



Best practices in the deployment of smart grid technologies

To reap the expected benefits from the smart grid, U.S. utilities face steep organizational hurdles, significant process complexities, and difficult governance issues.

**Anjan Asthana,
Adrian Booth, and
Jason Green**

U.S. utilities plan to install more than 40 million two-way smart meters in homes and businesses over the next 5 years and other smart grid projects are not far behind, spurred by \$4.5 billion of federal stimulus funding and rapidly maturing technology. To varying degrees, the electric utility industry around the world is joining in. In an industry where the pace of technology adoption has been measured historically not in months or years but decades, this surge in activity is a challenge of unprecedented scope and scale, one that would test the managerial capability of any industry.

The complexity of smart grid projects will add to that challenge, as utilities will have to make

significant investments in information technology, an area generally outside their core competence. The smart grid will be as integral to core systems as enterprise resource planning (ERP) is to the manufacturing industry; it will be as geographically diverse as a new telecommunications network. Successful deployment will require strong coordination across customary organizational boundaries, significant process change, and rigorous governance.

The first stage of a smart grid rollout is generally in the deployment of smart meter technology. Here the record of utility companies has been mixed—unsurprising given the level of complexity involved. Some utilities have had to interrupt



their rollout of smart meters to reassess the technology selected, and some have switched vendors. Still others have incurred hundreds of millions of dollars in cost overruns due to systems integration issues. And some utilities have failed to realize the expected benefits from smart meter projects because of change-management issues.

These false starts, cost overruns, and sub-par results—as well as the many successes—have been highly instructive. Based on these experiences, a set of best practices is emerging that can improve the odds of success. McKinsey’s experience in supporting utilities has led to ten emerging best practices across three major categories which together define successful smart grid deployment.

Vision and business case

1. Define the smart grid vision and develop the road map to get there

Smart grid applications have many potential benefits, and it is important for utilities to determine which of them they will seek to maximize: reduction in operational cost? improved reliability? reduction in greenhouse gas (GHGs) emissions? When all these objectives are important, relative prioritization becomes a critical step, a process which should take account of the strength of their connection to overall corporate strategy. If, for example, a utility’s focus is on operational benefits and reliability, it should align its smart grid vision by focusing on grid-side benefits as opposed to customer-facing applications. (More detail on these factors

Exhibit 1

The do’s and don’ts of smart grid deployment

Where to do it	What to do – 10 best practices	What not to do
Vision and business case	<ol style="list-style-type: none"> 1 Define a smart grid vision and the road map to get there 2 Build a compelling business case tailored to technology maturity and the regulatory environment 3 Develop a capability-driven regulatory case articulating stakeholder costs and benefits, and addressing technology obsolescence and security concerns 	<ul style="list-style-type: none"> • Pursue stand-alone projects when each becomes a positive business case • Assume technology is a static choice and business-case framework of one service area will work in another • Translate internal business case into a regulatory filing and assume regulators and stakeholders will understand it
Implementation	<ol style="list-style-type: none"> 4 Set up program architecture that considers risk and industry maturity 5 Select technologies for the long term and use pilots strategically 6 Pursue true strategic sourcing to optimize providers capabilities while minimizing risk 7 Maintain significant business focus on IT integration activities 	<ul style="list-style-type: none"> • Assume a narrow approach to systems integration will succeed • Map technology to current needs or fail to test technology marketing claims • Use a procurement-led process that fits other categories of spend where functionality is well known • Assume clear business requirements will lead to successful IT integration
Operations and change management	<ol style="list-style-type: none"> 8 Employ lean operations techniques to accelerate cost-effective technology deployment 9 Actively define end-state business processes and change required to deliver 10 Set up cross-functional governance across all key business units 	<ul style="list-style-type: none"> • Scale up current capabilities and assume an unrealistic learning curve • Plan on capturing the benefits in the business case without significant change management • Lead the project from either an IT or single business unit perspective

can be found in the accompanying article, “U.S. Smart Grid Value at Stake: The \$130 Billion Question,” pp. 4-11). Emerging best practices include:

- *Create a vision and road map* that incorporates all available information even though significant uncertainties exist. The most effective utilities pull together thought leaders from across the organization to develop a comprehensive inventory of smart grid opportunities. This inventory is then prioritized by calculating the value at stake from each application according to financial metrics (both capital and operating expense), reliability, customer satisfaction, safety, and the environment. This opportunity assessment can then be combined with an analysis of the technical and change-management measures that each opportunity will require to be realized. The result of this multi-step analysis is the smart grid road map, which specifically connects the goals in the smart grid vision with the investments needed to get there. The road map should enable management to communicate clearly its smart grid vision to employees, customers, regulators, shareholders, and vendors.
- *Develop a capability to assess new technologies* as a key input into the vision. Smart grid technologies evolve far more rapidly than traditional utility assets, so a best practice for smart grid deployment is a regular assessment of the enabling technology. The increased bandwidth now standard for AMI deployments, for example, has created an opportunity for grid-focused applications to run on the same AMI network, offering the potential for broad coverage at incremental cost. Companies must track technological and economic developments and continually re-evaluate their technology strategy.
- *Treat the vision as a living document* that needs to be periodically updated and refined based on experience and learning. With all the uncertainties, it is as important to be flexible in approach while incorporating key lessons.

2. Build a compelling business case tailored to technology maturity and the regulatory environment

The road map will indicate the stages of smart grid deployment. First wave applications are often AMI/smart meter, grid applications, and demand-side management programs. To deploy these applications, utilities use an iterative process. First a business case for each is built which defines the impact of the application. The business cases can then be used to gain the support of relevant stakeholders, including company leadership, regulators, and ratepayer advocates. The goal is an optimal balance between benefits, costs, flexibility, and risks management.

- *Each business case is unique.* The business case for each utility will vary according to the regulatory regime, company goals, and design of the existing grid. One utility, for example, found that demand-side management benefits generated 40 percent of the value in the business case through rates and behavior change, while for other utilities it was under 20 percent. The business case must demonstrate how financial and non-financial benefits will be realized across the value chain through grid efficiency, operational efficiency, customer satisfaction, environmental impact, and the ability to support future technologies and applications. These determinations will have substantial impact, most notably on the regulatory strategy and benefit-realization approach.



- *The business case should materially shape the smart grid program.* The benefits defined in the business case should guide subsequent decisions about technology vendors, functionality, and changes to utility operations (i.e., business process redesign). Investments can be prioritized according to the relative size of the benefits, the investment required, risks, and technical dependencies involved.

3. Develop a clear, capability-driven regulatory case

Regulators view smart meter and smart grid initiatives as tools to drive efficiency and environmental and customer benefits, while minimizing rate impact. We have seen regulators respond positively to filings that:

- *Explain the benefits and timeline* by organizing them into categories which allow commissioners and advocates to understand the value created and how benefits will accrue over time. Engaging stakeholders early ensures that the final scope, selected technologies and plan for realizing benefits are

well understood by the time the filing is submitted.

- *Define capabilities, not technologies,* by collaborating with the regulator. For example, the regulator and the company might agree that the filing will require that customers have access to timely usage and pricing information, but leave the choice of the specific technology to the utility.

- *Communicate the uncertainties* by identifying for regulators their potential size and the steps being taken to reduce the associated risk. In demand-side management (DSM), for instance, the size of the benefit is difficult to predict precisely, but utilities can cite results from similar deployments. Regulator concerns can be assuaged by conducting a Monte Carlo simulation¹ to show that the business case is positive even under conservative assumptions for DSM benefits.

- *Actively address risks like security and technology obsolescence* that regulators might

¹The most commonly used technique of probabilistic modeling, the Monte Carlo simulation was named for the casino at Monte Carlo to indicate the random sampling element of the method. The approach involves taking an underlying deterministic model and running it several thousand times, with different values for the input assumptions fed into the model for each iteration. The software for the Monte Carlo simulation is easy to use, and with proper upfront structuring, even a complex business model requires only a few minutes of computation time.

Finally, utilities should communicate the results of the pilot to regulators to set expectations around actual value to be captured through full deployment

target by addressing them and describing mitigation tactics.

Implementation

4. Set up a program architecture that considers risk and industry maturity

Will the utility act as the prime contractor and assume all the implementation risk? Is a “build-operate-transfer” process an option? How many vendor contracts will a project require? And how much risk will remain for the utility to manage? The right program structure and operating model can dramatically reduce the risk of the overall project, as long as key considerations are addressed, including the maturity of business processes, the number of reference examples of similar projects, and the maturity of the technology itself. Key components of the program architecture include:

- *A clear and simple description of who is taking what risk.* Given a relative lack of experience with smart grid technologies and projects, utilities may find it tempting to transfer project risk to a third party, such as a technology vendor or a systems integrator. Smart grid projects will ultimately affect many of the core business processes within the utility, however, and third-party re-designs can be difficult. In addition, few reference cases and few industry standards are available to define an appropriate agreement with a third party. The result is that the price of shifting risk from utilities to a third party is steep and therefore utilities end up bearing more risk than initially desired.
- *Clear roles and responsibilities of the parties involved.* Although simple in concept, many programs kick off without clear roles as a result of the inherent complexities and unknowns.
- *A smooth transfer from project deployment to business operations.* Many smart grid projects last more than 4 years. As a result, the project itself takes on many business operations without a clear “cut-over” to a business-as-usual, so the project approach to business operations is inefficient.

5. Select technologies for the long term and use pilots strategically

Given the rapid evolution in smart grid technology, utilities should consider the following questions when choosing their technology partners:

- *Is the technology proven?* Distinguishing between “vaporware” and tested functionality is difficult when few reference cases exist. Utilities should canvas early adopters on the true capabilities of specific products, the time required for system readiness and longer-term reliability. Along with successful integration into their core systems, utilities should evaluate how technologies comply with existing and emerging standards.
- *What is the risk of technical obsolescence?* How well does the vendor conform to industry standards? Does the vendor employ open access as opposed to proprietary access? The NIST

smart grid working group has not yet established all the needed standards for smart meters and other smart grid programs. Utilities can directly affect the standard-setting process by forming alliances with vendors or standards groups, many of which already exist.

- *Do technology choices take into account the long-term priorities set out in the road map?* Just as streaming video necessitated significant upgrades to communication networks, future smart grid applications will require greater capabilities, such as low latency for critical grid applications or high bandwidth for interactive customer applications. Utilities must build the capacity for such applications into their systems.
- *Can the new technology be integrated with other utility systems?* Smart grid applications must mesh with utilities' critical legacy systems, such as customer information and outage management, as well as with new grid and customer applications. If a vendor has had difficulty integrating with back-office systems, it could signal a risk of IT cost overruns in the future.
- *What is the "ecosystem" of providers?* Smart grid deployments require a variety of partners like systems integrators, hardware providers, and hosting companies. To avoid being locked into vendor-supplied support or paying for a system integrator's on-the-job training, it is important to verify the existence of a broad ecosystem of companies behind the vendor and the proposed technology.
- *What is the total cost of ownership?* Ongoing costs can dwarf upfront investments. As utilities consider expanding beyond advanced meters into grid applications, a fundamental architectural question will have to be decided:

should their AMI network support their grid applications as well? Utilities must consider the incremental cost to deploy and maintain a separate network for grid applications against the potential for increased latency, lower bandwidth, and security issues raised by operating a single network.

Pilots can be used both to demonstrate the technical feasibility of vendor systems and to validate assumptions about costs and benefits in the business case. Demonstrations of technical feasibility best begin with a process of identifying the questions the pilot will address and defining the metrics and evaluation criteria for the technology. Estimated costs in a pilot, such as installation per device, immediate failure rates, systems integration, and O&M, can be checked against real-world experience. Perhaps more importantly, the pilot should test the most significant and uncertain components of the business case. Finally, utilities should communicate the results of the pilot to regulators to set expectations around actual value to be captured through full deployment.

6. Pursue true strategic sourcing to optimize providers' capabilities while minimizing risk

How smart grid technology is purchased is nearly as important as what is purchased. General procurement best practices can ensure that vendors deliver the expected functionality, meet utility timelines, and understand the price-performance trade-offs the utility will accept. Utilities can also work with suppliers on pricing, which may be more fluid in a rapidly evolving area like smart grid technology than in a mature market. Because many applications are unproven, best practice must include supplier capability assessments to determine whether selected vendors can deliver what they contract in the volumes and timelines required.



Utilities have adopted a number of best practices to build true partnerships with their vendors while ensuring high levels of performance.

- *Optimize the contract structure* by building “off-ramps” with AMI vendors, allowing for the re-evaluation of technology providers at defined milestones (for example, 100,000 meters installed or a certain geography covered). In systems integration contracts, many utilities have found that fixed-price contracts with well-defined metrics for quality and schedule compliance control costs better than time-and-materials contracts.
- *Consider managed services* as a way of outsourcing functions that had been regarded as core, such as managing network operations. At a minimum, allowing the vendor to stabilize the systems at the start of a deployment minimizes risk and creates a bridge for the utility to build its internal capabilities. Budgeting annual cost reductions in contracts ensures that utilities and their vendors benefit from the service provider’s operational improvements.
- *Set performance expectations* through service-level agreements (SLAs), with metrics such as up-time, valid meter reads and valid bills.
- *Develop a performance dialog with vendors* by evaluating performance on a quarterly basis—more often during the initial stages of a deployment.
- *Set up regular workshops* with other utilities deploying similar technology to share best practices, discuss potential pitfalls, and jointly develop solutions.

7. Maintain significant business focus on IT integration activities

Three critical factors must be weighed as part of IT systems integration:

- *Project management focus on critical-path activities.* A smart grid program schedule typically contains thousands of activities, but only a subset of them define the critical path. Once a technology has been selected, the program team needs to manage the elements that could have the largest negative impact on cost and schedule time. Focusing the attention of the program team and management on the most crucial tasks can assure that budgets and dates are met.
- *Iterative deployment versus a “big-bang” approach.* Unlike a traditional waterfall release strategy, this test-and-learn mindset shortens the time to launch and creates greater alignment with the business by allowing more chances for course corrections as functionality is released and adopted by the frontline. To prevent the “fire-fighting” mentality that many utility IT organizations have developed during AMI or smart grid deployments—and the inevitable cost overruns that are its by-product—utilities should target a greater number of simpler releases that

can be transitioned easily to lower the cost of O&M support. Additional features can be layered on top of a functioning base, minimizing ongoing front-line change and accelerating the realization of benefits.

- *Business requirements designed to support new processes.* The designs must be detailed enough for the technology provider—software vendor, systems integrator, or in-house IT staff—to use as a foundation for detailed technical design. As part of this process, the business and IT groups must map functionality for each step of the process flow and identify the degree of automation appropriate for each step. Following an agile software development approach might, for example, lead to a select few of the process steps being manual at the onset to minimize the risk, complexity and cost of the initial deployment.

Business operations and change management

8. Employ lean operations techniques to accelerate cost-effective deployment

Deploying smart grid technology will affect nearly all customer premises and much of the grid over a short period. Some utilities have deployed more than 15,000 smart meters a day across their service territories. To achieve that scale, utilities have looked at three factors.

- *Geographic sequencing* involves balancing initial benefit capture with operational efficiency and risk mitigation. For example, PG&E chose the warm Central Valley in California to capture near-term demand-response benefits from a region with high peak demand, while reducing risk by avoiding the more challenging topography and aging infrastructure in coastal areas.
- *Lean operations* help reduce the cost and risk associated with a broad deployment of smart grid technology. For example, lean inventory management reduces holding costs while ensuring sufficient safety stock. To improve productivity in the field, companies have separated complex work reserved for specialists from more routine installations. These utilities also follow best practices of front-line management—rigorously measuring and communicating performance through scorecards and metrics.
- *Root-cause analysis* can reduce failed installations by as much as 20 percent. In a smart meter project a typical cost driver, for example, is “meter not installed”: situations where a meter was not installed as expected, typically as a result of an inaccessible location. Really digging into the root cause oftentimes reveals problems that can be easily remedied. These easy wins can be encouraged with measures such as the linking of a bonus or compensation of a meter installer to an expected success rate.

9. Actively define end-state business processes and change required to deliver

Many utilities embark on smart grid programs without enough preparation, assuming that they will figure things out as they go along. This approach will often result in an inordinate expenditure of time and resources on problem and issue resolution.

- *Set up change management as a core capability.* Progressive utilities recognize that the smart grid will bring the biggest change in concentrated time to customer care and distribution operations in 30 years. This

requires concerted change management to ensure success. Once the benefits have been identified, utilities should communicate to everyone involved which of them they are committed to capturing, while defining the changes needed to achieve those benefits. (For more on change management during smart grid deployment, please see the accompanying article, “Maximizing Value from Smart Grids” pp. 33–37).

- *Define target state business processes early.* The best way to gain early buy-in and momentum is to initiate a cross-functional business process redesign effort early in the process. Including a broad representation of stakeholders and starting the process early allows the organization time to build awareness and prepare for the resulting change.

10. Set up cross-functional governance across all key business units

One of the unique aspects of smart grid projects is the cross-functional nature of the work required to be successful. The typical smart grid project cuts across customer care, distribution operations, engineering, IT, supply chain, and other organizations. In one situation, a cross-functional project team was set up but with unclear decision rights. The result was a project that drifted for several years as the project could not incorporate competing demands successfully. Key elements of good cross-functional governance include:

- *Cross-functional steering committee.* It is of critical importance to include all key stakeholders across lines of business and functions. Of particular importance to smart meter projects is having the heads of customer care, distribution, and IT on the steering committee.
- *Good project governance.* Smart grid programs often involve a wide array of capabilities and functions. And many resources will be involved part-time. All too often, the project can “drift” or fail to utilize its resources fully as a result of inadequate project governance.



The electric utility industry is on the verge of revolutionary change. Fully realizing the smart grid vision—smart meters, enhanced consumer energy management systems, automation in the T&D system, and integration of renewable energy—will require years of work and billions of dollars of investment. Utilities can leverage their considerable experience managing capital-intensive projects to ensure that these efforts deliver the benefits regulators, customers, and investors expect. Following the best practices identified here will improve their odds of achieving project goals, vaulting the industry into a new era in a timely and cost-effective way. ○