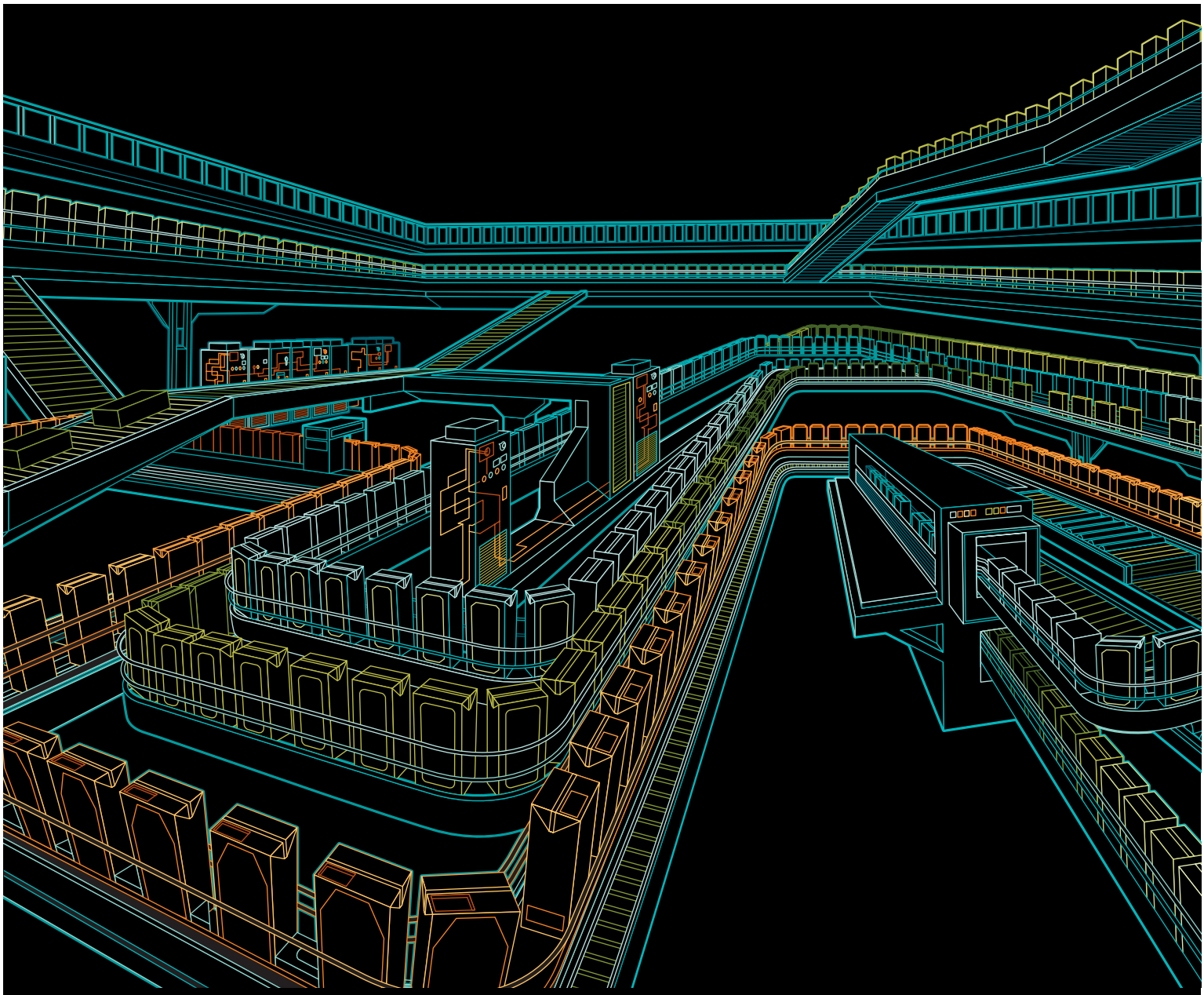

White paper

Energy efficiency and U.S. competitiveness
Applying product and process innovation to build long-term economic advantage.

Power and productivity
for a better world™

ABB

Executive summary

ABB Inc. presents this white paper to broaden the national discussion on energy efficiency by identifying near-term opportunities that could elevate the competitiveness of the United States while saving energy and protecting limited resources. While much of the domestic energy-efficiency dialogue focuses on individual consumption and single-point innovations, no method has as much potential for immediate payback as applying widely available products and processes to established infrastructure.

Energy efficiency is mandatory for the United States to maintain continued economic leadership in a global economy for multiple reasons, including:

- Demand for electricity and fuel to drive commerce is increasing.
- Our energy supply model is costly, inefficient and uncompetitive.
- Keeping up with growing nations as domestic growth flattens requires infrastructure investment.
- Efficiency upgrades feed private-sector job growth by creating new jobs and keeping cost structures for businesses down.

The biggest opportunity lies in how electricity is transmitted, distributed and managed; but such opportunities require the encouragement of private-sector investment. The national energy network, or grid, is too complex and expensive to realistically consider a wholesale upgrade. It involves multiple owners, hundreds of regulatory agencies and other public entities, and thousands of financial investors. It is also very capital intensive, so assets must be used over long periods of time to recover their upfront costs. Solutions must include finding ways to make the existing system more reliable and efficient. This paper discusses some of those solutions, such as HVDC, Combined Heat and Power, Volt/VAr and Demand Response.

Similarly, the U.S. industrial and building sectors could extend the use of their still-productive assets while improving energy efficiency by investing in technologies that make it easier to manage energy use. These include variable-speed drives, motor-control systems, high-efficiency motors and building-systems automation, among others.

Certainly, energy efficiency is a big challenge and needs “big ideas” considering the world’s energy needs increase daily. However, capital investment cycles and other political and economic realities also call for “big ideas” on how to make the transmission, distribution and management of energy immediately more productive. Such proven “ideas,” which are already in the market as available products and processes, need to be part of the larger discussion in order to make energy efficiency a reality for today and not just a dream for tomorrow.

Introduction: Make immediate action part of the conversation

Discussion about energy efficiency is as omnipresent as energy itself. It can be heard every day in schools, libraries, city halls, statehouses, and on Capitol Hill as groups and individuals with varied interests promote energy efficiency as key to our country's economic competitiveness and long-term success.

Unfortunately, most of the discussion centers on concepts that — taken on their own — are either too general or too specific to reap immediate and/or significant impact on how we generate, deliver and consume electricity in the United States. Teaching consumers about energy-saving choices is important, for instance, but it will take generations of incremental behavioral change for this alone to make a difference. Likewise, single-point inventions such as all-electric vehicles have the potential to substantially reduce dependence on carbon-based inputs; but timelines for the widespread adoption needed to deliver on promised rewards are lengthy and uncertain.

Therefore, any serious discussion about improving energy efficiency in the United States must include ideas on what can be done today with existing technology, economic models and infrastructure that could provide the biggest returns in the shortest time. History tells us that, while government has a role, private-sector businesses are best suited to take on such a challenge. Industry is more nimble, innovative, responsive — and better funded — than both the government and non-profit sectors. From sparking the Industrial Revolution to leading the country out of The Great Recession, business-led innovation applied to product and process has repeatedly paved new paths to progress and prosperity in the United States.

Any serious discussion about improving energy efficiency in the United States must include ideas on what can be done today with existing technology, economic models, and infrastructure that will provide the biggest returns in the shortest time.

This is not to say that non-profit organizations, regulatory agencies and elected officials are not a crucial part of the solution. They are. This white paper's intent is to broaden the energy-efficiency discussion by identifying near-term opportunities that are both wide enough and deep enough to elevate the competitiveness of the United States while saving energy and protecting limited resources. Specifically, this paper begins by describing the role of energy efficiency in global economic competitiveness, and then provides a deep examination of opportunities to improve energy grid efficiency and reliability. Following that are examples of current technologies that are already improving energy efficiency in factories and buildings.

Opportunities in these areas are plentiful and have the potential to provide significant improvements in energy efficiency on a national basis in a relatively short time. Additionally, they can be accomplished through support of activities that are bipartisan, beneficial to all Americans and driven largely by private-sector investment.

Energy efficiency and global economic leadership

We strongly agree with those who see ongoing efforts to improve the energy efficiency of the United States as mandatory for continued economic leadership in a global economy. Reasons include:

Demand for electricity and fuel to drive commerce is increasing.
The growth rate of energy consumption is expected to slow from 2010-2035, but overall electricity consumption will grow 23 percent over this period in both the developed and undeveloped world.[1]

At the same time, manufacturing output will grow 47 percent, driving up consumption of transportation fuels as suppliers and finished goods producers move chemicals and medicines, farm goods and packaged foods, autos and auto parts, industrial machinery and equipment, construction tools and materials, and other products to consumers. By 2035, heavy-duty trucks alone will consume the equivalent of 2.8 million barrels of oil each day, an 18 percent increase from 2010.[2]

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Additionally, home and workplace energy demand is expected to expand exponentially as we become a more technologically enabled society. Electricity consumption totaled nearly 3,884 billion kilowatt hours (kWh) in 2010 and was more than 13 times greater than electricity use in 1950.[3]

Our energy supply model is costly, inefficient and uncompetitive:
Over the past 20 years, U.S. businesses have become the world's experts on cost and cash flow management. Just-in-time inventory management, technology investments and other efficiency efforts have powered vast improvements in labor and process productivity, and have dramatically improved cash-to-cash cycles. Unfortunately, the cost model to produce energy has not kept pace with other efficiency gains. The dollars U.S. companies spend filling their energy demand with current processes provides an uncompetitive return on investment. Investing in new equipment and processes could close this gap and return immediate cost savings to companies, consumers, governments and the economy at large.

"On average, an additional dollar invested in more efficient electrical equipment, appliances and buildings avoids more than two dollars in investment in electricity supply." — International Energy Agency's World Energy Outlook.[4]

Keeping up requires infrastructure investment:
Global population projections point to flat or shrinking growth in the developed world over the next 40 years just as populations and middle-class wages in developing countries explode.

Already, China, India and other countries with the world's highest-growth economies are investing billions of dollars annually in infrastructure — utilities, factories, office buildings and public facilities ranging from school buildings to water-treatment plants. This intense investment is happening without the weight of legacy infrastructure, which in most cases is comparatively less energy efficient but not yet at the end of its useful life.

This reality puts the United States at a marked disadvantage when it comes to producing, delivering and consuming energy because the growing economies will be using the newest, most efficient technology, structures and systems while older-but-still-valuable capital remains in use here. The gap goes beyond power grids and utility substations: Everything from houses to steel plants will need far less energy to operate, giving the emerging economies a huge economic advantage.

"Globalization has upended the way we think about America's place in the world... It has become painfully apparent that U.S. infrastructure, once the envy of the world, is now strained and aging, while other nations are constructing bullet trains, cutting-edge broadband networks, public transit systems, modern ports, and energy delivery systems, while making significant investments in alternative energy." — *Jobs for America: Investment and Policies for Economic Growth and Competitiveness*, Milken Institute.[5]

Efficiency upgrades feed private-sector job growth:

Investment in energy efficiency offers more than short–term construction and engineering jobs — although these would be in the thousands; it also facilitates the transition of all industries into more modern efficient growth engines through private-sector wealth creation. Jobs created by this dynamic are generally well paying, full-time and long lasting.

First, let's take a look at how investing in energy efficiency would create thousands of jobs in the very near term. Considering infrastructure investment alone, energy-sector modernization through expansion of smart grid and clean coal technology, renewable resources and nuclear energy could create nearly 1.5 million new jobs over two years, according to the Milken Institute. Improving natural gas infrastructure and capacity would add even more.

Summary of Economic Impact By Infrastructure Project (2010-2012)

	Investment (US$B)	No. of Jobs, direct impact	Earnings, direct impact (US$B)	No. of Jobs, total impact	Earnings, total impact (US$B)	Output, total impact (US$B)
Smart grid	24.0	219,578	9.1	649,627	25.1	82.0
Nuclear energy	15.0	139,145	6.1	397,271	15.6	48.7
Renewables (solar, wind, biofuels)	14.5	115,874	4.8	337,558	13.1	44.3
Clean coal technology	2.55	24,018	1.1	66,127	2.6	7.9

Source: Jobs for America: Investment and Policies for Economic Growth and Competitiveness, Milken Institute

As for long-term jobs created by these investments, consider the potential for monetary savings described in the next three sections. Along with the rate of consumption (i.e., cost) of energy throughout our economy, the potential for reinvestment of savings in private-sector innovation and capital is enormous. And these investments, of course, are the true catalysts to long-term job creation.

Moreover, efficiency upgrades improve cost competitiveness and make it more economically viable to retain domestic manufacturing over the allure of lower-cost foreign sourcing.

Utilities: Increasing efficiency and reliability with existing infrastructure

An important aspect of increasing energy efficiency is simultaneously increasing energy reliability. This reduces one of the greatest risks to modern U.S. commerce: power interruptions.

Power outages are a mere nuisance to many people, but can be devastating for businesses of all types and sizes. It's another example of how our methods of energy creation, delivery and consumption have not kept up with efficiency advances elsewhere in the economy. Business leaders consider loss of power to be a major risk to sales and profitability. They spend millions of dollars annually trying to avoid interruptions and ensure against them, and for good reason. According to researchers (Ernest Orlando Lawrence Berkeley National Lab, September, 2004), the annual cost of power interruptions could be as high as $135 billion.[6]

Businesses in retail e-commerce rely exclusively on electronic signals to make and fulfill sales. Without power, they have no way of doing business and would immediately start losing sales to competitors. Online customers are loyal to reliability, not nationality.

In modern goods-producing industries, information powers the flow of inventory. It's common for a series of electronic signals passed from company to company to company to be the impetus for all of a supply chain's activity — from the ordering of raw materials to payment for finished goods. If those signals can't circulate for lack of power, activity stops, orders go unfilled and sales grind to a halt. Bills go unpaid.

Likewise, online retail sales continue to grow and reached $51.4 billion in the final quarter of 2011, a 5.8 percent increase over the 2010 final quarter.[7] Businesses in retail e-commerce rely exclusively on electronic signals to make and fulfill sales. Without power, they have no way of doing business and would immediately start losing sales to competitors. Online customers are loyal to reliability, not nationality.

Yet, the infrastructure system that delivers energy to these businesses and their customers is faltering. The national energy network is too complex and expensive to realistically consider a wholesale upgrade. It involves multiple owners, hundreds of regulatory agencies and other public entities, and thousands of financial investors. It is also very capital intensive, so assets must be used over long periods of time to recover their upfront costs.

Discussions about how to make the U.S. energy supply more valuable, then, must include finding ways to make the existing system more reliable and efficient. This provides benefits to all stakeholders. Some technologies that are doing this are at work behind-the-scenes, while others empower energy consumers to control their own consumption. Here are some examples:

HVDC: Electricity-delivery processes that use existing technology and reduce the amount of electricity lost in transmission.

High-voltage direct current (HVDC) transmission is an increasingly attractive option because less electricity is lost in its transmission than with transmission of conventional Alternating Current (AC). In addition, HVDC requires fewer transmission lines, meaning that less land needs to be cleared. Because special equipment is needed to convert electricity from AC to Direct Current (DC), HVDC is cheaper only over long distances. But, with demand for long-distance transmission growing as use of renewable energy sources expands,[8] HVDC is an attractive efficiency multiplier.

Another advantage of HVDC is that it can be used to more efficiently connect different AC networks. HVDC allows electricity flow to be controlled rapidly and accurately in terms of both the power level and the direction. It can compensate for fluctuations in the power flow, making HVDC the ideal technology for linking wind farms, for example, where uneven production could otherwise disrupt the reliability of the overall network.

Substation communications: More effective and less vulnerable to outages.
Benefits of continued investment in substation technology include the ability to transmit and distribute large amounts of electricity to increasingly crowded cities, using as little space as possible.

Improvement in communication technology is an example. ABB has played a leading role in the development and implementation of IEC 61850, the first global standard for the control and protection of substation equipment that enables real-time, open communication between substation devices — regardless of the manufacturer. The new standard has significantly enhanced substation performance and enables just a few fiber optic cables to replace thousands of interconnecting copper wires.

Volt/VAr: Enabling utilities to increase grid capacity and efficiency.
Through technology that enables them to more efficiently balance loads, utilities can make their existing grid infrastructure work more productively. Through coordinated and integrated Volt/VAr control, utilities can make near real-time adjustments of power settings, increase distribution capacity and reduce capital expenses, have greater insight into the health of their equipment, reduce loss of energy during distribution, and increase reliability through better systemic load flow management.

Customer-incented load reduction and grid optimization techniques are among the most promising initiatives to reduce demand.

Combined Heat and Power (CHP): On-site production provides sustainable model.
Combined heat and power (CHP) is an integrated set of technologies for the simultaneous, on-site production of electricity and heat. CHP is energy efficient, making use of heat produced during power generation and avoiding generation and transmission losses. CHP solutions provide efficient, reliable, and more affordable power for businesses and institutions. CHP is now installed at more than 3,500 commercial, industrial and institutional facilities across the nation.

CHP systems today represent almost 9 percent of the nation's total electricity capacity. A recent study by Oak Ridge National Laboratory[9] has found that significant benefits would accrue by raising the CHP share to 20 percent.

Demand Response: Managing peak load makes current assets more efficient.
Managing peak load is one of the most critical drivers in the utility industry, even though the slow economy has resulted in flatter load growth. With rising fuel and construction costs, as well as the long lead time required to plan for and build generation resources, many utilities are concentrating on using a smarter grid to help delay or even eliminate constructing new plants. In fact, the majority of smart grid projects coming online are focused on reducing peak load and using a variety of technologies — including distributed renewables and energy storage.

In addition, customer-incented load reduction and grid optimization techniques are among the most promising initiatives to reduce demand. As smart metering and building technologies proliferate, demand-response (DR) programs are growing in number and sophistication. Some utilities have implemented advanced distribution management systems (DMS) to optimize the network for voltage and VArs using a technique called distribution system DR (DSDR) to reduce peak demand.

These two approaches try to address the peak load problem by starting from different points. DR works from the demand side, while DSDR seeks to make the supply side more efficient. Each method can be effective at limiting peak load.[10]

Industrial sector: Lower energy costs, more R&D and more jobs

Regular plant energy audits are most effective when they are part of a strategic corporate energy management program.

The U.S. industrial sector uses more energy than any another other sector in the United States to produce goods and ship them to market. Energy-efficiency improvements within the industrial sector have the potential to return huge economic rewards to the country at large, not only because of the immediate cost savings but because those savings would likely be invested directly in research and job creation.

"Manufacturers perform 50 percent of the research and development in the United States and are the leaders in developing and deploying innovative solutions across the manufacturing economy. No segment of American society has as much to gain from efficiency and waste reduction measures as the manufacturing sector and the consumers they serve... It is widely acknowledged that process and building system energy efficiency and conservation offers immediate and cost-effective opportunities to cut these costs."[11]

Whereas the energy-delivery network addressed in the prior section is made complex by its multiple ownership, manufacturers generally control their own facilities and therefore can relatively easily improve energy efficiency by making investments that begin returning savings immediately.

An invaluable first step in industrial energy efficiency is conducting a plant/building energy audit, which can compare energy performance with "best practices" and reveal opportunities for savings.[12] The audits can be self-assessments or conducted by an outside party. According to the U.S. government's EnergyStar program energy audits help managers to:

– Identify actions for improving energy performance;
– Prioritize projects; and,
– Track progress.

"Regular plant energy audits are most effective when they are part of a strategic corporate energy management program. Corporate energy programs are ideal for replicating the savings opportunities identified through plant energy audits at other facilities. Through the corporate energy network, information can be shared, and savings multiplied."[13]

Often, manufacturers can achieve efficiency by adding energy-saving equipment and solutions such as variable-speed drives and motor-control systems. Adoption of industry-accepted best practices also helps to capture tangible energy efficiency benefits and often with minimal capital expenditure.

Variable-speed drives: Untapped opportunity to improve the efficiency of existing motors in a variety of industries.

A variable-speed drive regulates the speed and rotational force — or torque output — of an electric motor. There are millions of motors in use in industry and offices around the world. They operate sewage and irrigation pumps, milking machines and ski lifts, paper machines and power-plant fans, sawmill conveyors and hospital ventilation systems. We estimate that ABB drives in operation worldwide save about 115 million megawatt hours of electricity every year, the equivalent of 14 nuclear reactors. In terms of CO^2 emissions avoided, the amount is greater than that produced each year by the entire country of Finland.

Motor-control systems: Reducing energy consumption while maintaining flexible capacity.

The vast majority of the world's industrial motors are oversized and inefficient because companies commonly buy more powerful motors than are actually needed to protect themselves from power spikes and uncontrolled overload.

An intelligent, or software-based, motor-control system allows businesses to manage the status, condition and energy consumption of all the motors in a plant. This enables the installation of smaller, correctly specified motors that consume far less energy and reduce greenhouse gas emissions. Replacing an oversized, 37-kilowatt motor with a 30-kilowatt motor would save a typical medium-sized site with 200 motors about 180,000 kilowatt hours a year, and avoid the generation of 90 metric tons of CO^2 emissions.

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Commercial building upgrades: Savings through automation

Commercial and residential buildings account for about 38 percent of global end-user energy demand, mainly for heating, cooling and powering electric appliances. These systems also are among the top three contributors to CO^2 emissions in the United States and increasingly are subject to state, local and federal mandates to improve energy efficiency.

Indeed, some groups are calling for the federal government to require all commercial buildings to post energy-efficiency disclosure labels, similar to home appliances. These advocates[14] say such a policy could:

- Create more than 23,000 net new jobs by 2015 and more than 59,000 jobs by 2020, resulting from increased demand for energy efficiency services and technologies, and from the reinvestment of energy cost savings by consumers and businesses into the economy.
- Reduce energy costs for building owners, consumers and businesses by approximately $3.8 billion through 2015 and more than $18 billion through 2020.
- Generate more than $7.8 billion in private investment in energy efficiency measures through 2020, yielding $3 to $4 in energy cost savings for every dollar invested.
- Reduce annual energy consumption in the U.S. building sector by approximately 0.2 quadrillion BTUs by 2020, equal to taking more than 3 million cars off the road each year.

Additionally, there is evidence that having a strong energy-management practice increases business value in the real estate marketplace.

“The value of strong energy management as a proxy for overall organizational management is increasingly recognized by financial analysts. Recent studies by Innovest Strategic Value Advisors found that leaders in energy management achieved superior stock and financial performance over laggards in energy management.”[15]

Conclusion: Keep talking, but start doing

We believe that there is no singular solution for achieving global competitiveness through energy efficiency; and that while moderating consumer consumption and entirely new energy models are part of the equation, so is immediate investment in existing infrastructure with widely available technology. Such investment holds the promise of results and can be most easily implemented as the responsibility falls largely on the private sector.

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