

POWER SYSTEMS OF THE FUTURE: THE CASE FOR ENERGY STORAGE, DISTRIBUTED GENERATION, AND MICROGRIDS

SPONSORED BY IEEE SMART GRID, WITH ANALYSIS BY ZPRYME

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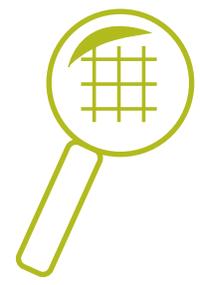
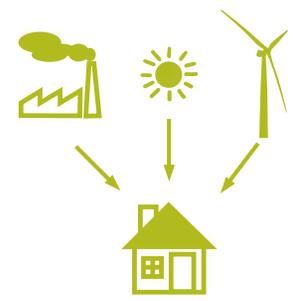
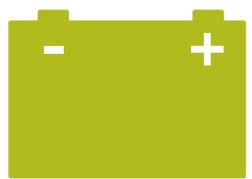


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Executive Summary

Collectively, energy storage, distributed generation, and microgrids will drive the evolution of energy markets over the next five years. These technologies will increase the adoption of the smart grid, and spur new markets for software and systems that integrate these technologies into modern and future energy systems. In fact, this inaugural report developed by Zpryme's Smart Grid Insights and IEEE Smart Grid finds that 69% of smart grid executives believe energy storage technology and distributed generation are very important to increasing smart grid development. Half (50%) said microgrid technology was very important to the development of the smart grid.

The purpose of this report is to showcase how these technologies will evolve given the rapid deployment of smart grids across the globe. Industries most likely to deploy these technologies are also examined. Further, the report highlights the major benefits that can be obtained from the deployment of energy storage, distributed generation, and microgrids.

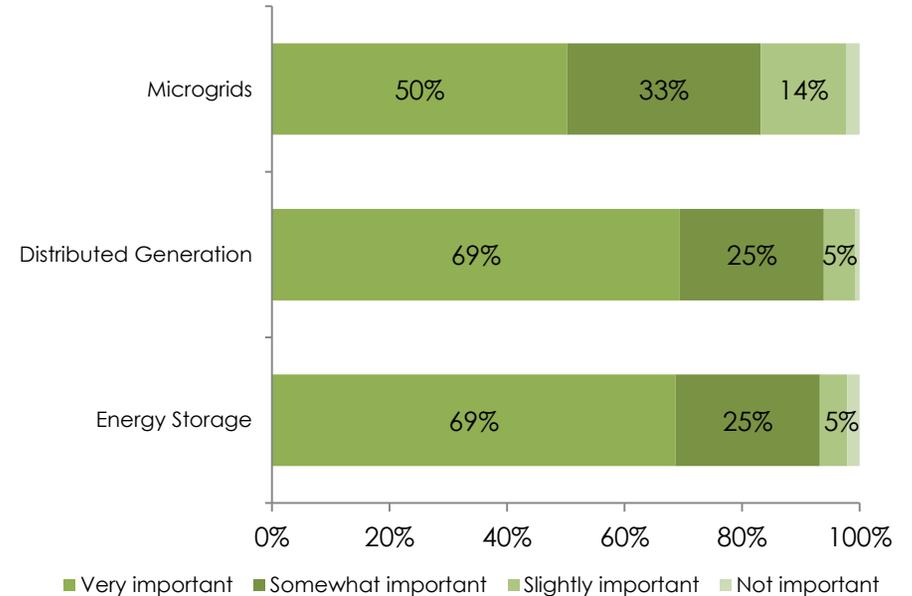
Methodology

This study was conducted by surveying 460 global smart grid executives in September of 2012. Respondents were asked 25 questions on energy storage, distributed generation and microgrids. The survey was conducted on the internet.

Due to rounding, some percentages in this report may not total 100.

How important are these technologies to increasing smart grid development?

(figure 1, source: Zpryme & IEEE)



Key Findings

Energy Storage

- The top three rated benefits of energy storage were to meet peak demands, to improve power reliability, and to reduce costs.
- The biggest challenges hindering energy storage adoption were costs, deployability, and lack of standards.
- The storage technology with the highest demand over the next five years will be lithium-ion battery systems.

- The global region with most growth in energy storage over the next five years will be North America.
- Thirty-five percent of respondents indicated global capacity for grid-scale energy storage would increase up to 5 gigawatts over the next 5 years. Another 33% said global capacity would increase by 5.1 gigawatts to 10 gigawatts over the next 5 years.
- Government-backed R&D, industry R&D, and private/venture capital are the areas of highest importance when it comes to storage technology development.
- The enabling technologies that were most important for integrating grid-scale storage were: energy management systems, distribution management systems, and communications technologies.

Distributed Generation

- The top three benefits of distributed generation were: supply can be added where needed, reduced infrastructure costs, and improved power reliability.
- The distributed generation technologies most in demand over the next five years are solar and wind.
- Industries most likely to deploy distributed generation were: utilities, residential, manufacturing, and government (non-military).

- Europe is the global region likely to see the most growth in distributed generation in the next five years.
- Twenty-eight percent of respondents indicated global capacity for distributed generation would increase by 10.1 gigawatts to 15 gigawatts over the next 5 years. Another 22% said global capacity would increase by 5.1 gigawatts to 10 gigawatts over the next 5 years, while 21% said global capacity would increase by more than 20 gigawatts over the next 5 years.
- The integration of renewable energy sources is most important to the deployment of distributed generation technology.
- Enabling technologies that were most important to successful deployment were: distribution management systems, energy management systems, and communications technologies.

Microgrids

- Benefits of microgrids most often chosen were to meet local demand, to enhance grid reliability, and to ensure local control of supply. Because microgrids contain technology from distributed generation and storage, the challenges from those two technologies are transferable to microgrids.
- The top three industries most likely to deploy microgrids over the next five years are healthcare/hospitals, government (military and non-military), and utilities.

- Europe is the global region that will see the most growth in microgrids over the next five years.
- Thirty-nine percent of respondents indicated global capacity for microgrids would increase by up to 5 gigawatts over the next 5 years. Another 28% said global capacity would increase by 5.1 gigawatts to 10 gigawatts over the next 5 years.
- The need for standards was more important for developing microgrids (when compared to distributed generation and energy storage).
- Enabling technologies that were most important were: energy management systems, distribution management systems, communications technologies, and sensors.

Overall Conclusions

1. External funding from both the private and public sector are still needed to develop microgrids, distributed generation, and especially grid-level storage. Funding for both R&D and for projects and pilots will assist in developing more cost effective solutions for these technologies, and enable utilities and end-users to validate the business case for these technologies. Pilots and projects will also assist in developing a set of best practices when it comes to installation, application, and optimization of each of these technologies.
2. Europe leads the world in adopting/utilizing distributed generation and microgrids, whereas

North America is prominent in storage technology. Aggressive smart grid deployment, emission reduction, and renewable resource targets are fueling the demand for these technologies in both Europe and North America. Thus, look to these regions to take the lead when it comes to developing and deploying next-generation distributed energy systems. These two regions view the advanced electric grid as a gateway to innovation, energy independence, and economic security.

3. Energy management systems, distribution management systems and communications technologies were found to be the most important enabling technologies for distributed generation, microgrids, and energy storage. The distributed energy systems of the future must be able to interact and connect across to centralized and decentralized electrical networks. They must also be able to support advanced grid services such as net metering, load aggregation, and real-time energy monitoring. Last, applications delivered in the cloud will likely dominate the market.

Emerging Themes

The key findings in this report reveal strong growth potential for energy storage, distributed generation, and microgrid technologies. The findings provide a framework for increasing the adoption of these technologies. We have developed seven key themes that can be considered collectively or independently by stakeholders to develop detailed technology and planning roadmaps for each of the three technologies.

1. **Emergence of Distributed Energy Systems:**

Distributed energy systems will increasingly be used to meet the electricity demand of the future for utilities, residential, commercial and industrial customers. These systems will serve different functions and offer various benefits depending on the specific needs of end-users. For example, an eco-friendly city in the U.S. or the U.K may build a microgrid to support the energy needs of their local government. In turn, this would lower the community's carbon footprint and reduce the city's overall electricity expense. Alternatively, a rural community in India, China, or Brazil may build a microgrid to provide its residents with a reliable source of electricity. Initially, utilities must lead this effort, but it will be residential, commercial and industrial users who will ultimately be the largest end-use market for these systems.

2. **End-Users Must Drive Demand for New Energy Systems:**

Technology prices cannot come down or mature without customer demand. Further regulation, policies, or subsidies cannot create a viable or competitive market on their own.

Significant investments in customer awareness and education and marketing have to take place if customer demand is going to increase for energy storage, distributed generation, and microgrids. Governments often support R&D for new technologies, but they should also support the customer education and education efforts of utilities and manufacturers.

3. **Market Driven Innovation:** Innovation will lead the market for energy storage, distributed generation, and microgrids from an introductory phase into a high growth phase. Innovation is also the key to creating a sustainable competitive advantage in the market for each of these technologies. Manufacturers are closest to their customers and must therefore closely integrate customer feedback into their R&D roadmaps.

4. **Increased Stakeholder Coordination on R&D, Funding, and Standards:** Coordination efforts on standards, R&D, and funding have often been a strong point for the electricity industry, but these efforts have fallen short when it comes to energy storage, distributed generation, and microgrids. Increasing stakeholder coordination on R&D and funding can streamline overall industry efforts to drive down technology costs. Further, tying R&D and funding to performance milestones will also help in advancing technologies that show the most promise.

5. **Digital Energy Systems:** Energy systems will become increasingly digitized or connected to support advanced smart grid functionality, and distributed

energy systems. Interoperability is another element of digital energy systems that will be essential to fulfilling the promise of energy storage, distributed generation, and microgrids. In the future, it should be just as easy for a utility to install distributed solar into their system as it is for a rural community to install a microgrid. This future is only achievable when a significant portion of the modern electric grid is intelligent enough to integrate many types of technologies with vastly different uses and characteristics.

6. **New Revenue Streams and Third-Party Providers:**

Energy storage, distributed generation, and microgrids offer utilities and end-users the opportunity to create new revenue streams by selling power back to the grid, and from the management of distributed energy systems. Additionally, start-ups, niche energy service firms, and conglomerates will enter the market as service providers who focus specifically on integrating and managing these technologies for commercial and industrial users. Third-party providers will generate revenues from selling power into energy markets and by earning service fees from the end-users.

7. **Adoption of Sustainable Cost/Benefit Analysis**

Model: Driving down the costs of energy storage, distributed generation, and microgrids is one of the major challenges to advancing the deployment of these technologies. That said, environmentalists, academics, economists, NGOs, and major corporations have long made the case for developing sustainable and environmental data as a core input when considering new projects or

investments. Thus, it is now time for the rapidly changing utility industry to re-evaluate the way they make investment decisions in emerging technology. A transition to a sustainable cost-benefit analysis may in fact speed up the adoption of emerging technologies as their relative costs may significantly decrease using a new analysis framework. Analytical frameworks such as life-cycle analysis (LCA), environmental cost-benefit analysis, sustainable cost-benefit analysis, and green building cost-benefit analysis all provide foundations for the development and an advanced cradle-to-grave economic analysis approach for valuing emerging technologies.

Clearly, such a framework will rely heavily on the availability of relevant data, but the industry should consider that data or inputs that are not available today are likely to be available in the near future. Thus, a lack of data should not inhibit the development of a new framework for valuing emerging technologies.

Assessment, Implications, and Recommendations

The survey results (presented in figures 2 – 27) in this report offer key insights about the market opportunities for energy storage, distributed generation, and microgrids. In this section we present our assessment about each respective technology, the major implications of the data, and recommendations that can assist in advancing the deployments of these technologies.

Energy Storage

Assessment

Over the next five years, the market opportunity for grid-scale energy storage is expected to be strong, especially in North America, Europe, and Asia. In order to ensure the market can live-up to its potential over the next five years, utilities, vendors, investors, and governments must work closely together to drive down the costs of these technologies. Research labs, scientists, and academia must also do their part to push the innovation envelope.

As a whole, the industry prospects are lucrative, but individual pure players face an uphill battle when it comes to trying to stay viable over the long-run. Thus, energy storage pure players will be well served to seek partnerships with global power engineering companies who have the utility contacts and the cash that can ensure long-term sustainability for pure players.

Overall, the environment is ripe to secure new energy storage pilots and projects with utilities. The down side is that many pure players will not be able to maintain viability over the next five years. Although lithium-ion

energy storage systems appear to be the current energy storage darling, there is plenty of room for technology breakthroughs in the energy storage market. Finally, utilities and their customers will be the overall 'winners' as electrical systems will become more stable and peak power wholesale costs decrease – ultimately leading to lower or more stable electricity prices for customers.

Implications

- Grid-scale storage is a viable technology that utilities can deploy to level their load curves, especially during peak demand times.
- If the costs of grid-scale storage technologies do not significantly decrease over the next five years, the market will not realize its full potential. Industry experts from the U.S. Department of Energy, EPRI, and KEMA estimate that costs must decrease by at least 50% relative to today's costs in order to for energy storage technologies to realize mainstream adoption. If the costs do not significantly decrease utilities will continue to rely upon gas fired turbines (peaker plants) for load shifting and renewable integration.
- Lithium-ion energy storage systems will drive the grid-scale energy storage market growth. However, fuel cell energy storage systems stand to make a big impact on the market as well.
- Relative to other emerging clean-technologies such as wind or solar power, the return on investment for energy storage technologies will take longer to realize. Thus, companies seeking to win a sizeable

share of the grid-scale storage market must be willing to make a long-term commitment to investing in new technology and R&D.

- Increased adoption of grid-scale energy storage will drive growth for advanced energy management systems and distribution management systems.

Recommendations

- Utilities should build a business case for grid-scale storage by evaluating the long-term savings to the energy system. The first major savings will come in the form of a reduction in wholesale power purchases during peak demand. The next major savings area should account for decreased operational costs and outages that materialize from having a more reliable energy system.
- Grid-scale energy storage vendors or manufacturers should build their solutions to maximize the savings that can be achieved by providing supplemental power to meet peak demand.

Distributed Generation

Assessment

Distributed solar energy is poised to make distributed generation an attractive solution for utilities that need to meet the electricity needs of their large commercial and industrial customers. Further, distributed generation is central to advancing social, environmental, and broader economic goals such as raising living standards for poor citizens, bringing power to rural areas, reducing carbon

emissions, and sustaining the economic growth of rapidly growing countries that have unstable national grids. In the long-run, the grids of the future will be characterized as personal, dynamic, distributed, networked, and fairly easily to integrate into a central electric system. Thus, the importance of intelligent and enabled technologies such as sensors, IEDs, and network management systems must not be overlooked when planning small or large scale distributed generation.

Implications

- Utilities, home owners, and manufacturing facilities will increasingly look to distributed generation technologies to meet their electricity needs.
- National, regional, and state level renewable energy policies and incentives are a major force when it comes to advancing distributed generation deployments. In fact, distributed solar resources are expected to account for half of all distributed generation deployments over the next five years.
- Advanced distribution management systems will be needed to support the rapid growth and deployment of distributed generation. As distributed generation becomes more prominent, advanced distribution management systems will be needed to optimize many different distribution networks that vary in size to minimize losses, increase grid reliability, and to integrate renewable energy sources.

Recommendations

- Commercial and Industrial end users should be educated and made aware about the benefits of using distributed energy sources and technologies.
- Driven by industry stakeholder consensus and discussions, governments should set a national vision for distributed generation targets.
- Enabling technologies such as distribution management systems, energy management systems, communications, and sensors must be optimized for flexibility and scalability to ensure seamless integration into modern electricity systems. However, these same systems should also be able to account for multiple distribution resources that will play a prominent role in future energy systems.

Microgrids

Assessment

Microgrids deployments will increase significantly over the next five years. Microgrid use in mission-critical operations for governments and the military will create lucrative opportunities for manufacturers and technology vendors. Deployments and pilots in North America and Europe will also pave the way for large-scale installations in the developing world. Further, the emergence of sustainable or smart cities and communities will advance the adoption of microgrids.

The microgrid opportunity has yet to be seized by a single manufacturer or technology vendor. Thus, the next five

years will see the emergence of many firms seeking to tap into this market, but only a handful will emerge with the contacts, technology, and value proposition to survive the market shake-out.

Implications

- Rapidly growing countries and rural communities will increasingly deploy microgrids to meet their electricity needs. Additionally, hospital facilities, military facilities, and government buildings will be amongst the first to deploy microgrids over the next five years.
- Microgrid deployments will stall without the development of standards and strong industry R&D.
- An array of enabling technology opportunities will be borne from the microgrid market. Particularly, opportunities will be lucrative for providers of communications technologies, energy management systems, distribution management systems, and sensors.

Recommendations

- Microgrid developers and solution providers should optimize their offerings to meet the current and future needs of hospitals and military facilities in the developing world.
- The developing world will not be able to sustain their economic growth if they try to build centralized electrical systems/grids (such as those in the U.S.). Thus, industry stakeholders should develop

advanced distributed energy systems (including microgrids) that are scalable and affordable to meet the future energy needs of the developing world.

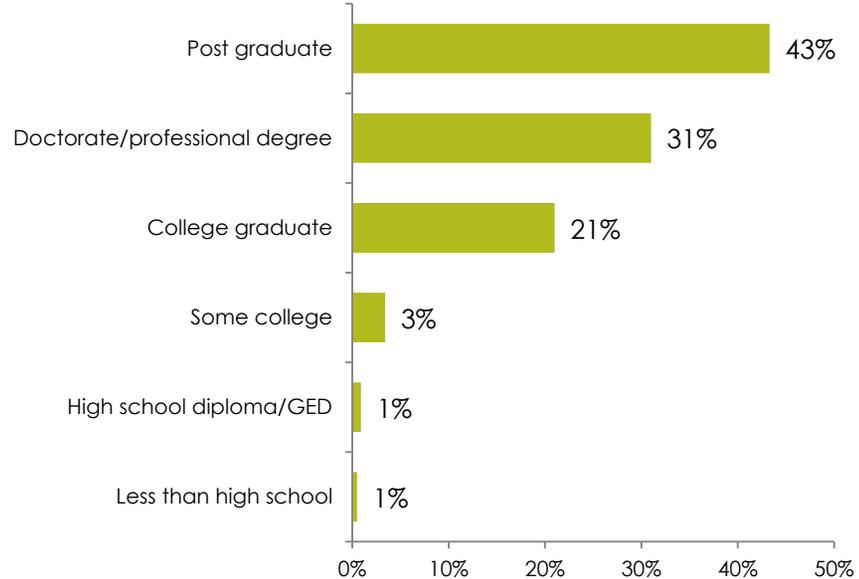
- Stakeholders should set a timeline or agenda to develop standards for microgrids.

Survey Respondent Characteristics

Education

The education level for this group of respondents was quite high. Only 2% had a high school or lower education, while 21% were college graduates, 31% had a doctorate or professional degree, and 43% recorded a post graduate education level.

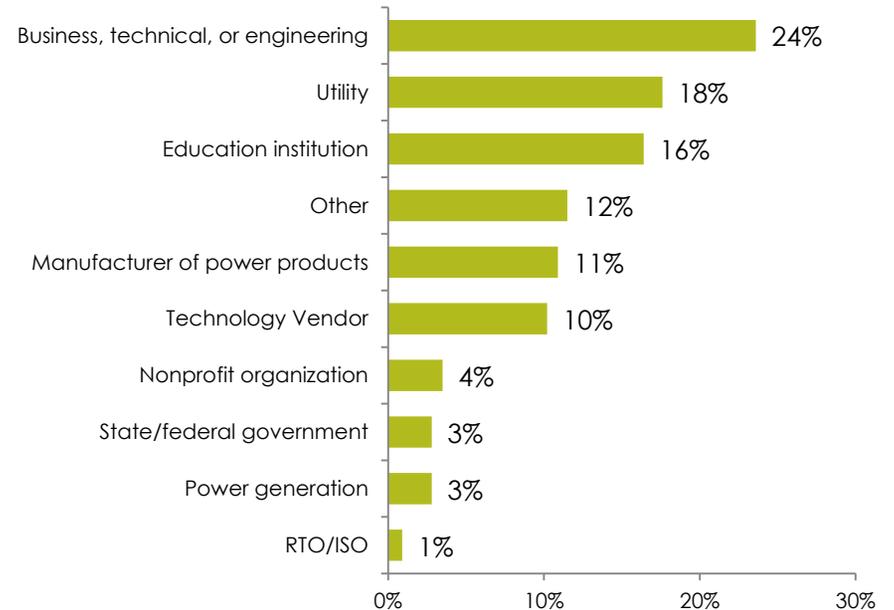
What is your education?
(figure 2, source: Zpryme & IEEE)



Industry

The top three industries that were represented were: business, technical, or engineering (24%), utilities (18%), and education institutions (16%).

What industry are you in?
(figure 3, source: Zpryme & IEEE)

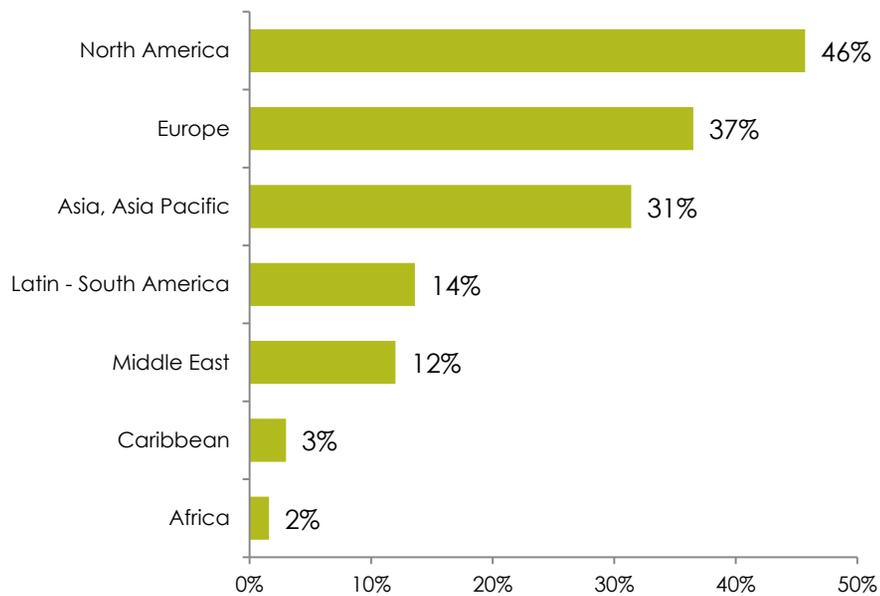


Geographic Focus

Most of the respondents' geographical areas of focus were North America (46%), Europe (37%), and Asia/Pacific (31%). Much less focus was reported for Latin-South America (14%), Middle East (12%), Caribbean (3%), or Africa (2%).

What is your current geographic focus?

(figure 4, source: Zpryme & IEEE)

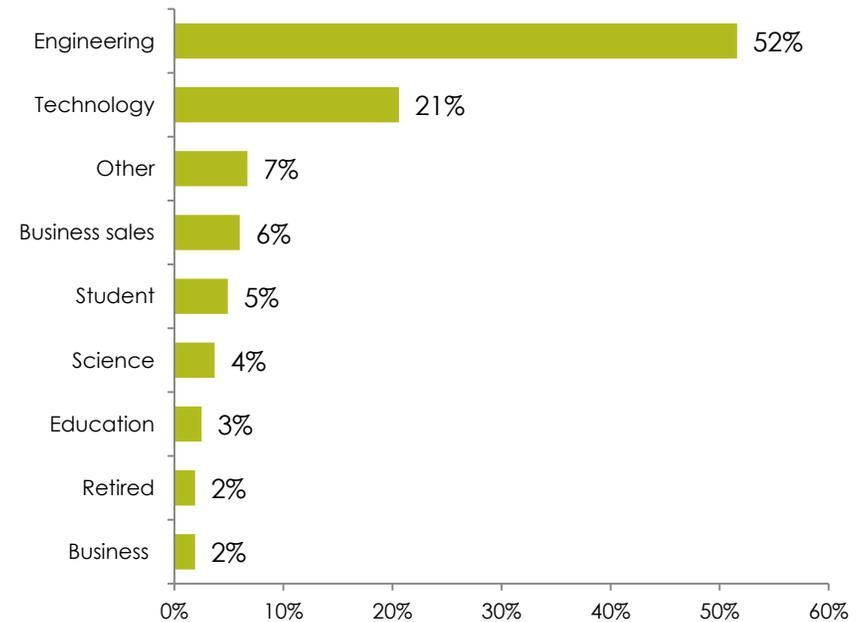


Major Occupation Field

The major occupation fields were by far engineering (52%), and technology (21%). Nearly three-fourths of the respondents were from these two fields.

What is your major occupation field?

(figure 5, source: Zpryme & IEEE)

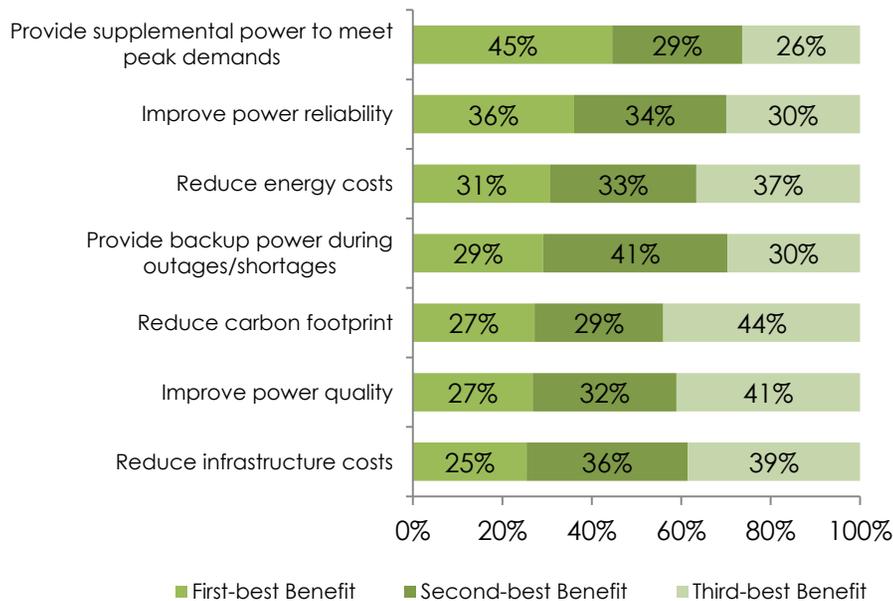


Grid-Scale Energy Storage

Top Benefits of Energy Storage

The top three rated benefits (in terms of frequency of response) of grid-scale storage were: to provide supplemental power to meet peak demands (45%), to improve power reliability (36%), and to reduce energy costs (31%). Other lower-selected benefits were: provide backup power during outages/shortages (29%), improve power quality (27%), reduce carbon footprint (27%), and reduce infrastructure costs (25%).

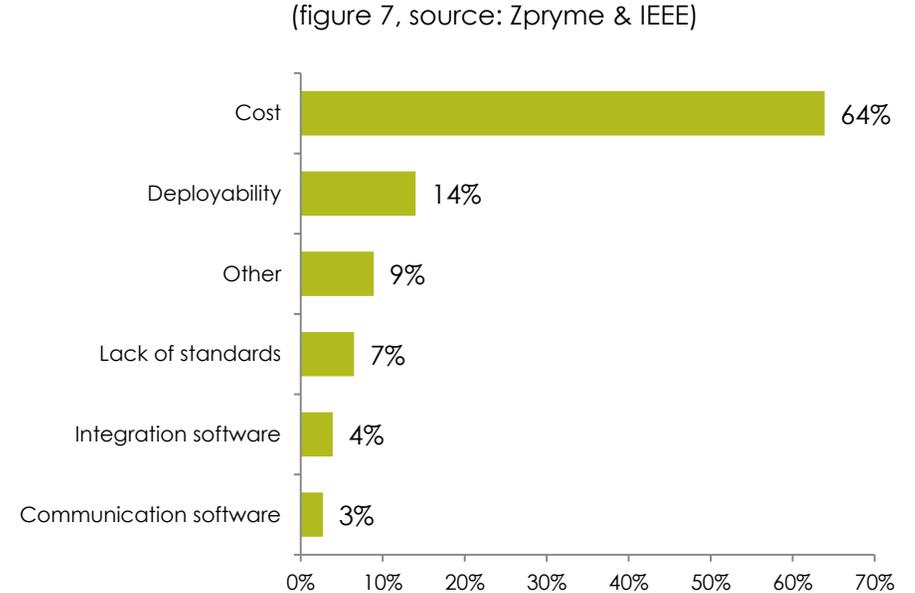
What are the top three benefits of grid-scale storage?
(figure 6, source: Zpryme & IEEE)



Challenges to Energy Storage Adoption

The biggest challenges to adopting energy storage technologies were: cost (64%), deployability (14%), lack of standards (7%), integration software (4%), and communications software (3%). Another 9% had other (not specified) responses.

What is the biggest challenge to energy storage adoption?
(figure 7, source: Zpryme & IEEE)

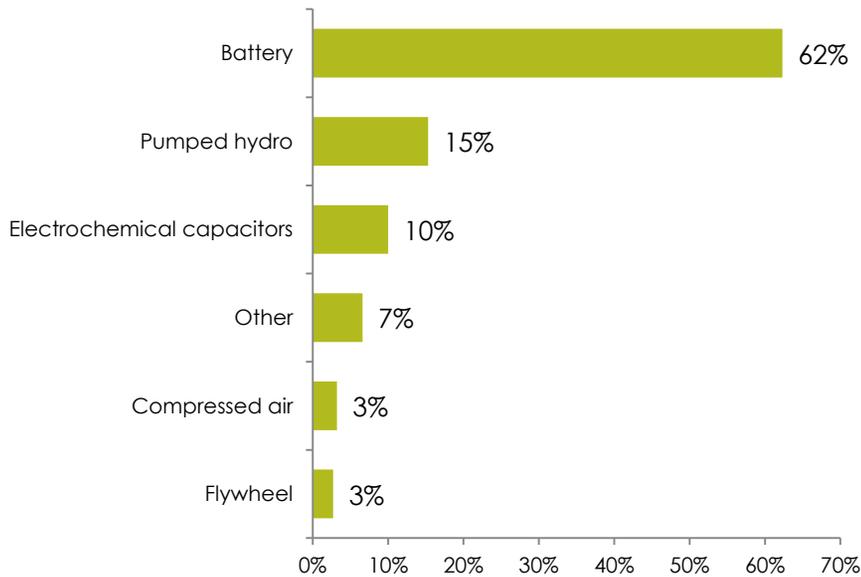


Energy Storage Technology in Highest Demand

The energy storage technologies that will be in highest demand over the next five years are: battery (62%), pumped hydro (15%), electrochemical capacitors (10%), compressed air (3%), flywheel (3%), and other (7%) not specified.

Which energy storage technology will be in highest demand over the next 5 years?

(figure 8, source: Zpryme & IEEE)

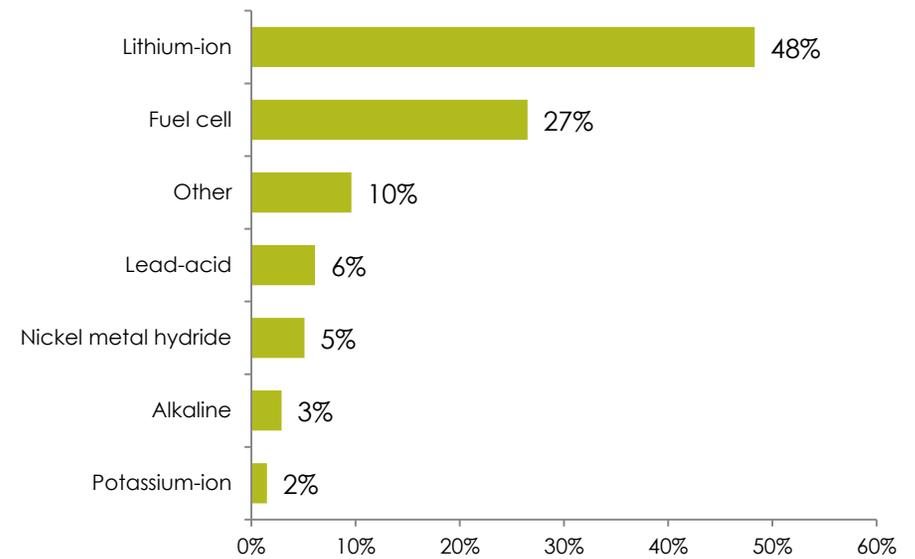


Battery Technology in Highest Demand

The type of battery chosen as highest demanded over the next five years was: lithium-ion (48%), fuel cell (27%), lead-acid (6%), nickel metal hydride (5%), alkaline (3%), and potassium-ion (2%), with 10% choosing a battery type not listed.

Which type of battery will be in highest demand over the next 5 years?

(figure 9, source: Zpryme & IEEE)

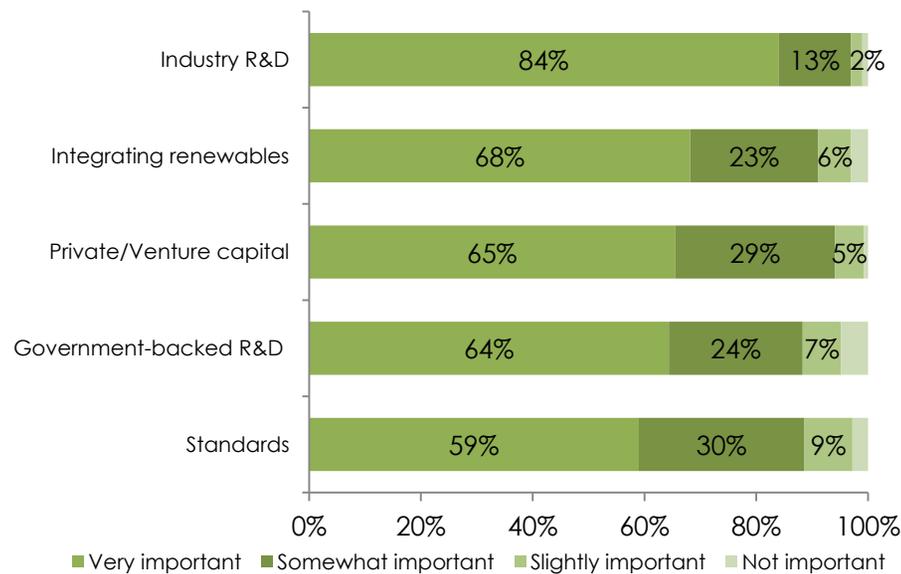


Areas Most Important for Deployment

Several areas were rated on their importance to deploying and/or developing grid-scale storage and the top three rated revealed: industry R&D (84% said very important), integrating renewables such as wind and solar (68% said very important), and private/venture capital (65% said very important).

How important are each of the following areas to deploying or developing energy storage?

(figure 10, source: Zpryme & IEEE)

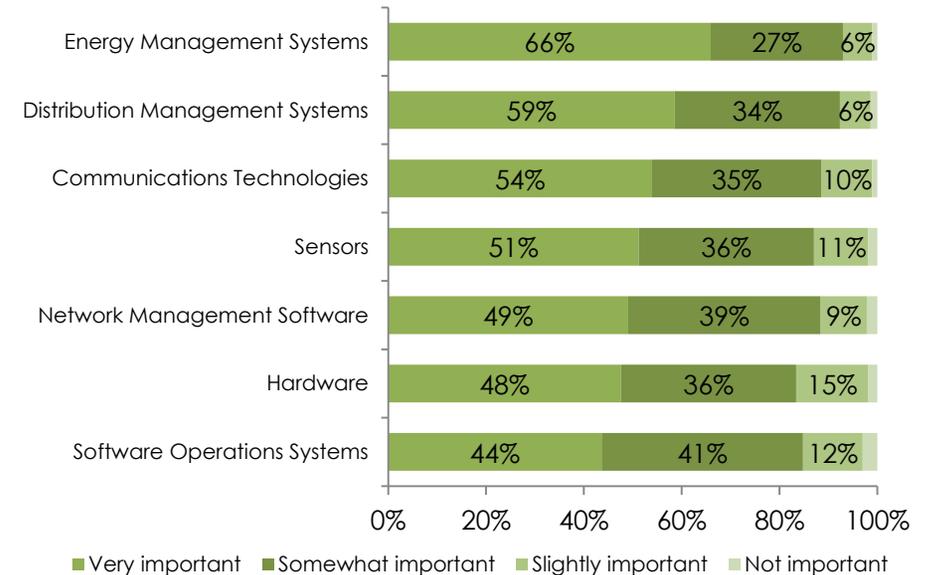


Technologies Important to Integrating Energy Storage

Separate enabling technologies were rated on their importance to integrating grid-scale storage and the top three rated revealed: energy management systems (66% said very important), distribution management systems (59% said very important), and communications technologies (54% said very important).

How important are the following technologies to integrating grid-scale energy storage?

(figure 11, source: Zpryme & IEEE)

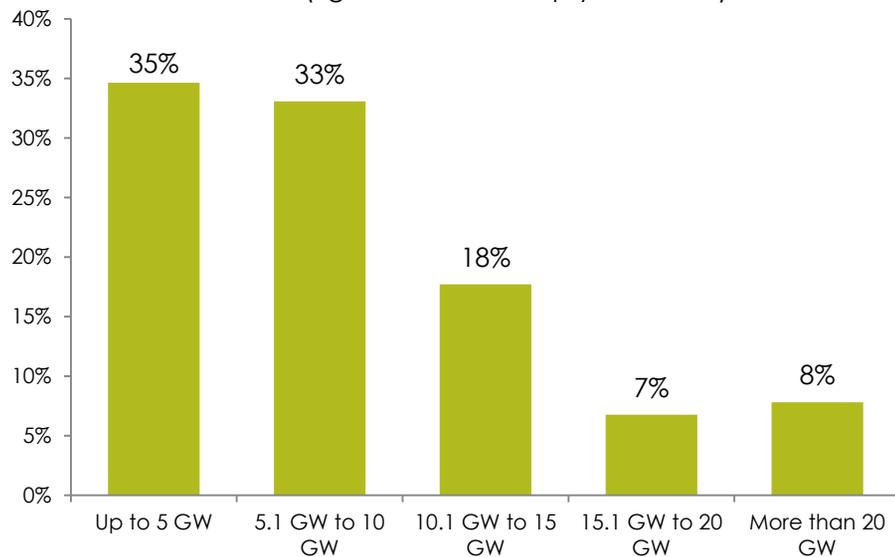


Increase in Global Capacity of Energy Storage

Thirty-five percent of respondents indicated global capacity for grid-scale energy storage would increase up to 5 gigawatts over the next 5 years. Another 33% said global capacity would increase by 5.1 gigawatts to 10 gigawatts over the next 5 years. Only 8% of respondents said global capacity would increase by more than 20 gigawatts over the next 5 years.

Over the next 5 years, how much will global capacity increase?

(figure 12, source: Zpryme & IEEE)

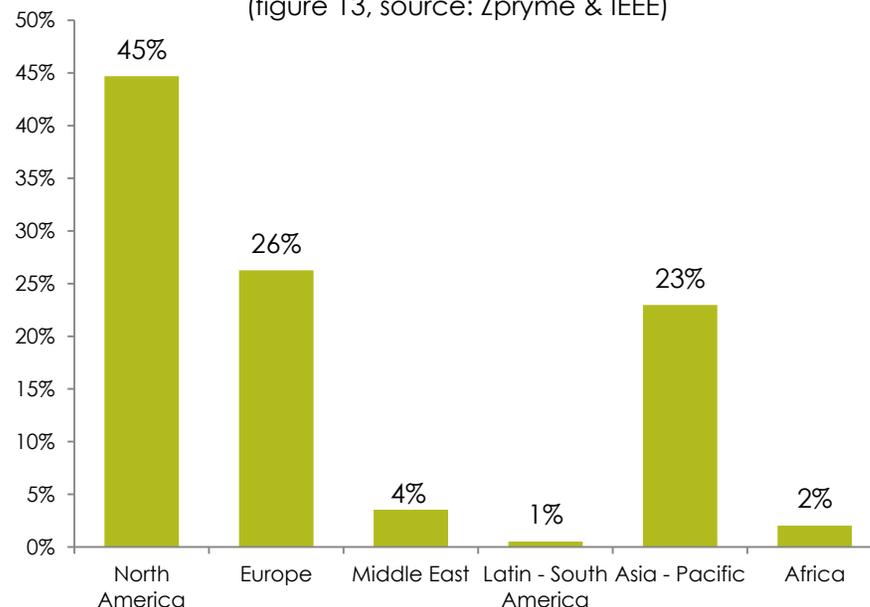


Regional Growth of Energy Storage

When it comes to grid-scale energy storage, nearly half (45%) of respondents said North America would see the most growth over the next 5 years. Another 26% said Europe would grow the most over the next 5 years. Twenty-three percent said Asia – Pacific would grow the most over the next 5 years.

Which region will see the most growth over the next 5 years?

(figure 13, source: Zpryme & IEEE)



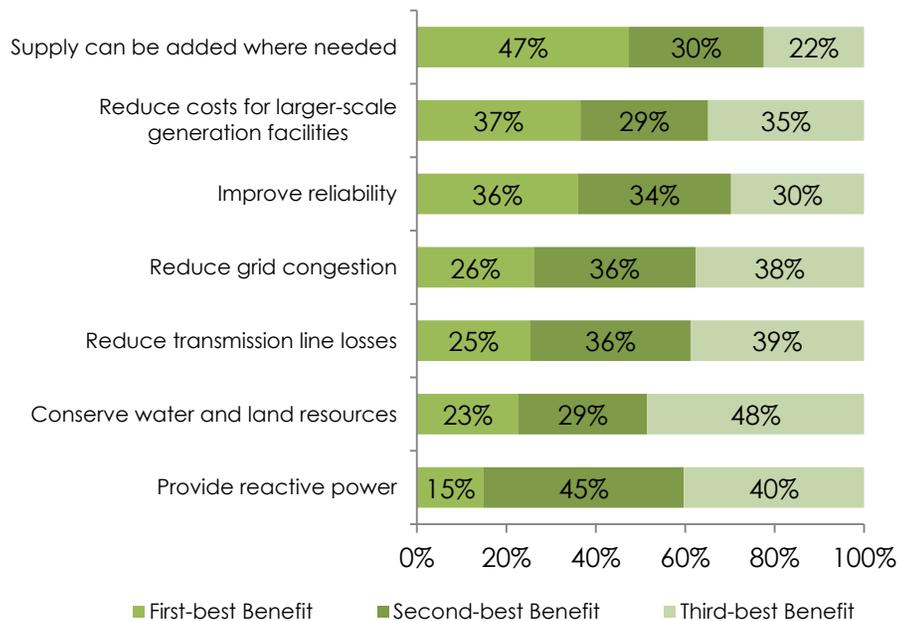
Distributed Generation

Top Benefits of Distributed Generation

The top three benefits for distributed generation were: supply can be added where needed (47%), reduces costs compared with larger-scale generation facilities (37%), and power reliability is improved (36%). The least chosen benefits were: reduce grid congestion (26%), reduce transmission line losses (25%), conserve water and land resources (23%), and provide reactive power (15%).

What are the top 3 benefits for distributed generation?

(figure 14, source: Zpryme & IEEE)

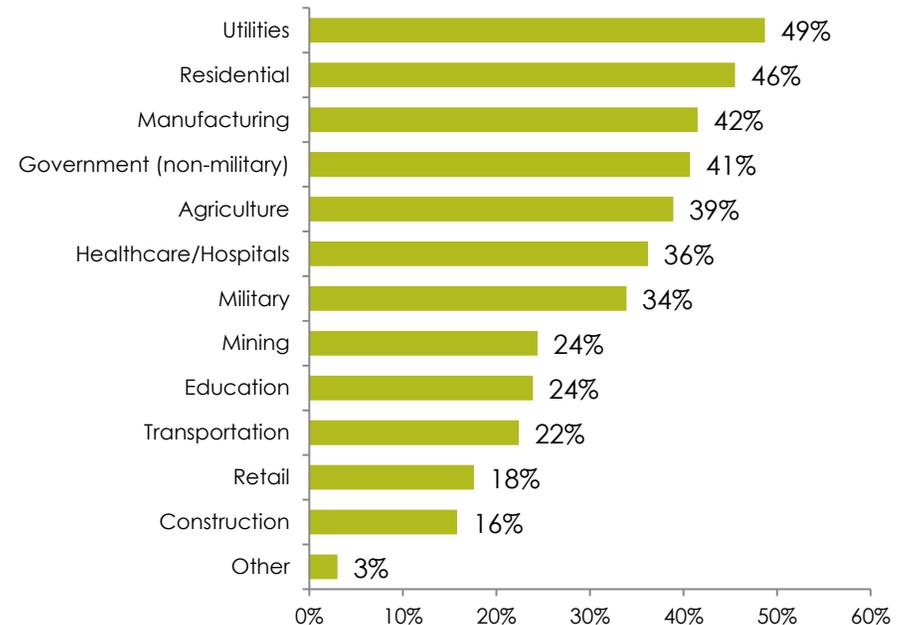


Industries Most Likely to Deploy Distributed Generation

The top three industries most likely to deploy distributed generation over the next five years were: utilities (49%), residential (46%), and a near tie for third, manufacturing (42%), and government (non-military) (41%).

Which industries are most likely to deploy distributed generation over the next 5 years?

(figure 15, source: Zpryme & IEEE)

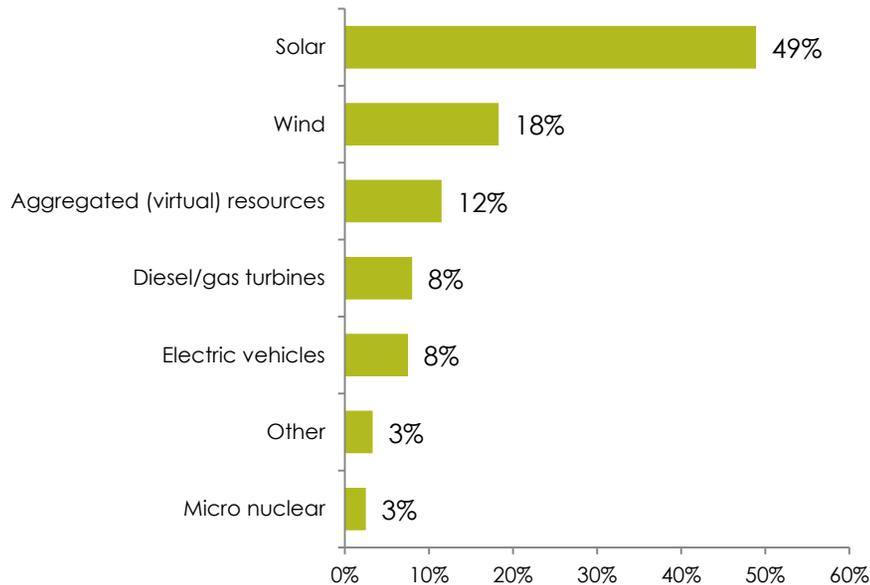


Distributed Generation Technology in Highest Demand

The distributed generation technologies that will be most demanded in the next five years were (in descending order of frequency): solar (49%), wind (18%), aggregated (virtual) resources (12%), diesel/gas engines (8%), electrical vehicles (8%), micro nuclear (3%), and other (not specified) (3%).

Which distributed generation technology will be in highest demand over the next 5 years?

(figure 16, source: Zpryme & IEEE)

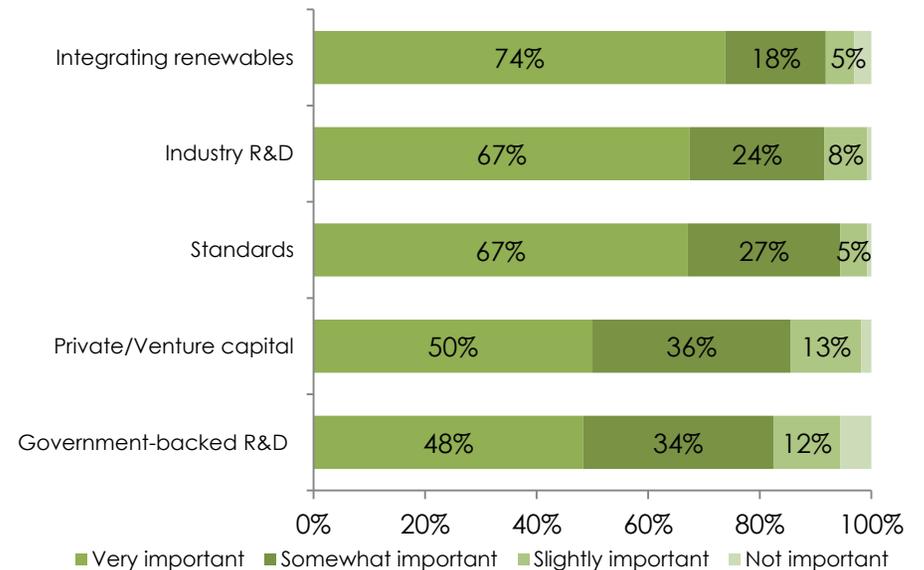


Areas Most Important for Deployment

Several areas were rated on their importance to deploying and/or developing distributed generation and the top three rated revealed: integrating renewables such as wind and solar (74% said very important), industry R&D (67% said very important), and standards (67% said very important).

How important are each of the following areas to deploying or developing distributed generation?

(figure 17, source: Zpryme & IEEE)

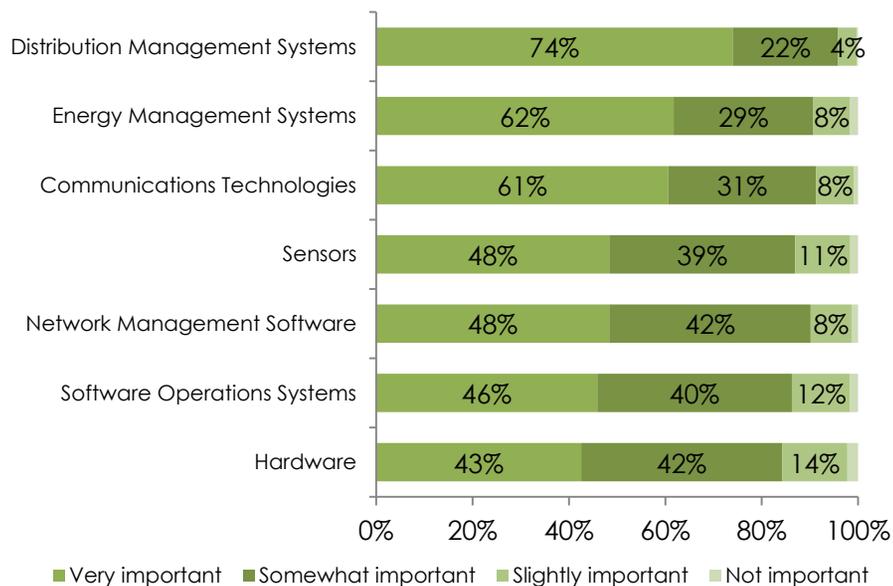


Technologies Important to Integrating Distributed Generation

Enabling technologies for distributed generation were rated as to their importance to integrating distributed generation. The top three were: distribution management systems (74% said very important), a near tie between energy management systems (62% said very important) and communications technologies (61% said very important), and a tie between sensors and network management software (both at 48% saying very important).

How important are the following technologies to integrating distributed generation?

(figure 18, source: Zpryme & IEEE)

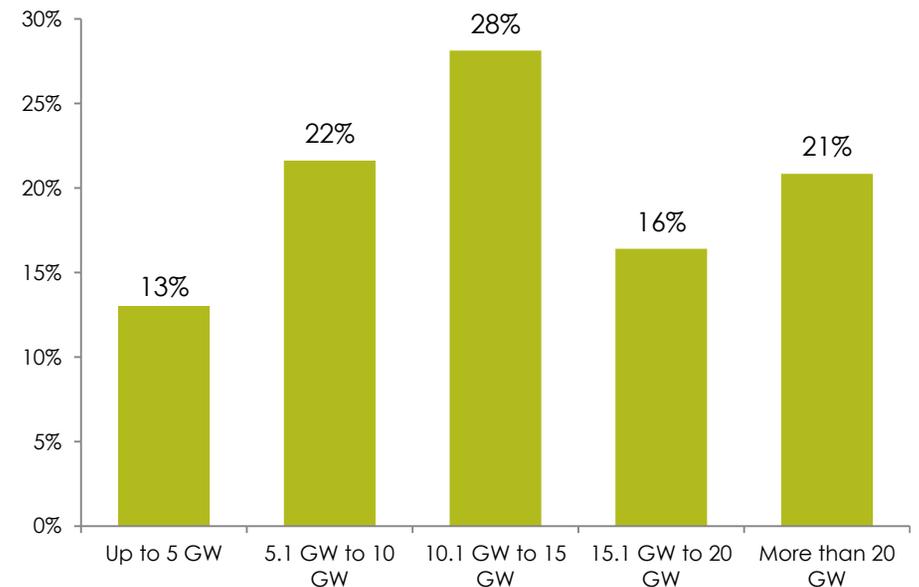


Increase in Global Capacity of Distributed Generation

Twenty-eight percent of respondents indicated global capacity for distributed generation would increase by 10.1 gigawatts to 15 gigawatts over the next 5 years. Another 22% said global capacity would increase by 5.1 gigawatts to 10 gigawatts over the next 5 years, while 21% said global capacity would increase by more than 20 gigawatts over the next 5 years.

Over the next 5 years, how much will global capacity increase?

(figure 19, source: Zpryme & IEEE)

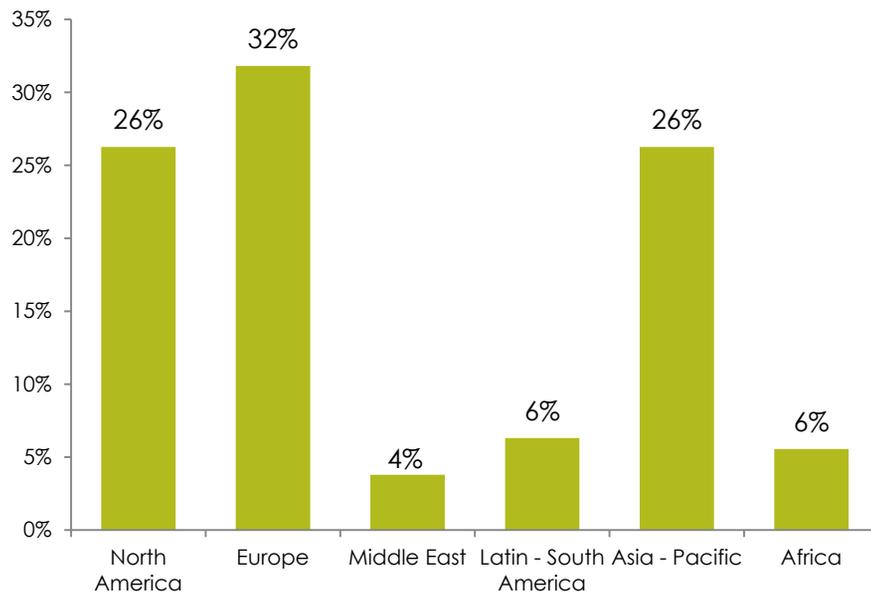


Regional Growth of Distributed Generation

Thirty-two percent of respondents said Europe would see the most growth in distributed generation over the over the next 5 years. Another 26% said Asia-Pacific would growth the most over the next 5 years. Twenty-six percent said North America would grow the most over the next 5 years.

Which region will see the most growth over the next 5 years?

(figure 20, source: Zpryme & IEEE)



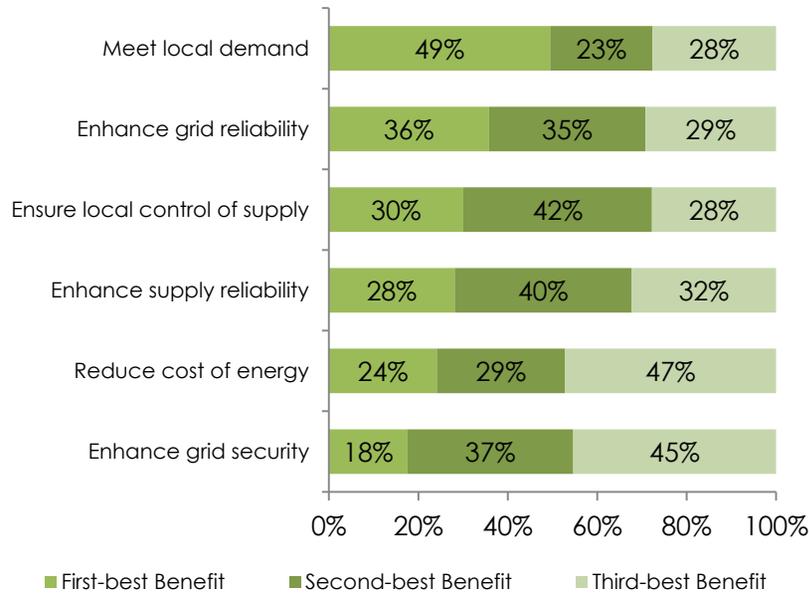
Microgrids

Top Benefits of Microgrids

The top three benefits of microgrids were: meet local demand (49%), enhance grid reliability (36%), and ensure local control of supply (30%). Other lower frequency responses were: enhance supply reliability (28%), reduce energy cost (24%), and enhance grid security (18%).

What are the top 3 benefits of microgrids?

(figure 21, source: Zpryme & IEEE)

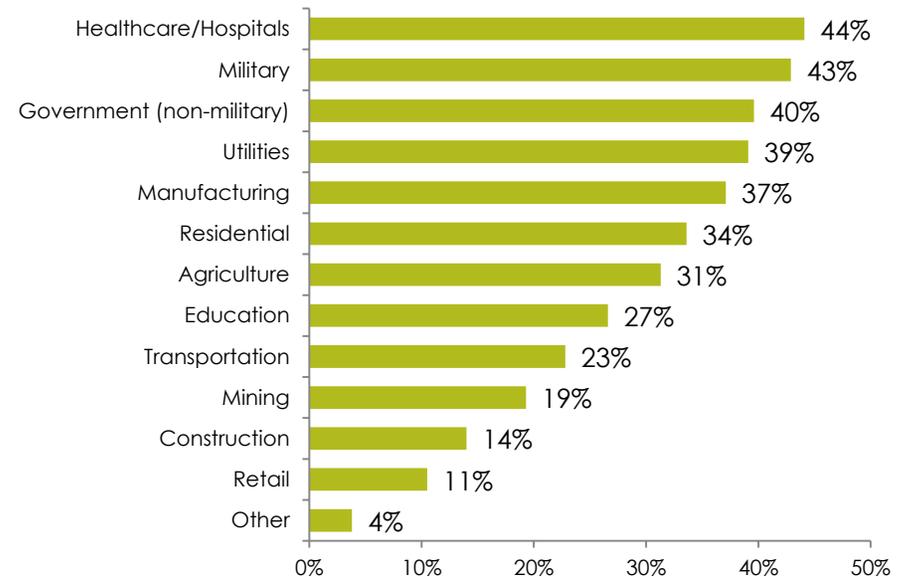


Industries Most Likely to Deploy Microgrids

The top three industries most likely to deploy microgrids over the next five years were reported to be: healthcare/hospitals (44%), military (43%), and a near tie for third, government (non-military) (40%), and utilities (39%).

Which industries are most likely to deploy microgrids over the next 5 years?

(figure 22, source: Zpryme & IEEE)

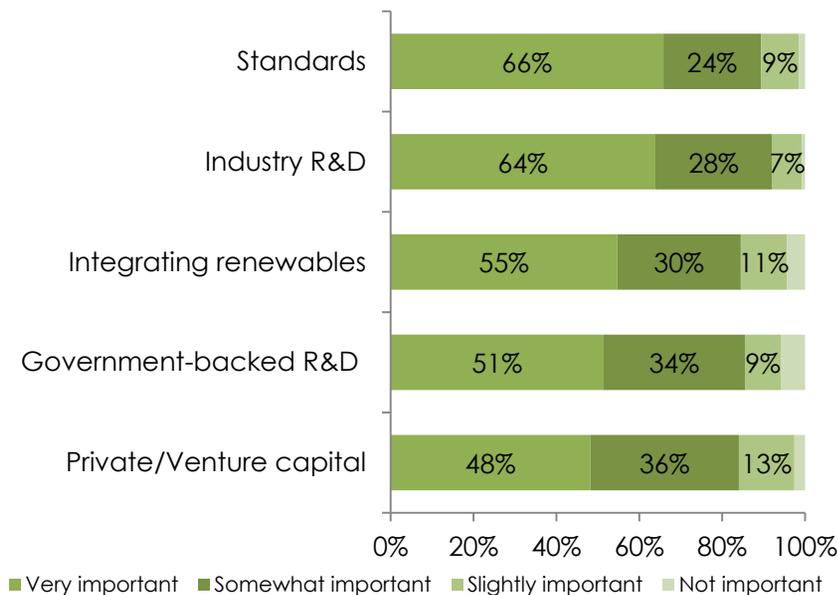


Areas Most Important for Deployment

Several areas were rated on their importance to deploying and/or developing microgrids and the top three rated revealed: standards (66% said very important), industry R&D (64% said very important), and integrating renewables such as wind and solar (55% said very important).

How important are each of the following areas to deploying or developing microgrids?

(figure 23, source: Zpryme & IEEE)

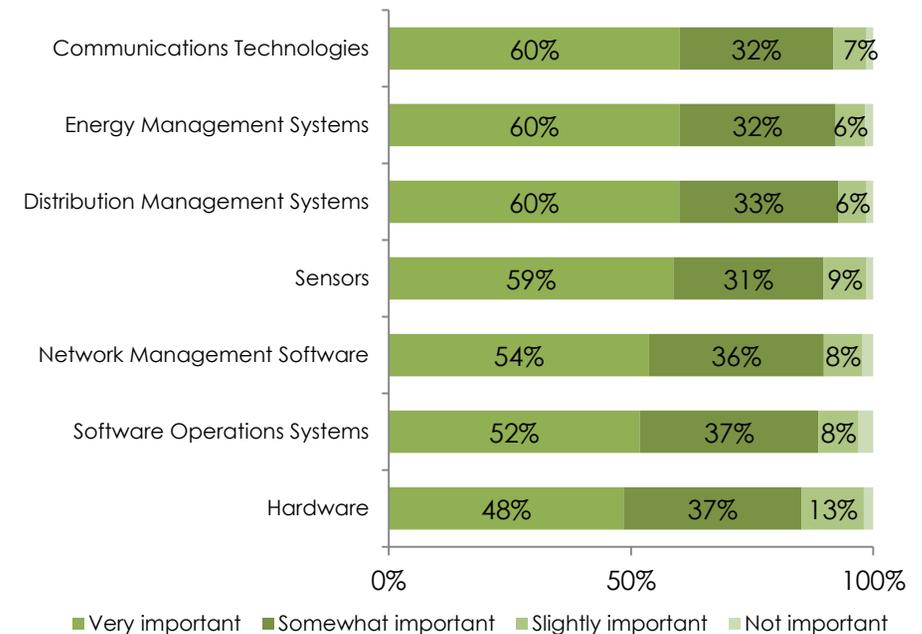


Technologies Important to Integrating Microgrids

Enabling technologies for microgrids were rated as to their importance to integrating microgrids. The three highest rated were: a four-way near tie as very important among communication technologies (60%), energy management systems (60%), distribution management systems (60%), and sensors (59%); network management software (54% said very important); and software operations systems (52% said very important).

How important are the following technologies to integrating microgrids?

(figure 24, source: Zpryme & IEEE)

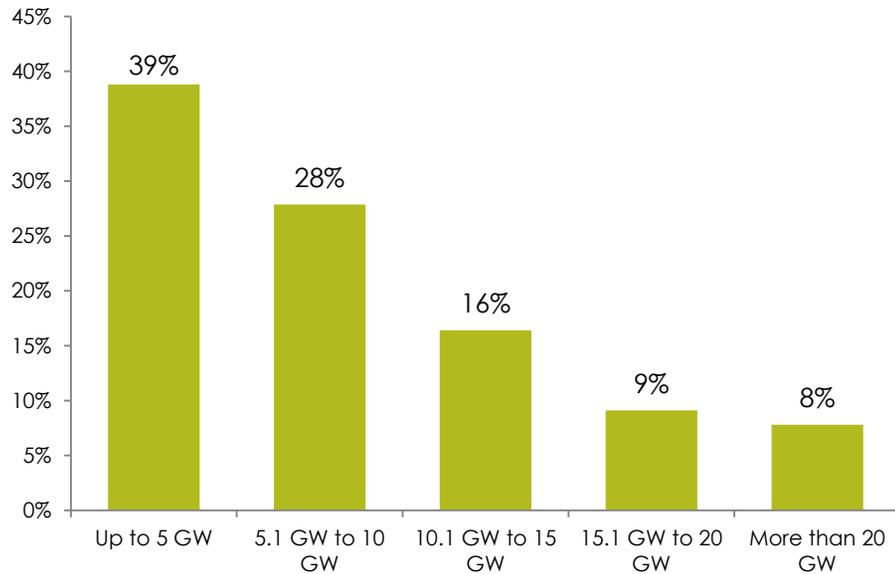


Increase in Global Capacity of Microgrids

Thirty-nine percent of respondents indicated global capacity for microgrids would increase by up to 5 gigawatts over the next 5 years. Another 28% said global capacity would increase by 5.1 gigawatts to 10 gigawatts over the next 5 years. Only 8% said global capacity would increase by more than 20 gigawatts over the next 5 years.

Over the next 5 years, how much will global capacity increase?

(figure 25, source: Zpryme & IEEE)

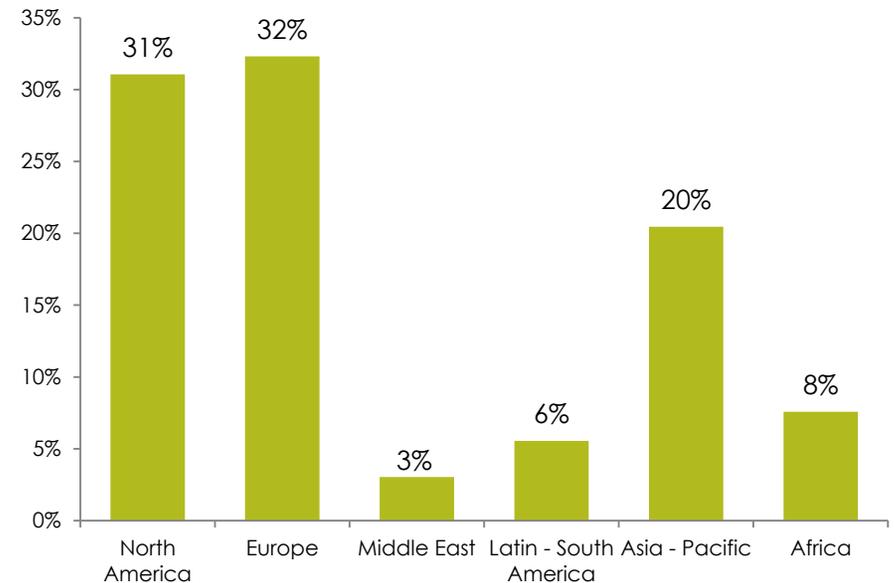


Regional Growth of Microgrids

Thirty-two percent of respondents said Europe would see the most growth in microgrids over the over the next 5 years. Another 31% said North America would growth the most over the next 5 years. Twenty percent said Asia-Pacific would grow the most over the next 5 years.

Which region will see the most growth over the next 5 years?

(figure 26, source: Zpryme & IEEE)

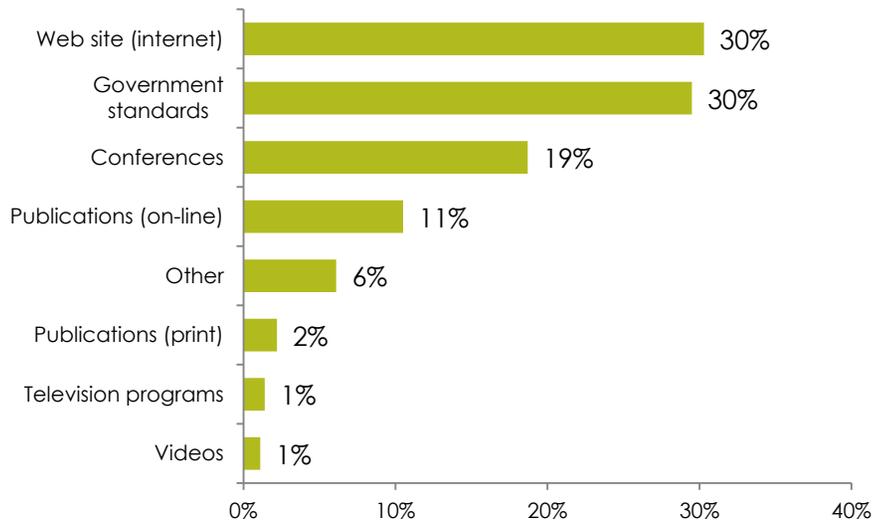


Industry Collaboration

A final question asked for the best way to coordinate the use of the three technologies (storage, microgrids, and distributed generation) among industry, vendors, and utilities. The most frequent answers were: a tie between web site (internet) and government standards (both at 30%), conferences (19%), and publications (on-line) (11%). Ninety-percent said these four methods were preferred as the best way to coordinate deployment

What is the best way to coordinate use of storage, microgrids, and distributed generation among industry, vendors, and utilities?

(figure 27, source: Zpryme & IEEE)



Market Issues for Energy Storage, Distributed Generation, and Microgrids

This section will briefly discuss energy storage, distributed generation of electricity, and microgrids. Although each will be considered separately in the following sections, in fact, they are interconnected in their deployments. As well, all three are associated with the smart grid as energy consumption is becoming more efficiently managed around the globe. Added emphasis to the importance of pursuing these three concepts is the growing world-wide demand for electricity that is hampered by voltage disruptions, brownouts, and blackouts. In the U.S. alone, the cost of service interruptions is estimated to be \$71 billion by 2020.¹

Some of the difficulty associated with controlling electricity demand is that planning is based upon 20 – 30 year predictions.² This time horizon does not suit the rapid adjustments needed to cope with electricity's demand in today's world. In fact, several factors are pushing for adoption of increasing storage, distributed generation, and microgrids.

Project Highlights

Energy Storage

Numerous utilities are currently engaged in pilot projects to install and assess energy storage build outs. Southern California Edison (SCE) has eight sub-projects. The storage facility, consisting of lithium-ion batteries, comes in four

units and 16 installations. One battery is for integrating photovoltaics, one for a distribution transformer, one is located on the distribution feeder, and one to a car shade over a parking garage.³ The focus of the SCE project is to improve system reliability.

In Australia, Infigen has begun work on a one megawatt photovoltaic and energy storage plant in New South Wales.⁴ Infigen believes energy storage will be a key enabling technology for renewables.

In China, the Zhangbei project is the country's first big move into the energy storage market.⁵ China is trying to capture all of the energy that is produced by wind generators, because now almost 17% of the wind-generated power is curtailed. An integrated storage system would help capture more of this wind-generated energy.

Distributed Generation

The largest smart grid project in the U.S. begins this fall (2012). The huge project involves 11 utilities in Idaho, Montana, Oregon, Washington, and Wyoming.⁶ The project is partially supported by a \$178 million matching Recovery Act fund from the Energy Department and will involve 60,000 utility customers. An objective of the project is to facilitate the integration of renewable

³ Carson, P. Duke and So Cal Ed: Let's Talk Energy Storage. www.intelligentutility.com/article/, July 8, 2012.

⁴ Beetz, B. Australia: Infigen to Build PV Integrated Energy Storage Demonstration Project. www.pv-magazine.com/news/details/, July 18, 2012.

⁵ How China Will Impact the Grid-Scale Energy Storage Market. www.greentechmedia.com/articles/read/, July 30, 2012.

⁶ www.smartgridnews.com/artman/publish/, June 14, 2012.

¹ www.marketwire.com/press-release/, August 7, 2012.

² Farrell, J. The Political and Technical Advantages of Distributed Generation. www.ilsr.org/, July 6, 2011.

resources, which will be handled by a new transactive control and coordination network.

Microgrids

In India, the Mera Gao Power Company, assisted by a \$300,000 grant from the U.S. Agency for International Development, is deploying its first commercial microgrid in nine villages (with plans for 40 more).⁷ Currently, the microgrid only supports lighting and cell phone charging; but this is what the villagers say they want.

ZBB Energy, in collaboration with the Illinois Institute of Technology and the Department of Energy are deploying a \$12 million project that will provide a microgrid template for universities, military bases and business parks.⁸ This project aims to help manage power during outages.

The U.S. Defense Department is leading a \$30 million effort to coordinate a group of traditional and renewable energy sources into a smart microgrid for military installations.⁹ The program is known as SPIDERS (Smart Power Infrastructure Demonstration for Energy Reliability and Security).

Market Overview

Energy Storage

The benefits of energy storage are many: power improvement (quality and reliability), infrastructure cost

reduction, energy cost reduction, smoothing peak loads, and providing emergency back-up power.¹⁰ However, as of 2010, only 2% of global electricity supply leveraged energy storage applications.¹¹ There are many different types of energy storage technologies available: compressed air, pumped hydro, electrochemical capacitors, flywheels, batteries (lead-acid, lithium-ion, molten salt, flow, etc.), thermal, and vehicle to grid.¹² The projected energy storage market for the U.S. for 2015 is over \$10 billion with the following breakdown: pumped hydro (\$6.6 billion), compressed air (\$0.52 billion), batteries/capacitors (\$2.4 billion), and flywheels and others (\$0.49 billion).¹³ A market projection for 2050 for energy storage rises by up to an addition 205 gigawatts of electricity, if the growth in renewable resources is sustained.¹⁴

Over the next five years, advanced batteries and thermal storage technologies are forecast to be the largest growth opportunities.¹⁵ Presently, 90% of all storage capacity is in the form of thermal (1000 megawatts) pumped hydro (115 megawatts), or compressed air (500 megawatts).¹⁶ Trabish estimates that in five years without tax incentives, the total storage capacity will be: thermal (1221 mw, 50.4%), hydro (500 mw, 20.6%), batteries (460 mw, 19.0%), compressed air (122 mw, 5.0%), flywheel (105 mw, 4.3%), and fuel cells (18 mw, 0.7%).¹⁷

¹⁰ Galing, B. Smart Grid Micro Energy T&D and Storage. [SBI Energy](#), January 2010.

¹¹ Shah, A. and Shuffat, S. Energy Storage Technologies in Utility Markets Worldwide. [SBI Energy](#), August 2010.

¹² Ibid.

¹³ Ibid.

¹⁴ The Power Storage Technologies Market Outlook. [Business Insights](#), December 2010.

¹⁵ [www.pnnewswire.com/news-releases/](#), 2012.

¹⁶ Trabish, H.K. The Energy Storage Market Quadruples in Five Years.

[www.greentechmedia.com/](#), February 6, 2012.

¹⁷ Ibid.

⁷ [www.smartgridnews.com/artman/publish/](#), May 1, 2012.

⁸ Content, T. Chicago Micro Grid Launches with Developed Energy Storage System. [www.jsonline.com/blogs/](#), July 30, 2012.

⁹ Perera, D. DoD Aims for Self-Reliance with SPIDERS Microgrid. [www.utilityproducts.com/news/](#), July 24, 2012.

The key trends shaping the direction of energy storage are low regulation requirements, growth in renewable energy integration, growth in microgrids, growth in ancillary services (e.g., demand response, off-load pricing), and CES (computerized electricity system) application adoptions.¹⁸

The market for advanced batteries is projected to double each year over the next five years reaching \$7.6 billion in 2017.¹⁹ New battery developments, such as the vanadium redox flow battery, are gaining momentum due to their ability to balance the production flows of several different types of energy sources in a single facility.²⁰ But, until batteries obtain parity with existing technologies, the energy storage market will remain anemic.²¹

The prospects for energy storage are greatest, according to some sources, where it can be coupled with renewable energy resources such as wind and solar.²² But the energy storage marketplace is dominated by a large group of small and volatile players, which can lead to some very promising takeover targets.²³ The market for community energy storage systems which have small 25 kw battery packages (versus large utility-based), will become increasingly commonplace.²⁴

¹⁸ Market Evaluation for Energy Storage in the United States. KEMA. www.copper.org/about/pressreleases/, 2012.

¹⁹ www.virtual-strategy.com/, August 7, 2012.

²⁰ Hyslop, M. Grid Scale Energy Storage: The Holy Grail of America's Energy Revolution. <http://greentechnologyinvestments.com/>, July 13, 2012.

²¹ www.eosenergystorage.com/, 2011.

²² Simpkins, J. www.wallstreetdaily.com/, July 11, 2012.

²³ Ibid.

²⁴ Cappuccino, G. Storage: An Indispensable Ingredient in Future Energy. <http://theenergycollective.com/>, July 17, 2012.

Distributed Generation

Distributed generation (DG) offers several benefits: supply is closer to where needed, DG can use existing distribution lines, lower costs are obtained through reducing transmission line losses, grid congestion is lowered, reactive power is available, and reliability is enhanced.²⁵ Generation of energy can be provided by: diesel and gas engines, micro turbines, wind, solar, electric vehicles, biomass, small hydroelectric, and micro-size nuclear generators.²⁶ Other advantages for DG include: local ownership of facilities with coincident political support, closer location to population centers, avoidance of eminent domain conflicts, and easily absorbed into existing grid systems (up to 15% of total in California).²⁷ The National Renewable Energy Laboratory found in 2010 that the potential integration of wind and solar energy was 35% for the western U.S. electric grid.²⁸

A recent Pike Research Report stated that Europe will be the largest market for renewable distributed energy during 2012 – 2017, but Asia-Pacific will see the most rapid growth in solar, wind, and fuel cell power sources.²⁹

The global distributed energy generation market is forecast to be \$140.7 billion in 2015 (up from \$64 billion in 2010).³⁰ The composition of the 2015 projection is \$66.4 billion for renewables, and \$74.3 billion for fuel-based technologies.³¹ The drivers for increasing DG are:

²⁵ Reitenbach, G. The Smart Grid and Distributed Generation: Better Together. *Power Magazine*. April 1, 2011.

²⁶ Ibid.

²⁷ Farrell, op.cit.

²⁸ Ibid.

²⁹ www.pikeresearch.com/research/, 2012.

³⁰ www.adhesivemag.com/articles/, December 6, 2011.

³¹ Ibid.

environmental concerns, age/deterioration of existing transmission and distribution facilities, the lower costs for infrastructure, and lower regulatory constraints.³²

Another forecast by Pike Research for solar energy is over \$154 billion by 2015.³³ Clearly, the solar market is projected to increase markedly over the next five years due in some measure to the rapid drop in costs for photovoltaics over the last three years.³⁴ However, small wind turbines are still a more cost effective source for distributed renewable energy in many parts of the world.³⁵

Microgrids

Basically, microgrids are simply smaller versions of the larger electric grids, and are designed to serve local electricity needs. Microgrids contain power generation, storage, distribution lines, and connect with a larger grid. The benefits of microgrids include: ability to better integrate distributed generation sources, ability to operate autonomously (also called “islanding”), better security control, ability to quickly adapt to new technologies, less line loss, and the ability to generate DC current.³⁶ Microgrids have applicability at commercial and industrial sites, institutions (universities, hospitals), small communities, military bases, and remote locations.³⁷ A breakdown of the North American microgrid market in 2015 will reflect: institutional (47%), small community (19%), commercial/industrial (19%), military (8%), and remote (off-

grid)(7%).³⁸ John Westerman reports an annual \$2 billion U.S. market in microgrids by 2015.³⁹

Although microgrids offer several distinct advantages over traditional electricity delivery, the market is relatively small. In fact, some estimate that the market for microgrid projects related to smart grid development is only at 5% of the total smart grid market.⁴⁰

Campus environments represent the largest sector for the global grid-connected microgrid market today.⁴¹ Pike research estimates that between 2011 and 2017, campus microgrids will rise to \$777 million in annual revenue and produce 1.6 gigawatts of electricity.⁴² By 2017 the global remote/off-grid market is projected to be \$10.2 billion and generating 1.1 gigawatts of electricity.⁴³

In 2010, North America had nearly a 74% share of the microgrid market of \$4 billion; but by 2020 it is expected that the microgrid “pie” will be more evenly distributed around the globe.⁴⁴ And by 2020, the total microgrid market is expected to climb to \$14.92 billion with an output of 5.67 gigawatts of electricity.⁴⁵

Government Support

Government support can take several forms, from the direct disbursement of grant money to the use of tax

³² <http://wikipedia.org/wiki/>, 2012.

³³ www.pv-magazine.com/news/details/, April 11, 2012.

³⁴ www.pikeresearch.com/, February 8, 2012.

³⁵ Ibid.

³⁶ Galing. op.cit.

³⁷ Ibid.

³⁸ Westerman, J. Opportunities in the Energy Industry-Microgrids. Horizon Energy Group. <http://cdn.osisoft/soft/corp/en/media/>, March 2011.

³⁹ Ibid.

⁴⁰ www.marketwire.com/press-release/, August 7, 2012.

⁴¹ www.pikeresearch.com/newsroom/, December 14, 2011.

⁴² Ibid.

⁴³ www.smartgridnews/artman/publish/, June 14, 2012.

⁴⁴ www.sbiereports.com/Microgrids-2835891/, February 1, 2011.

⁴⁵ www.marketwire.com/press-release/, June 29, 2012.

incentives. Also, the level of government support varies from national/federal to state/local. The examples below are not meant to be a comprehensive listing of all types of support, but rather offer several examples of the differing types.

Energy Storage

The report by Trabish⁴⁶ states that tax incentives (those proposed in the U.S. Storage Act – S. 1845) would likely increase the energy storage market by 400% to 2300 megawatts over five years. But without these tax incentives, only about 1294 megawatts would be realized. In California, AB 2514 (an energy storage bill) will set procurement targets for California utilities to purchase energy storage which are needed to stabilize the grid.⁴⁷

In China, the power market is not structured to provide incentives, so the energy storage market will be driven by policy (e.g., feed-in tariffs, directives to develop storage).⁴⁸

In Great Britain, the Department of Energy and Climate Change is introducing a subsidy for energy storage.⁴⁹

In the U.S., the Department of Energy announced in August 2012, a total of \$30 million for 12 projects under the Advanced Management and Protection of Energy Storage Devices and \$13 million for seven projects for small

businesses for energy storage in stationary power and electric vehicles.⁵⁰

Distributed Generation

The support in this area focuses upon individual technologies of electricity generation. For example, photovoltaic (PV) projects that were awarded loan guarantees by the U.S. Department of Energy are expected to build three gigawatts of electricity generation from 2013 to 2015.⁵¹

On July 1, 2012, Japan implemented feed-in tariffs which require utilities to buy electricity from renewable sources at preset premiums for up to 20 years.⁵²

The top five most popular government policy measures are: capital grants, subsidies, loans or rebates (first); a tie for second place between voluntary renewable energy targets and tax incentives (exemptions, rebates, credits); and a tie for third place between feed-in tariffs and competitive tendering/bidding.⁵³

Through the U.S. Office of Electricity Delivery and Energy Reliability, the Department of Energy's Renewable and Distributed Systems Integration program's goal is to reduce peak load on distribution feeders by 20% by 2015.⁵⁴

And in California, regulators extended a subsidy on May 24, 2012, for rooftop solar panel installations whereby

⁴⁶ Trabish, op.cit.

⁴⁷ Carus, F. Energy Storage: The Missing Link in Evolution of Solar. www.pv-tech-org/, July 11, 2012.

⁴⁸ How China Will Impact the Grid-Scale Energy Storage Market. www.greentechmedia.com/articles/read/, July 30, 2012.

⁴⁹ Ellis, V. Energy Storage Subsidy to be Announced in Autumn. www.energylivenews.com/2012/, August 3, 2012.

⁵⁰ www.chattanooga.com/2012/8/2/23148/, August 2, 2012.

⁵¹ US Solar-White Paper. Bloomberg New Energy Finance. June 4, 2012.

⁵² Simkins, op.cit.

⁵³ Patel, V and Coble, M. The New Era in Distributed Generation: Delivering Resources to Every Corner of the World. www.generatinginsights.com/whitepaper/, 2010.

⁵⁴ Reitenbach, op.cit.

utilities are forced to buy excess electricity at current market prices.⁵⁵ Also in California, government support for distributed generation is: to reduce permitting, inspection and interconnection costs by 50% over the next three years (begun in 2011) through standardization of forms, unification of local codes, reduction of paperwork, increasing access to funds, and addressing local land use policies that restrict renewables settings.⁵⁶

Microgrids

Some of the above examples include portions of microgrids (storage, renewable generation) so that microgrids as separate entities don't stand out as unique recipients of government support.

California Senate Bill 843 proposes to create new electricity markets where subscribers buy kilowatts from renewable sources and receive credit against their bill for kilowatts produced and sold back to the utility.⁵⁷ This means customers who live in multi-family housing with shared roofs could function as a microgrid for producing and consuming electricity.

Each of the U.S. military forces has committed to build a gigawatt of renewable generation capacity by 2025, and the Defense Department is testing microgrids to keep power in case of disaster or attack.⁵⁸ Further, an agreement was reached between the Department of the

Interior and some of the Defense Department's land holdings for utility-scale solar, geothermal, and wind power.⁵⁹

Standards Overview

The Institute of Electrical and Electronics Engineers (IEEE) has been directly involved in standards setting and development since the inception of the smart grid and the three connectional components that are being discussed in this report. Further, the U.S. government has also had direct involvement with IEEE.

Energy Storage

Even though standards are a necessary element in the energy storage arena, the associated regulations that emanate from these standards can become somewhat daunting. For example, estimates range from a doubling to a tripling of regulation requirements from 2012 to 2020 in the wholesale markets for energy.⁶⁰

The IEEE 1547 standard for the interconnection of distributed energy resources is most applicable to the energy storage area.⁶¹ The energy storage interconnection guideline (6.2.3) is appropriate here.

At the state level, California's AB 2514 addresses details about how storage fits into the grid.⁶²

⁵⁵ Roland, Alternative Billing to Encourage Distributed Energy Reduction. <http://globalgargoyles.com/2012/06/12/>, June 12, 2012.

⁵⁶O'Donnell, A. Bay Area Goals and Support for Gov. Brown's 12,000 MW Distributed Generation Initiative. www.ecocloud-sv.com/forum/, September 21, 2011.

⁵⁷ Hertzog, C. Can new Market Participants Make the Grid More Resilient? <http://theenergycollective.com/>, August 7, 2012.

⁵⁸ Clarke, C. Interior, Defense Departments Team Up to Build Renewables. www.kcet.org/news/rewire/, August 6, 2012.

⁵⁹ Ibid.

⁶⁰ Market Evaluation for Energy Storage in the United States. KEMA. www.copper.org/about/pressreleases/, 2012.

⁶¹ www.nist.gov/smartgrid/upload/7-Energy_Storage_Interconnection.pdf.

⁶² Carson, P. Energy Storage and California Regulators. www.intelligentutility.com/article/, July 30, 2012.

Distributed Generation

The same basic standard, IEEE 1547.2, is noted for distributed generation.⁶³ The document provides requirements for the U.S. for the performance, operation, testing, safety, and maintenance of the interconnection among distributed sources of energy. At the state level, New York's Standard Interconnection Requirements addresses technical guidelines for interconnection and application procedures.⁶⁴

Microgrids

IEEE created islanding standards in July 2011.⁶⁵ This IEEE standard is P1547.4 and governs the design, operation, and integration of distributed resource island systems with the grid.⁶⁶

Utilities Leading the Way

Several recent utility projects have been noted already in the Market Highlights section, but a few more examples are provided below.

Energy Storage

In San Francisco, California, the Sacramento Utility District is integrating a zinc bromine flow battery system in utility substations.⁶⁷ The objective is to integrate electricity from

solar and wind into the grid system. A zinc bromine flow battery is perceived as cheaper, and more reliable than lithium-ion.

Distributed Generation

The Tennessee Valley Authority (TVA) has resumed its support of renewable electricity projects of up to one megawatt in generation capacity.⁶⁸ The initial customer response was so large, TVA had to delay new requests to accommodate the overload. Qualifying projects using biomass, solar, wind, or hydroelectric are eligible and TVA will buy 100% of the green power at the existing retail rate.

As of March 2012, 15 states and 19 utilities have approved specific support mechanisms for distributed generation in the form of performance-based incentives, renewable standards carve outs (amounts required for renewable generation), or community programs.⁶⁹

Microgrids

A demonstration project led by Chevron Energy Solutions and funded by \$6.9 million from the D.O.E. with additional funds from the California Energy Commission and the California PUC is deploying a microgrid at the Santa Rita Jail in Dublin, California (the fifth largest jail in the U.S.).⁷⁰ The microgrid's newly installed two MW lithium ferrous phosphate batteries can carry the electricity load when grid power is lost, and the microgrid will turn on the back-up generators when the batteries are depleted to both recharge the batteries and provide full power to the jail.

⁶³ Basso, T and Friedman, N. IEEE 1547 National Standard for Interconnecting Distributed Generation: How Could It Help My Facility? National Renewable Energy Laboratory, November 2003.

⁶⁴ <http://energy.gov/savings/interconnection-standards-16>, 2011.

⁶⁵ <http://eon.businesswire.com/news/eon/>, May 10, 2012.

⁶⁶ www.pikeresearch.com/newsroom/, December 28, 2011.

⁶⁷ Leopold, G. Utilities Ponder Storage as Solar Soars. www.eetimes.com/electronics-news/, July 9, 2012.

⁶⁸ www.sustainablebusiness.com/index.cfm/, July 19, 2010.

⁶⁹ www.emerging-energy.com/Content/, March 27, 2012.

⁷⁰ <http://vcresearch.berkeley.edu/news/>, March 19, 2012.

Energy Storage

Over the next five years, the energy storage market will go through a disruptive shift as many pure players will be forced out of the market due to poor cash positions and an inability to secure stable contracts with utilities. Manufacturers who survive this shake out will be in a strong position to win significant market share and profits. Governments, specifically Japan, South Korea, and China, will also continue to make strong investments in energy storage as these countries are determined to lead the world when it comes to clean technologies.

The findings in this report reveal strong opportunities for energy storage integrators who provide enabling applications, as well as for technology-agnostic energy storage system providers that offer flexibility and reliability over more proprietary solutions. However, until these systems become highly standardized, speed to market will require the expertise of integrators who can incorporate energy storage into the Smart Grid, and make renewable sources a more viable part of the energy mix.

In the long-run, we see both utilities and end-users being winners as energy storage technology contributes to a much more reliable and stable grid across the globe. Investors that take a long-term approach to investing energy storage will see strong returns. Last, we anticipate a handful of global firms will eventually dominate this market, as they will likely purchase existing pure players with the most advanced technology and incorporate them into their large scale solutions.

Distributed Generation

Over the next five years, the distributed generation market will become the darling of the energy industry. National and state level policies and incentives for renewable resources will further give rise to third-party service providers who specialize in distributed generation integration for commercial and industrial users. Further, a new entire ecosystem of industry stakeholders and integrators will be developed around distributed generation.

The findings in this report indicate the solar and wind distributed generation providers stand to make substantial profits if they can stay viable in the short-run. Large commercial and industrial users will increasingly work with utilities to deploy advanced distributed energy systems.

In the long-run, distributed generation will be driven by commercial and residential end users who are able to sell power back to the grid. However, this functionality will not materialize without a significant roll-out of smart grid technology at the national level.

Microgrids

Over the next five years microgrid deployments will prove to utilities and end-users that they are viable solutions to meet the primary energy needs for industries that can't afford to be without electricity for even a few minutes. Additionally, many new entrants will enter the market, but they will face many of the same challenges as energy storage providers. Further, emerging markets will deploy microgrids to support economic growth and to bring

power to citizens who would not otherwise have access to it.

The findings in this report show the enormous potential that an integrated microgrid, combining renewable energy generation, strategically selected software, and energy storage solutions can offer to end users across the globe. The microgrid system has a great potential in large commercial and industrial complexes, military bases, hospitals, shopping malls, apartments, residential complexes, educational institutions, and remote un-electrified locations.

In the long-run, as energy storage and renewable energy manufacturing prices decrease, we see global deployments increasing three-to four-fold.

About IEEE:

About IEEE Smart Grid

Since the inception of the global smart grid movement, IEEE has been at the forefront. IEEE leverages its strong foundation and collaboration to evolve smart grid standards, share best practices, and publish developments in energy transformation. Additionally, IEEE provides related educational offerings and hosts leading international conferences to further the smart grid efforts. Each year, IEEE hosts a range of international conferences on smart grid, power and energy topics, and provides professional and educational resources including the IEEE Smart Grid Web Portal, and the IEEE Smart Grid Newsletter. Learn more at <http://smartgrid.ieee.org>.

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