MAKING MODERN LIVING POSSIBLE

Industry Research & Report: Smart Grid

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Executive Summary

Today, billions of dollars are being spent in the United States by electric utilities, product manufacturers and government agencies to establish policies, protocols and products that will ultimately improve grid reliability and restoration efforts; integrate intermittent renewable resources such as wind and solar; use "managing appliances" in homes and businesses; and provide sophisticated energy management technologies and services.

But is this how commercial building owners view the smart grid? Are building owners, consulting engineers and heating, ventilating, and air-conditioning (HVAC) product managers on the same page as smart grid proponents? This population of smart grid stakeholders is important. According to the U.S. Dept. of Energy, commercial buildings are responsible for about 18 percent of the total U.S. energy budget, spending approximately $139 billion annually for electricity alone, and this does not take into account the billions of dollars that utilities and building owners are investing in technologies and services that help to make facilities more energy efficient.

The researchers of this study, commissioned by Danfoss to illuminate how building owners, consulting engineers and HVAC managers in North America perceive the smart grid, and what would motivate them to make smart grid investments, interviewed 30 industry professionals -- 10 people each from three sample sets: commercial building owners, independent consulting engineers and commissioning providers, and HVAC and controls manufacturers.

The key findings include:

1) **Increased communication is needed between utilities and their customers** on the value of smart grid deployments and how customers can tap into those savings. Survey responses indicate there is widespread skepticism and little awareness on what the smart grid is, what it can do and how much it will cost.

2) **The value proposition for building owners needs clearer definition**. Utilities need to know what their customers are expecting from the smart grid as their wants, needs and expectations will vary considerably. Some customers are primarily concerned about reliability, while others may be focused on power quality and others may be most worried about costs. The study confirms that any smart grid investment made by building owners has to compete with other potential investments, from increased insulation to new tile in the foyer; smart grid programs are amongst the heavy competition for owners' dollars.

3) **There are technology issues with building controls**, as buildings will interact with the smart grid through building automation and energy management systems, which will respond automatically or semi-automatically to messages sent by utilities to curtail energy usage at scheduled times. However, many buildings do not have the control systems or do not have properly designed, installed, operated or maintained systems, resulting in poor control. Retro-commissioning or retrofits may be needed first in order to ensure a return on investment on smart grid technologies.

4) HVAC and buildings controls **manufacturers have taken an early interest and leadership role** in smart grid developments and relevant products well before data communications protocols and other foundational elements are in place.

Introduction

The transformation of the current infrastructure for generation, transmission, distribution and consumption of electricity to that of the smart grid is underway. The smart grid is being positioned as a modernization of an electrical grid to meet the requirements of today's economy: improving reliability and restoration efforts; integrating variable renewable resources; using managing appliances and other "smart" devices to help operate the grid more efficiently; avoiding, or at least deferring, huge infrastructure investments; providing consumers with the information and tools to use energy more efficiently and at lower cost; and enabling utilities and their consumers to work together in ways never before possible to ensure the most efficient balancing of utility supply options with consumer demands. The smart grid also promises to support the national goal of energy independence by helping to move away from foreign oil to increased reliance on electric transportation fueled by renewable and domestic resources.

The U.S. transformation was kick-started in 2007 by a $4.9 billion infusion of American Recovery and Reinvestment Act (ARRA) stimulus funds, which was designed to support "shovel ready" smart grid projects and regional smart grid demonstrations. The governments of China, Japan, South Korea, Germany and the U.K., among others, are also investing in smart grids for their respective countries. This raises the stakes on the United States to remain competitive in the development of smart grid technologies and to make its electric grid as reliable and environmentally friendly as possible.

Manufacturers of grid equipment, such as power-line sensors, or end-use devices, such as home appliances and commercial HVAC equipment, have begun to develop smart grid products, as well as leadership positions and marketing strategies to propel their products into the marketplace.

Consumer and trade media have also begun to become interested in the smart grid market. Hot-button issues, such as privacy and security concerns, and visually stimulating images of plug-in electric vehicles, solar arrays and wind farms make for great press. New advertising campaigns from manufacturers and utilities are also supporting greater media attention to the smart grid.

But lost in all of this activity has been the value proposition for commercial building owners. Is there a perceived need for the smart grid? Are they willing to pay any costs for smart grid technologies? What are the benefits to building owners, and are the benefits more compelling than the barriers? What are manufacturers and consulting engineers thinking? And, since they respond to owners seeking independent guidance and quality products for their facilities, what are engineers and manufacturers hearing from owners, and how are they preparing to respond to their customers' inquiries?

This research project aims to shed light on these questions through interviews with a total of 30 owners, engineers and manufacturers in the non-residential buildings industry. The results of this study will help all smart grid stakeholders understand how owners, and those who serve them, view benefits and barriers, and what would stimulate them to make investments or discourage them from doing so.

Research Study Design

Purpose

The purpose of this study is to identify what building owners, consulting engineers and HVAC manufacturers are currently thinking about the smart grid, i.e., how they perceive and prioritize benefits, barriers and motivations for smart grid investments in building systems.

Methodology

A qualitative research study comprised of thirty 30-minute interviews was administered over the telephone to a nationally distributed sample set of 10 building owners, 10 consulting engineers and 10 product manufacturers. This data set provides a benchmark of the breadth, depth and conviction of early smart grid barriers, benefits and motivators.

The central research questions guiding the design of this research study were:

1. What do building owners know and think about the smart grid, and what do they perceive as barriers, benefits and motivators?

2. What do consulting engineers know and think about the smart grid, and what do they perceive as barriers, benefits and motivators for building owners?

3. What do HVAC manufacturers know and think about the smart grid, and what do they perceive as barriers, benefits and motivators for building owners?

4. How well do the results concerning owners' perspectives from engineers and manufacturers compare to the results from owners themselves?

Subjects were called and interviewed from lists held by The Ivanovich Group or obtained for the purposes of this study. There were no incentives, such as honoraria, entries to drawings or other incentive to participate.

The interviewees represent a solid mix of titles, companies, professions and locations. Table 1 provides a distillation of interviewee data that also protects their privacy. For each sample set, the titles, company names and states were sorted in ascending alphabetical order to prevent alignment of any information to any person. Note: for the public version of the report, Table 1 has been further cleansed for privacy protection.

Owners - Title	Company (type of buildings)	State
Director of Construction	Property Management Firm for Leased Commercial Space	California
Director of Physical Plant	Hospital Center	California
Director, Engineering & Facilities Management	Major University	California
Energy Engineer Tech	Real Estate Financial Advisors Firm	Louisiana
Facility manager	Government Services Administration	Maryland
Managing Principal	Major Hotel Chain	Missouri
Mechanical Engineer / Project Manager	Private University	New York
Property manager	National Park Service	Oregon
Utilities Coordinator	An Oregon School District	Virginia
VP Operations	Pharmaceutical Manufacturer	Washington DC
Engineers - Title	**Company (type of firm)**	**State**
CEO	MEP Consulting Firm	California
Director of (Large U.S. City) Operations	Controls Consulting and Commissioning Firm	Georgia
Electrical engineer	Midwestern MEP Consulting Firm	Georgia
Electrical engineering manager	International MEP Consulting Firm	Illinois
President	Southeast Commissioning Firm	Minnesota

Engineers - Title	Company (type of firm)	State
President	National Commissioning Firm	Nevada
Principal	National MEP Consulting Firm	Nevada
Principal Mechanical Engineer	National MEP Consulting Firm	Oregon
Senior Engineer	National MEP Consulting Firm	Texas
Senior VP - (Major California City)	National MEP Consulting Firm	Wisconsin
Manufacturers - Title	**Company (type of product)**	**State**
Applications Engineer	Energy Recovery Ventilation Products	Illinois
Director, Building Performance Products	Engineering and Architectural Design Software	Indiana
(Withheld)	Thermal Storage Systems	Massachusetts.
Management	Commercial HVAC Products	Massachusetts
President	Control Products and Information Services	Minnesota
President	Commercial HVAC Products and Controls	New Jersey
President	Building Automation Systems	New York
President and Chief Technology Officer	HVAC and Controls Products and Energy Services	Tennessee
VP (Withheld)	Industrial-Scale HVAC Products	Texas
VP Marketing	Commercial HVAC Products	Washington DC

Table 1: Summary of sample titles, companies and locations.

Engineering firms ranged from one-person boutique consulting firms to international firms with locations in major U.S. cities. Two of the firms specialize in commissioning. Because the smart grid spans both mechanical and electrical engineering, three of the engineers interviewed were electrical engineers. Titles were predominantly senior executive (director, president, vice president and principal), where decisions are made for business development and communications. Some engineers were project managers for engineering design or commissioning.

Manufacturers were primarily HVAC product manufacturers; three specialize in controls and building automation systems, and one is a vendor of software for building design. Titles were predominantly in senior executive (president, vice president), where strategic decisions are made for markets, products and communications.

Owners represented a large variety of construction types, including industrial, K-12 schools, university campuses, commercial offices and government facilities. Titles were predominantly at the senior management level in facilities and plant services, where knowledge about energy and building systems decisions is strong.

Slightly more than half (52 percent) of the respondents claimed to be involved in smart grid activities. Those who are active range from just getting started to being on the leading edge of smart grid research, development and application. One engineering firm already has sophisticated smart grid services, i.e., "We are engaged in preparing buildings for the smart grid so they can actually use the technology. We do the analytics electronically; identify problems that are occurring from operational perspective so they can eliminate firefighting modes operators are in…; improve their efficiency for satisfying occupants; and help occupants be more productive by making their environment much more effective for them."

Manufacturers indicated they are developing products ahead of the market. Several distinguished being active in the market from only having smart grid products. One manufacturer, who answered "no" to the question, said, "We would like to be [active] if there was a market for it. We're sitting here waiting with a solution for when the market is ready." Another who answered "no" said, "Not exactly. What we're doing is the smart controller part on our units--working with the wireless interfaces. We're preparing for it, but not actively doing it yet."

Smart Grid Timeframe

Together, data in Table 2 and Figure 1 show that 57 percent of the respondents said it would be likely or very likely there would be some form of the smart grid operating in the United States within three to five years. However, there is a lean toward not likely with 30 percent more votes for "not likely" than "very likely." Manufacturers aligned more with owners than engineers when answering this question, and engineers were the most polarized sample set.

Sample	Highly likely	Likely	Not likely
Owners	1	4	5
Engineers	3	3	4
Manufacturers	0	6	4
All respondents	4	13	13
All respondents	13.3%	43.3%	43.3%

Table 2. Likelihood the smart grid will be a reality in the United States.

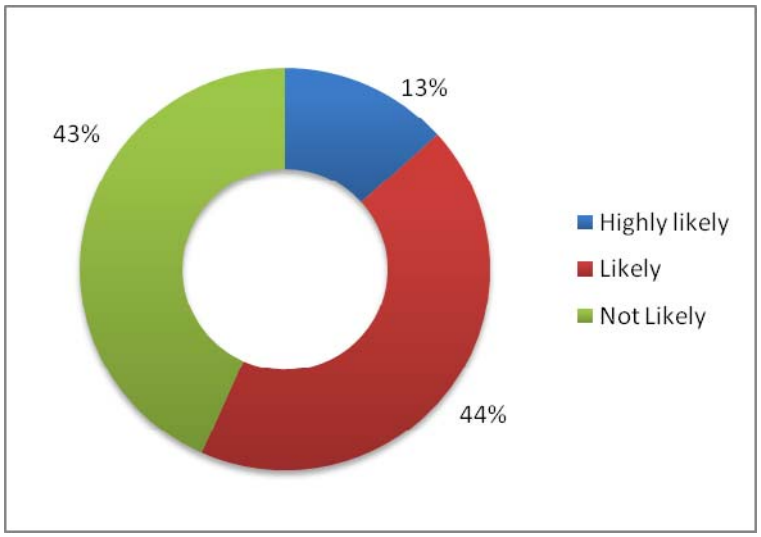

Figure 1. Likelihood the smart grid will be a reality in U.S. (All respondents)

When asked to qualify their answer, owners, engineers and manufacturers responses tended to split along professional lines.

Owners answering "unlikely" mentioned large-scale organizational issues, such as government intrusion or incompetence. For example, one owner stated, "I just can't see a whole lot of people on board with it yet." Another commented, "Three to five years is a little quick for the government." Another said, "I think we're in a gridlock right now. Regretfully, it's turning into a political instead of an infrastructure question and that's going to bog it down. Lack of efficiency in Washington, D.C., will keep it from coming to fruition." Some of the positive remarks stated opposite opinions, for example, "It's likely

because the government is putting money and a lot of effort into it and it's something that the U.S. needs to do to be competitive."

Engineers answered in a very literal fashion, i.e., that the smart grid was either partially in place today, or that parts will be in place within three to five years. Their answers were nuanced toward technical issues and the scale of the grid. For example, "We'll have a smarter grid, but not a smart grid because there are communications issues, such as they haven't gotten interactivity protocols for interoperability." Another commented, "The smart grid covers a scope from end user to generation provider. We already have some components in place, like ISO interconnects…standards aren't out yet and then the loads, meters, etc. need to be in place. I don't see that happening in 3 to 5 years."

Manufacturers tended to qualify their projections with the scale of the effort and the speed with which it can be undertaken. For example, one interviewee stated, "It's not likely because I don't think they can get everything in place; there are segments that have to be upgraded and I don't think coordination can happen in 3 to 5 years." On the other hand, manufacturers were excited about the scale of recent initiatives. For example, "It's likely because the Department of Energy has made substantial investments in smart grid infrastructure, so there's more money going in. Regulatory bodies have bought in, so utilities are deploying technology to make the smart grid."

In summary, data show most respondents believe elements of the smart grid will be in place within three to five years, but that it is unlikely the smart grid will be substantially complete within three to five years. By a slight margin, owners viewed the smart grid as less likely to be a reality within the same time span than engineers and manufacturers.

Barriers and Benefits

This research study employed two different types of questions to ask respondents to identify barriers and benefits for building owners adopting the smart grid. The first question was unprompted, so the answers were top of mind. This question was followed up by having respondents rate specific barriers and benefits on a scale of 1 to 4, with 1 being no barrier or benefit and 4 being a strong barrier or benefit.

Barriers

The open-ended responses show substantial variability and some respondents named three or four barriers where as others mentioned only one. The results were grouped into categories, as shown in Figure 2 and Table 3, that could be analyzed.

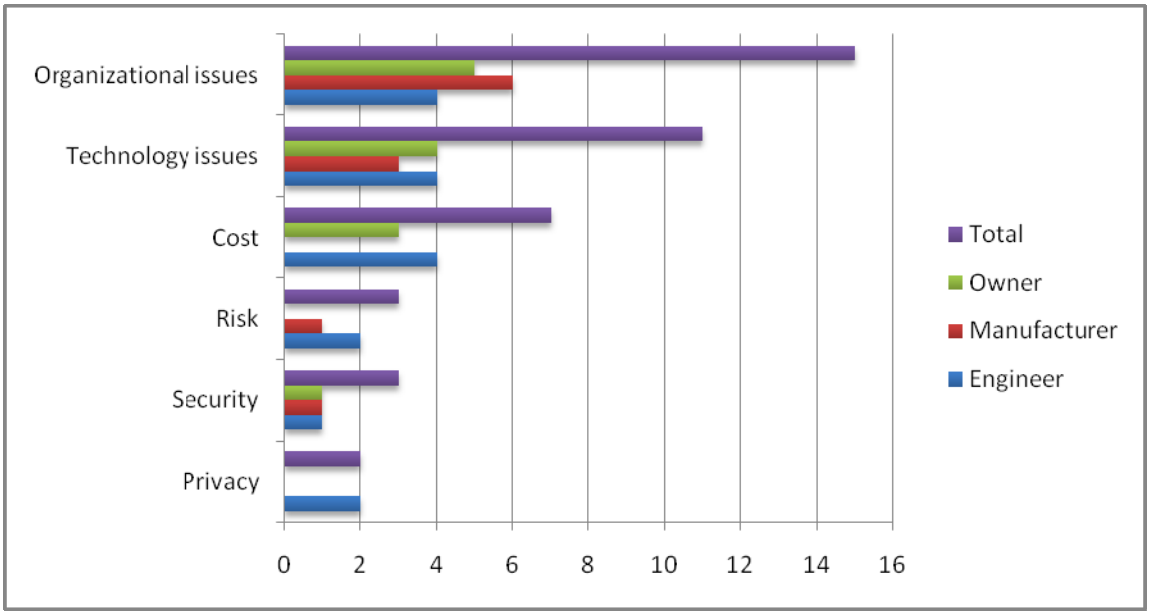

Figure 2. Barriers to owner adoption of smart grid.

Barriers for Owners to Adopt Smart Grid	Organizational Issues	Technology Issues	Cost	Risk	Security	Privacy
Engineer	4	4	4	1	2	2
Manufacturer	4	3	0	1	1	0
Owner	5	4	3	1	0	0
Total	15	11	7	3	3	2

Table 3. Tallies for responses about barriers to owners adopting the smart grid.

Organizational issues cited as barriers include references to whole external entities, such as utilities and the government, and to owners' staffing or internal issues. Some key interview comments are noted below:

- "Information in a free society is not a requirement. When utilities start using it as a hammer, it's no longer a free society and that kind of regulation/information becomes invasive." --Manufacturer
- "I don't know the utilities have done a good job of telling them [owners] what the benefits are going to be." --Manufacturer
- "Finding the right people to get educated on the subject. It's not a barrier, but it is a decision." --Owner
- "The primary issue to making it happen is getting somebody to take a leading position and getting other people to accept that position and build on it..." --Owner
- "Contractual obligations and the obligations of owners to tenants to iron out who gets the advantages that come from the smart grid and how those advantages are shared. Plus the cost issues for getting smart grid implemented. The advantages may be obvious, but the costs for getting them may be quite large". --Engineer

Technology issues include references to controls and protocols. Again, some key interview comments reflect the data as a whole:

- "First thing that comes to mind is the event of a widespread failure – not so much to generation systems, but to information systems. If it goes down, there's an unknown that the resource could still be delivered. The drawback is being too reliant on an ephemeral system. Pulse and wires…those are reliable and tangible." --Owner
- "There doesn't seem to be accepted standards about the communications yet, like if they're doing Zigbee or RF or power line carrier." --Engineer
- "Oh yeah. First (barrier) is to get their building under control. As much as we wish to believe we have high-tech controls, most aren't under control." --Engineer
- "I think it goes back to those tech innovations; they're up in the air…indecision about communications protocols that will work and finding the right technology solutions may be challenging, initially." --Manufacturer

Mentions of cost, risk, security and privacy were very specific, such as:

- "Higher taxes. Higher cost." --Owner
- "I'm sure the initial costs for installation are an issue." --Owner
- "If there [are] no offsets to cost of implementing, then owners will be less willing to buy into the program unless it's mandated by legislation." --Engineer
- "Cost of metering [is a barrier]. There is no perceived benefit for metering from owner side." --Manufacturer

Concerning barriers, data in Table 3 (above) suggest that owners have concerns other than costs that smart grid stakeholders need to address. First, cost came in a solid third place, well behind "organizational issues" and "technology issues." Second, the issues of privacy and security came in last.

When the respondents were asked to rank specific barriers on a scale of 1 to 4, different results emerged. Table 4 shows that the results into two groupings with subsets: 1) "no barrier" with "small barrier;" and 2) "moderate barrier" with "large barrier." Grouping allowed barriers to be ranked in descending order, so the strongest barriers became evident, as shown in Table 5.

Barriers for Owners to Adopt the Smart Grid (All respondents)	No Barrier + Small	Moderate Barrier + Large
Lack of knowledge about the smart grid	26.6%	73.3%
Costs	36.6%	63.3%
Lack of perceived benefits	46.7%	53.3%
Loss of autonomy or control of facilities	50.0%	50.0%
Lack of technological capabilities	46.6%	50.0%
Failure of utilities to deliver on promises	50.0%	46.7%
No or little time to deal with smart grid opportunities	56.7%	43.4%
Security	60.0%	40.0%

Table 4: Barriers scored on a scale of 1 to 4 with 1 being no barrier and 4 being a strong barrier.

Table 5 shows that although cost still did not come out on top, it moved up a spot to second place compared to the previous, open-ended question. Respondents' primary concern was lack of knowledge about the smart grid—owners need to be better informed so they could make intelligent investment decisions. Security ranked at the bottom of concerns.

Barriers for Owners to Adopt the Smart Grid (Owners Only)	No + Small	Moderate + Large
Costs	20.0%	80.0%
Security	60.0%	40.0%
No or little time to deal with smart grid opportunities	60.0%	40.0%
Loss of autonomy or control of facilities	60.0%	40.0%
Lack of knowledge about smart grid	60.0%	40.0%
Lack of technological capabilities	60.0%	30.0%
Lack of perceived benefits	70.0%	30.0%
Failure of utilities to deliver on promises	60.0%	30.0%

Table 5: Owner-only responses on barrier rankings.

Benefits

The aggregated data indicate the owners had very strong opinions on costs being a barrier (Table 6), with 80 percent classifying costs as a moderate to large barrier. Owners showed distinctly less concern for

everything else, with all other barriers scoring 40 percent or 30 percent as a moderate or large barrier. Security, however, did come up higher in the ratings when specifically listed as a potential barrier.

Benefits to building owners for adopting the smart grid	Information and Energy Management	Lower Cost	Real-Time Pricing	Reliability	Environment	Trendy
Engineer	5	4	4	2	2	0
Manufacturer	4	2	3	1	0	1
Owner	5	7	0	1	1	1
Total	14	13	7	4	3	2

Table 6. Open-ended responses to the benefits of the smart grid to building owners.

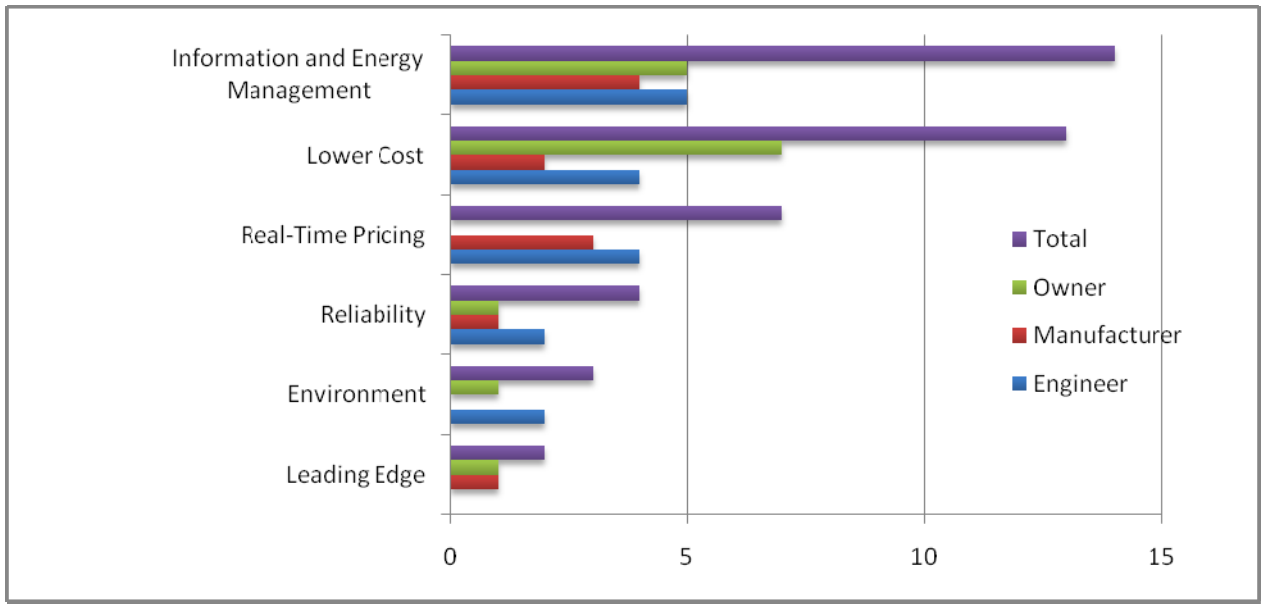

Figure 3. Ranking benefits of smart grid adoption.

Respondents showed substantial agreement about benefits in both the open-ended question (Table 6) and the rankings question (Figure 3). In the open-ended question, Information and Energy Management superseded Lower Cost as the most frequently mentioned benefit.

The prominence of Information and Energy Management in the rankings highly indicates that owners want information to make energy decisions, not just to decide whether or not to adopt smart grid technologies.

The prominence of Lower Cost is expected, as was owners' mentioning Lower Cost more than often than engineers and manufacturers. The low count for manufacturers is interesting as it is consistent with manufacturers not mentioning cost at all in the unprompted question about barriers (Table 3). Manufacturers tended to mention technology or organizational issues when unprompted. However, when asked to explicitly rank cost as a barrier to owners, manufacturers rated it 70 percent as a moderate or

large barrier, just behind the owners ranking of 80 percent, and explicitly ranked lower cost at 90 percent, as did both owners and engineers, for an average of 90 percent for all respondents (as shown in Figure 3). This concludes cost barriers and benefits may not be top of mind to manufacturers, but they instinctively react to it when mentioned.

Real-time Pricing (RTP) came in a distant third. It is interesting that owners did not name RTP as a benefit while a total of seven engineers and manufacturers, which comprises 35 percent of the non-owner sample, did. This may indicate engineers and manufacturers presume incorrectly that owners are knowledgeable about real-time pricing.

The unprompted outlier responses for Environment and Trendy were included in this report because they merit watching. The Environmental benefits attributed to the smart grid that interviewees noted were reducing greenhouse gas emissions and making better use of resources. Carbon reductions were not among the list of benefits we asked respondents to rank, so the fact that it was mentioned by 10 percent of the interviewees when unprompted indicates there is some awareness of the potential environmental benefits of the smart grid. For example, at the Danfoss Symposium in October 2010, a representative of Southern California Edison (SCE) said that SCE's smart grid communications strategy divides customers into distinct pools based on personality or characteristics; one of the pools contains the environmentally conscious and another includes "technology trend setters." The data in Table 6 supports this approach.

Looking at the ranking of benefits in Table 7, respondents indicated that most of the benefits listed would be well received by owners. All but one of the benefits (Support Charging of Electric Vehicles) scored above 50 percent as being a moderate to large benefit and four of the benefits scored 70 percent or above.

The largest benefit was Lower Electricity Costs, and the second largest benefit, Better Access to Usage Data, correlates well with the open-ended response Information and Energy Management benefits in Table 6. One finding in the data worth examining in greater detail is the high ranking for owners generating and selling onsite power. This parameter was skewed by manufacturers having a 90 percent rating and engineers having a 70 percent rating compared to owners having a 60 percent rating; however it could indicate a growth opportunity for onsite renewable energy systems if packaged with smart grid technologies.

Benefits for Owners Who Adopt the Smart Grid (All respondents)	**No + Small**	**Moderate + Large**
Lower electricity costs	10.0%	90.0%
Better access to usage data	20.0%	80.0%
Easier for owners to generate and sell onsite power	26.7%	73.3%
Shorter duration of power outages as a benefit	30.0%	70.0%
Benefits for Owners Who Adopt the Smart Grid (All respondents)	**No + Small**	**Moderate + Large**
Easier integration of remote wind & solar power	40.0%	60.0%
Create new markets for energy services	40.0%	60.0%

Fewer power outages as a benefit	43.3%	56.7%
Support charging of electric vehicles	56.7%	43.3%

Table 7: Benefits scored on a scale of 1 to 4 with 1 being no benefit and 4 being a large benefit.

Looking at only the owners' ranking of benefits shown in Table 8, the top two positions are essentially unchanged. Shorter Duration of Power Outages becomes a clear third place and Generating/Selling Onsite Power slips to a four-way tie as a mid-range benefit.

Benefits for Building Owners Who Adopt the Smart Grid (Owners only)	**No + Small**	**Moderate + Large**
Lower electricity costs	10.0%	90.0%
Better access to usage data	10.0%	90.0%
Shorter duration of power outages	20.0%	80.0%
Fewer power outages	40.0%	60.0%
Easier for owners to generate and sell onsite power	40.0%	60.0%
Support charging of electric vehicles	40.0%	60.0%
Create new markets for energy services	40.0%	60.0%
Easier integration of remote and solar power	50.0%	50.0%

Table 8: Owners' ranking of benefits.

Altogether, the strongest benefits expected to owners are Lower Electricity Costs and having more information with which to manage energy, which could also be viewed as lowering energy costs. Shorter Duration of Power Outages would also be a strong benefit to owners. Outages lasting several days could have significant impacts to almost any type of building, and are/would be more severe than frequent outages of short durations that are handled by emergency/standby power systems.

Motivations

Researchers asked interviewees to respond to six yes/no questions about what would motivate building owners to invest in smart grid technologies for their buildings (such as demand-response capabilities and thermal storage). The data show owners, engineers and manufacturers agreed on the top four motivators: More Effective Communications from Utilities; Financial Incentives; Significant Cuts to Electricity Rates, and Security (Figure 4).

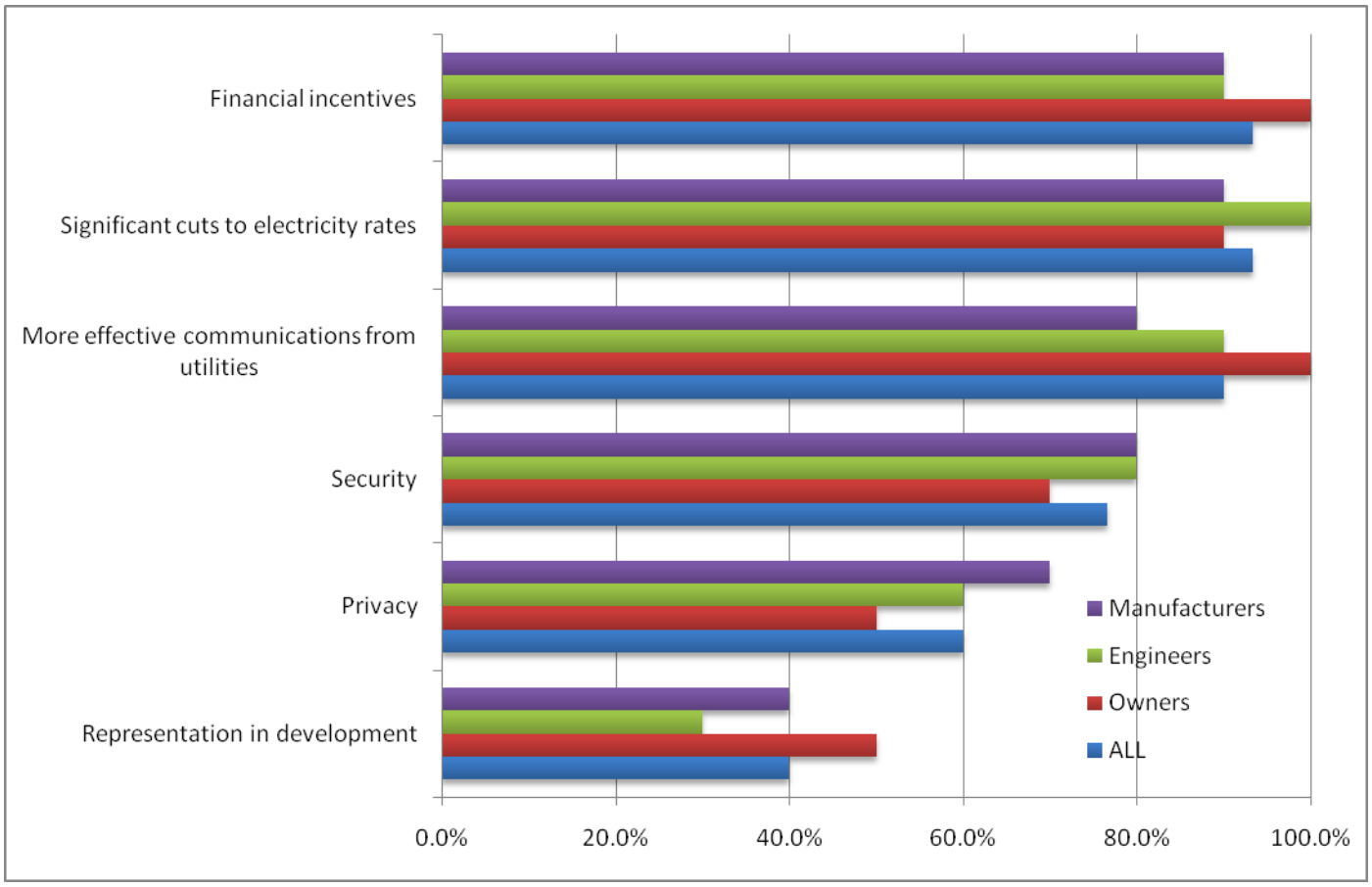

Figure 4: Motivating factors for building owners to invest in the smart grid.

Again, Security placed lower than Communications from Utilities, which indicates owners will value having more information for making decisions about the smart grid rather than assurances that the smart grid is secure. These results are consistent with other questions in the survey, indicating that the respondents are quite certain of their positions.

Ranking last among motivators is Representation in Development. Responses indicated owners do not have the time or interest to participate in the development of smart grid codes, standards and policies. Some respondents disagreed, saying the more owners participated in smart grid developments, the more likely they would adopt smart grid measures because they would know more about them and they would more likely benefit owners.

Comparing the responses of owners to the other sample sets, the largest deviations are in the importance of More Communications by Utilities with owners; Privacy; and the Representation of owners in smart grid developments. The responses of engineers and manufacturers under-predicted owner responses on

Communications and Representation, and over-predicted owner responses on Privacy. To a lesser extent, engineers and manufacturers also over-predicted owner responses on Security as well.

What these findings indicate is that manufacturers and engineers have a good sense of what owners want or need from the smart grid with respect to lower first costs and lower operating costs. It's well known in the buildings industry how important costs are to owners in the decision-making process, which would naturally extend to smart grid investments. However, when stating what would motivate owners on issues more unique to the smart grid, engineers and manufacturers were less accurate.

Financial Incentives

Financial incentives were prompted as rebates, tax breaks and other means to reduce the first costs of smart grid investments. By and large, almost every respondent said such incentives would motivate building owners. As one owner said, "Owners love financial incentives." Another owner elaborated a bit by saying, "YES, absolutely…First, I don't know what it costs to begin with, but if you're asking, it's not cheap, so if I go into this I want some kind of partnership."

Outlier responses expressed opposition to tax breaks, calling them a form of government intrusion on free markets. As one manufacturer put it, "You're getting into politics. That's a bunch of BS. It should all be reflected in a better rate. The cost of their power goes down – not that the government is going to give them some tax breaks. You'll no longer have a market solution."

Significant Cuts to Electricity Rates

Lower electricity rates were almost unanimously said to be a motivator for owners investing in the smart grid. One manufacturer responded, "For all companies, it's a ROI calculation and incentives would make that a more attractive return." An engineer responded with, "Well, that's always a good thing--a smart grid-specific rate that's cheaper than a baseline rate; distinct from rebates and the like…"

Two owners had nuanced answers important to note. One responded that rate cuts would be a motivator because, "…We might be able to save a position or two from our current cuts." The other owner, the only one who said rate cuts would not be a motivator, said, "Lower rates are a twin-edged sword. Everyone wants lower rates, but if the rates are low, people won't be motivated to make investments. Lower power rates will be de-motivating in the long term." Mathematically, in the calculation of ROI, he's correct, unless, without smart grid, the rates go up. This position was stated by the only manufacturer who said lower rates would not be a motivator, "I don't think [smart grid] will reduce rates but [it will] keep them from increasing. Smart grid will slow the increase in rates and bring on renewables."

More Effective Communications from Utilities

One engineer commented, "Before most of my clients would participate, they'd want to know what's in it for them." Another responded, "I think once they have the info about how they can improve their performance and reduce their total cost of ownership they will be inclined to go in that direction." One engineer expressed that better communications from utilities would not cut it—owners would prefer other sources: "Have to consider the source. Owners would say yeah, yeah, yeah… PGE or Edison. I'll read it, but there's a reason they're sending it to me. If it came from a third party or another credible organization, it would be better."

Owners tended to agree with the engineers; one saying, "The more we know about a resource or option for receiving resources…the better. It's better to know more because sometimes we could find opportunities for doing better." One owner cut to the chase, "Because the more we know about it the more likely we'll use it."

Security
Security as a motivator scored in fourth place; however, it still scored highly with 80 percent of engineers and manufacturers and 70 percent of owners, agreeing it would be a motivator. It is difficult to imagine anyone in the buildings industry saying that having assured security would not be a motivator.

As the owner representing a school district commented, "Security is a concern or factor to the degree where we are security conscious as a school district providing a safe environment for our students." Another owner saw security as a potential threat to loss of business, "Security is a motivator because I don't want someone to shut down my building. You're talking about putting people out of business."
The smart grid, however, represents non-violent security—such as a white-collar crime as indicated by one respondent, "It's an issue that has to be solved, but it won't cause investment." A manufacturer agreed, saying, "That (security) will be a requirement for the smart grid to be successful; it will be an expectation; not a motivator. It would be a de-motivator if not addressed. If not addressed, and there's not a comfort level, I don't think it will go anywhere."

The data suggest that security consciousness is high, and that having a secure smart gird must be synonymous with having a smart grid—poor security is not an option.

Privacy
While privacy did not score highly compared to other motivators, those who felt it would be motivating had strong reactions to making energy data public. For example, one manufacturer said, "Privacy is a big concern. They [owners] don't want their utility bills made non-private. That's a big concern for a lot of them. It's business sensitive information." An engineer spoke from personal experience, saying, "I've had people not want to get involved in energy conservation because, if their figures were going to be public, they don't want it." One person equated smart grid privacy with the impact of social media on business practices, saying, "I think that privacy is very much on the minds of people because of personal stuff translating into business stuff. For example – I think the explosion of Facebook and things like that—people are realizing it's easy for their privacy to be compromised on a personal level. That's raised the awareness that their business practices and processes need to be up-to-speed; many of which are not."

The reasons for privacy not being a motivator were widely scattered. Some felt privacy is not an issue or believe it to be an over-hyped issue. Others indicated privacy, in the form of energy bills being made public, is not a concern to them because they represent a government institution. Still others indicated energy data is simply not business sensitive. In summary, privacy will have to be assured for those who are concerned about it.

Representation in Development
While representation in smart grid development was the lowest-scoring motivator for building owners, half of the building owners interviewed said it would be a motivator. Their reasons were strong: the more owners that are at the table, the better their interests will be represented. Also, some equated participation in development to gaining the knowledge needed to arbitrate whether or not to participate in the smart grid. For example, one owner said, "If you get owners involved in the beginning, they will see the true benefits; they'll totally understand how it will impact and relate to their company […] and see it as legitimate and not see it as marketing spin…"

Implications for HVAC Technologies

Researchers asked interviewees to describe new technologies or refinements for HVAC systems they foresee in next five years for smart grid adopters.

The majority of responses from each of the three populations were oriented around building automation systems integrating with smart grid capabilities, or HVAC systems directly (without the BAS) integrating with smart grid capabilities. Engineers and manufacturers were more detailed than owners, but all three populations were very consistent in projecting developments primarily in the fields of information technology and data communications, which are, in fact, the smart grid's value proposition from a building perspective.

The data suggest engineers and manufacturers seem excited about having buildings become more dynamically operated. Dynamics, they said, would come in several ways, including:

- Building automation systems interacting with the smart grid to implement strategies such as automated demand response, demand limiting, pre-cooling and load shedding;
- Individual HVAC equipment would directly interact with the smart grid to achieve similar strategies as with the BAS. Respondents cited improvement to control panels that would "end the control panel as we know it;"
- More use of VFDs, and HVAC equipment becoming more efficient at part-load conditions;
- More use of natural/passive cooling and ventilation, which would require sophisticated controls to integrate the switch from mechanical to passive systems, and back, based on smart-grid inputs.

Several thermal technologies were specifically mentioned as being refined for smart grid applications:

- Thermal storage;
- Heat pumps, refined for improved cold-climate performance;
- Energy recovery.

Engineers emphasized the increased role of building automation systems, indicating a predisposition for integrated building systems responses to smart grid events. Six of the 10 said BAS controls, protocols or high-level programs would advance to implement smart grid functions such as automated demand response and demand management. Engineers mentioned advanced software, such as "background analytics" and "diagnostic algorithms" that "ensures equipment runs like it's supposed to."

Some of the more illuminating responses are illustrated below.

- "I think you'll have control systems that will have more sophisticated routines for demand management and demand response."
- "Thermal storage will continue to be refined in use and popularity. Energy recovery is another one. Changes in heat pump technology will continue to grow, especially in colder climates. Increased use of VFDs will help with recovery systems from a demand-limiting point of view."
- "I see background analytics running the information from the BAS as well as from sub-metering aspects of the meter…to improve operational efficiency."

While some manufacturers gave a nod to BAS advancements, manufacturers expressed controls refinements in terms of HVAC equipment communicating directly with the smart grid rather than through a BAS to the smart grid. One manufacturer said it this way, "I think that what will happen is that the unit—all the operating pieces of equipment—will have smart/communicating controllers that can be connected through the smart grid. The days of the system control panel are basically over then. When plugged into the grid, the optimization of those components will happen on a server somewhere; the operator interface will be a smart phone or whatever they dream up next."

Manufacturers also foresee greater standardization among controls, even the "Holy Grail" of controls interoperability: "For commercial buildings, it's going to have to be smart grid communications. Technology will have to be integrated into the design of the HVAC systems—plug and play. Predetermined control strategies that work in communication with the smart grid will have to be incorporated into the [HVAC equipment] design."

Building owners were split about 50 percent providing informed responses and 50 percent throwing their hands in the air and guessing at controls or sidestepping the question. Those who answered the question cited developments in controls or in buildings or equipment performing smart grid functions, such as demand management. However, very few interviewees elaborated. Among the owners, verbatim responses worth noting are below.

- "[I foresee] HVAC systems responsive to demands of the grid – load shedding, with pricing structures to make that more attractive."
- "I see that the individual controllers will have to be a lot more cooperative with how they communicate…both within a facility and between buildings…Facilities. I think the devices will have to be a lot more flexible; they will have to understand how to cooperate with a lot of different thing at the same time."
- "What GSA is struggling with now is integrating systems using BACnet with other IT systems. So, the biggest challenge is to bring together smart grid with everything else people are doing over the Internet. The smart grid is another type of IT system to be integrated on IT networks."

These points are very strong, but I wouldn't include the verbatim responses. Researchers also asked if specific technologies would promote smart grid adoption, namely:

- Better integration of HVAC, controls and lighting
- More use of thermal storage for shifting loads
- Demand response for dimming lights, resetting thermostats, etc.
- Internet access for large equipment, such as compressors

Figures 5a, 5b, 5c, and 5d diagram the responses for each sample set and for the average of all respondents. Better Integration received the highest number of positive responses, followed by Demand Response and Thermal Storage. Data for each of the technologies is detailed below.

Integration of HVAC, Controls, and Lighting

Integration was viewed widely as a promoter of smart grid adoption. Some saw it as a way to increase building efficiency overall, not just as a way to interact with the smart grid. For example, one engineer stated, "Lighting and HVAC don't know what the other is doing, but they interact with each other. If I had more control than on/off, I'd reduce lighting, which would reduce cooling load on HVAC. So this would improve my response to pricing signals." An owner put it pragmatically, "Yes, absolutely. The more one-stop shop you have, the better off you are."

One outlier response by an engineer who answered "no" to Integration was based on his concerns with the pace of integration today. He said, "No--because I don't know if it will drive. I've been seeing it get pushed for over five years and people still aren't doing it. So will smart grid really make a difference?" Another engineer's response was similar, but his response couched an eye toward fixing the problem, "Right now for complex building projects you'll spend an extra 1 percent for integration. If that were more evened out using protocols, it would help drive down costs and promote more adoption rather than on a project by project basis."

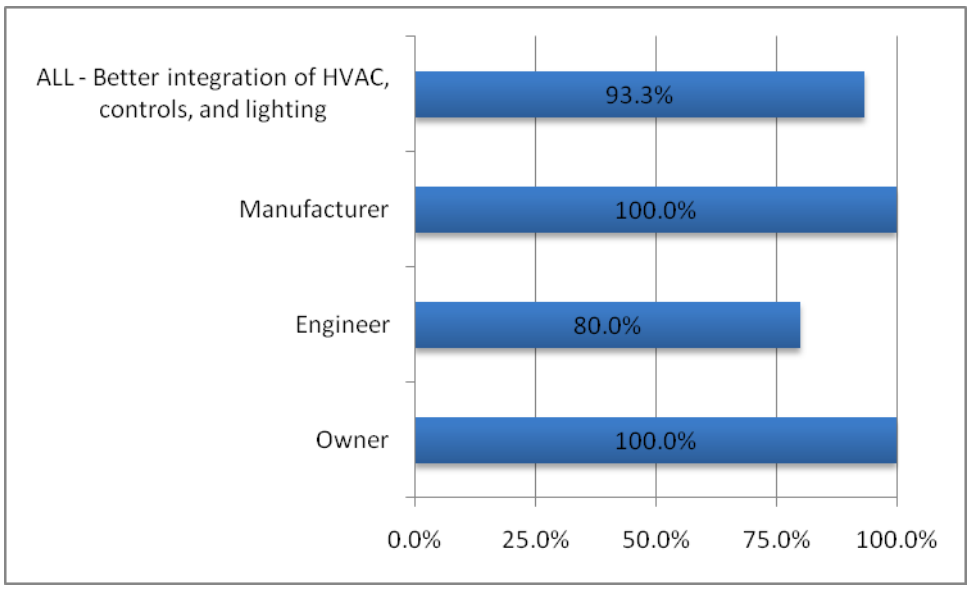

Figure 5a: "Yes" responses to impact of better integration of HVAC, controls and lighting.

Thermal Storage

Thermal storage was not as positively viewed, especially by owners. Two owners registered "no opinion" responses because they did not know enough about thermal storage to give an informed opinion. Two of the three "no" responders said that thermal storage was dependent on load profile--it required large building loads to be cost effective.

It is interesting to note one of the interviewees who answered "no response" works for a university that uses thermal storage—he indicated he did not see it as an application suitable for widespread use. Another owner made the same point, but couched in a "yes" response: "Absolutely, but driven by size of building. You can't do that for a 4-unit apartment building."

Engineers and manufacturers agreed that thermal storage would be beneficial for shifting thermal electrical loads to off-peak hours when rates are less expensive. For example, one engineer commented, "Yes, because you have the ability to shift your loads; especially if you can shift loads off peak. I've been a fan of thermal storage if you have the room and way to incorporate it into your operations. But without economic incentives…and the technology have been less than stellar in past 15 years and people have had to abandon it. So if it evolves, it'll be good."

One owner who said "no" to thermal storage mentioned footprint and load profile, but seemed to agree that thermal storage would be a viable technology in certain situations: "Thermal storage takes footprint; and it's an investment that requires a large load profile. If you get your peak down, great."

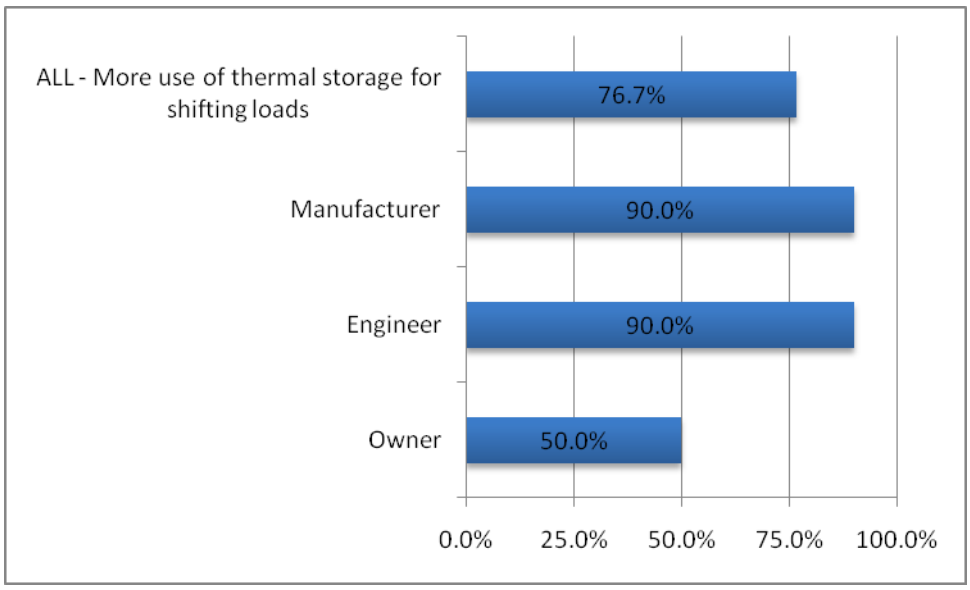

Figure 5b: "Yes" responses on thermal storage as a promoter of adoption of the smart grid.

Demand Response

Almost all respondents viewed demand response positively. Some respondents, however, had important caveats in their answers that should be noted. The reservations centered on how much control over their facilities owners are willing to give utilities. Said one owner, "Yes, but control sequence must be endorsed by the owner—the owner would dictate turndown strategies." The one "no" response among owners echoed this reservation, "We have classrooms…I can't imagine the utilities would have a response for us for changing what's inside our classroom."

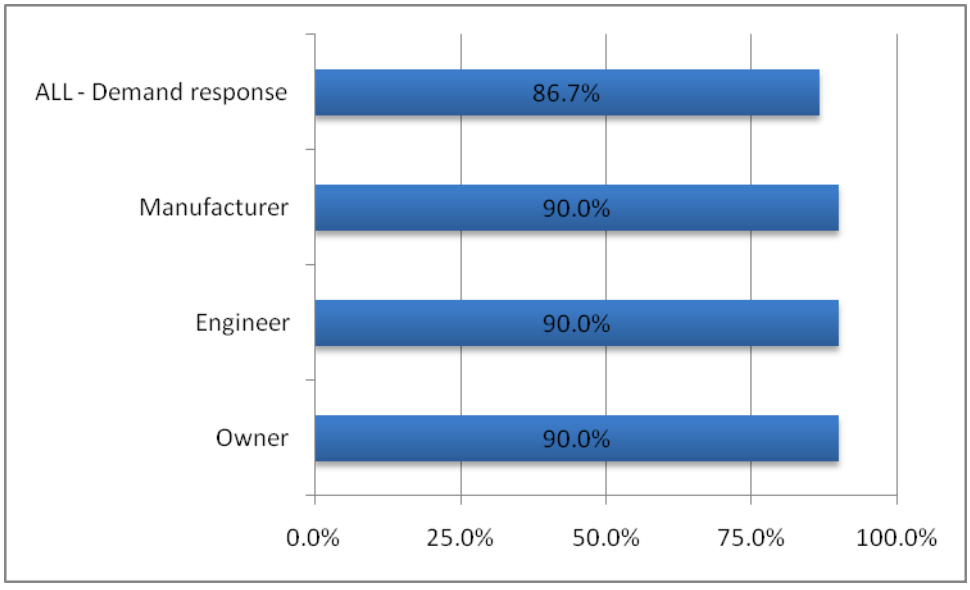

Figure 5c: "Yes" responses to use of demand response as a promoter of adoption of the smart grid.

Engineers expressed concern about controllability issues. Yes, demand response is a good idea, but it could cause problems. One engineer commented, "Yes, if we can do it well. I suspect people will say 'That will never work' because they've been burned from unreliable systems." Another engineer responded, "I'm not a fan of it personally. Automated demand response is one of the things coming

because of smart grid. My worry is building owners won't like it because it would automatically do things in buildings…it will automatically reduce HVAC…"

One of the reasons some building professionals fear or dislike demand response is they believe turning down lights and HVAC thermostats will impact occupants. As one manufacturer said, "I think there is more use of demand response to reduce peak demand. The only thing you have to be concerned about is…for instance, green buildings talk about comfort and productivity; if people are less comfortable [the implication is] they are less productive. With energy being 100th the price of a person [salary] per square foot, it will not be acceptable to have people become less comfortable from demand response."

Internet Access for Large Equipment

Providing large equipment with direct Internet access to the smart grid was the least-favored technology for promoting smart grid adoption. Some viewed it as a security risk; others as just not being needed. Those who spoke in favor of it cited the inevitability of all equipment having built-in communications. Said one manufacturer, "I think that will be a requirement of manufacturers to integrate communications capabilities into their systems. I guess the answer is yes, but it translates more into a requirement to get to what manufacturers want to do. As this starts unfolding, this will be on the list of must-haves to tie into the grid."

A very forward-looking owner who has very expensive equipment in his facility saw Internet connectivity as a potential benefit to increasing the service life of equipment, "Some of the benefits I can see right there is if I have a particular unit that knows there's a catastrophic failure coming before it comes, it can go to a self-preservation mode within that unit. Looking at equipment—how would you want to operate if you know it would lose power or if dirty power was coming in. If info could be fed forward, you're not just looking at utility savings but hardware savings. People have to see that. Say equipment life is 5 years, because of dirty power from utilities. Would smart grid take it to 10 years?"

Confirming their answers to the unprompted question about HVAC technology developments five years from now, engineers tend to want building controls and smart grid interaction to be centralized. Said one engineer, "You're talking specifically about a compressor; you'll have to integrate the whole HVAC…for components, no you have to integrate the whole system." Another stated, "I see the BAS as being the gateway." Even one of the "yes"-responding engineers qualified his answer toward the BAS, "Moderately at best. There's a level of granularity below that that needs to be advanced rather than having large pieces of equipment being enabled."

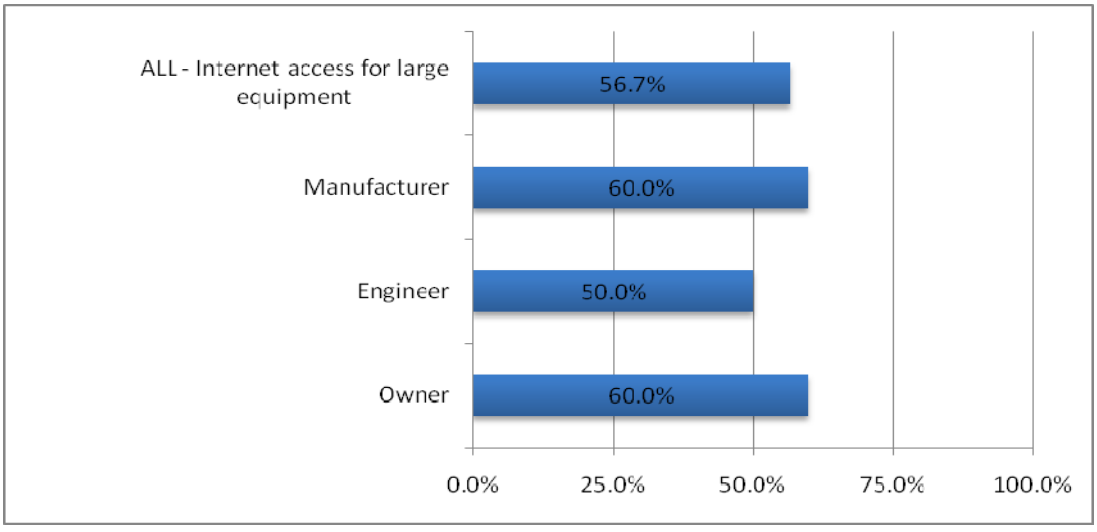

Figure 5d: "Yes" responses to Internet access to the smart grid would promote adoption.

Summary Conclusions and Insights

Numerous insights resulted from this study, which could help accelerate development and adoption of the smart grid, especially among commercial building owners. The following are conclusions and recommendations for companies and individuals that endeavor to accelerate the development and adoption of smart grid technologies.

Regarding Owners

A major emphasis of this study was determining what owners perceive as barriers and benefits of the smart grid, what will motivate them to invest in smart grid technologies for their buildings, and what technologies they view positively. The following are insights based on analysis of the data.

In the immediate future, utilities need to expand communications with owners. Owners need more instruction on what the smart grid is or will be, and what the value proposition is for them, their buildings and their tenants. As part of the instruction, owners need specific information on first costs and operating costs and an accounting of what the benefits will be so they can make decisions based on return-on-investment, payback or whatever criteria they use.

The data show that most, but not all, owners will expect financial incentives to buy down procurements first-cost and operating expenses. Owners are not dwelling on security and privacy concerns. They view these as starters, not motivators.

Currently, smart grid communications from utilities emphasize reduced power outages and durations of power outages, and the ability to integrate solar and wind generators and facilitate plug-in electric vehicles. By and large, owners are not highly motivated by these capabilities. Other than cost considerations, owners were more responsive to enhancements to energy-usage reporting that would help them operate their buildings better.

One interesting data point worth paying close attention to came from the COO of a pharmaceutical plant. He voiced many complaints about power quality, saying that it caused premature wear-and-tear on expensive equipment that then had to be replaced more quickly than it should at high capital expense. He also said that other industrial owners are having similar experiences and, altogether, industrial building owners show widespread disapproval of the quality of the U.S. electrical grid.

Data indicate that both operational and financial issues equal weigh on owners. In addition to fixing controls, some buildings may need operational refinements such as staff training and development of new managerial functions and accounting systems. Having available time may also be an issue, however, as one respondent opined, “If it’s important enough, owners will make time for it.”

Regarding Utilities

Utilities were not included as a sample set in this study, but the findings will help them develop and administer smart grid programs to serve owners. Here are a few conclusions that would benefit utilities in particular.

Owners are very interested in obtaining more energy-usage data, which they could use to improve operations. Utilities may want to develop enhanced energy reporting services and promote them as a service enhancement reserved for customers enrolled in smart grid programs.

Utilities need to differentiate. Not all owners have the same needs, sensitivities, priorities and resources. There is a clear need for utilities to develop smart grid solutions and methods of communicating them to niche markets.

Utilities can apply lessons learned from other growth markets for energy services. To get buildings to integrate well with the smart grid, their controls in many buildings will have to be improved first; otherwise, smart grid strategies could exacerbate building conditions such as comfort and indoor air quality, and even energy consumption. Given the surge in retro-commissioning activity in the United States over the past five years, utilities may want to consider providing rebates for smart grid audits similar to the rebates they provide for audits and studies associated with retro-commissioning.

Regarding Engineers and Commissioning Providers

The smart grid provides a structure for buildings to respond to price signals if the buildings' settings and control systems are optimized to respond to these factors. Building designers and OEMs will need to have a thorough understanding of control strategies and technologies for demand response, pre-cooling, demand limiting, etc. in order to capitalize on the full potential of the smart grid.

Commissioning providers will also require supplemental training and education on smart grid related control strategies and technologies. Providing "smart grid services" will become a growth market akin to the growth of LEED consulting and the fields of commissioning and retro-commissioning.

Regarding Products and Technologies

While there appears to be traction on the smart grid's promises involving renewable energy and plug-in electric vehicles, owners would more widely appreciate a focus on the development of a value proposition that reduces first costs and operating costs.

HVAC equipment and controls firms are actively engaged in smart grid product development. Most offerings are or will be focused on enhanced communications capabilities, leading to better integration with networks tied to the smart grid. Some of these networks may not involve building automation systems.

Thermal storage systems positioned in the market as a smart grid technology for shifting electricity consumption associated with comfort cooling to nighttime (off-peak) rates. Although it scored highly overall as a motivating technology, data show that a high fraction of building owners are either unaware of how thermal storage works, or they believe that thermal storage is not appropriate for most buildings.

Manufacturers are hard at work making their products smart grid capable, which, to them, means they will be able to communicate on networks beyond building automation systems, will be more efficient at part-load conditions and will be able to ramp up and down as needed in a controlled fashion. As one manufacturer put it, the smart grid will "end the control panel as we know it."

However, the capability of allowing large equipment to communicate directly with the smart grid via Internet connections ranked low among perceived benefits, indicating that integrated systems and internal networks controlled by the owner are more desirable at this time.

While owners, engineers and manufacturers view demand response as a technology that will accelerate smart grid adoption, they caution that owners will not want to relinquish control of their facilities to utilities. Utilities offering automated demand response programs, which are among the most important smart grid technologies, will need to carefully tailor program rules and communications to consider "owner autonomy" issues.

Smart Grid Market Developments

The data show engineers will try to keep smart grid integration tied to building automation systems. The data also indicate that some will have the knowledge, experience and customer support to integrate smart

grid approaches with sustainability or green-building approaches. These approaches will push the envelope of integration by using smart grid sequences of operation (such as demand response and pre-cooling) to involve natural/passive cooling and ventilation approaches.

These approaches will require very high-end controls solutions reserved for signature buildings. When such projects appear, they should be carefully studied for performance before being publicly declared winners; otherwise, attempts to recreate them in other buildings may be premature (the systems in the signature buildings will not work) or the subsequent installations will not be properly engineered, installed or operated. Early failures can do more harm than the good intended by premature ballyhooing of smart grid technology application.

However, as some owners mentioned, appearing trendy or cutting edge can benefit the real estate value or performance of a building, so having signature buildings publicize smart grid capabilities could inspire other building owners toward smart grid solutions that are not as high-tech, but smart grid nonetheless.

The smart grid trajectory for market penetration will likely follow the Everett Rogers Technology Adoption Lifecycle (Figure 6). It is difficult to guess where commercial building owners will place on the curve for smart grid technology. Certainly, it will vary by state and by utility district. Regulations will play a roll, as well, such as whether time-of-use pricing structures are allowed. It can be assumed that the leading states would be in the early adopter to early majority levels for commercial buildings, and most of the other building owners in the late majority.

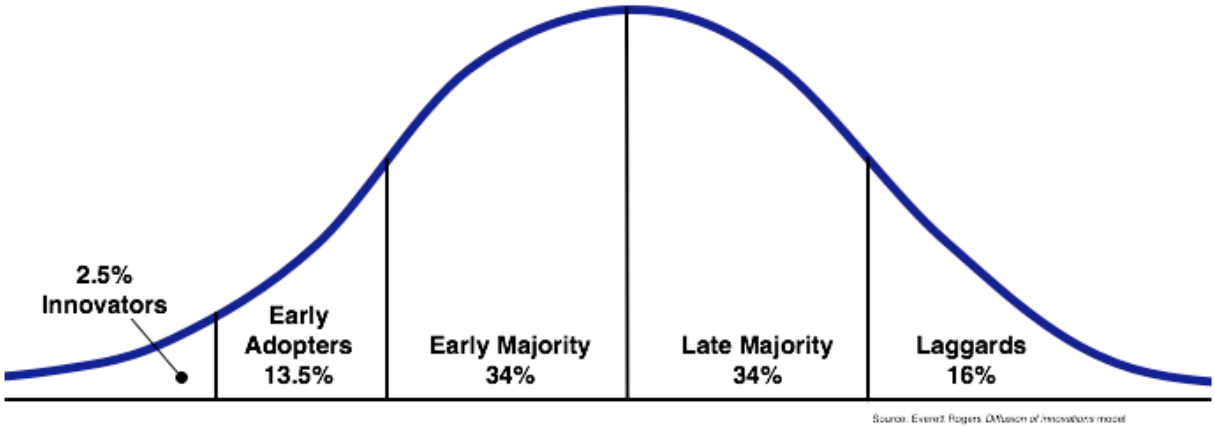

Figure 6: The Everett Rogers Technology Adoption Lifecycle, downloaded with permission from Wikipedia, http://en.wikipedia.org/wiki/File:DiffusionOfInnovation.png.

Many of the respondents mentioned that equipment standards, communications protocols and other foundational elements for technology development and application have not yet been completed. The National Institute of Standards Technology (NIST) is leading the development of these standards and protocols. Adoption of the smart grid will accelerate as these foundations are built and released to the public.

Final Insight

Although 52 percent of the interviewees said they were activity engaged in smart grid activities, only 13 percent said the full potential of the smart grid would be a reality in United States in the next three to five years, and 43 percent of them said it was unlikely. These figures illustrate that the smart grid is seen as being very early in its development, and, in some ways, that's very true. For example, NIST is still working on many of the technology and protocol standards; however, demand response, pre-cooling, thermal storage and demand limiting are practiced widely in many regions of the country. From a

building perspective, much of what commercial building owners will need to do to be smart grid-compatible is already possible. But, as one engineer said regarding thermal storage, “We don’t use the technologies we have now to shift loads.”

For that matter, the same is true for building technologies across the board for energy efficiency, indoor air quality, acoustics, etc. Unless smart grid adoption is compulsory, smart grid technologies will be competing with all of the other things buildings owners can invest in to make their buildings better, including gold-plated plumbing fixtures and marble floor tiles.

Therefore, establishing a credible high-ROI value proposition for building owners for investing in smart grid is critical. Additionally, that value proposition has to be communicated widely and frequently to building owners so they get the message. They are looking for this value proposition now, but what they are finding is that the promises and descriptions of advancements to come are not important to them today.