an 11 percent reduction in energy consumption at zero net cost in a $100-per-barrel oil-price scenario. More than half of this potential would be economically viable even at an oil price of $40.

What, then, are the practical actions that shippers can take?

Increasing the value density of shipped products

Value density is a measure of a product's economic value against its weight or volume. Increasing the value density reduces the amount of volume transported, depending on the product category. One action shippers can take, for instance, is redesigning product packaging. We estimate that

30 percent of the truck space used to transport finished goods is taken up by packaging material or empty space. One computer manufacturer recently eliminated nearly all throw-away primary packaging for its notebook PCs by developing a compact, stylish messenger bag, which now carries the notebook from factory to retail shelf and is part of the product acquired by the customer. This reduced consumer-facing packaging by 97 percent, and the optimization of the laptop packaging led to a quarter fewer trucks being required to deliver the laptops.

Shippers can also change the shape of a product to reduce value density. For example, a retailer and a wholesaler partnered to redesign milk containers to make them stackable, thus eliminating the need for shipping crates. They achieved substantial fuel savings.

Consumer goods companies can remove the filler material traditionally used to make products look bigger. One such company removed water from its detergents, reducing product sizes by a factor of two and cutting transport costs in half. Because mere size is one of the ways customers tend to judge the value of a product, this measure was supported by a marketing campaign emphasizing that the new smaller product was more powerful and could therefore deliver the same performance despite its smaller size.

Increasing value density can mean big savings for some companies. For consumer durables, for example, reductions in transport volume of 20 to 30 percent are typical. For other companies, however, the savings will be smaller or negligible. With bulk commodities, such as crude oil and grain, there are few opportunities to increase product value density. Looked at in total across sectors, however, the optimization of product value density and packaging could reduce energy use in distribution by 2 to 3 percent, without affecting product functionality.

Reducing the average distance that products travel

In many global supply chains today, there are ample opportunities to redesign geographical production and sourcing footprints so that products need not be shipped as far—thus making the chains less energy intensive. One way to squeeze transportation costs out of a final product is to move the production of noncore components—for example, primary packing, handbooks, and power cables in the case of electronic goods—to the region where the items will be sold. Local sourcing of such components reduces the total ton-kilometers required—and at oil prices above $100 per barrel, the higher costs of transport begin to outweigh the additional cost of near-shore production for many goods.

A holistic review of supply chains will reveal such breakpoints and will allow companies to optimize the design of their production process, location footprint, transportation, and inventory (Exhibit 3).

Changing the mix of transport modes

By changing the modal mix, shippers could potentially reduce the energy intensity of supply chains by some 5 percent. Moving goods by air or by truck is more energy intensive than doing so by ship or rail, and so a shift from the former to the latter modes can have a major impact on oil consumption. In fact, container-based ocean freight has grown much faster than air freight over the past two decades, with the result that the energy intensity of transporting goods has already been reduced significantly (Exhibit 4).

Exhibit 3

Supply chain redesign and modal mix—example: laptop

Transport volume in thousands of tons (equivalent to production network with 15 million units)

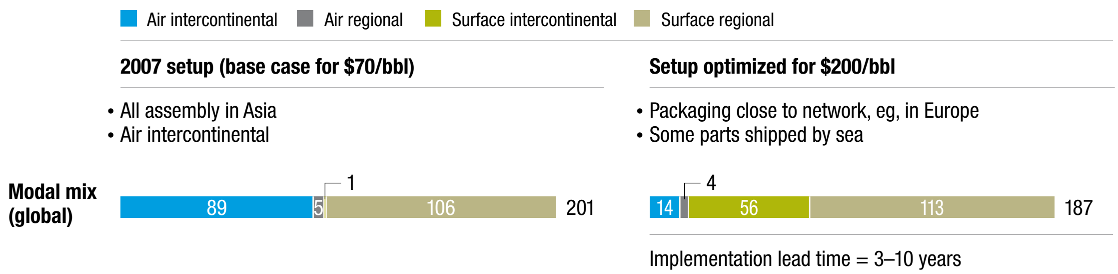
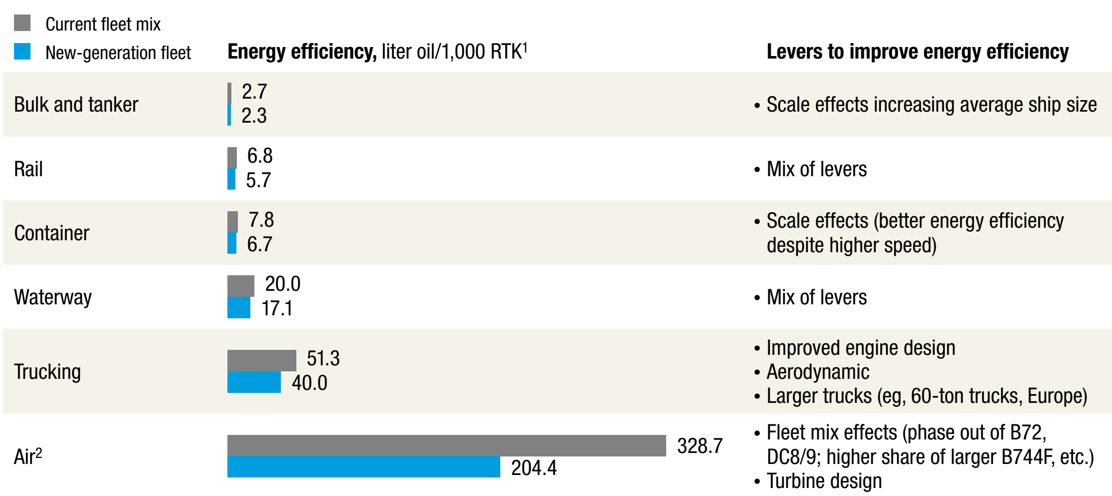


Exhibit 4

Energy efficiency of different modes varies widely, with different levels of improvement potential

Modal mix—energy efficiency of different modes



[1]RTK: Revenue ton-kilometer.
[2]Load factor of 70% assumed. Current fleet mix based on DC-10 consumption + 15%. New fleet mix based on 747-400F-ER + 15%.

Shippers can achieve a shift in the modal mix in three different ways:

- An **outright modal shift** for a given "leg" (or section) of a transport chain can deliver real energy-saving results but is sometimes difficult to achieve. For example, a shift from air to ocean transport for a transpacific journey reduces the port-to-port energy intensity by a factor of 30 but also increases the lead time from 2–3 days to around 3 weeks.

- **Sequential multimodal transport** could, for example, see a long-haul truck journey replaced by rail transport for the first and longer part of the journey, with delivery by truck maintained for the last mile. Note, however, that such a shift will be highly dependent on the ability of operators, governments, regulators, and investors to make rail transport more efficient and competitive. Sequential multimodal solutions can also be built through a combination of air and sea freight.
- **Parallel multimodal transport** is particularly interesting for goods with a value density of $10 to $50 per kilogram. It entails the parallel use of different modes of transport for the same products on the same trade lane. The slower, more energy-efficient mode of transport, such as ocean freight, is used for the base load, while a faster, less energy-efficient mode, such as air freight, is reserved for peak demand and urgent replenishment.

Optimizing the mix of transportation modes and inventory levels is not a trivial task, but achieving the right mix can be rewarding, given that cost and energy consumption can be reduced even at constant inventory levels. Further, the capital tied up in inventory and transport can be included and optimized in this planning process.

It will be increasingly important for shippers and third-party providers, as part of their purchasing decision making, to assess their suppliers' capabilities to ship goods with different modes of transport and access to energy-efficient assets. Should the price of oil rise, providers with inefficient transport assets will either have to raise rates and surcharges or face a higher risk of bankruptcy—potentially forcing shippers to sign up with new providers at peak rates. On the other hand, when oil prices are low, the downside in signing with a carrier with state-of-the-art equipment is comparatively small.

Actions for carriers and governments

Carriers have even greater opportunities than shippers to improve their energy efficiency. Indeed, many have already begun the task. In container vessels, for instance, fuel burn per ton-kilometer has declined by 15–25 percent over the past 15 years, thanks to advances in technology, such as improved propulsion and increased vessel size. These improvements will continue to drive efficiency gains in the next decade and beyond (Exhibit 5).

More efficient use of transport assets by individual operators represents a further opportunity—particularly slower shipping speeds and greater load factors.

Of course, procuring new, more energy-efficient assets requires a substantial investment, as does building the infrastructure needed to support those assets, such as berthing capacity for larger vessels and increased rail freight capacity. But the opportunity is substantial, and the crisis can be used to accelerate the replacement of assets. A 10 percent reduction in air freight demand, for example, could mean a 20 percent reduction in air freight–related fuel consumption—provided that the oldest and least fuel-efficient aircraft are grounded. However, there is the danger that the setbacks of 2001 could be repeated. That year a low oil price helped the players with the least efficient assets compete, discouraging others from investing and preventing the industry from improving its structure and energy efficiency.

Governments will need to be cognizant of these challenges when developing regulation and shaping economic stimulus packages. They will also need to regulate or operate systems that improve the collective usage efficiency of transport—air traffic control being an obvious starting point.

Exhibit 5

Container shipping and air freight have the largest efficiency potential

Energy intensity and reduction levers by mode

	2008 base, liter oil/1,000 RTK[1]	**Reduction potential 2008–20,** % (multiplicative)			**2020 scenario,** liter oil/1,000 RTK[1]	
		Asset	**Individual**	**Collective**		**Main levers**
Bulk	3.1	11	8	2	2.5	• Propulsion technology • Increase in vessel size[2] • Speed/avoidance delays
Tanker	4.7	8	7	2	4.0	• Propulsion technology • Speed profile
Rail	7.0	17	7	0	5.4	• Engine optimization • Train length • Speed profile
Container	10.6	19	26	10	5.7	• Increase in vessel size • Reduce/maintain speed[3]
Inland waterway	19.8	17	6	2	15.1	• Reduce port time • Fleet mix • Propulsion technology
Truck	67.0	21	11	1	45.9	• Fleet mix/scale effects • Airframe and engine technology
Air	334.2	38	12	3	177.4	• Fleet mix/scale effects • Turbine improvement

[1] RTK: Revenue ton-kilometer.
[2] Infrastructure is critical enabler for increase in average truck size (accounted for in asset technology).
[3] Historically, larger vessels steam at higher speed, eg, 25 kts for post-Pananmax (class of container ship with a cargo capacity exceeding 10,000 TEU) vs. 16 kts for Handysize vessels (carriers of 20,000 long tons deadweight).

What, then, are the practical steps that carriers and governments can take?

1. Improving transportation asset technology

Improving the energy efficiency of assets such as ships, aircraft, and trucks could reduce the energy intensity of goods transportation by as much as 20 percent by 2020, with close to half of this potential realizable even at oil prices of $40 per barrel. There are four main opportunities:

- **Scale** is an important and often underestimated driver of energy efficiency in transportation. Typically, doubling the capacity of a transport asset increases its energy efficiency by 20 to 25 percent. Bigger vessels have less surface per volume, and thus drag is lower than with two or more smaller units with the same total capacity. This is still an underexploited lever. In container shipping, roughly 40 percent of the existing world capacity as of 2008 is on order and yet to be built. This new supply will increase the average size of vessels on intercontinental trade lanes from about 5,100 TEU[5] in 2008 to approximately 6,200 TEU in 2015. Similar trends apply in air freight and for the trucking industry, particularly in developing markets with smaller average transport unit sizes.[6]

5 Twenty-foot equivalent units.

6 Due to road conditions and other influences, the average truck size in developing economies such as China and India is less than half that in countries of the Organisation for Economic Co-operation and Development (OECD).

- **Relative drag** can be reduced by improving the shape or surface quality of the transportation asset. This is particularly true for trucks, whose aerodynamics are currently poor. Improved surface quality can reduce resistance for ocean vessels. For example, 50 to 80 percent of resistance is created by surface friction, which can be greatly reduced through modern hull-coating technology.
- The **payload ratio** describes the cargo-carrying capacity of the asset relative to its total weight in laden condition. An increase in the payload ratio can be achieved by using lightweight construction materials and designs, thereby enabling the asset to carry more cargo at constant energy usage. With the introduction of carbon fiber composite as a main material for structural components in the aerospace industry, there is new potential to make aircraft more energy efficient. Other technologies for trucking and rail can have a similar effect on the energy efficiency of these modes.
- **Propulsion systems** convert energy, mostly by burning a fossil fuel in an internal combustion engine or turbine and transmitting this energy onto a propulsion-providing device, such as the propeller of an ocean vessel. Improvement in propulsion technology is a relevant lever across all modes of transport. Beyond optimizing existing components, there are further opportunities to add new technology, such as waste-heat recovery for container vessels.

2. Achieving greater individual usage efficiency

The operator of a transport asset can improve energy efficiency using various levers, notably speed, load factor, maintenance regime, and route planning. Some of these levers require enhanced capabilities in planning and scheduling. Others essentially involve a trade-off between energy consumption and cost, on the one hand, and the cost of capital, on the other. If operators choose to apply all these levers consistently, energy intensity could be reduced by some 11 percent in the reference scenario of $100 per barrel.

In particular:

- **Load factor:** Increasing the load factor of a transportation asset always improves energy efficiency, although the exact gain varies by mode of transport and type of vessel, vehicle, or aircraft. With trucks, for instance, an increase of the load factor of approximately 1 percent (for example, from 66 percent to 66.7 percent) would improve energy efficiency by between 0.5 and 0.7 percent.

- **Speed:** Average speed is a key driver of energy consumption. In general, the rule in energy efficiency is "the slower, the better." But there is an obvious trade-off: slower speed lowers the number of loops a vessel can make in a given time period, to take an example from shipping. Also, faster means of transport reduce inventory and obsolescence cost, which shippers appreciate. This has pushed up container-vessel speeds to 25 knots and more. A 10 percent reduction of average vessel speed would lead to improved energy efficiency of 12 to 20 percent, depending on vessel type and operating conditions.

- **Speed profile:** A balanced speed profile helps reduce energy. Vessels and vehicles consume disproportionately more energy at higher speeds, and so speed peaks should be avoided. For example, a vessel that steams at an average speed of 12 knots for 10 days consumes up to 60 to 70 percent less fuel than a vessel that sits idle for five days and then steams at a speed of 24 knots to make up the lost time.

- **Maintenance:** Advances in maintenance technology and more frequent maintenance also reduce the fuel burn of transport assets. Maintenance of filters and control settings, for example, can have a major impact on the efficiency of combustion engines. Hull cleaning removes algae and thereby lowers surface friction. Of particular interest are propellers and turbine blades: both for ocean vessels and aircraft, regular cleaning of these parts improves energy efficiency.

- **Route planning:** Optimization of routes is a versatile lever with relevance to all transportation modes. Tour planning for delivery trucks—minimizing total distance traveled and time lost in traffic jams and at traffic lights—is already a relatively well-known tool. In air traffic management and voyage planning, route optimization based on the latest weather forecasts and operating conditions is still relatively unexploited. Such planning can maximize tailwind conditions and enable ships to steam in favorable currents and through calm areas.

- **Other operating conditions:** Several other conditions, such as load planning, vessel trim, operation of auxiliary units (such as the auxiliary power unit, or APU, in aircraft), and the use of control surfaces, also influence the energy efficiency of transportation assets. A thoughtful approach to these conditions can help increase the energy efficiency of supply chains.

3. Improving the collective use of transport assets and infrastructure

Decreasing traffic bottlenecks and ensuring more direct connections between the major centers of production and consumption could lead to a reduction in energy intensity of some 1 to 3 percent.

There is a relatively large opportunity in air transport. Air traffic management is still subject to national restrictions, with not all routes available to all airlines, and some aircraft are required to fly long detours from their optimal course because they lack overflight rights or other permissions. Similarly, congestion of airports and poor slot management cause unnecessary fuel burn.

In shipping, the main opportunity lies in expanding infrastructure, such as berthing capacity at ports for large vessels and deploying state-of-the-art handling equipment and management technology such as load optimization tools. Elimination of waiting due to port congestion and shortened turnaround times in ports could be used to reduce the speed at which vessels need to steam to meet their schedules—thus lowering energy consumption.

For ground transport, smart traffic management can reduce the idle time that trucks and other vehicles spend in traffic jams. Utilization-based pricing of road usage—such as that already employed in Singapore—increases the cost to drive at peak times, thereby reducing congestion and the total consumption of fuel by trucks and vans.

□ □ □

Making supply chains much more energy efficient will require all stakeholders to play their part—by deploying engineering resources to energy-related tasks, by making the investments needed, and by implementing energy-efficient operating procedures. Achieving an energy-efficiency revolution in supply chains is challenging but not impossible. And it is economically sound, even when taking into account today's oil-price level.

Data centers: How to cut carbon emissions and costs

By William Forrest, James M. Kaplan, and Noah Kindler

Every large organization depends on vast arrays of servers to run applications, support electronic communications, and provide productivity tools. But building and operating the data center facilities required consumes ever-larger portions of technology budgets and contributes to greenhouse gas emissions. For some information-intensive businesses, data centers represent half of the corporate carbon footprint.

McKinsey's work in this area suggests that companies can double the efficiency of their data centers through more disciplined management, reducing both costs and greenhouse gas emissions. Specifically, companies need to manage their technology assets more aggressively so existing servers can work at much higher utilization levels. They also need to make significant improvements in forward planning of data center needs in order to get the most from their capital spending.

The modern corporation runs on data. Data centers house the thousands of servers that power applications, provide information, and automate a range of processes. There has been no letup in the demand for data center capacity, and the power consumed as thousands of servers churn away is responsible for rising operating costs and steady growth in worldwide greenhouse gases.

Our work suggests that companies can double the energy efficiency of their data centers through more disciplined management, reducing both costs and greenhouse gas emissions. In particular, companies need to manage technology assets more aggressively so existing servers can work at much higher utilization levels; they also need to improve forecasting of how business demand drives application, server, and data center–facility capacity so they can curb unnecessary capital and operating spending.

Data center efficiency is a strategic issue. Building and operating these centers consumes ever-larger portions of corporate IT budgets, leaving less available for high-priority technology projects. Data center build programs are board-level decisions. At the same time, regulators and external stakeholders are taking keen interest in how companies manage their carbon footprints. Adopting best practices will not only help companies reduce pollution but could also enhance their image as good corporate citizens.

A costly problem

Companies are performing more complex analyses, customers are demanding real-time access to accounts, and employees are finding new, technology-intensive ways to collaborate. As a result, demand for computing, storage, and networking capacity continues to increase even as the economy slows. To cope, IT departments are adding more computing resources, with the number of servers in data centers in the United States growing by about 10 percent a year. At the same time, the number of data centers is rising even more swiftly in emerging markets such as China and India, where organizations are becoming more complex and automating more operations and where, increasingly, outsourced data operations are located. This inexorable demand for computing resources has led to the steady rise of data center capacity worldwide. The growth shows no sign of ending soon, and typically it only moderates during economic down cycles.

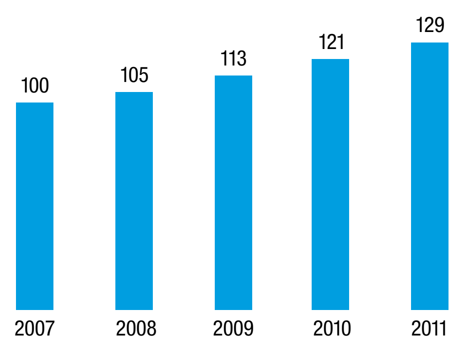
This growth has led to a sharp rise in IT costs (Exhibit 1). Data centers typically account for 25 percent of total corporate IT budgets when the costs of facilities, storage devices, servers, and staffing are included. That share will only increase as the number of servers grows and the price of electricity continues its climb faster than revenues and other IT costs. The cost of running these facilities is rising by as much as 20 percent a year, far outpacing overall IT spending, which is increasing at a rate of 6 percent.

Exhibit 1

Growth threatens profits

Growth of data center costs, disguised example, $ million

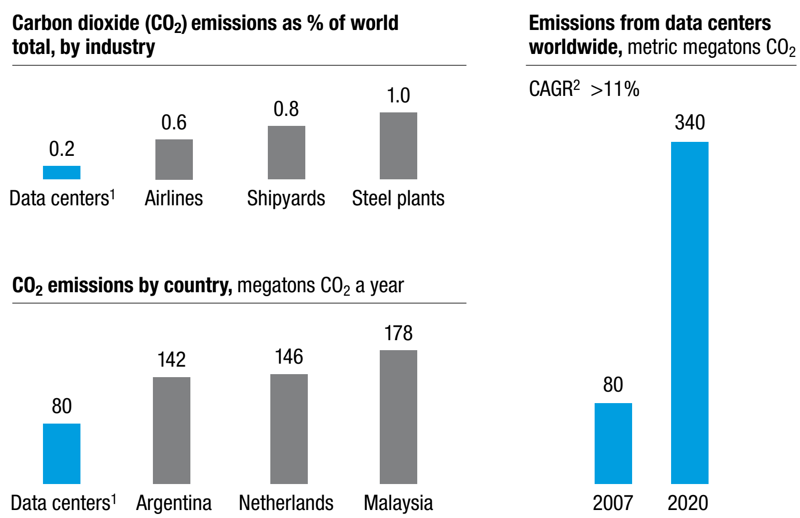
Growth drivers
- 40% growth in transaction volume
- 16% growth in volume of database records
- Aggressive new product-development plans in multiple business units
- High regional demand in Asia



Spending increases on data centers are reshaping the economics of many businesses, particularly those that are intensive users of information such as finance, information services, media, and telecom. The investment required to launch a large-enterprise data center has risen to $500 million, from $150 million, over the past five years. The price tag for the biggest facilities at IT-intensive businesses is approaching $1 billion. This spending is diverting capital from new product development, making some data-intensive products uneconomic, and squeezing margins. The environmental consequences also are stark, as rising power consumption creates a large and expanding carbon footprint. For most service sectors, data centers are a business's number-one source of greenhouse gas emissions. Between 2000 and 2006, the amount of energy used to store and handle data doubled, with the average data facility using as much energy as 25,000 households. Already, the world's 44 million servers consume 0.5 percent of all electricity, with data center emissions now approaching those of countries such as Argentina or the Netherlands. In the United States alone, growth in electricity used by data centers between now and 2010 will be the equivalent of ten new power plants. Without efforts to curb demand, current projections show worldwide carbon emissions from data centers will quadruple by 2020 (Exhibit 2).

Exhibit 2

Data centers' large carbon footprint



[1]Including custom-designed servers (eg, Google, Yahoo), consumed and embedded carbon.
[2]Compound annual growth rate.

Source: Advanced Micro Devices; *Financial Times*; Gartner; Stanford University; Uptime Institute; McKinsey analysis

Regulators have taken note of these developments and are pressing companies for solutions. In the United States, the Environmental Protection Agency (EPA) has proposed that large data centers use energy meters as a first step toward creating operating-efficiency standards. The European Union, meanwhile, has issued a voluntary code of conduct laying out best practices for running data centers at higher levels of energy efficiency. Government pressure to reduce emissions will likely increase as data center emissions continue to rise.

Far-reaching challenges

In information-intensive organizations, decisions affecting the efficiency of data center operations are made at many levels. Financial traders choose to run complex Monte Carlo analyses, while pharmaceutical researchers decide how much imaging data from clinical trials they want to store. Managers who develop applications decide on how much programming it will take to meet these demands. Those managing server infrastructure decide on equipment purchases. Facilities directors decide on data center locations, power supplies, and the time frame for installing equipment ahead of predicted demand (Exhibit 3).

Exhibit 3

Unintended consequences

Banking example

New growth		Potential impact
New products, services	Real-time balance information	• Movement from batch processing to real-time processing requires large increase in processing power • Need to upgrade to new and more powerful servers, as well as to change transaction processes
	Increase in online transactions	• Increased small-transaction flows and higher number of interbank transactions • Reduced credit card transaction volume • New applications to process nontraditional payments
	Value-added services for commercial cards	• New applications (ie, integrate transactions in real time, process payroll, checks, interbank transactions) • Increased transaction volume and online processing requiring increase in processing power
	Change in geographic portfolio	• Increase in foreign-currency transactions • New applications to incorporate geographic legal procedures • Increase in round-the-clock use of servers, thereby reducing maintenance window
M&A activity	Acquiring a competitor	• Increased transactions • Potential new supply of data centers from acquired card provider; need to integrate various data center technologies
Macroeconomic shock	Economic downturn	• Idle or underutilized capacity in data centers • Increased number of collections agencies and terminals • Increase in cost per transaction due to lower volume • Need to reduce cost

These decisions are usually made in isolation. A sales manager may choose to change transactions from overnight to real-time clearing, or a financial analyst may want to store multiple copies of historical data—without thinking about the impact on data center costs. Applications developers rarely think of fine-tuning their work to use the fewest number of servers, or of creating design applications that can be shared across servers. Managers buying them may select those with the lowest prices or those with which they're most familiar. But these servers may waste electricity or space in data centers. Frequently, managers purchase excess devices to guarantee capacity in the most extreme usage scenarios, creating large amounts of excess capacity. And managers often build facilities with excess floor space and high cooling capacity to meet extreme demands or all expansion contingencies.

Multiplied across an organization, these decisions result in both costs and environmental implications. In many cases, existing servers could be decommissioned and plans for new ones shelved without diminishing the ability of companies to manage data. This can be accomplished using well-known techniques, including virtualization, which in effect share capacity by seeking unused portions of servers to run pieces of applications. But this doesn't always happen, since no one executive has end-to-end accountability. Within the organization, managers optimize for their own interests, resulting in the inefficiency observed in most data centers. In many instances, only a single software application runs on a server.

Within one media company, almost a third of the nearly 500 servers we analyzed had utilization rates below 3 percent, and nearly two-thirds were below 10 percent. This company used none of the number of readily available management tools for tracking use. On a global basis, we estimate daily server utilization generally tops out at 5 to 10 percent, wasting both energy and employed capital. A common response from data center managers is that the servers exist to provide capacity for extreme situations, such as the shopping crunch on the day before Christmas. However, the data generally don't support this assertion: when average utilization is very low, so is peak usage. Furthermore, sprawling data facilities are sometimes only half occupied by servers and related equipment, suggesting hundreds of millions of dollars in wasted capital spending. Even in data centers that companies report as full, a walk down the aisles often reveals significant gaps within racks of servers, where equipment has been decommissioned.

These mismatches arise in part from the difficulty of forecasting data center requirements. Operating time frames are one problem. Data centers take 2 years or more to design and build and are expected to last at least 12 years, so capacity is added well in advance of the actual needs of business units. At the same time there is an incomplete understanding of how business decisions affect one another, how they translate into the need for new applications, and how much server capacity is needed to meet demand. Many companies, for example, would have difficulty forecasting whether a 50 percent increase in customer demand would require 25 percent or 100 percent more server and data center capacity. In the extreme, we have seen some facilities lie half empty years after opening; other companies complete one data center only to find they need to build a new one almost immediately.

Considering that data centers have become a costly asset, accountability for financial performance is poor. Financial and management responsibility for facilities often falls to real-estate managers who have little technical expertise and few insights into how IT relates to core business issues. Those managing server operations, meanwhile, rarely see data on crucial operating spending such as electricity consumption or the true cost of the real estate occupied by the IT equipment. Conversely, when IT managers decide on additional applications or new servers, they sometimes use only basic metrics such as initial hardware costs or software licenses. Figuring out the real costs requires consideration of facilities operations and leases, electricity use, support, and depreciation. These charges can multiply the initial purchase cost of a server by a factor of four or five. Combined with the siloed decision making and accountability issues discussed above, extra servers are often added as insurance with little discussion of cost trade-offs or the needs of the business. In the absence of true cost analysis, overbuilding, overdesign, and inefficiency become the rule.

Reforming data center operations

When we began our research, we expected to find that building new energy-efficient data centers would offer the best hope of reducing their cost and carbon footprint. New facilities could take advantage of current technologies that make use of natural cooling and of power supplies that produce fewer emissions. However, we also learned that the most dramatic reductions in cost and carbon emissions come from improving the low efficiency of data centers that companies already operate. Through better management of assets, more accountable management, and setting clear goals for reducing energy costs and carbon emissions, most companies can double IT energy efficiency by 2012 and halt the growth of their data centers' greenhouse gas emissions. Indeed, the greenest data center is the one that you don't have to build.

Manage IT assets aggressively

One large company's approach illustrates the potential gains from a disciplined use of existing servers and facilities. The company's plans for meeting its 2010 information needs called for increasing the server base and building a new data center to house these servers and other IT equipment. Its board already had approved the plans, which represented a significant amount of the company's capital spending that year. It has since radically revised them. More than 5,000 rarely used servers will be shut down. Virtualization of some 3,700 applications—15 percent of the companywide total—will allow a reduction in the number of active servers to 20,000, from 25,000. The company has also replaced some older servers with those that use electricity 20 percent more efficiently.

These changes enabled the company to shelve its data center expansion plans, saving $305 million in capital investment costs. Projected operating expenses (for fewer servers and less power consumption) are set to fall by $45 million, to $75 million. Taking into account decommissioning and virtualization, the average server will run at 9.1 percent of capacity rather than the current 5.6 percent. The company will still meet its growing data needs, but reduction in power demands means that CO_2 emissions over the next four years will be cut to 341,000 tons, from 591,000 tons.

Companies can also save by better managing rising demand for data. Business units should review policies on how much data should be retained and whether to scale back some intensive data analyses. Some transaction computation can be deferred, thus reducing peak use of servers, and not all corporate information requires extensively backed-up disaster recovery capabilities.

Get better information

Better forecasting and planning is the foundation for data center efficiency gains. Companies should track how their forecasts for data needs vary with real demand and then provide bonuses to those business units that are able to minimize deviations. Data center managers should incorporate the most complete view of future trends in their models, such as organizational growth and business cycles. Input from data centers, applications architects, and facilities operators can be used to improve these models. One global communications company instituted a planning process that included developing scenarios for data growth for each of its business units. While the company eventually concluded that it needed additional capacity, a large portion of future needs was met using existing assets, saving 35 percent in planned capital expenses.

True accounting for costs

In many organizations, data centers are treated as buckets waiting to be filled, rather than as scarce and expensive resources. To combat this tendency, companies can adopt true cost of ownership (TCO) accounting when estimating costs for new servers or additional applications and data. Lifetime costs of running applications and operating servers are rarely included in spending decisions by business units, software developers, or IT managers. Building them in upfront can help limit excess demand.

One financial institution adopted TCO accounting for all the applications that supported its trading and investment-banking products. It resulted in first-ever discussions with IT managers about which investments in software applications were actually producing adequate returns, providing a road map for reducing areas of overinvestment and IT inefficiency. Multiplying these conversations across business units can bring much-needed discipline to decisions that ultimately have an impact on data center costs.

Centralize responsibility

Managing these kinds of changes may be difficult. Many in large organizations don't recognize the cost of data. Demands for data center services arrive from across the enterprise. Responsibility for meeting those demands falls across IT departments (including operations and application development), facilities planners, shared services groups, and corporate real-estate functions. There is no single standard for reporting the costs.

We suggest a new governance model for managing data center needs, with full responsibility and accountability falling to the CIO. Under such a regime, the CIO would have much greater visibility into the data demands of business units and could enforce requirements that energy consumption and facilities costs figure into return-on-investment calculations for new data projects requiring additional servers or software applications. We also suggest that CIOs employ a new metric for measuring progress (see sidebar, "Improving data center efficiency"). With sharpened accountability, the CIO will have greater incentive to seek improvements, such as virtualization and better use of existing facilities. Since this model vests much broader responsibility with the CIO for key business decisions, it needs full support from the CEO and a change in organizational mind-set that business unit requests for added data center capacity won't always be met.

In addition, the CIO should publicly commit to the goal of doubling data center energy efficiency as a way of encouraging improvements and of helping the business to get ahead of regulatory or other stakeholder pressures. Our analysis indicates that nearly every company is capable of doubling its data center energy efficiency over the next three or four years using currently available techniques and technology. Achieving this goal requires stronger data center management, better planning, and increased accountability.

Data center inefficiency is widespread, and it has become a major concern worldwide. But there is significant opportunity for improvement. Following the recommendations outlined above can create a virtuous cycle of better data center management leading to more efficient energy use, lower costs, and steady reductions in carbon emissions.

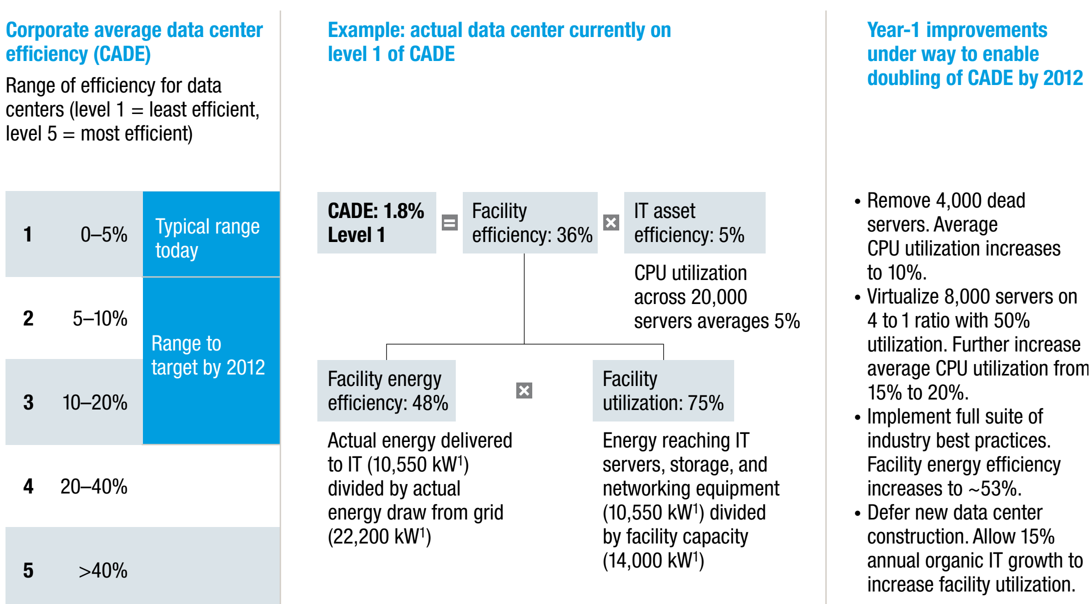
Improving data center efficiency

As part of a program for data center improvement, we suggest employing a new metric: corporate average data center efficiency (CADE). Similar to the United States' Corporate Average Fuel Economy (CAFE) mileage standards, CADE takes into account the energy efficiency of facilities, their utilization rates, and the level of utilization of servers in the data center. Multiplying these factors together yields the overall efficiency of the data center, or CADE (exhibit). Companies that reduce costs and emissions will improve their data centers' CADE scores. That's similar to how better mileage bolsters CAFE ratings in the auto industry.

To establish targets for improvement, we set five CADE tiers. Those centers operating at CADE level one are the weakest in terms of efficiency; most organizations initially are likely to fall within the lower ranges. Shutting down underused servers, employing virtualization, and using space within facilities more efficiently will raise CADE scores. CADE also allows companies to benchmark across data center facilities, or against those of rivals, as well as set and track performance goals for managers.

Exhibit

A new efficiency metric



[1]Kilowatts.

Source: Uptime Institute; McKinsey analysis

Electrifying cars: How three industries will evolve

By Russell Hensley, Stefan Knupfer, Dickon Pinner, and Nadeem Sheikh

Upon entering the mainstream—in a few years or a couple of decades—electrified cars will transform the auto and utilities sectors and create a new battery industry. What will it take to win in a battery-powered age?

Electrified vehicles: A glossary
The more conventional term "electric car" actually describes the all-electric sedan. But vehicles using electricity—electrified vehicles—actually come in a variety of forms.

Hybrid-electric vehicle: Such a vehicle has two or more energy storage systems, both of which must provide propulsion power, together or independently. The internal-combustion engine is typically the primary system, with the electric motor used to power the vehicle for short distances or to support the main engine—for example, when the vehicle idles at a stoplight.

Plug-in hybrid-electric vehicle: These vehicles have one energy storage system: a battery recharged with power from either an onboard generating device (for example, a small internal-combustion engine) or an electricity supply into which the vehicle can be plugged.

Battery-electric vehicle: This kind of vehicle has one energy storage system, a battery, and no primary onboard means of generating electricity. You transfer energy to the vehicle by plugging it into an electricity supply or by exchanging the battery for a charged one.

It's a safe bet that consumers will eventually swap their gas-powered cars and trucks for rechargeable models. Electrified transport, in some form, would seem to be in our future. But how long will investors have to wait for the bet to pay off? Years? Decades?

Bears would bet on decades. For the next ten or so years, the purchase price of an electrified vehicle will probably exceed the price of an average gas-fueled family car by several thousand dollars. The difference is due largely to the cost of designing vehicles that can drive for extended distances on battery power and to the cost of the battery itself. What's more, the infrastructure for charging the batteries of a large number of electrified vehicles isn't in place, nor is the industry tooled to produce them on a mass scale. In any case, consumers aren't exactly clamoring for battery-powered sedans.

Bulls are betting on intervention by government. They think that concern over energy security, fossil fuel emissions, and long-term industrial competitiveness will prompt governments to seek a partial solution by creating incentives—some combination of subsidies, taxes, and investments—to migrate the market to battery-powered vehicles. In fact, governments across many regions are starting to act in this way. The bulls also note that electrified vehicles can address certain niches whose economics could be favorable more quickly, such as delivery and taxi fleets in large cities or elements of military fleets. In some countries, such as Israel, electrified vehicles already make economic sense because buyers get substantial tax breaks from the government. The bulls include innovators preparing new products and business models (such as the packaging of battery leasing and recharging costs) designed to make electrified vehicles more attractive to buyers.

Sooner or later, electrified vehicles will take off, changing several sectors profoundly. Let's assume that these vehicles will share the roads of the future with other low-carbon options, such as cars running on biofuels and vehicles with more fuel-efficient internal-combustion engines. Even then, significant sales of electrified vehicles could dramatically reshape the fortunes of the automotive and utilities sectors and propel the rise of a multibillion-dollar battery industry.

The stakes are high for companies in these industries. In the near term, executives should determine how to win revenues and contain costs if the governments of China and the United States, for example, live up to their promises to stimulate consumer purchases of electrified vehicles. Planning should also begin on strategies and on ways to build capabilities if early adoption creates a sustainable market.

Running on electrons

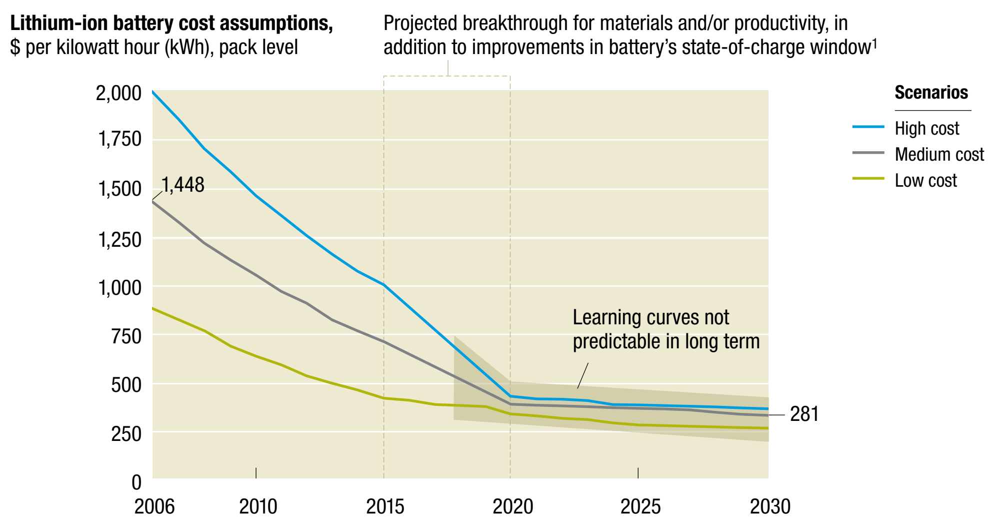
The economics of electrified vehicles start with the batteries, whose cost has been declining by 6 to 8 percent annually. Many analysts predict that it will continue to fall over the next ten years as production volumes rise (Exhibit 1). Battery packs now cost about $700 to $1,500 per kilowatt hour, but that could drop to as little as $420 per kilowatt hour by 2015 under an aggressive cost-reduction scenario. Even then, the upfront purchase price of electrified cars would be quite high. We estimate that by 2015, a plug-in hybrid-electric vehicle with a battery range of 40 miles (before the need for a recharge) would initially cost $11,800 more than a standard car with a gas-fueled internal-combustion engine. A battery-powered electrified vehicle with a range of 100 miles would initially cost $24,100 more.

Subsidies could help bridge the difference. China announced that it will cover $8,800 of the cost of each electrified vehicle purchased by more than a dozen of its large-city governments and taxi fleets. Business innovation could address costs too. In the solar-technology market, for instance, SunEdison owns, finances, installs, operates, and maintains solar panels for customers willing to adopt the technology. The company then charges these consumers a predictable rate lower than the one they paid for traditional electric power but higher than the actual cost of generation. That allows the company to recoup its capital outlay and make a profit.[1] Innovators are considering similar models to cover the battery's upfront cost and recoup the subsidy by charging for services.

1 SunEdison's model also takes advantage of US state-level incentives for solar power.

Exhibit 1

Learning curves



[1] State-of-charge window is the available capacity in a battery relative to its capacity when full. Conservative applications work within a 65% window, whereas more aggressive applications use 80%; over the next 5 to 10 years, most applications will likely migrate to the higher value.

Source: OEM and supplier interviews conducted in Asia, Europe, and North America; McKinsey analysis

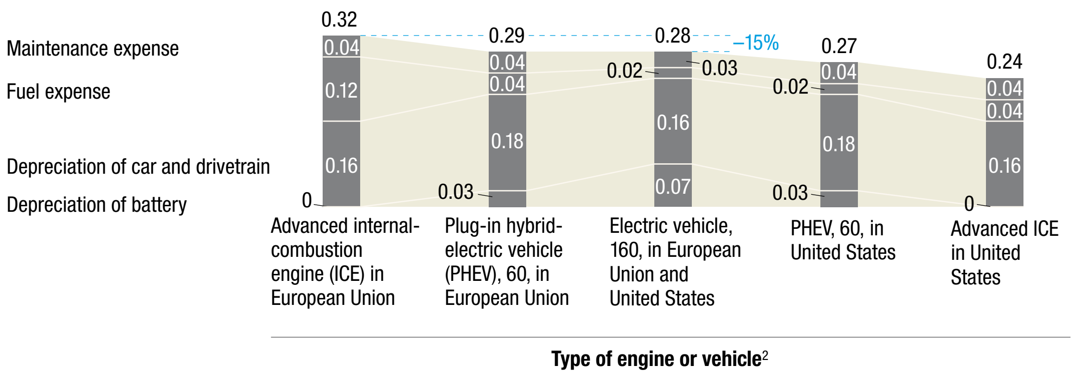
To sway buyers, electrified vehicles—hybrids, plug-in electric hybrids, or all-electric cars (see "Electrified vehicles: A glossary")—must be cheaper to operate than gas-fueled ones. The difference between the total lifetime costs of a car with an internal-combustion engine and an electrified car will depend for some time on the difference between the price of gasoline at the pump and the cost of the battery and of recharging it (for those who own the battery) or the cost of leasing a battery and of recharging services. Oil prices have fluctuated wildly over the past two years, and electricity prices vary throughout the world. In Europe, electrified cars (for example, plug-in hybrid-electric vehicles with a 60-kilometer range) could have lower total running costs, assuming an oil price of $60 a barrel and current electric rates.[2] In the United States, electrified cars will be less expensive on a total-cost-of-ownership basis only if the price of gasoline exceeds $4 a gallon and electric batteries can go 40 miles before a recharge, or if the government gives manufacturers incentives that subsidize the cost of production (Exhibit 2).

2 Clearly, this is a very conservative estimate. The McKinsey Global Institute estimates that energy demand will accelerate when the global economy rebounds, with a predictable impact on oil prices. For more, see MGI's March 2006 report, "Averting the next energy crisis: The demand challenge," available free of charge on mckinsey.com/mgi.

Exhibit 2

Electric avenue

Total cost per km of operation, $, 2012–15 projection[1]



[1]Assumes fuel cost of $3.00 per gallon (United States), $1.69 per liter (European Union); battery pack cost of $500 per kilowatt hour (kWh); total cost of ownership calculated for first 5 years of ownership; 20,000 km annual distance driven; standard vehicle (eg, Volkswagen Golf) with cost of $20,000 before engine, drivetrain, battery, etc.; advanced ICE vehicle is 30% more efficient than 2008 Volkswagen Golf.
[2]60 and 160 refer to number of kilometers vehicle can drive on fully charged battery.

The proliferation of electrified vehicles will also require an infrastructure, such as recharging stations. China's State Grid is speeding up plans to build charging facilities in at least three of the country's largest cities by 2011, and the US state of Hawaii has announced plans to build as many as 100,000 charging stations for electrified vehicles by 2012. Investments in capabilities to manufacture the vehicles are needed as well. China, which set a goal of producing half a million electrified cars annually by 2011, has announced that it will invest $1.4 billion in R&D for the purpose. The United States has committed $2 billion in stimulus spending to help companies manufacture batteries and $25 billion for government programs to encourage carmakers to retool their production lines to produce larger numbers of more fuel-efficient vehicles, including electrified ones.

Of course, consumers may decline to buy electrified vehicles for any number of reasons: the distance drivers can go before recharging, for example, may undermine acceptance. But on a more fundamental level, electrified vehicles will go mainstream at a pace determined by government action to make gasoline more expensive; to reduce the cost of producing, buying, or operating electrified vehicles; or some combination of these two approaches.

Preparing for tomorrow

There is little point in trying to predict how many electrified vehicles of one kind or other will be on the road by any given year, because so many factors are unpredictable. Governments could aggressively promote the use of electrified vehicles, for example, and then lose tax revenues when drivers spend less money on gasoline at the pump. Will lawmakers in Europe and the United States be willing to sacrifice tax receipts that pay for the upkeep of roads in order to help control climate change? If not, how will the tax burden be migrated to the new fuel: electricity? Besides, electrified vehicles are a nascent technology, and it's too early to say how the rate of adoption by consumers in different segments will evolve or how costs will be optimized.

But here's a number to contemplate: electrified vehicles would enter the mainstream if about 10 percent of all cars on the roads were battery-electric or plug-in vehicles, running solely on electric power. That would mean sales of six million to eight million electrified vehicles a year by 2020, which would change whole sectors dramatically. Let's look at the opportunities and challenges for the three key ones: autos, batteries, and utilities.

Automakers

Electrified vehicles pose an enormous threat to incumbent automakers. The internal-combustion engine and transmission are the core components they have focused on since outsourcing the manufacture of many other components and subassemblies. In a world where vehicles run on electrons rather than hydrocarbons, the automakers will have to reinvent their businesses to survive. Nonetheless, incumbency is also a strategic strength in this sector. Attackers face significant entry barriers, including manufacturing scale, brand equity, channel relationships (for instance, dealership networks), customer management, and capital.

Moreover, electrified vehicles open up opportunities for incumbent automakers. These cars could help them meet increasingly stringent emission regulations and avoid fines. The low-end torque of electric motors can accelerate cars more quickly, smoothly, and quietly, which could provide distinctive new value to buyers. Automakers could also beat attackers to the punch in tapping assets such as plants and dealership networks to introduce new business models, such as selling transport services rather than products. To achieve any of this, auto executives will need to consider the strategic role of electrified vehicles. The plans of the automakers, for example, must include a clear understanding of the way they will prioritize R&D across a portfolio of vehicle platforms, from hybrids to plug-in hybrids to battery-electric models to cars powered by internal-combustion engines.

Automakers should also consider how their relationships with the battery makers will evolve, as well as the role technology standards will play in fitting batteries into vehicles. (Most large automakers are currently partnering with battery companies to develop the electrified or hybrid vehicles they are preparing to launch.) Battery makers and tier-one suppliers will try to secure the value implicit in owning core skills, including innovation in batteries and in the new features they could make possible. Over time, value will probably shift from the battery cell to the electronics and software of the power- and thermal-management system, which determines a car's actual performance. Executives should develop plans to capture that value when the shift occurs.

Executives should consider the evolution of the downstream business too. Will utilities, gas stations, car companies, or other third parties own the recharging infrastructure and the real estate it occupies, for example? Will processing intelligence and data collection sit in the recharging infrastructure or in the vehicle? Strategists should also think about whether dealers or players like Wal-Mart will sell cars and batteries and about how the supply chain for electrified vehicles differs from the present one. In all likelihood, for instance, demand for lightweight materials will grow, while demand for exhaust systems and mufflers will shrink.

Battery producers

In a world where consumers buy six million to eight million electric-drive vehicles each year, annual sales of batteries might come to $60 billion, and value will start shifting to them from oil.[3] Over the long term, the sector's growth potential is vast, and even the near-term prospects look sunny. For now, battery makers can reap high margins from differentiated battery chemistries that provide a cost, performance, and safety edge. It also helps to win government grants, announced by the European Union and the United States as a stimulus measure to increase domestic battery capacity. The grants have been designed to attract additional private investment.

Nonetheless, battery manufacturers face many challenges. As capacity ramps up, the cells of batteries (their basic element[4]) will become a commodity, like many other automotive components. Value will migrate from the cell-level chemistry to the level of battery-pack systems, including power- and thermal-management software, and to the electronics optimizing a battery's performance in a specific vehicle. To retain value in the longer term, battery makers may want to partner more closely with the automakers' tier-one suppliers—which aggregate components into vehicle systems, such as steering systems or dashboards—or with the automakers themselves. The latter route would help battery makers preserve more value because they would supplant the tier-one suppliers, but to succeed they would have to obtain the required systems integration skills, knowledge of cars, and key auto relationships. Considering the resources needed to achieve these goals, battery makers would have to ask themselves whether they have the engineering resources to scale the necessary capabilities across a number of vehicle platforms, model derivatives, and OEMs.

Even in the near term, the battery makers can no longer put off some unresolved questions. How, for instance, will these companies protect their intellectual property in process-driven chemistries in order to prevent reverse engineering? One battery maker has spread different parts of its proprietary process across its factories in China, reducing the chance that former employees will reengineer the "secret recipe" for a competitor. So far, patents haven't been heavily contested, but that could change as volumes and revenues grow. This possibility, as well as the uncertain strength of key patents, means that battery companies must think carefully about how to defend their intellectual-property positions and whether to attack those of rivals. The most important question, however, may be which part of the value chain of batteries will take on the warranty risk associated with them. Carmakers don't want to do so. Emerging battery companies may not have the balance sheets to offer warranties credibly. Incumbents with strong balance sheets and battery

3 Assuming 2020 battery pack costs of $350/kWh and a battery pack capacity of 14 kWh and 30 kWh for plug-in hybrid (60 km range) and battery-electric vehicle (160 km range), respectively.

4 A typical battery used in automotive applications may contain 25 to 150 component cells, depending on the energy density of the battery and the cells.

businesses—Johnson Controls, NEC, or Samsung, for instance—could provide this service if the opportunity looks ripe.

The evolution of the aftermarket for batteries is an open question. Since none of them have been tested in large numbers under the real (and diverse) driving conditions they will encounter over their lifetimes, it isn't clear yet how much residual value there will be. Indeed, batteries at the end of their lives may be liabilities, not assets, because of their recycling costs. (Ninety-seven percent of the lead in lead-acid batteries can be recycled, but lithium is trickier to handle and currently less valuable than lead.) Executives should bake the cost of managing lithium and other component materials into the business model or find ways to ensure that the cost accrues somewhere else in the value chain.

Leading battery makers are already thinking through ways to scale up manufacturing, because they know that there will be first-mover advantages, such as increased automation, increased procurement leverage, and new form factors. These companies are also investing significant sums in R&D for the next generation of battery chemistries. The reason is that the complicated interplay among a battery cell's core elements (such as the cathode, electrolyte, separator, and anode) determines different aspects of the cell's performance—for example, power density, energy density, safety, depth of charge, cycle life, and shelf life, which determine the choice of batteries for particular vehicles. Since cell materials account for 30 to 50 percent of the cost of a battery pack, many battery makers are also considering the pros and cons of integrating vertically into key materials.

Finally, battery makers should also think about the possibility of moving into new products or services. These might include offerings for transport sectors (such as maritime, locomotives, trucks, and buses) and for utilities, which might be interested in voltage and frequency regulation, power-management services, and bulk energy storage. Fast charging—applications to deliver lots of power to batteries very quickly, in minutes rather than hours—might be another source of revenues. All of these applications have very different energy and power density needs, as well as different capital requirements and operating expenses. Battery companies will need to place their bets and manage their portfolios carefully.

Utilities and infrastructure providers

Quite apart from electrified vehicles, policies to improve energy efficiency or reduce carbon emissions pose a serious challenge to utilities, whose revenues and profits will come under pressure as businesses, governments, and private homes—stimulated by government investments and by new standards and policies in China, Europe, and the United States—use energy more efficiently. Meanwhile, the utilities' per-unit generation costs will rise in the near term with the faster adoption of renewable forms of energy, such as solar and wind—intermittent sources that must be supported by a new transmission and distribution infrastructure. Furthermore, any carbon tax or cap-and-trade scheme will affect energy prices and, potentially, the utilities' long-term profitability.

Electrified vehicles, however, create new revenues for utilities. If 20 percent of the cars and trucks sold in a local market (for example, certain parts of California) over the next decade have electric drives, recharging them could represent up to 2 percent of total electricity demand, according to our analysis of local markets where electrified vehicles might take off first. If vehicles were charged mainly at night, utilities could satisfy much of this demand without installing any significant additional generation capacity.

The charging of electrified vehicles might help utilities profit from carbon-abatement taxes and trading mechanisms as well. These companies, for example, could take steps with their regulators to capture emission credit for the abatement that utilities make possible in the transport sector. In addition, they could reposition themselves in the minds of their customers not only as electricity companies but also as enablers of an environmentally sustainable economy. Any failure to play an active leadership role exposes utilities to the risk of being disintermediated in the residential or commercial segments by other service providers, such as large IT players that already have strong positions in homes (for instance, Cisco and IBM), or by emerging innovators.

Charging at night is the key, however. If utilities don't install smart systems that control the time when a vehicle can charge, they could struggle to meet peak demand, assuming, as many do, that owners will want to plug in their cars upon returning home in the evening. (Many utilities already struggle to provide enough power in the peak-use early-evening hours.) Worse, electrified-vehicle owners, especially in the early years, will probably cluster together in certain affluent neighborhoods. The incremental demand may be enough to blow out transformers in these areas and require new investments in power generation.

Blowouts would reduce the reliability of the system and the satisfaction of its customers, as well as require expensive investments. Electrified vehicles, we assume, will be twice as popular in certain markets in California than they will be in other parts of the United States. If sales of such vehicles reach 1.8 million in that state by 2020, inadequately managed charging could require upward of $5 billion in incremental investments in transmission and generation infrastructure. This incremental peak-time power will almost certainly come from fossil fuels, which will raise carbon dioxide emissions and force utilities to spend more for emission allowances if they can't get credit for the increased "well to wheel" efficiency of electrified vehicles.[5]

To meet the challenge of charging vehicles and of a "smart" charging infrastructure, utilities must start planning now for the necessary technologies, costs, infrastructure partners, and business models. Regulated utilities could try to build the required investment into the rate base by convincing regulators of the business logic. They can also work with automakers to provide a seamless experience for consumers: when someone walks into a dealership to buy a new electrified car, the local utility should know—and be ready to install the right equipment in the customer's home.

Electrified vehicles will become a reality—sooner, as the bulls believe, or later, as the bears do. That will change the competitive landscape of the automotive, battery, and utilities sectors and have an impact on several others. Companies that act boldly and time their moves appropriately will probably enjoy significant gains; those that don't will not. But timing is critical: jumping in too early or late will be costly. Buckle up and hang on for the ride.

5 These emissions could be mitigated if new power facilities were located outside of cities and the emissions were captured and stored.

Capturing the consumer opportunity in energy-efficient products

By Sheila Bonini and John Patience

Makers of energy-efficient products should give themselves a pat on the back. Despite the slowdown in consumer spending in the United States and elsewhere in 2008 and early 2009, some companies report that sales of their energy-efficient and "green" (or environmentally friendly) products continue to be strong or are growing.[1] Sales of hybrid vehicles, "green" detergents, and organic products all grew in the United States during 2008, while sales of energy-efficient lightbulbs remained steady (Exhibit 1).

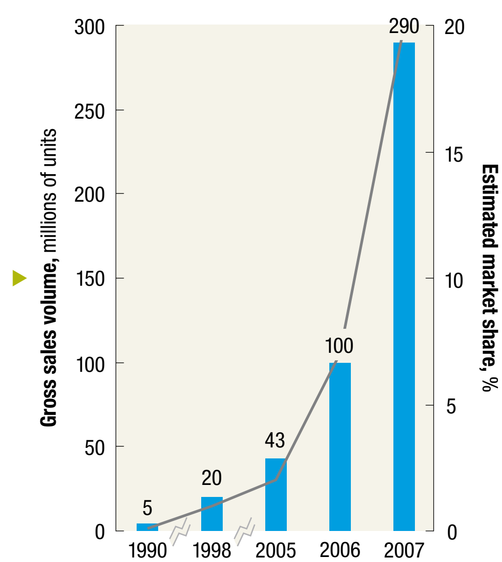
Exhibit 1

Compact fluorescent lightbulbs case study

Product evolution of compact fluorescent lightbulbs (CFLs)

Attribute	1992	2002	2005
Price range	$15–25	$3–10	$0.98–15.00
Life	9,000–12,000 hours	6,000–12,000 hours	6,000–12,000 hours
Type of ballast	Magnetic or electronic	Electronic	Electronic
Dimmable	No	Few	Some
Incandescent sized CFLs	None	Some	Many
Available wattages	9–34	2–59	2–59
Number of CFL manufacturers	<10	100	100

Market share of CFLs



Source: Platts (with some data from Ecos Consulting), June 2002; *Washington Post*; McKinsey analysis

1 Philips, for instance, reported that its sales of "green" products went from 20 to 25% from 2007 to 2008, up from 15% in 2006.

But these manufacturers shouldn't start celebrating just yet—they still have a lot of work to do. New research suggests buyers in many developed and developing nations still do not have the information they need to feel comfortable buying appliances, lightbulbs, and other goods that use less energy. At the same time, a decreasing number are willing to pay a premium for such products. Consumers voice these concerns despite the fact that the majority of them continue to view environmental issues as a top concern.

These are the conclusions of two studies conducted by McKinsey: the first, an ongoing multiyear study of thousands of consumers in seven nations on their attitudes about environmental and other social issues and on their behaviors related to purchasing energy-efficient or "green" products; the second, a 2008 study of North American residential consumer awareness of energy-efficiency issues.[2] The research shows that barriers continue to stand in the way of consumer adoption of energy-efficient and environmentally friendly products. In particular, these findings suggest that makers of energy-efficient products need to step up efforts to help consumers understand the savings gained by using them, despite the higher upfront price tag these products sometimes carry. Also, they need to provide consumers with better access to energy-efficient products. Consumers, even if willing to buy these products, report they cannot always find them easily.

Consumers across the world have consistently said that the environment (including the dangers of climate change) is one of their top social concerns, and on the whole they rank this as a higher concern today than they did in 2006, when we launched our multiyear study. However, respondent sentiment dipped slightly in 2008, with 51 percent of survey respondents indicating environmental issues as a concern, versus 55 percent in 2007 (although still up from 47 percent in 2006). By comparison, other social issues consumers ranked high in 2008 include concern over health care and other employee benefits (32 percent of respondents), affordability of products for low-income buyers (31 percent), and demand for healthier and safer products (30 percent). On a separate question measuring how worried they are about global warming and climate change, 83 percent of respondents said in 2008 they were somewhat or very worried, down from 88 percent of respondents expressing concern in 2007.

A significant gap remains between consumers' general concern about global warming and their awareness of specific actions they can take—through products they buy—to help address the problem. In 2008, for instance, only 45 percent of all respondents around the world said that using energy-efficient products is one of the most important actions they can personally take to reduce the threat of global warming, down from 47 percent in 2007. Recycling, in consumers' estimation, has higher impact (56 percent in 2008, up from 51 percent in 2007). Yet the number of consumers who show a willingness to use energy-efficient appliances to help make a difference is far higher—in fact, 68 percent in 2008. This was down slightly from 2007 (71 percent) but still reveals a gap between concern and understanding.

It is important to note that responses varied geographically, with a greater proportion of Chinese respondents aware of the advantages of energy-efficient appliances than their European counterparts. Chinese respondents also cited driving fuel-efficient vehicles and driving less as beneficial actions they can take (Exhibits 2 and 3).

2 The two studies included: a September 2008 survey of sustainability issues of 4,377 consumers across the US, UK, Germany, France, Brazil, India, and China; and a 2008 North American survey of 2,000 residential energy users.

Exhibit 2

Main actions consumers say they can take to help stop climate change in 2007 and in 2008

% of respondents[1]

What can individuals do to help stop climate change?

2008 / 2007

	Total	United States	United Kingdom	France	Germany	India	China	Brazil
Recycle	56 / 51	65 / 51	63 / 59	62 / 56	34 / 30	59 / 54	32 / 27	79 / 76
Use energy-efficient appliances	45 / 47	38 / 41	44 / 51	27 / 33	43 / 43	61 / 65	69 / 73	33 / 30
Drive less/use public transportation more	44 / 41	36 / 33	27 / 30	45 / 48	38 / 37	47 / 43	65 / 61	48 / 37
Drive a more fuel-efficient car	35 / 38	45 / 52	31 / 28	30 / 28	34 / 41	37 / 42	35 / 27	31 / 43
Call for increased regulation of business emissions	32 / 40	20 / 30	16 / 24	40 / 51	29 / 34	23 / 25	24 / 32	70 / 83
Adjust your thermostat to use less energy	21 / 21	29 / 23	25 / 22	20 / 23	20 / 19	15 / 14	31 / 40	5 / 6
Purchase locally produced products	19 / 14	19 / 13	27 / 20	23 / 13	26 / 22	17 / 12	9 / 9	11 / 8
Improve insulation in your home	18 / 13	16 / 10	35 / 17	30 / 26	28 / 23	10 / 10	6 / 5	5 / 3
Fly on airplanes less	9 / 9	2 / 3	16 / 18	10 / 10	22 / 20	8 / 7	6 / 6	2 / 2
Purchase carbon offsets/credits	7 / 7	4 / 4	2 / 5	2 / 2	10 / 10	11 / 14	17 / 15	3 / 4
Reduce consumption of beef	5 / 3	4 / 3	5 / 3	3 / 3	5 / 3	7 / 5	4 / 2	5 / 3
Nothing	2 / 4	6 / 11	3 / 7	2 / 2	3 / 6	1 / 2	0 / 0	1 / 1
Other (please specify)	2 / 2	4 / 3	1 / 2	1 / 2	1 / 1	2 / 3	0 / 1	4 / 5

[1] Respondents could select more than one activity.

Source: September 2008 McKinsey survey of 4,377 consumers; September 2007 McKinsey survey of 7,751 consumers

Exhibit 3

Consumers are increasingly willing to use energy-efficient appliances

% of respondents[1]

Which of these would you personally be most willing to do?[2]

■ 2008
■ 2007

	Total	United States	United Kingdom	France	Germany	India	China	Brazil
Recycle	75 / 64	90 / 71	91 / 79	67 / 56	62 / 56	71 / 61	40 / 38	99 / 80
Use energy-efficient appliances	68 / 71	68 / 72	70 / 74	35 / 47	77 / 73	79 / 80	78 / 84	66 / 64
Drive a more fuel-efficient car	52 / 51	60 / 56	48 / 46	47 / 42	51 / 54	58 / 58	42 / 38	59 / 64
Drive less/use public transportation more	51 / 42	38 / 33	39 / 37	45 / 38	51 / 41	63 / 47	69 / 56	57 / 48
Adjust your thermostat to use less energy	46 / 49	68 / 63	65 / 62	36 / 43	49 / 52	30 / 37	45 / 50	22 / 27
Purchase locally produced products	38 / 35	48 / 44	57 / 47	30 / 24	48 / 42	32 / 30	20 / 20	28 / 33
Improve insulation in your home	31 / 35	38 / 44	53 / 52	39 / 38	35 / 34	28 / 32	16 / 21	10 / 16
Call for increased regulation of business emissions	29 / 39	23 / 35	22 / 33	29 / 39	19 / 33	23 / 32	23 / 32	66 / 70
Fly on airplanes less	18 / 18	18 / 20	24 / 26	13 / 10	32 / 28	14 / 15	17 / 13	7 / 14
Reduce consumption of beef	14 / 16	16 / 21	13 / 18	9 / 10	15 / 18	18 / 19	11 / 10	18 / 17
Purchase carbon offsets/credits	9 / 12	8 / 13	10 / 14	3 / 4	8 / 12	14 / 20	17 / 16	6 / 9
Nothing	2 / 3	4 / 6	2 / 4	3 / 2	3 / 5	2 / 2	1 / 0	2 / 1
Other (please specify)	2 / 1	2 / 2	2 / 1	1 / 1	2 / 1	2 / 1	0 / 0	4 / 1

[1]Respondents could select more than one activity.
[2]Numbers adjusted in order to make 2008 comparable to 2007. Question was asked differently in 2008 (eg, respondents were allowed to select multiple answers in 2008 whereas in 2007 only one answer was allowed).

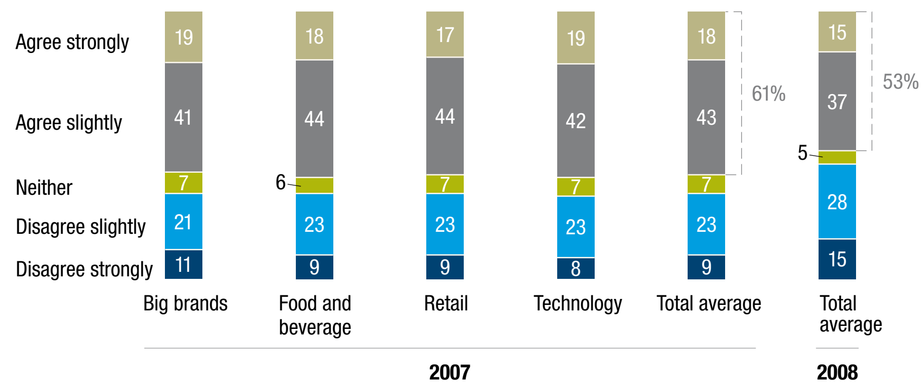
Source: September 2008 McKinsey survey of 4,377 consumers; September 2007 McKinsey survey of 7,751 consumers

The research also reveals gaps in consumer understanding. For instance, consumer willingness to pay a premium for energy-efficient products declined in 2008, perhaps reflecting tightened household spending in the face of the economic downturn (Exhibit 4). However, digging down into the data uncovers other factors influencing consumers. A significant number of respondents who purchased energy-efficient refrigerators and washing machines said their primary motivation was to save money on energy costs, putting environmental concerns second. By contrast, about one out of every five consumers who declined to purchase these energy-efficient appliances cited sticker price as the barrier, illustrating that they did not understand the longer-term cost savings (Exhibit 5).

Exhibit 4

Percentage of consumers willing to pay more for energy-efficient and environmentally friendly products in 2008 decreased from 2007

Categorize your agreement with the statement 'I am willing to pay more for environmentally friendly products,' 2007 vs. 2008[1]



[1] Figures may not sum to 100%, because of rounding.

Source: September 2008 McKinsey survey of 4,377 consumers in Brazil, China, France, Germany, India, United Kingdom, United States; September 2007 McKinsey survey of 7,751 consumers in Brazil, Canada, China, France, Germany, India, United Kingdom, United States

Exhibit 5

Initial price is a main reason consumers do not purchase energy-efficient refrigerators

% of respondents

Why have you not purchased these products? [Energy efficient refrigerators]

Reason	Group	Total	United States	United Kingdom	France	Germany	India	China	Brazil
I don't need one right now	All consumers	41	46	48	43	46	31	36	30
	Influentials	38	51	29	51	47	35	32	35
The initial price is too much	All consumers	20	24	16	22	20	17	14	27
	Influentials	21	22	20	19	10	22	19	27
I have no use for it/don't need it	All consumers	10	10	8	14	6	12	13	6
	Influentials	7	8	9	5	4	7	11	2
I've just not thought about it	All consumers	9	7	8	8	6	17	6	9
	Influentials	12	5	11	5	5	20	10	10
I don't know enough about them	All consumers	8	4	4	6	3	15	15	8
	Influentials	10	5	6	7	4	12	15	8
The cost savings aren't enough to justify buying	All consumers	8	7	7	6	6	10	10	7
	Influentials	11	12	10	5	7	14	14	6
They aren't available to me	All consumers	5	2	2	5	1	14	9	2
	Influentials	10	2	5	4	3	18	13	7
I keep forgetting/ haven't got round to it	All consumers	5	1	6	2	3	12	4	7
	Influentials	7	1	4	6	9	9	8	8
I don't believe they are better	All consumers	4	1	1	5	2	11	7	5
	Influentials	7	2	7	1	2	11	11	5
I don't see the benefit	All consumers	3	2	3	1	3	5	3	3
	Influentials	4	5	3	2	3	7	4	2
They aren't good quality	All consumers	3	1	0	2	0	10	2	2
	Influentials	5	2	3	2	5	7	5	3
I don't like the brand/image	All consumers	2	0	2	2	2	7	3	1
	Influentials	4	2	4	2	5	5	4	3
Other/don't know	All consumers	9	6	10	8	14	8	7	12
	Influentials	8	9	12	8	12	8	4	10

Source: September 2008 McKinsey survey of 4,787 consumers in U.S. (n = 679), U.K. (n = 607), France (n = 622), Germany (n = 621), India (n = 605), China (n = 624), Brazil (n = 619), Korea (n = 410)

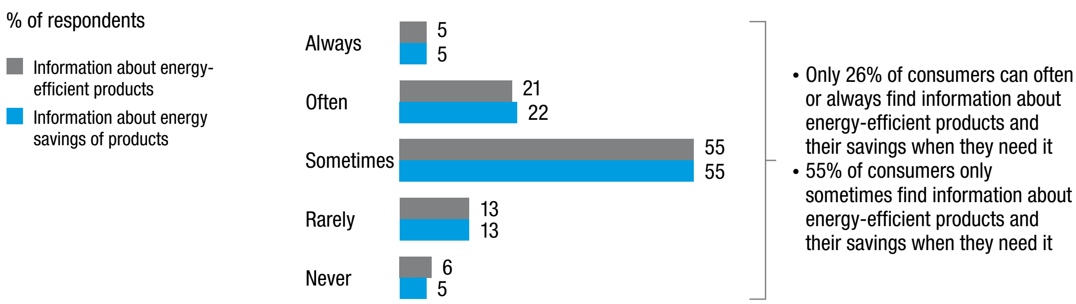
What this suggests is that many consumers who understand the savings potential of buying products that use less energy are willing to pay more up front for these appliances and lighting products—but they are still in the minority. Most consumers are still having trouble figuring out whether buying these products is a good deal for them or not.

Nearly three-quarters of consumers in our research say that they do not have access to the information they need to make an informed purchase of an energy-efficient product, or that the information is inadequate (Exhibit 6). Many consumers are aware of what programmable thermostats are, for instance, but less than a third of them say they understand the benefits of these products. Similarly, about half of consumers understand the benefits of energy-efficient lighting (Exhibit 7).

Exhibit 6

Most consumers feel availability of information about energy-efficient products is inadequate

Most consumers can only sometimes find information when they need it[1]



[1] Respondents were asked, "How often are you able to find information about energy-efficient products when you need to?" "How often are you able to find information about energy savings provided by energy-efficient products?" n = 731, all indicated they did not buy compact fluorescent lightbulbs (CFLs), TVs, programmable thermostats.

Source: Burke market research

Only about 20 percent of the North American consumers we surveyed on residential energy efficiency know how much any individual product contributes to their household energy bill. The majority of consumers underestimate energy usage from lighting, electronics, appliances, and devices that draw electricity, such as fans, chargers, and small electronic devices. And less than half of consumers are aware of energy-efficient options for space heaters, consumer electronics, and home office equipment.

Finally, many consumers say they do not know where to buy energy-efficient products. A majority of the North American consumers we surveyed report that energy-efficient products are either unavailable to them in retail stores or they don't know where to shop for them. This finding underscores general consumer confusion about energy-efficient products. For example, 75 percent of consumers who considered buying but did not purchase an energy-efficient television found them unavailable in retail stores. Yet 83 percent of those who actually purchased an energy-efficient television said they did not know if they were available in retail stores, suggesting they were not aware of the energy-saving features of the product they took home with them.

Clearly, marketers, retailers, utilities, governments, and nongovernmental organizations (NGOs) need to redouble efforts to educate consumers on the benefits and availability of energy-efficient products. Reducing residential energy consumption is one of the biggest opportunities that developed nations have to improve energy security and reduce harmful greenhouse gas emissions. For consumers, energy efficiency at home saves money.

One approach to raising consumer awareness of the economic benefits of energy-efficient products—and to help bridge the gap between consumers' concern for the environment and their understanding of how they can play a part in addressing the problem—is developing outreach partnerships. Several alliances have been successful, providing a large platform to increase communications to consumers. Alliances also allow companies to leverage brands, knowledge, and resources of other parties to build awareness of energy-efficient options and drive adoption.

Exhibit 7

Compact fluorescent lightbulbs and thermostats—a lack of understanding

Profile of programmable thermostat nonbuyers,[1]
n = 995 (buyer/nonbuyer = 101/894)

Average age	40.1 years
Annual household income	$61,000
Own vs rent	39% rent (vs 16% buyer)
Type of residence	29% multiunit building (vs 14% buyer)
Average stay at residence	5.8 years
Square footage of residence	1,672
Monthly utility bill	$129

Programmable thermostat purchasing funnel for nonbuyers[2]

Key barrier limiting product sales

Awareness of energy-efficient (EE) products	Understanding/ importance of EE products	Quality and features of EE products	Price	Availability
67% of nonbuyers were aware of programmable thermostats	32% consider EE benefits of programmable thermostats important	60% perceive programmable thermostats as having better features than traditional thermostats	45% feel programmable thermostats cost too much	N/A

Profile of compact fluorescent lightbulb (CFLs) nonbuyers,[1]
n = 2,002 (buyer/nonbuyer = 1,078/924)

Average age	37.4 years
Annual household income	$55,000
Own vs rent	45% rent (vs 29% buyer)
Type of residence	34% multiunit building (vs 22% buyer)
Average stay at residence	5.3 years
Square footage of residence	1,600
Monthly utility bill	$125

CFL purchasing funnel for non-buyers[3]

Awareness of energy-efficient (EE) products	Understanding/ importance of EE products	Quality of EE products	Price	Availability
85% of nonbuyers were aware of CFLs	51% consider energy-efficient lighting products important	59% perceive quality of CFLs as better than or equal to that of regular bulbs	65% feel CFLs cost too much 66% feel price is most important criteria	N/A

[1]Statistically significant at the 10% level compared with buyers.
[2]Calculated as a percent of consumers aware of programmable thermostats.
[3]Calculated as a percent of consumers aware of CFLs.

Source: Burke market research

The Northwest Energy Efficiency Alliance (NEEA), for instance, a not-for-profit organization funded by electric utilities and supported by state governments and interest groups, has worked with makers of energy-efficient products to help reduce energy usage in one region of the United States. One NEEA program, involving more than 600 appliance retailers and 12 manufacturers of washing machines, helps consumers obtain discounts and rebates on purchases of the most energy-efficient machines. According to NEEA, this resulted in a 4 percent increase in overall market share from 2006 to 2007 for energy-efficient washing machines. Other established partnerships with which companies can work include the California Energy Commission's Energy Efficiency Division, Alliance to Save Energy, and Resources for the Future.

One early model for this approach was Energy Star, established in 1992 as a joint program of the US Environmental Protection Agency and Department of Energy. Its mission was to educate consumers on the benefits of energy efficiency and drive adoption of more energy-efficient products and practices. The agencies' efforts have demonstrably paid off: products in more than 60 categories carry the Energy Star label, qualifying the product as energy efficient, and more than 70 percent of US consumers are aware of what the label means.

Lowe's taps Energy Star's well-recognized brand and messaging in its marketing and communications material. The giant retail chain uses in-store messaging to direct customers to Energy Star products, including signage and audio messaging, and promotes specialized collateral, such as booklets on Energy Star tips. In addition, Lowe's has dedicated Energy Star advertising, mails an Energy Star–oriented newsletter to hundreds of thousands of customers, sends promotional literature in mailings to credit card users, and highlights Energy Star advice on its Web site. Lowe's says that these efforts boosted sales of Energy Star–qualified products by 45 percent in one year.

These efforts suggest that there is substantial growth potential for energy-efficient products, if and when consumers become more aware of their real benefits. Many buyers know that products using less energy will save them money. But how much they can save and how soon they can win back the premium purchase price paid at the register for an energy-efficient product—all that remains a mystery to them. This mystery is a barrier to sales of these products.

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