



# Intelligent Efficiency:

Innovations Reshaping the Energy Efficiency Market

a special report by:

  
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**“We can’t realize a clean energy economy without an aggressive focus on energy efficiency. Businesses understand that and policymakers are starting to embrace that need. As a result, the market is spawning a range of exciting new technologies and business models to make our economy more efficient.”**

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## ABOUT GREENTECH MEDIA’S EFFICIENCY COVERAGE

Greentech Media has leveraged its world-leading research and award winning journalism team to become the leading voice in the renewable energy market for information in emerging technologies. This year, GTM is expanding that authority into the energy efficiency industry. Stephen Lacey, previously of Climate Progress and Renewable Energy World, has joined our editorial staff as a Senior Editor covering energy efficiency. The coverage on our website will help those along the value chain of the energy efficiency market understand the trends and make decisions. Make sure to follow our coverage at: [www.greentechmedia.com/channel/efficiency](http://www.greentechmedia.com/channel/efficiency) or subscribe to our RSS feed:

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## CHAPTER 1

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# How energy efficiency is evolving into “intelligent efficiency”

The last two major economic revolutions were caused by the convergence of two factors: communications and energy.

In the 1800s, the convergence of printing technology and steam power created the first form of mass communications - bringing with it sweeping changes in literacy and education. In the 1900s, the convergence of radio and television with electricity and the oil-powered combustion engine created the modern consumer-based society we know today.

We are now on the verge of a third revolution, argues economist Jeremy Rifkin. This one will be abetted by the convergence of the internet and distributed energy, creating new ways to do business, communicate, and build wealth. Rifkin calls this a “new economic paradigm for the 21st century.”

This new paradigm is already reshaping the way we think about energy efficiency.

All around us, embedded in every commercial building, manufacturing facility and corporate campus, is a vast, untapped energy resource: efficiency. In the past, that resource was hidden, ignored or misunderstood by the companies sitting on the potential, and recognized only by a small group of energy professionals.

But with dramatic advances in web-based monitoring, real-time data analytics and utilities using peak pricing, that hidden resource is now becoming something tangible - an asset that companies can measure, manage, procure and sell.

This isn't the stale, conservation-based energy efficiency Americans often think about.

“In the past, energy efficiency was seen as a discrete improvement in devices,” says Skip Laitner, an economist who specializes in energy efficiency. “But information technology is taking it to the next level, where we are thinking dynamically, holistically, and system-wide.”

This emerging approach to energy efficiency is information-driven. It is granular. And it is empowering consumers and businesses to turn energy from a cost into an asset. We call this new paradigm “intelligent efficiency.”

That term, which was originally used by the American Council for an Energy-Efficient Economy in a 2012 report, accurately conveys the information technology shift underway in the efficiency sector.

The IT revolution has already dramatically improved the quality of information that is available about how products are delivered and consumed. Companies can granularly track their shipping fleets as they move across the country; runners can use sensors and web-based programs to monitor every step and heartbeat throughout their training; and online services allow travelers to track the price of airfare in real time.

Remarkably, these web-based information management tools are only now coming to the built environment in a big way. But with integration increasing and new tools evolving, they are starting to change the game for energy efficiency.

Although adoption has been slow compared to other sectors, many of these same technologies and applications are driving informational awareness about energy in the built environment. Cheaper sensors are enabling granular monitoring of every piece of equipment in a facility; web-based monitoring platforms are making energy consumption engaging and actionable; and analytic capabilities are allowing companies to find and predict hidden trends amidst the reams of data in their facilities and in the energy markets.

This intelligence is turning energy efficiency from a static, reactive process into a dynamic, proactive strategy.

We interviewed more than 30 analysts and companies in the building controls, equipment, energy management, software and utility sectors about the state of the efficiency market. Every person we spoke to pointed to this emerging intelligence as one of the most important drivers of energy efficiency.

“We are hitting an inflection point,” says Greg Turner, vice president of global offerings at Honeywell Building Solutions. “The interchange of information is creating a new paradigm for the energy efficiency market.”

Based on our conversations with a wide range of energy efficiency professionals, we have identified the five key ways intelligent efficiency is shaping the market in the commercial and industrial (C&I) sector:

- The decreased cost of real-time monitoring and verification is improving project performance, helping build trust among customers and creating new opportunities for projects;
- Virtual energy assessments are bringing more building data to the market, leveraging new lead opportunities for energy service professionals;
- Web-based energy monitoring tools are linking the energy efficiency and energy management markets, making efficiency a far more dynamic offering;
- Big data analytics are creating new ways to find trends amidst the “noise” of information, allowing companies to be predictive and proactive in efficiency;
- Open access to information is strengthening the relationship between utilities and their customers, helping improve choices about efficiency and setting the foundation for the smart grid.

Figure 1-1: How Intelligent Efficiency Creates Value for Customers



Source: GTM Research

At its core, energy efficiency is still about the nuts and bolts of changing equipment and improving the physical components of a facility. Information is not a panacea and is not a substitute for the physical integration of new systems. But it is becoming the glue binding the holistic, system-wide approach that is starting to define the intelligent efficiency business.

“It is rapidly becoming much cheaper to measure efficiency and analyze that data alongside lots of other information so companies can actually take action,” says Robert Hutchinson, managing director of the Rocky Mountain Institute. “These information technologies are transforming the efficiency business. They are incredibly powerful.”

Driven by the convergence of instantaneous communication and distributed energy resources, the world is entering a new phase of economic growth. The evolution of intelligent efficiency parallels that larger shift that is now underway. In this report, we detail crucial pieces of that shift.

## CHAPTER 2

## How intelligent efficiency is opening new pathways for projects

The pool of energy efficiency resources in the built environment is vast. Together, buildings and industry account for more than 70 percent of America's energy consumption each year. This represents an enormous opportunity for businesses looking to tap into energy efficiency reserves. However, most facilities are not yet sophisticated enough to reap the full potential of the efficiency resource.

A number of organizations have modeled potential energy efficiency gains using existing equipment and communications technologies.

In its well-known 2009 report *Unlocking Energy Efficiency in the U.S. Economy*, McKinsey showed that \$520 billion in economy-wide investments could feasibly save 23 percent of projected energy demand by 2020 - saving \$1.2 trillion in the process. The industrial sector represented 40 percent of that potential and the commercial sector represented 25 percent.

In a 2012 analysis, Deutsche Bank Climate Advisors found that the U.S. building sector could leverage \$279 billion in efficiency investments, offering \$1 trillion in savings over the next decade.

The Rocky Mountain Institute went even further in its 2011 *Reinventing Fire* plan. RMI's strategy outlined how dramatic efficiency gains in transportation, commercial buildings and industry could help grow the economy 158 percent by 2050 with the addition of no new fossil fuels or nuclear energy. The plan would theoretically save \$5 trillion in energy costs while achieving average internal rates of return of 33 percent in buildings and 21 percent in industry through new investments in efficiency, demand response and on-site energy generation.

The list of reports from credible organizations on the potential for energy efficiency is long. But the limiting factors facing the market are nearly as substantial as the resource itself.

Johnson Controls, one of the leading companies in the building controls and energy optimization space, releases a yearly survey of the global building efficiency market. Every year, the market barriers remain the same. They include:

- Lack of awareness of opportunities for energy savings.
- Lack of technical expertise to design and complete projects.
- Lack of certainty that promised savings will be achieved.
- Inability of projects to meet the organization's financial payback criteria.
- Lack of available capital for investment in projects.

These problems are all exacerbated by the old efficiency paradigm defined by information scarcity.

"The most amazing part of our business is that the vast majority of companies we work with in the C&I space don't even know how much they spend on energy," says Gregg Dixon, senior vice president of marketing and sales at EnerNOC, a leading demand response and energy services company. "That gives you a sense of how far we have to go to make better energy management decisions."

This basic lack of awareness about energy use within many organizations feeds into every barrier identified above. Without accurate information, it's difficult to understand the initial opportunity, even tougher to design a project, and nearly impossible to verify whether you're actually saving energy. Those uncertainties make it hard for companies to justify spending money on efficiency upgrades. They also make projects less attractive for investors.

These barriers also stem from the natural tension in how facilities are run. Choices about energy-efficiency projects are often made by many players in a company or institution, with each of those players taking a different approach.

The facilities manager who cares solely about reliability and keeping occupants comfortable may be resistant to new, relatively unknown technologies. The chief financial officer primarily concerned about managing her company's quarterly finances may be nervous about the upfront cost of upgrades. And the sustainability officer focused on environmental performance may propose ambitious solutions that are outside the comfort zone of both the CFO and the facilities manager. These contradictory positions within a company can add up to uncertainty, delays or poor decision-making.

"The biggest constraint is the way companies operate," says Stefan Heck, a sustainability and resource productivity expert at McKinsey & Company. "But the awareness has been building, particularly as companies use information technology to get a handle on their performance."

Figure 2-1: Intelligent Efficiency Can Help Address Market Barriers

MARKET BARRIER	INFORMATION-RELATED CAUSE
Lack of awareness about energy savings	Poor information about company energy expenditures; poor information on portfolio-wide performance
Lack of technical capability	Poor communication between facilities managers, operators, and company executives; lack of information about offerings in the market
Lack of certainty about savings	Poor modeling techniques; poor communication between service professionals and customers
Poor project performance	Lack of equipment connectivity; poor data analysis; incomplete monitoring and verification
Lack of capital for projects	Poor information about the market; lack of data on project performance

Source: GTM Research

Sometimes all it takes is a little information awareness to get companies thinking seriously about energy efficiency. Consider the experience of EnerNOC. A decade ago, EnerNOC started out in the traditional demand response market helping C&I customers reduce demand at peak times. As its data analytics capabilities grew with better hardware and improved cloud-based software, the company branched out into energy procurement and energy efficiency services. With more than 13,500 sites worth \$1.7 billion in energy expenditures in its project portfolio, EnerNOC now simply sees itself as an energy management company.

"The types of data we're collecting are becoming broader and deeper. So we are simply in the business of automating and collecting real-time energy data to make better energy decisions that result in financial benefit. That is what we do," says EnerNOC's Gregg Dixon.

The company engages both the operation and finance sides of the client firm when selling its services. It's particularly important to talk to the operations side in the industrial sector where energy bills are often handled by the personnel managing plants. In the commercial and institutional space, decisions around energy costs are often pushed from facilities managers up to the chief financial officer. Bringing both parties to the table is extremely important, says Dixon. But the finance side is often where decisions are made.

However, there is usually a severe lack of attention to detail when it comes to energy use, even among financial experts. Sweeping the dust off utility bills and tracking basic data is the first order of business. To start, EnerNOC will look at billing information, set some basic targets, and then begin implementing and tracking basic operational changes.

"Once customers begin to track energy, they want to do more. And the way they do more is to get more sophisticated," says Dixon. "They very often ask, 'What's next?'"

The next level of value is created through tracking commodity usage data at a more granular level. That includes reading meters and control equipment in five-minute increments. EnerNOC then starts normalizing that usage data and comparing it to other facilities. That usually encourages a customer to start thinking about efficiency in a portfolio-wide context.

The final level of granularity enables companies to track specific pieces of equipment – chillers, boilers and pumps, for example – and normalize performance against external factors to understand anomalies. All the data is analyzed in order to predict and respond to changes in the energy market, occupancy, or weather.

When companies are exposed to all of this data, their choices often go beyond simple efficiency retrofits. With the opportunity to sell demand reductions into the capacity markets, the regional energy markets, or the regulation markets, energy efficiency becomes a real resource with a tangible market value.

"You can get really crazy with this stuff. You start at a very basic level by analyzing bills and then you get really sophisticated in order to bring in incredibly deep savings," says Dixon. "The higher-quality data available helps drive decision-making."

All of the energy efficiency companies we spoke with said the same thing. Once customers get a little bit of information about their energy use, they're often hungry for more. The ability to track that information on a very granular level, normalize the data, and compare it to other facilities in a portfolio plays a strong role in breaking down the barriers to projects.

"Ultimately, it comes down to optimizing on tangible information or data so there is clarity around what measurements need to be made and to attach a value to those measurements," says Rich Kroes, director of product strategy at Oracle's applications division. "That's what will drive projects and demonstrate success."

Information is not the end-all solution to breaking down the barriers to energy efficiency. But it is a major catalyst for project development, which helps make companies more comfortable and engaged in the process.

CHAPTER 3

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## From audits to installations, how companies are using intelligence to evaluate opportunity

We all know the stereotype of a facilities manager: he's the guy working from a desk in the windowless basement somewhere, periodically walking through a building with a clipboard to manually check if equipment is functioning properly. He lacks information beyond what he can see with his Excel spreadsheets; he is reactive to problems; and he is resistant to any change that he perceives will compromise comfort or reliability in the facility.

Like any stereotype, this is a gross overgeneralization. In fact, facilities managers and others in charge of building operations have had access to reams of data for decades. In the 1980s, direct digital controls enabled buildings and factories to operate under a central, programmable system. In the 1990s, personal computing opened up new opportunities to transmit and monitor information about the performance of a facility. They just haven't had the most sophisticated tools with which to act on all the data that is being generated.

"We've always had a lot of data. The most exciting thing from my perspective is that we can now identify about 100 things instantaneously in that data for our customers and make recommendations," says Greg Turner of Honeywell. "We haven't even scratched the surface in terms of data mining."

Figure 3-1: EnerNOC's Operations Center Monitors Thousands of Buildings in Real Time



Source: EnerNOC

Utilities have also generated vast amounts of information through meter readings, often without having the capability to analyze it. The deployment of advanced metering infrastructure is only increasing the rate and volume of data generation. According to GTM Research's report *The Soft Grid 2013-2020: Big Data & Utility Analytics for Smart Grid*, advanced meters create 2,880 times the amount of data at 15-minute intervals compared to the traditional monthly readings of conventional meters.

Improving analytical capabilities using information from meters, building management systems and individual pieces of equipment are now starting to change the way companies model, sell and develop energy efficiency projects.

"Today, the best energy service companies start with an integrated approach, teaching their engineering teams both building equipment and internet technology," says Jon Guerster, CEO of Groom Energy. "Some of us have realized early that adding internet-based intelligence to more efficient equipment is a powerful combination."

Here are three compelling ways that intelligent efficiency is impacting the project development process.

### **3.1 Virtual energy assessments**

Historically, energy efficiency audits have been performed onsite by energy service professionals. But capabilities to perform remote energy efficiency audits of buildings are improving with cheaper online tools and better visual dashboards, shifting some of the initial audit activity to new players.

Companies like FirstFuel, Noesis, Retroficiency, SPARC, and others have developed tools to assess building performance remotely. These companies target different areas of the market, but all of them are looking to do the same thing: speed up the auditing process, cut costs, and increase the volume of business for service professionals.

"The normal approach is to count lights, look at HVAC units and put together PDF reports that take weeks and thousands of dollars to complete," says Bennett Fisher, CEO of Retroficiency. "If you extrapolate that over five million buildings and 80 billion square feet, it's going to take every auditor around the clock just to find the right buildings. We want to rapidly identify those buildings."

By tracking daily, hourly, and 15-minute consumption data, Retroficiency can create an initial audit of a building's performance in minutes. So far, the company has performed virtual audits on 300 million square feet of buildings. Retroficiency then sells that data back to utilities or service professionals, who use it to perform more detailed assessments on site. Fisher says the online software can cut audit costs by 50 percent to 80 percent.

FirstFuel is another up-and-coming company that sees remote monitoring as a way to dramatically scale the energy efficiency market. Similar to Retroficiency, FirstFuel remotely analyzes energy consumption data and creates a "CAT scan" of a building. It then provides that information to utilities or federal agencies for further action.

Figure 3-2: FirstFuel's Remote Building Analysis Portal



Source: FirstFuel

Based upon analysis of its database of buildings, FirstFuel says that more than half of identified efficiency savings are operational – meaning they only take minor adjustments to equipment or behavior to fix. This trend is of deep interest to FirstFuel’s utility and government customers, which haven’t had access to that kind of information through traditional auditing.

“Not only are the fixes for operational issues very cost-effective and low-touch to implement, but they have been largely ignored or under-invested in by efficiency programs, primarily because they couldn’t be easily found and most people didn’t know how big they could be,” says Indran Ratnathicam, director of marketing at FirstFuel.

SPARC takes a slightly different approach. The company works directly with building owners to provide virtual assessments of entire portfolios in the private and public sector. Rather than pass the information on to another auditor, SPARC will perform an on-site assessment and then install energy monitoring equipment in the building itself. Last summer, the company signed a contract with the U.S. Department of Veterans Affairs, where it identified \$3.5 million in energy savings potential using its analytics platform. SPARC is currently collecting 2 billion data points per year at the facility.

Noesis Energy addresses the market from another angle, working to create an open market for virtual energy assessments. The company has created a free online service where building owners can plug in consumption data, measure a baseline, and visualize how buildings are performing. Energy service professionals can use the site to model projects and pitch their services to those building owners. Noesis currently has 7,600 registered users and is tracking 1.2 billion square feet of buildings in all 50 states.

“The site allows anyone to put a project in and specify the savings and cost in an open way,” says Noesis CEO Scott Harmon. “It allows end-users to make an apples-to-apples comparison between multiple projects. If you click on different projects, the savings are shown in a clear and open way.”

Honest Buildings, an online platform that connects professionals in the real estate market, is jumping into energy efficiency and building a product similar to Noesis. By working with the dashboard company Lucid Design Group to model and disclose building energy performance, Honest Buildings wants to bring more transparency about efficiency to real estate transactions.

All of these companies concede that virtual energy assessments are no replacement for a physical audit. But having a low-cost way to quickly monitor millions of square feet of buildings can cut costs for the energy service companies doing that work. It can also uncover hidden trends as more information is gathered. This is a major improvement from the spreadsheet era of data collection.

### 3.2 Energy dashboards

Cloud-based energy dashboards are flooding the market. No matter where a company is on the value chain – from site assessment to full-service energy procurement – the use of dashboards is ubiquitous. The reason for this is very simple: visual representation of energy use is an effective way to change consumption patterns.

Using dashboards in the C&I sector to track energy use is nothing new. But customization and granularity have improved dramatically, making offerings far more attractive. It's also an extremely low-cost way to get into the market. This has brought more entrepreneurs from the tech world into the energy efficiency business. However, because there are so many companies offering these tools, the need to branch out beyond simply having a dashboard for its own sake is crucial.

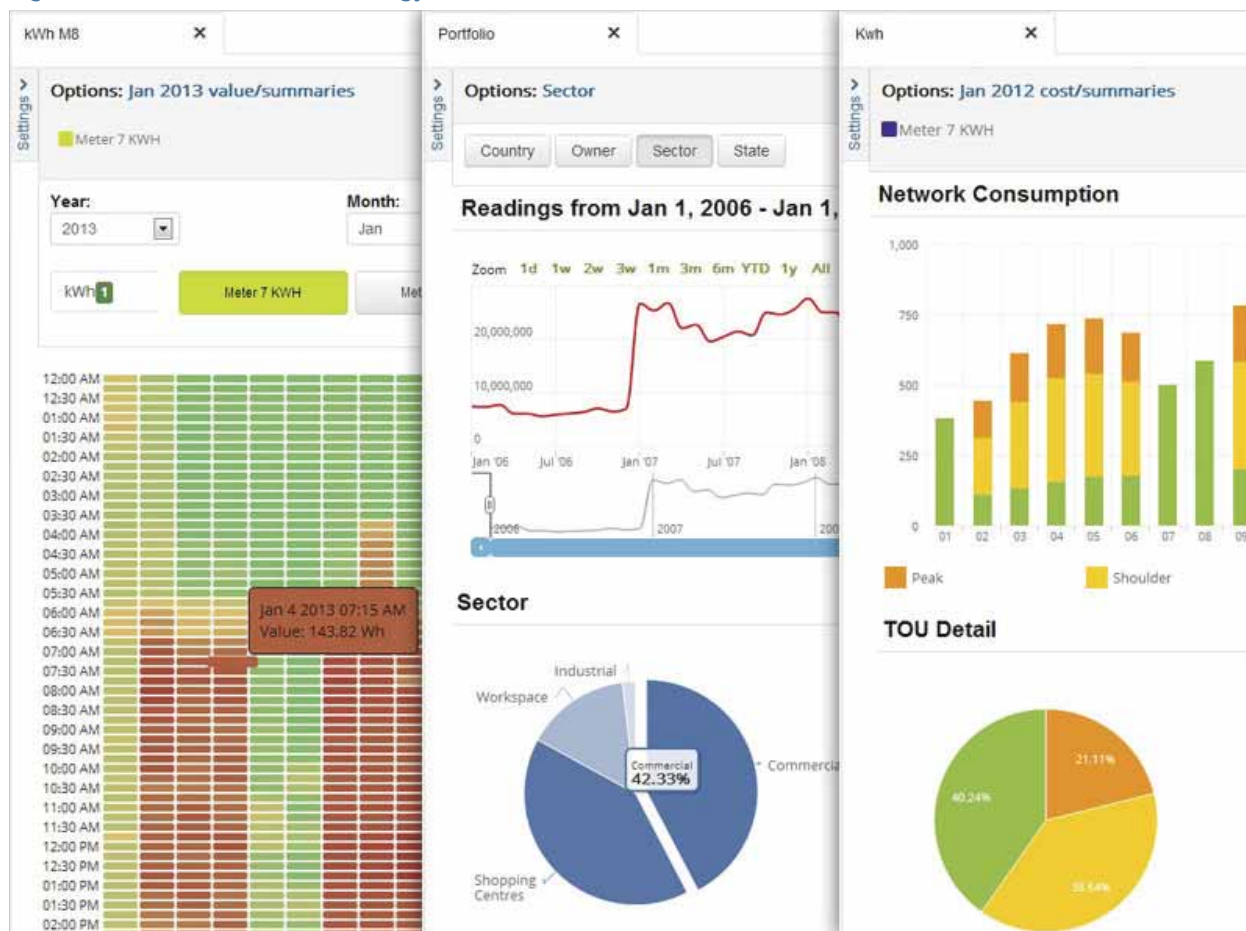
“The coolest dashboard in the world won't save one BTU of energy if somebody doesn't grab a wrench and fix the equipment, adjust an operating schedule or take action to improve the infrastructure,” says Clay Nesler, vice president of global energy and sustainability at Johnson Controls.

While very bullish on information tools like dashboards, many of the big companies with deep technical expertise in the C&I sector are skeptical of some of the companies offering these products. Many of them are tech startups with no background in building management or energy. Without an effective technology or service offering that spurs action, more information won't do any good – no matter how engaging the platform.

“There are few barriers to entry in the software area. It's not that difficult to create these software programs quickly. What's difficult is finding a channel to the market and helping companies actually take action,” says Nesler. “A better interface doesn't necessarily save energy.”

Nearly every major building controls vendor has a cloud-based energy-monitoring platform; Honeywell, Johnson Controls, Schneider Electric and Siemens are the main players with offerings. These companies have deep business channels and can offer the software as part of a full-service building management solution. But are they as good at software as the tech startups now beginning to flood the market?

Figure 3-3: Switch Automation's Energy Dashboard



Source: Switch Automation

“Most of the large companies have very vibrant R&D labs, understand the value chain, understand how buildings work, and have integrated that into their software. Innovation is happening across the spectrum. It’s not just with the small guys,” says Nesler. (Interestingly, Johnson Controls has opened its platform up to outside developers creating new apps, some of them startups.)

With anyone able to get into the space at low cost, there’s a lot of innovation happening in dashboards. But even the software startups don’t think energy management dashboards are the end-all solution.

“Dashboards are not a big market. It’s like fighting over a banana peel in the backyard. The goal is to create markets and unlock this enormous revenue opportunity. It’s a means to an end,” says Scott Harmon of Noesis Energy.

The target audience for dashboards is also changing. Initially, these tools were used for marketing basic energy information to customers in a retail store or students in a school hallway. Now they’ve moved up to facilities managers, who use them for operational purposes. Dashboards are also increasingly being implemented at the executive level in order to illustrate energy use and spur action on a broader company level. In response to the shifting needs in the market, most companies developing dashboards are building different widgets and interfaces that focus on different types of decision-makers.

While the market for dashboards may be getting saturated, it doesn't make web-based energy visualization tools any less important. The need to display information in a clear, engaging format is pressing. The big unknown is how many of the startups can find a market channel, prove they can add value and compete with well-established companies.

### 3.3 Data analytics

On the other end of the project development spectrum, data analytics are playing a big role in monitoring and verifying performance. The deep analysis of information is also unlocking previously unseen opportunities in efficiency across entire building portfolios. This is where intelligent efficiency becomes truly intelligent.

The global management consulting firm Accenture estimates that smart buildings could save businesses \$25 billion a year in energy costs. But all the intelligent equipment in the world won't make a building any smarter without solid data analytics capabilities.

Having more data isn't always a good thing. There are now endless streams of information coming in and out of facilities through advanced meters, sensors, actuators, controllers, and building management systems.

"We see lots of example where people already overloaded with data," says Groom Energy's Jon Guerster. "All analytics need business requirements to drive them, and companies need to define whether it matters."

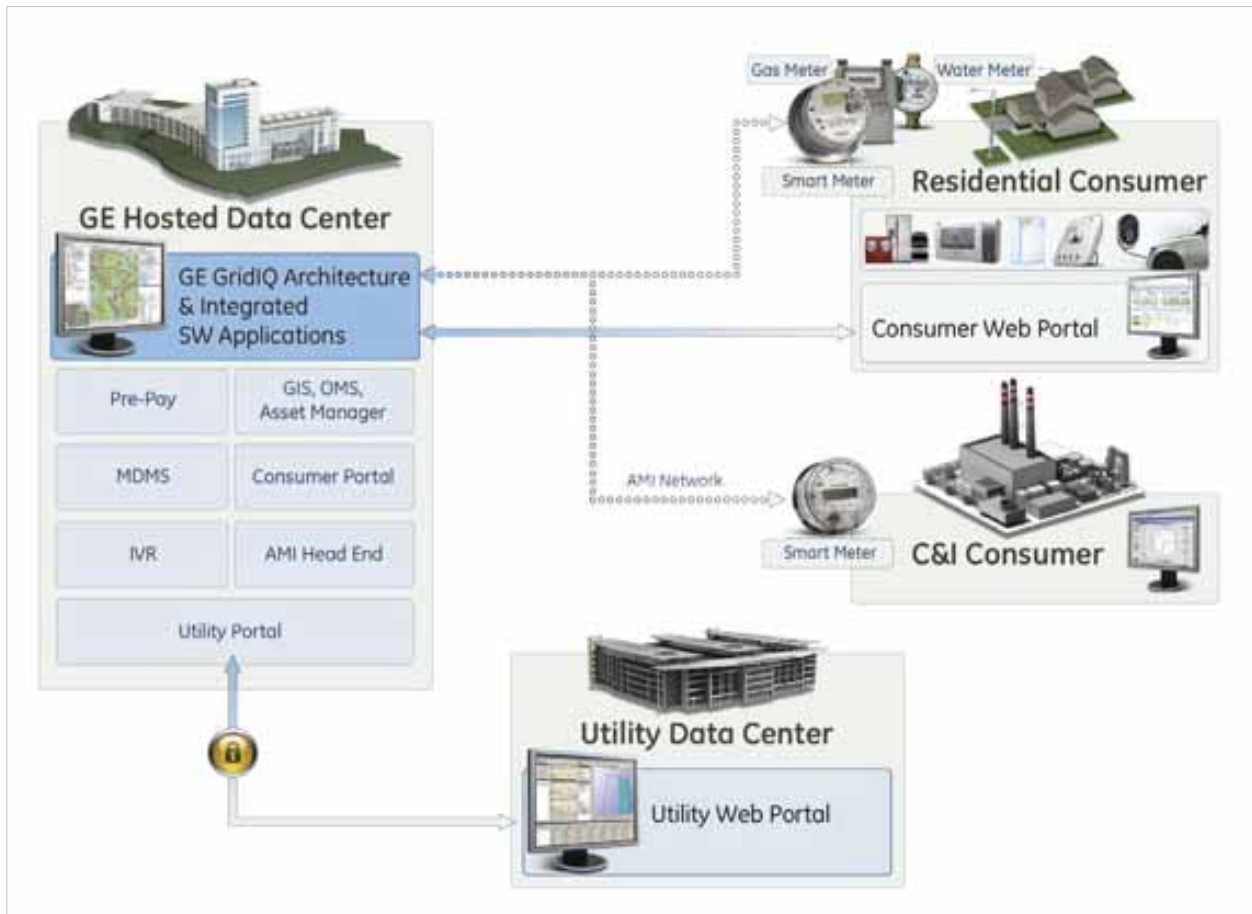
New interoperable, integrated control systems can take those discrete elements and allow them to communicate with one another. Being able to crunch data coming out of the control system and make accurate predictions is what separates a mediocre dashboard from the big players in information management.

"The graphical piece of dashboarding is easy. The real challenge is in slicing and dicing the data," says Rich Kroes, director of product strategy at Oracle's applications division. "We want to mold that information, normalize it and provide meaningful insight into the impacts on the business."

The data analytics space is where the most sophisticated companies are getting a leg up. Accenture, EMC Corporation, EnerNOC, General Electric, IBM, Oracle and Honeywell are just a handful of the large players with dedicated energy data analytics services in-house. Other up-and-coming data analytics companies such as AutoGrid, C3 Energy, Opower and SkyFoundry are also creating new tools for understanding trends in data.

As companies develop better predictive algorithms based upon an increasing number of inputs, software solutions are becoming the "check engine" light for a building, while also playing the role of mechanic who can offer advice on how to fix the problem.

Figure 3-4: General Electric's Grid IQ Data Analytics Platform



Source: General Electric

“That’s the paradigm our building owners are looking at,” says Greg Turner of Honeywell. “They don’t want to constantly look at the system for the problem, they want the system to find and look at the problem. New software is what’s making that possible.”

New software programs can get very granular by finding equipment failures through temperature sensors or learning the performance of mechanical systems to change the sequencing of chillers and variable speed drives. The continuous monitoring, tweaking and verifying helps customers more easily measure the performance of energy-efficiency projects. Under the old energy efficiency paradigm, the strategy was “set it and forget it.” But data analytics make intelligent efficiency a continuous process that more closely resembles energy management.

“I think data is a key driver,” says Clay Nesler of Johnson Controls. “As buildings become more complex, the goal is to let the software and analytics identify the problems, making them much easier to operate.”

Most importantly, building energy management systems often do not need to be replaced in order to harvest this data. Many of the analytic platforms being developed layer on top of existing controls and management systems.

As companies grow increasingly sophisticated in their approaches to managing information across large portfolios of buildings, the next step is finding patterns in the massive streams of data being generated. The value of extracting new knowledge in real time about how energy is consumed in the built environment has attracted both large companies and tech entrepreneurs to the efficiency sector. Being able to tap into the data and find answers to previously unknown problems is what big data is all about.

“This is going to have a huge impact. We cannot predict now what information we’re going to find in the noise, but there’s no doubt there’s a lot to be discovered,” says Kathrin Winkler, chief sustainability officer at EMC Corporation.

EMC, an operator of data centers and provider of information technology solutions, created its Greenplum division in order to build its big data analytics capabilities. Winkler says that the company sees energy management and energy efficiency as two of the most promising sectors in the data analytics space.

“We are starting to see the correlation between the inflows, the outflows and then everything happening in a certain context. Weather, sporting events, and conditions in the economy - these all shape the way people behave. This has major implications for understanding the way energy moves,” says Winkler.

That also has major implications for making consumers of energy into proactive participants in the market. By identifying hidden trends in energy consumption at both the local and global level, companies will be more empowered to take action and reduce energy consumption.

## CHAPTER 4

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### How information is accelerating technology adoption and performance

It's easy to get excited about the potential for software and information technology to spur action. At the end of the day, however, energy efficiency is still about deploying physical systems in the built environment. As a result, the market will move at a pace that more closely resembles the traditional energy market rather than the rapid adoption cycles that are common in the information technology sector.

"The capital stock turnover is much lower than, say, mobile phones. It's going to take years for these technologies to fully penetrate," says Stefan Heck with McKinsey. "Naturally, in that cycle, it takes a while for this to reach full volume."

While adoption will not happen quickly, information technology has the potential to accelerate new technology deployment. Seamlessly integrating the IT world and physical devices – a process commonly known as machine-to-machine (M2M) communications – is a major focus for the largest companies working in the energy sector.

According to an analysis from the Carbon War Room, M2M communication technologies have the potential to reduce carbon dioxide emissions in the energy sector and the built environment by nearly 4 gigatons by 2020, an amount that represents roughly 8 percent of global carbon emissions in 2011.

Recognizing this immense environmental and economic value, energy companies are embracing these technologies. By deploying remote sensors on all of its equipment and analyzing granular data, GE has developed a new business strategy around what it calls the "industrial internet." Siemens, another company active in the building efficiency sector, models its business strategy around the well-known "internet of things" concept. And beyond the large industrial players, there is a vibrant ecosystem of technology companies working to connect devices in innovative ways through this framework.

Whatever this new connectivity comes to be called, the outcome is the same: blending real-time communications with physical systems will dramatically enhance the capabilities of that equipment.

Here are three ways that intelligent efficiency is changing the way companies integrate and operate equipment.

#### 4.1 Lighting

Lighting represents one of the easiest efficiency opportunities in the C&I sector. According to the Energy Information Administration (EIA), lighting accounts for 12 percent of the electricity consumed in America. In commercial buildings, lighting makes up 21 percent of electricity use; in the industrial sector, it makes up between 20 percent and 38 percent of consumption depending on the facility. And lighting in manufacturing facilities makes up 2 percent of all U.S. electricity consumption, according to data gathered by the EIA.

The opportunity in this sector is vast, particularly for the solid-state LED technologies that have come down steadily in cost. But lighting retrofits are about more than installing a set of discrete fixtures. Programmable LED technologies with system-wide monitoring capabilities are turning lighting into an incredibly smart component of a facility – sometimes the smartest component.

A number of LED companies are layering software, building controls, and lighting together systems together. Adura Technologies, Bridgelux, Daintree Networks, Enlighted, Digital Lumens and Redwood Systems are some leading companies developing networked solutions that enable granular controllability of lighting.

Digital Lumens, a company that operates in the industrial and manufacturing sectors, is representative of the intelligent shift underway in lighting.

Digital Lumens takes a system-level approach to lighting. Inside each of the company's LED fixtures is a small computing platform with sensors that monitor local conditions like occupancy, temperature, energy consumption and light quality. The fixtures wirelessly feed that information back to a central management platform called LightRules, which matches it against the rest of the system. Each fixture can then make local decisions in real time based on those inputs; the central network records those local actions and learns from them for future optimization.

The company has installed 500 of its large-scale intelligent lighting systems worldwide. Many of those customers have been able to reduce their lighting costs by 90 percent, paying back the investment within two years. But the company sees itself as far more than an installer of lighting fixtures. Its intelligent platform could help Digital Lumens evolve into an energy management player with a much broader reach.

“We’re moving into much more than just lighting,” says Tom Pincince, CEO of Digital Lumens. “Often, we’re the first smart thing in a building, so we’re being begged by our customers to add other things.”

Figure 4-1: Before-and-After Photos of a Digital Lumens Customer Facility



Source: Digital Lumens

Similar to the experiences of other service and technology companies we spoke with, Digital Lumens' customers continually ask for more when they get system-wide visibility on their energy use for the first time. In order to adapt to increasingly complex demands, Digital Lumens is developing new functions that spill over into other markets and applications beyond lighting.

“Our approach is to deliver a complete solution to the customer,” says Pincince. There aren't many companies doing something quite like this. You have lighting companies, you have controls companies and you have energy management platforms. But few are developing a platform like this that is so locally intelligent.”

There are a number of other startups broadening their communications platforms to other building systems. This type of innovation is turning lighting from a discrete unit into an integral component of a building's intelligence. It's also putting pressure on traditional lighting companies, which see the wave of change hitting the market.

New advances in LEDs and lighting controls have “changed everything” for Philips Lighting, the world's leading manufacturer of the technology, says North America CEO Ed Crawford.

“We have to reinvent ourselves,” says Crawford. “If we didn't change, we'd really run the risk of being left in the dust. The business as we've known it over the last 100 years won't be the same in five years.”

That change embraced by Philips and others is not just in the technology itself, but in how the technology is applied. As solid-state LEDs offer increasingly sophisticated controllability, companies are thinking about lighting in entirely new ways. This is reshaping traditional players in the lighting market, potentially allowing them to move into new areas of data collection and energy management.

#### **4.2 Heating, ventilation and air conditioning**

After lighting, heating and cooling systems are often the next biggest items to tackle in the built environment. Air conditioners, boilers, chillers, furnaces, heat pumps, and packaged air handlers represent nearly half of all energy consumed in U.S. buildings, according to the Department of Energy. In data centers, cooling alone represents 45 percent of energy end-use.

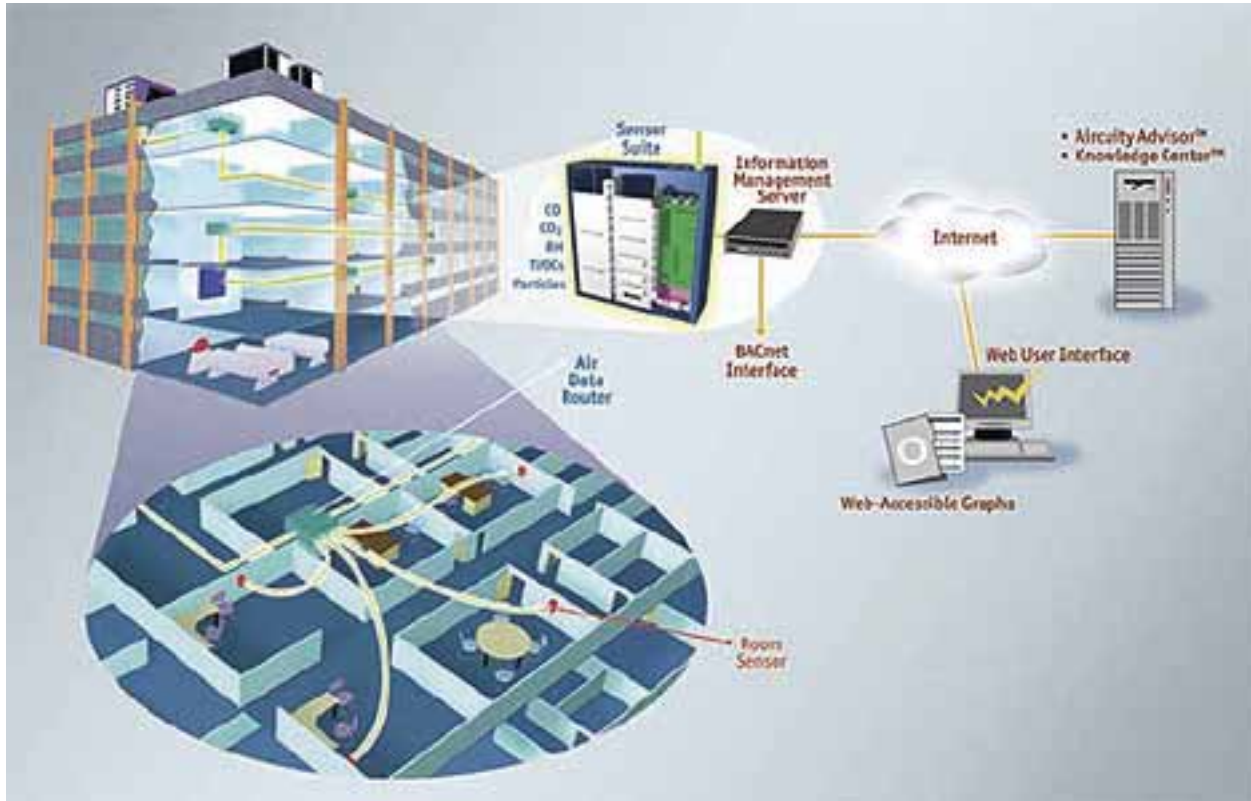
HVAC units offer massive potential for reducing or shifting load in facilities. According to the Consortium of Energy Efficiency, one quarter of all commercial HVAC units are oversized relative to the spaces in which they are used.

There are a number of ways companies are optimizing the performance of these systems: variable-speed motors improve energy consumption based on dynamic usage requirements; smart thermostats can make decisions on their own about how to operate an HVAC system; cloud-based software allows for seamless remote monitoring; and demand-controlled ventilation responds to dynamic occupancy levels and local factors in real time through these monitoring capabilities.

“Buildings are consistently over-ventilated,” says Chuck McKinney, vice president of marketing at Aircuity, a demand-controlled ventilation company. “Optimizing the performance of a ventilation system is a big piece of energy management and efficiency.”

Aircuity operates in variable occupancy buildings like laboratories, hospitals, schools, and commercial offices. Its system, called OptiNet, takes air samples from “critical zones” around a facility and sends them back to a central sensing location. The central architecture allows Aircuity to use fewer high-grade sensors, thus reducing the need for calibration to maintain accuracy. It then uses back-end analytics and a monitoring dashboard to give facilities managers a way to target airflow. This is particularly important in buildings where occupants are moving to different areas throughout the day.

Figure 4-2: Aircuity’s Demand-Controlled Ventilation System



Source: Aircuity

“This is an easy plug-and-play efficiency measure that has massive potential. We can go into any variable air system and add controls overlay,” says McKinney. “We provide the building management system with smarter signals. And in many cases, we’re doing the initial analysis of an environment and making recommendations of what can be done.”

Optimizing HVAC use can offer significant savings. However, it can be a potential headache for facilities managers if sizable swings in temperature occur. It is also a potential nightmare for critical facilities like data centers, which need continuous air conditioning to keep servers at an optimal temperature. But sophisticated controls and web-based monitoring capabilities are creating change in this market, as well.

“Data centers are a tough area, because if you turn off the wrong air conditioner or overheat a router, you can effectively shut down the facility. Bad things happen. People lose their jobs and [companies] lose revenue,” says Mark Housley, CEO of Vigilent.

Data centers are the backbone of the digital revolution making intelligent efficiency possible. However, they still represent a major point of energy demand. According an analysis from Stanford University, data centers account for 2 percent of all of the electricity consumed in the U.S. Although data center energy use in America hasn't ballooned as quickly as projected because of the development of more efficient approaches to server operation, it is still growing. Globally, power consumption for these facilities expanded by 63 percent in 2012.

Vigilent offers intelligent energy management for companies like Verizon and NTT. The company also works in commercial buildings, but it mostly focuses on data centers where the energy opportunity is greatest. Because data centers need so much redundancy to keep equipment running, cooling loads are extremely high – often using far more air conditioning than is actually needed.

Vigilent installs wireless sensors that measure temperature, humidity, pressure and a range of other factors. Once it installs the equipment needed to analyze the facility, Vigilent dynamically adjusts cooling equipment to meet actual needs, thus eliminating superfluous redundancy. It also offers an online energy dashboard for visualizing a facility's energy use. Across its portfolio of 125 facilities, the company has shut down 40 percent of air conditioners and saved 20 percent of total energy consumption. In one facility, it shut down 70 percent of air conditioning.

The drop in cost of sensors and the dramatic improvement in analytics have allowed companies like Vigilent to offer reliable HVAC demand reduction services to some of the most demanding customers in the world.

“Five years ago, you couldn't get the sensors that you use today. It's not like people have been blind to this stuff. But over the last four or five years in the efficiency world, processing power and sensor data really has come a long way,” says Housley.

Building automation companies are combining this improvement in hardware with slick software to create more dynamic ways of monitoring heating, cooling and ventilation. Other up-and-coming players like BuildingIQ, Daintree Networks and Energent are building new levels of HVAC controllability, thus encouraging traditional equipment providers like Johnson Controls and Schneider Electric to innovate in this area. These advancements in equipment and back-end analytics – combined with a flood of smart thermostats on the user side – have the potential to drastically reduce HVAC energy use in the C&I sector.

#### **4.3 Energy storage and on-site generated energy**

Most consumers don't associate storage or on-site renewables with traditional energy efficiency. But the same types of analytics that are turning “dumb” lighting and HVAC equipment into dynamic systems are also driving intelligence in these sectors. This has significant implications for building efficiency projects.

“We see a gold rush going on into green energy,” says Andy Taylor, CEO of Applied Power Technologies, an energy management company focused on reliability. “We determined that a key piece of our business was to help our customers visualize it. This is another area where energy management and efficiency are becoming intertwined.”

The intelligent deployment of electric vehicle fleets, renewable energy systems, combined heat and power, and on-site storage is becoming a key offering of almost every company in the energy management space. Using these elements to dynamically manage load and reduce energy costs is just

as much an energy efficiency play as is installing new lighting or windows, says Allen Friefeld, senior vice president of public policy at Viridity Energy.

“When you actively manage these systems to create a better load factor, it means a more efficient operation for the customer and better efficiency for the grid. So it’s appropriate to think of active load management as a form of energy efficiency,” says Friefeld.

Viridity, a demand-side energy management company, uses its analytical capabilities to control equipment and match consumption to market conditions. Like other demand response companies, it sells energy reductions into the capacity markets, energy markets, or frequency regulation markets. In some cases, Viridity has multiple generation assets such as solar, co-generation and electric vehicles at a single site.

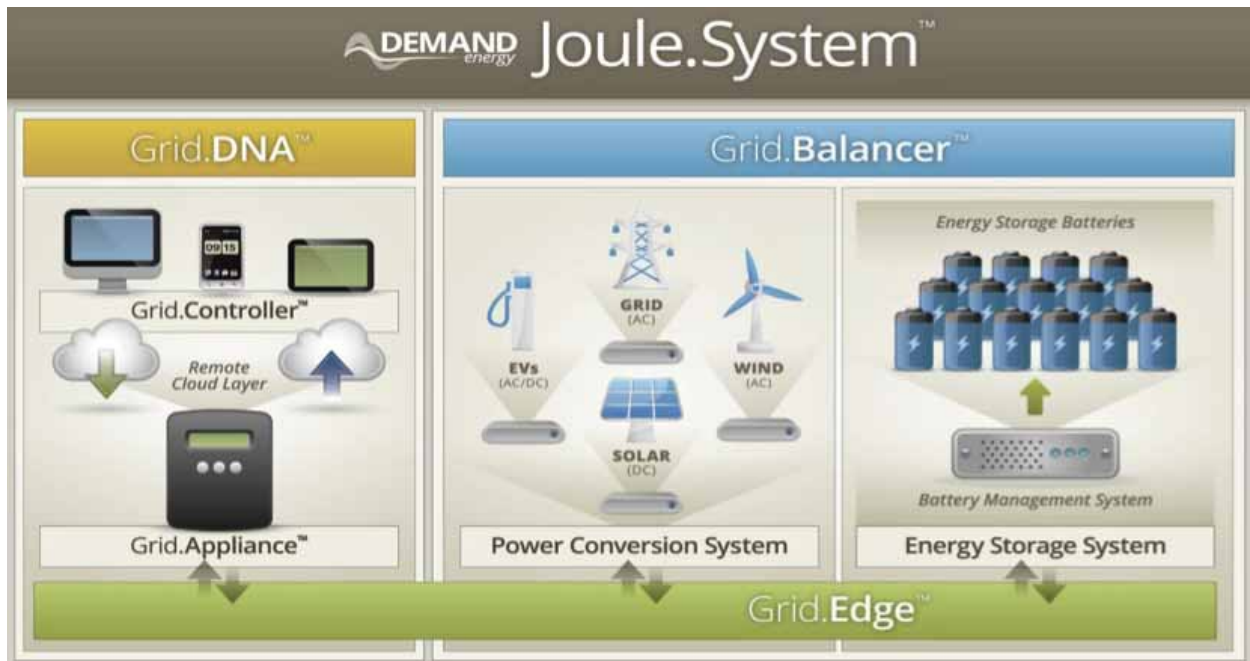
“Each of those assets has different operating characteristics and it’s a very challenging (but profitable) exercise to optimize the use of those assets,” says Friefeld. “Using these assets more wisely is an energy efficiency measure.”

On-site storage also continues to evolve as an interesting energy efficiency play in the built environment. Storage is typically seen as a grid-scale application to accommodate variable generation from renewable power plants; however, it is also commonly used for uninterruptible power supplies in commercial buildings and critical facilities. As thermal storage and chemical battery storage systems improve, these technologies are becoming a more popular component of energy management.

For Demand Energy Networks, a storage integration company that operates on the building level, intelligence is the key to expanding the market. The startup deploys an intelligent energy management platform with an integrated energy storage system to smooth out load on-site. It currently uses lead-acid batteries, although the company is technology-agnostic. The most innovative piece of the system is Demand Energy’s data analytics and software platform, which integrates with building controls and responds to changing conditions in real time.

“When you get intelligence in the building, a lot of people are stunned about how much they can see,” says Shane Johnson, vice president of North American sales at Demand Energy. “Many of our customers don’t even have a building energy management system.”

Figure 4-3: Demand Energy's Intelligent Storage Platform



Source: Demand Energy

The addition of a layer of intelligence is what sets these emerging storage capabilities apart. While a great deal of attention is paid to new battery chemistries, much of the innovation happening in storage is in the system integration. The focus on an intelligent architecture opens up new possibilities for integrating storage as part of demand response or straight energy efficiency projects.

“We have a much broader definition of efficiency related to how you control and operate the systems in a building,” says Johnson. “It’s a combination of all those systems at the edge of the network and [the way they are] coming together.”







Stem is another technology-agnostic storage player looking to deploy projects in buildings through a strong intelligence backbone. Although the company doesn’t see its storage platform as an energy-efficiency solution in the same way Demand Energy does, it is pursuing a similar cloud-based optimization solution that brings additional informational awareness to a building.

From lighting and HVAC equipment to solar and storage, these components are gaining a new level of intelligence that is enabling them to operate within the built environment at an integrated system level. Information awareness and data analytics are a key enabler of this trend in intelligent efficiency.

Figure 4-4: 20 Companies to Watch in Intelligent Efficiency

	<p>This start up wants to compete with established players in big data analytics. AutoGrid revealed a cloud-based energy data platform last year that will analyze reams of unstructured energy data. The company has set a target of delivering demand response services at one-tenth the cost of today's services through better analytics.</p>
	<p>BuildingIQ's smart control platform is bringing new intelligence to building HVAC systems. As it forms partnerships with large companies like Schneider Electric, BuildingIQ is looking to compete with the legacy vendors developing their own HVAC optimization technologies.</p>
	<p>Daintree started off with a wireless intelligent lighting platform. But the company is expanding far beyond that product, using its system to connect HVAC units, smart thermostats and other building controls into an integrated package. The company has opened up its platform to third parties, hoping to spur new innovations in data collection and analysis.</p>
	<p>This start up is blending traditional storage technologies with an intelligent monitoring platform, turning batteries into a more integrated piece of a building management system and blurring the lines between traditional energy efficiency and on-site generation assets.</p>
	<p>With an ever-expanding line of fixtures for C&amp;I customers and an increasingly smart lighting platform, Digital Lumens has become a leader in the intelligent LED sector. As the company grows its customer base, Digital Lumens wants to expand beyond lighting.</p>
	<p>A global provider of IT services and equipment, EMC has embraced energy efficiency as one of its core business strategies. Along with investing heavily in server virtualization and other data center efficiency technologies, EMC is looking to unlock hidden efficiency potential through its big data arm, Greenplum.</p>
	<p>This Canadian company has been operating intelligent facilities management projects in the industrial sector since the early 2000's, when it partnered with General Motors. Since then, it has racked up a list of big customers and continues to push into the U.S. smart buildings market.</p>
	<p>With a granular view of the grid better than what any utility sees, plus a strong focus on Big Data analytics from buildings, EnerNOC is rebranding itself from a traditional demand response company into a leading Intelligent Efficiency player.</p>
	<p>Enmetric is bringing a new level of intelligence to power strips. The company's platform allows corporate clients to monitor building or campus-wide plug loads and set rules for how they respond to certain conditions.</p>
	<p>GE is shifting its business toward the "Industrial Internet," an M2M connectivity strategy that spans various areas of Intelligent Efficiency: powerful sensors, building intelligence, storage, distributed energy and big data analytics.</p>
	<p>From HVAC systems to individual computers, Joulex has developed an intelligent energy management platform for data centers and office buildings. The company has modeled its software around security platforms, which require minimal software installations and can analyze individual data points very quickly.</p>
	<p>This energy dashboard company is focusing on a combination of social networking and building intelligence to help spur behavioral change. Lucid has developed products for Constellation Energy, Honest Buildings, Johnson Controls and Siemens.</p>
	<p>Perhaps the most well known maker of smart thermostats, Nest was co-founded by two former Apple executives. The company compares its smart thermostat to the first iPod, which spawned a revolution in mobile computing - leaving onlookers wondering what efficiency capabilities the company's device will unlock.</p>
	<p>Blending virtual audits with a comparison-shopping platform, Noesis is working to create an open market for energy efficiency. The service has the potential to unlock new opportunities for energy efficiency professionals and bring more transparency to the market.</p>

Source: GTM Research

	<p>Originally focused on paper-based residential energy reports using utility data, Opower has expanded to new mobile platforms and broadened its analytic capabilities to tens of millions of homes. The company is moving quickly into big data analytics to bring more transparency to homeowners and utilities.</p>
	<p>As a long-time global leader in lighting, Philips isn't resting on its laurels. The company is aggressively pursuing smart LED platforms in the residential, commercial and industrial sectors as it sees more competitive pressure from up-and-coming smart lighting companies.</p>
	<p>Similar to Demand Energy, Stem is avoiding developing new battery technologies and is instead focusing on a platform for building-level integration. With predictive analytics and visualization tools, the company's storage system is bringing new intelligence to the built environment.</p>
	<p>As it racks up customers like Verizon and NTT worldwide, Vigilent is proving to the toughest data center operators in the world that intelligent cooling management can drastically cut costs while maintaining reliability. The company's portfolio continues expanding, as the data center world gets more comfortable with the technology.</p>
	<p>As an up-and-coming demand-side management company, Viridity doesn't have the biggest portfolio of buildings. But like other leading players, it sees demand response as only the first iteration of a broader Intelligent Efficiency management platform for C&amp;I customers.</p>
	<p>Rather than focus on the C&amp;I sector or single-family homes, this building analytics company is targeting the multi-family housing market. Wegowise has picked up about 500 new buildings per month and is analyzing hundreds of millions of square feet of housing through its software.</p>

Source: GTM Research

CHAPTER 5

How information is helping utility companies deliver efficiency services

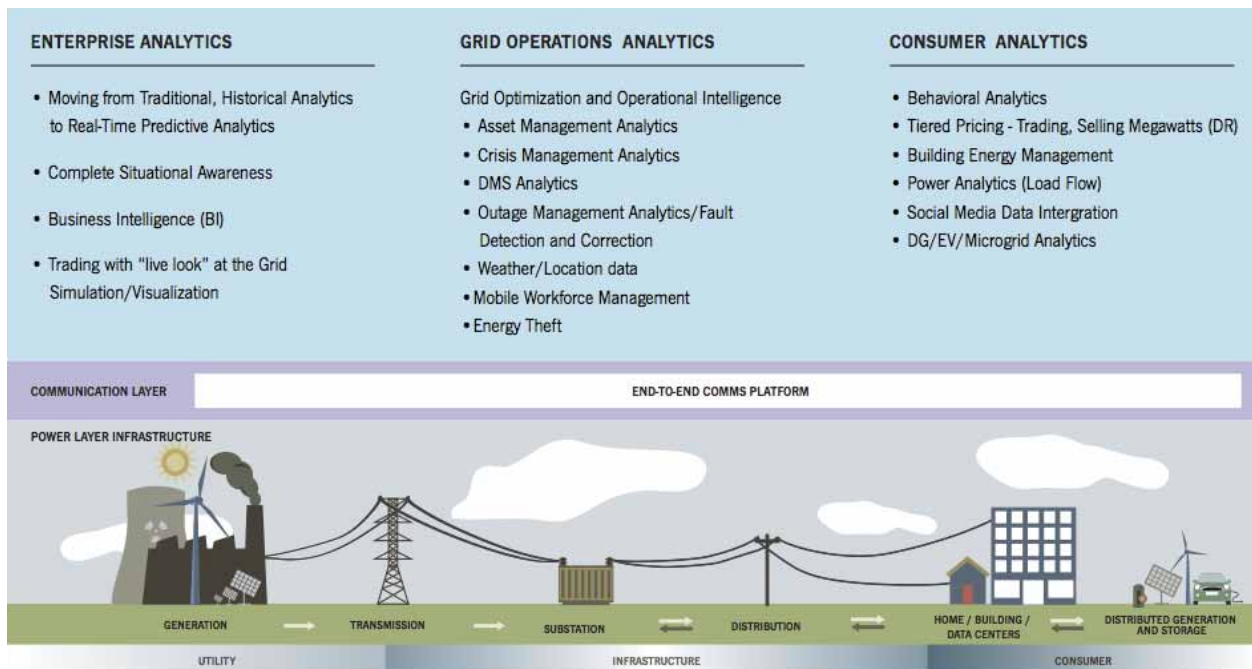
As intelligent efficiency starts making the built environment smarter, it has the potential to boost utility efficiency efforts.

Energy efficiency in the utility sector has historically been a very flat process. Under the old model, utilities would send paper notices to customers in the mail telling them about broadly conceived opportunities for retrofits or listing ways they can conserve energy. If a residential customer performed an upgrade, the utility would send a check in the mail; if a commercial or industrial customer got involved with demand response, the utility would pick up the phone and ask them to manually power down systems when it was necessary.

However, this dynamic is changing as utilities get more clarity on electricity use through advanced meters, build their in-house analytical capabilities and use data management services from third parties.

As the figure below shows, there are three primary areas for data analytics in the power sector. Utilities or third parties can analyze the data coming off the grid or from customers in a number of ways. They include data mining, predictive modeling, machine learning and simulating different scenarios across a portfolio of generation assets or buildings.

Figure 5-1: Utilities' Three Primary Domains for Analytics



Source: GTM Research's The Soft Grid 2013-2020: Big Data & Utility Analytics for Smart Grid

“This is one of the areas I’m most excited about,” says Jan Berman, senior director of energy efficiency strategy at Pacific Gas & Electric Company (PG&E). “We’re leveraging interval data from smart meters and combining it with publicly available information. Then we use analytics to provide very specific recommendations to customers.”

As a California-based utility, PG&E has operated under a 30-year old decoupling regime that encouraged utilities to separate revenues from electricity sales. That has created an ecosystem of innovation around efficiency that other regions of the country haven’t yet seen.

Over the decades, PG&E has created a far more dynamic process for deploying efficiency. Rather than simply sending rebate checks for projects, the utility works with technology manufacturers, vendors, retailers and other businesses to create new market channels for products. PG&E helps identify where energy-efficiency products are needed and works with upstream companies to deploy them. It’s a much different process than passively handing out rebates.

Better communications tools are broadening these channels. By using interval billing data, PG&E and other energy service providers are able to better monitor the performance of projects.

“We’re now able to model facilities before treatment and then compare their usage after process, behavior, technology and controls change,” says Berman. “We’re driving energy use down through a holistic application of efficiency rather than treating equipment as a standalone thing. This approach is in its infancy, but it’s helping us figure out how much more we’re saving with a holistic approach.”

While they’re still evolving, these tools are already having an impact. PG&E has more efficiency projects in its pipeline than ever before. Making information visible is giving customers clarity on how a project will perform and what the payback will be.

On the other side of the country, East Coast utility National Grid is seeing the same increase in activity, partly driven by better information gathering and communications tools.

“It’s a foundation upon which we’re building other kinds of services,” says Carol White, director of program strategy for National Grid in Massachusetts. “Those services include grid modernization, distributed resources, demand response, and all kinds of other sustainability-focused efforts that require providing good information.”

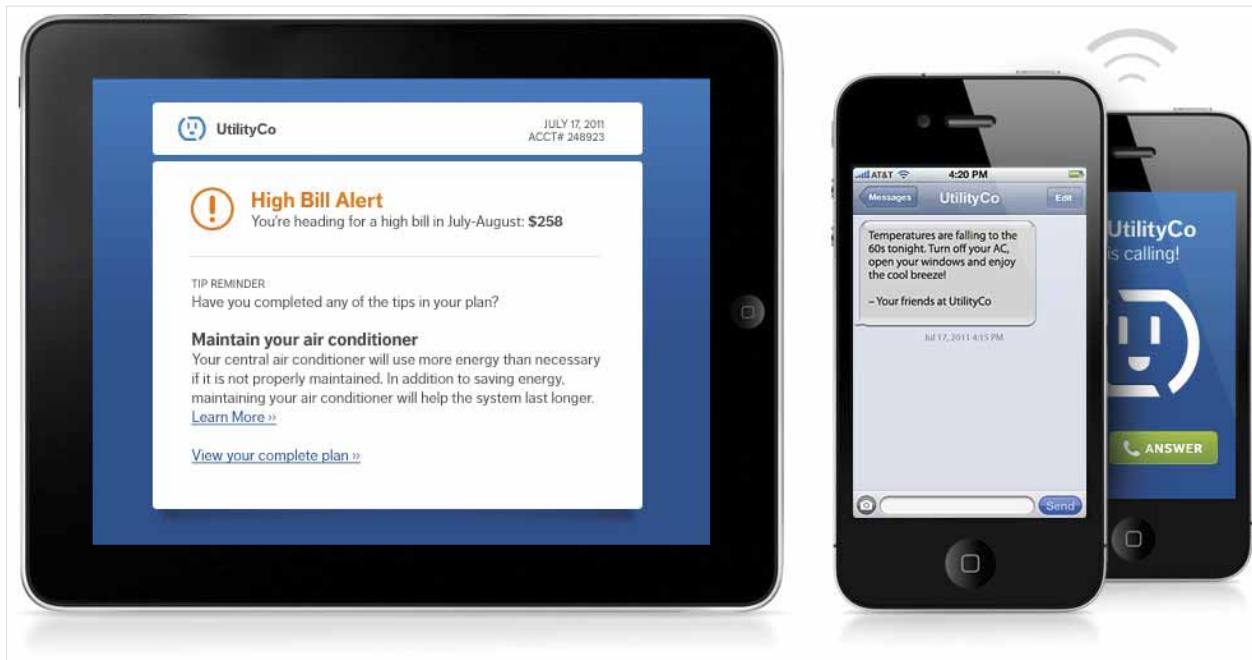
Like PG&E, National Grid is always looking for new ways to communicate with its electric and gas customers. That includes simple web portals, traditional marketing and interactive programs through social media. It also uses billing data for home energy reports that compare a homeowner’s energy use to others in the area, creating friendly competition to reduce energy use.

“There are all kinds of new channels that allow us to provide advice. They are allowing us to be more scientific in how we measure the impact,” says White.

The growth in third-party services has also helped utilities become more effective at delivering energy-efficiency services. As mentioned, virtual auditing tools are enhancing awareness about efficiency opportunities, thus helping utilities better target needs. And firms that are engaging directly with retail customers in innovative ways – Tendril, Nest and Opower being the best known – are also bringing in new value to utility customer-funded efficiency programs.

Opower, which helped develop National Grid’s home energy reports, is a pioneer in the residential space. The company started out by sending paper notices to homeowners with detailed energy reports drawn from utility data. Over time, Opower has created a suite of reporting products through email, text and mobile apps that give customers more clarity on their energy use.

Figure 5-2: Opower’s Mobile Energy Alerts Platform



Source: Opower

As it has expanded its portfolio to 75 utilities and partnered with providers of home energy management devices, Opower has gotten access to data from 50 million homes. The company is investing heavily in big data analytics to do ever more powerful things with that information. As of 2012, Opower said it was saving customers and utilities \$200 million annually – a big number, but only a fraction of what’s possible with better analytics.

On the other end of the spectrum, demand-response provider EnerNOC is gathering an extensive database of information on grid performance. In just ten years, EnerNOC has built the capability to monitor 27,000 megawatts of capacity across a broad portfolio of buildings in real time. That portfolio represents more than 3 percent of U.S. electricity consumption. As the company expands into new sectors like agriculture, it is gaining access to increasingly more granular information about the U.S. energy system and the built environment.

“We see more energy consumption in real time than any utility in the world today,” says EnerNOC’s Gregg Dixon. “That’s a huge value to the utility. They’re not technology companies and they often don’t know how to make sense of the data. So you have companies that are doing just that and bringing real value in data analytics.”

These monitoring capabilities are very broad in scope. But they start on the local facilities level, where building controls, energy management systems, and data analytics are boosting energy efficiency. These intelligent efficiency technologies are laying the foundation for the rollout of the smart grid, which will only increase connectivity and adaptability across the entire electricity system.

“Smart grids need smart buildings. It does no good if you can’t have that interchange of information,” says Greg Turner of Honeywell. “The software and better integration with the utility can help connect the smart grid. That’s new and different in the buildings world.”

CHAPTER 6  
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## The revolution in energy efficiency

“When energy revolutions occur, they require communication revolutions that are agile enough to manage them,” says economist Jeremy Rifkin about the emergence of a third industrial revolution. “You can’t really do one without the other.”

This precisely describes the conditions driving innovation in intelligent efficiency. As communications technologies become mature enough to create meaningful change – perhaps even revolutionary change – in the built environment, a vast number of companies are setting the stage for a new economic paradigm based on distributed energy.

The companies and technologies mentioned in this report represent only a tiny sliver of the ecosystem of innovation in the intelligent efficiency sector. There are thousands of companies working to bring low-cost software, cutting-edge equipment, and innovative business models to the efficiency market.

“This is a world where entrepreneurial, venture-backed companies are colliding with goliaths,” says McKinsey’s Stefan Heck. “This is a really dynamic time as a lot of these technologies compete. In many cases it isn’t clear how it will play out.”

Which companies fail and which succeed may alter the course of specific technology adoption. But it will not shift the macro trend underway: the built environment is getting smarter and companies are using the vast new reams of information to increase their level of sophistication in how they deploy projects. In turn, utilities and other energy providers are getting deeper insight into how their customers operate, further boosting the potential for efficiency.

Historically, energy efficiency was a one-dimensional process that involved replacing discrete pieces of equipment. But with instant communications and deep analytical capabilities, efficiency is becoming an ongoing process – one that is connecting energy management, storage, distributed renewables, and traditional efficiency sectors to create a dynamic market. It is also enhancing project performance as real-time monitoring allows for ongoing adjustment and verification across broad portfolios of facilities.

“Think about what a paradigm shift that is,” says Allen Friefeld of Viridity Energy. “It’s a different way to think about the traditional efficiency customer.”

Energy efficiency is also stereotypically known as being “boring.” That is no longer the case. Intelligent efficiency is making energy visible, turning retrofits from something a company “does” into something a company manages like any other physical asset.

Embracing energy efficiency as a dynamic resource is still a new concept for many businesses. But it is happening. Just like new drilling techniques and surveying capabilities are unlocking previously inaccessible resources in the oil and gas sector, information technologies are uncovering a deep well of efficiency reserves and reshaping the way companies think about how they use energy.

We have just begun to scratch the surface of what intelligent efficiency can deliver.

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