The Modern Grid Strategy

BUILDING A SMART GRID BUSINESS CASE

Developed for the U.S. Department of Energy
Office of Electricity Delivery and Energy Reliability
by the National Energy Technology Laboratory
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NETL

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INTRODUCTION

The transition to the smart grid will take many years and will be driven by the interests and desires of the primary beneficiaries—utilities, individual consumers, and society in general. Two key ingredients are needed to instill in each of these stakeholders the passion to support and invest in a smart grid.

The first of these ingredients is ***collective understanding***. This understanding is based on a clear vision that defines what the smart grid is, what it can do, how it will be implemented, and how each stakeholder will be affected. Clearly, communicating smart grid concepts to a critical mass of diverse stakeholders is difficult, but it is essential to gaining their alignment. The Department of Energy's Modern Grid Strategy (MGS) team, led by the National Energy Technology Laboratory, has developed a national smart grid vision and associated concepts. The team has conducted an outreach effort over the past few years reaching over 400 organizations, but more work is needed.

Understanding leads to alignment and ultimately to decision making. The following questions need to be answered to achieve collective understanding among all stakeholders:

- What is the smart grid and why should we care about it?
- How should the national vision be modified to fit regional-specific situations?
- What solutions are needed to achieve the regional-specific smart grid vision?
- What are the value propositions?
- What implementation plan optimizes the business case?

The second ingredient is ***motivation***. Alignment around smart grid concepts is important and helps ensure that all stakeholders are "pulling in the same direction," but without a compelling incentive to move forward, progress will be limited. Motivation emerges when a universal value proposition exists, that is, when a compelling business case is seen from each beneficiary's perspective. The degree of motivation depends on the strength of the value proposition—the stronger the business case, the stronger the motivation.

In 2004, the Electric Power Research Institute conducted a study to estimate the costs and benefits of developing the "Power Delivery System of the Future," a concept that was very similar to the MGS smart grid vision. The study indicated the overall benefit-to-cost ratio to implement this concept could be as high as five to one (5:1). These results have generally been confirmed by later studies.

Although these are very positive conclusions of reputable researchers, progress with smart grid implementation has been slow, suggesting there are still barriers on the road to a smart grid. Perhaps the high-level perspective of such studies—the lumping together of all benefits and all costs for all stakeholders—may be less compelling when viewed from each individual stakeholder's perspective. Regional differences may add further complications. This suggests a need to break down the analyses to address the individual interests and concerns of each entity—the utility, consumers, and society—so that each one is motivated to move forward.

Understanding what the smart grid vision and implementation plan is for a specific utility, state, or region and the associated value propositions from the perspective of these beneficiary groups is needed to provide the basis from which stakeholder motivation is created. This document describes a methodology for doing both: developing a region-specific smart grid vision and implementation plan and the associated business cases.

THE MGS NATIONAL SMART GRID VISION

The MGS team conducted a systems analysis of the electric grid and determined that stakeholders will value a smart grid that makes improvements in the following areas:

- Reliability—reduced outage frequency and duration, adequate power quality, and improved customer service.
- Security—reduced vulnerability to attack and natural events.
- Economics—downward pressure on future electricity prices, opportunities, and options for consumers to save on their energy bills.
- Efficiency—energy conservation by consumers, reduced system losses and reductions in operations, maintenance, and capital expenditures.
- Environmental Friendliness—enablement of intermittent renewables.
- Safety—protection for line workers and the public.

From these smart grid value areas or key success factors (KSFs), the required functionality for the smart grid was defined in terms of its principal characteristics (PCs). These seven PCs provide the foundation for the smart grid:

- Enables Active Consumer Participation
- Accommodates All Generation and Storage Options
- Enables New Products, Services, and Markets
- Provides Power Quality for the Digital Economy
- Optimizes Asset Utilization and Operates Efficiently
- Anticipates and Responds to System Disturbances
- Operates Resiliently Against Attack and Natural Disaster

This smart grid framework, developed by the MGS team, can guide utilities, states, and regions as they develop a specific smart grid vision for their particular situation(s).

METHODOLOGY

Figure 1 describes the process for creating the vision and building the business case for a smart grid based on the unique characteristics of the region. Each of the fundamental steps are summarized below and discussed in more detail in dedicated sections of this paper.

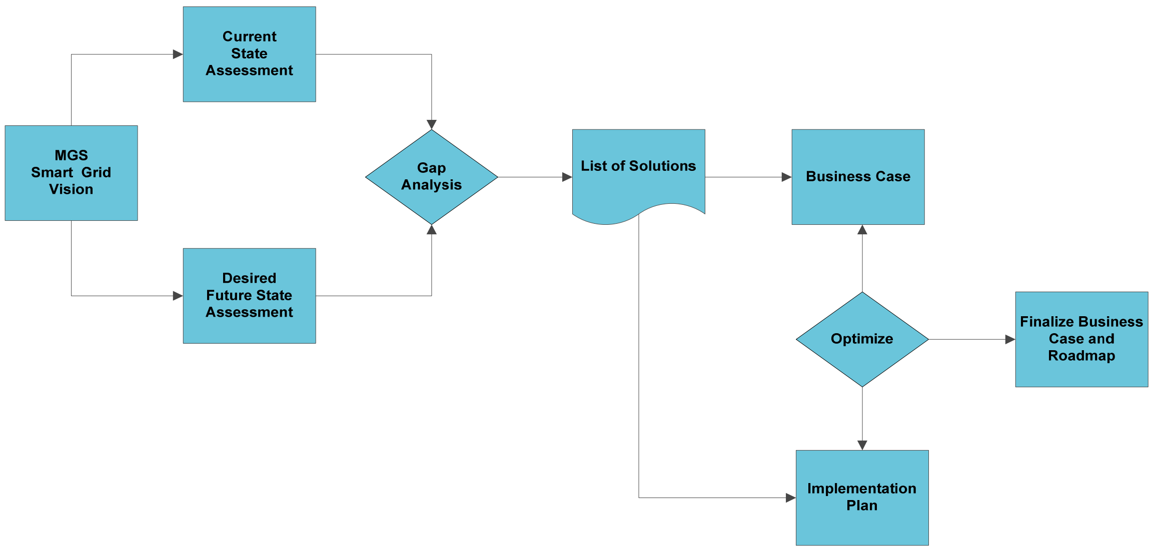

Figure 1: Smart grid Implementation plan process

The MGS smart grid key success factors and principal characteristics form the framework around which the region-specific implementation plan and business case can be developed. The KSFs identify the value areas for which benefits can be identified. The PCs guide the selection of which smart grid features are most desired and set the relative priorities for implementation.

Desired Future-State Assessment

In collaboration with the key stakeholders, a smart grid vision for the specific region (municipality, utility, state, market region, etc.) is developed. General agreement and understanding is reached on the goals to be achieved by the smart grid and how those goals will impact the PCs. Future socio-economic conditions are projected to verify they support this planned vision.

Current-State Assessment

The current technologies, processes, resources, regulatory climate, and consumer culture are assessed to establish the starting point from which the smart grid is defined. Particular emphasis on the utilities' current status in these areas is needed, as well as any future plans described in its 5-year Business Plan or Integrated Resource Plan.

Gap Analysis and Solutions

The smart grid vision defined in the desired future-state assessment is compared to the current-state assessment results to identify the gaps in the technology, regulatory policy, and consumer culture areas. Gap statements are written and the actions needed to reduce or eliminate them are defined.

Specific solutions are then identified based on the gap statements. These solutions will include new applications, technologies, processes, programs, regulatory and legislative policy, and consumer/societal outreach. Additionally, specific research and development projects needed to reduce investment risks are identified.

Business Case

Specific financial metrics are defined. Using the solution set identified above and the quantities and sequence assumed in the initial implementation plan, cost estimates are determined to design, procure, install, test, and place the solutions into operation. In addition to these capital costs, assumed operation and maintenance (O&M) costs are estimated where applicable. Using the goals defined above, specific benefits are cataloged and their values are estimated. The business case is then developed and the results evaluated. Multiple iterations may be required to optimize the business case.

Implementation Plan

The implementation plan establishes the timing, scope, and quantities for deploying both the solutions and any associated research and development (R&D) projects. The business case cash flows for both the costs and benefits are driven from this plan. It is modified iteratively until the business case results are optimized.

Optimization

Modeling, simulation, and other analysis tools, along with good engineering judgment, are used to adjust timing, solution scope, and quantities. These variables are captured in the implementation plan and are used as inputs to the business case. Various options and iterations are evaluated to determine the specific solutions that optimize the business case financial metrics.

Finalization

Once optimized, the final implementation plan and business case is summarized. The results are also broken down by the primary beneficiaries (utility, consumer, and society) and shared with each to help them understand the smart grid's value from their own perspectives. This process supports the decision-making process for all key stakeholders by revealing how and why a smart grid meets their specific needs and desires.

DESIRED FUTURE-STATE ASSESSMENT

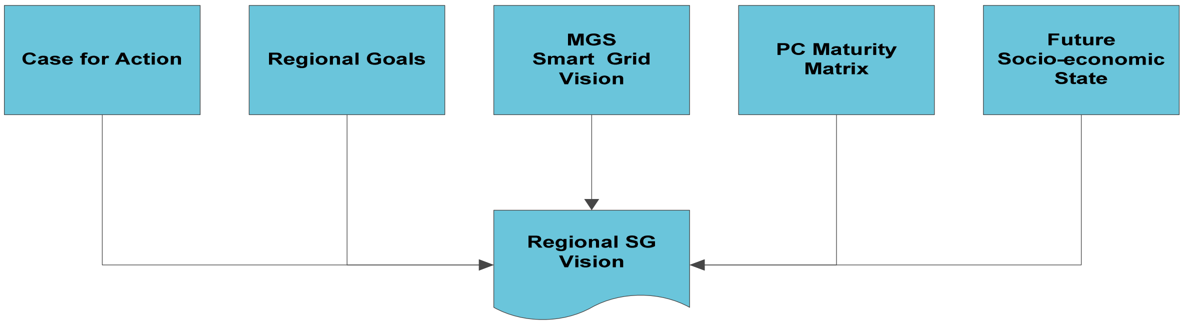

Figure 2: Developing the desired future state

Is a smart grid desired or needed?

The first step in developing the desired future state is to answer the question, “Why should we consider a smart grid?” for the specific region. The answer to this question should be considered from two perspectives—the cost of status quo, using the business-as-usual (BAU) approach for making grid investments, and the potential opportunities that a smart grid can provide. Some of the issues associated with BAU include:

- Today’s grid is aging, outmoded, and stressed.
- Unreliability is costing consumers and society billions of dollars annually.
- Today’s grid is vulnerable to attack and natural disaster.
- An extended loss of today’s grid could be catastrophic to our security, economy, and quality of life.
- Today’s grid does not address the 21st century power supply challenges.
- Demand for electricity is projected to increase 30% by 2030.
- Cost to build new generation is increasing dramatically.
- Electricity prices are going up.

The potential opportunities for a smart grid generally align with the KSFs listed below. Specific goals to be achieved by the smart grid in each area should be identified by the stakeholders.

Improved:

- Reliability
- Security
- Economics

- Efficiency
- Environmental Friendliness
- Safety

The nature and priority of these goals will be dependent on specific regional circumstances. For example, in areas with high-cost electricity, the economic value area may receive the highest priority. In areas with poor reliability, the reliability area may be more important, and so on. The value associated with achieving these goals compared to the costs of BAU should enable stakeholders to decide if a smart grid is desired. Reaching consensus to consider the implementation of a smart grid is a critical first step.

What is the regional vision for the smart grid?

A suggested starting point for defining that vision is the national smart grid vision as defined by its seven PCs, presented earlier. The regional goals developed by the stakeholders should be used to determine to what degree each of the seven PCs should be implemented. The MGS team has developed a Principal Characteristic Maturity Matrix (PCMM) to assist in identifying the desired degrees of maturity for each of the PCs. The PCMM will soon be available on the Modern Grid Strategy website.

Will the probable future regional environment support this regional vision?

Part of defining a regional smart grid vision is to understand what the probable future socio-economic state of the region might be. This understanding might identify specific issues that prevent or encourage the achievement of the vision. Some areas to be considered include:

- Regulatory Policy—traditional vs. willingness to change to support the smart grid.
- Economic Development—slow vs. rapid growth in electricity demand.
- Legislative Impact—slight vs. significant (e.g., carbon dioxide, etc.).
- Societal Acceptance—resistance vs. support.

Understanding the probable future states for these factors will help clarify the probability of success for smart grid implementation and will suggest where additional effort will be needed to make the vision reality.

The regional smart grid vision as described by its seven PCs is the output of this section.

CURRENT-STATE ASSESSMENT

Defining the current state in the region is a critical step and sets the starting point from which the transition to a smart grid begins.

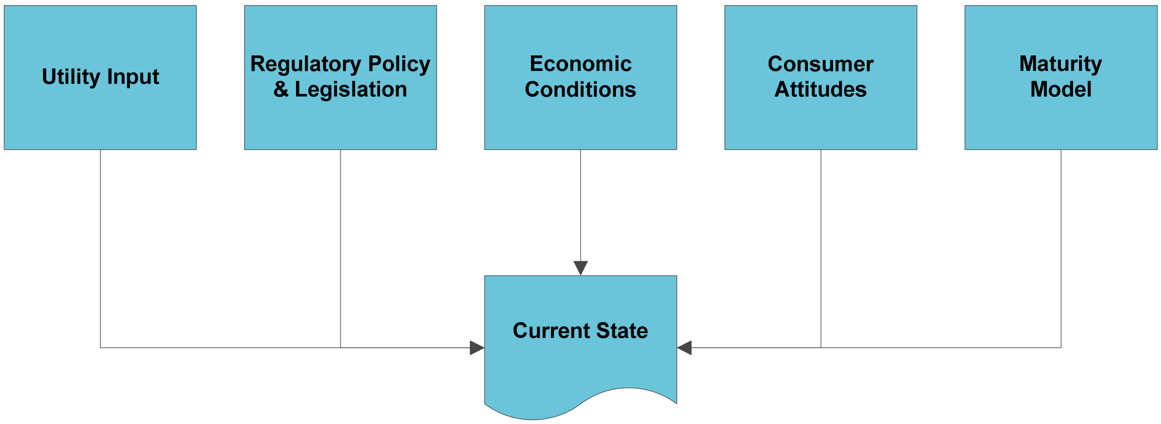

Figure 3: Determining the current state

Generally, the current state should be evaluated from the following perspectives:

- Technical—technologies, applications, processes, and systems currently deployed and in use, as well as currently approved plans for future investments in this area.
- Regulatory—policies that impact smart grid deployment and the current regulatory climate for change in policy.
- Legislative—existing and pending legislation that impacts smart grid deployment.
- Consumer—current consumer attitudes toward the smart grid.

Several inputs may be used to determine the current state in the region:

Technical

Carnegie Mellon University's Software Engineering Institute is the current steward of the smart grid Maturity Model developed by IBM. Use of this tool is a good way for utilities to assess their current smart grid maturity and provides good input for performing the current-state assessment. Additionally, the PCMM developed by the MGS team can also provide current state insights from an individual PC perspective. Additional research and discussions with utility staff may be required to address higher-level technical topics such as system topography, asset and customer data, specific operational history, etc.

Regulatory and Legislative

Discussions with regulatory staff and commissioners, Internet research, and input from stakeholders are good sources for this information. Understanding the region's willingness to change policy and legislation to support the implementation of a smart grid is important. In addition, the regulator's perspective on the economic conditions, business climate, and pending issues that might affect smart grid implementation is needed.

Consumer

Consumer surveys and workshops can provide good input on consumer attitudes and an independent perspective on the regional economic conditions and business climate. Input should be acquired from all consumer classes (residential, commercial, and industrial), consumer advocacy groups, and city mayors, etc.

The current state of the region in the noted areas for each PC is the output of this section.

GAP ANALYSIS AND SOLUTIONS

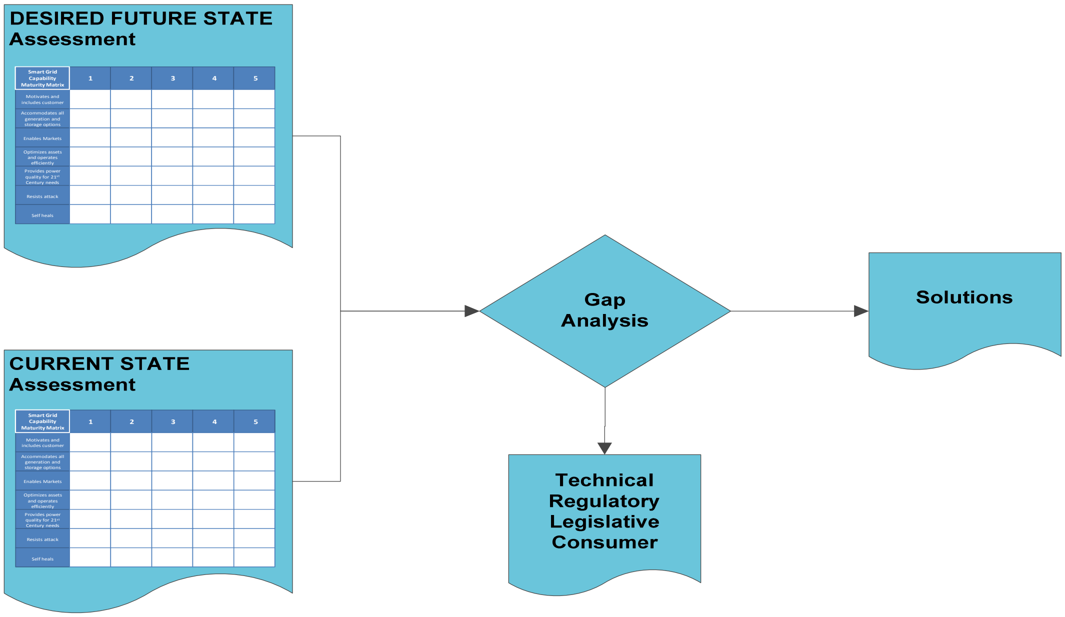

Figure 4: Analyzing the gaps and identifying solutions

The gap analysis compares the results from the desired future-state assessment with those from the current-state assessment. The gaps between these two assessments are characterized for each smart grid PC from four perspectives: technical gaps, regulatory gaps, legislative gaps, and consumer gaps. From each gap statement, solutions are selected to eliminate or significantly reduce the identified gaps. Where proven solutions do not yet exist, specific research and development needed to minimize deployment risk are specified.

Solutions

Many of the general smart grid solutions have been identified and cataloged. This list of solutions is provided in Appendix A and can serve as a reference to support the selection process for closing identified gaps. The solution set forms the starting point for what should be included in the implementation plan and business case. The breadth and depth of deployment, basic functional requirements, and deployment sequence for the selected solutions will be more clearly defined during the optimization phase of the process.

BUSINESS CASE

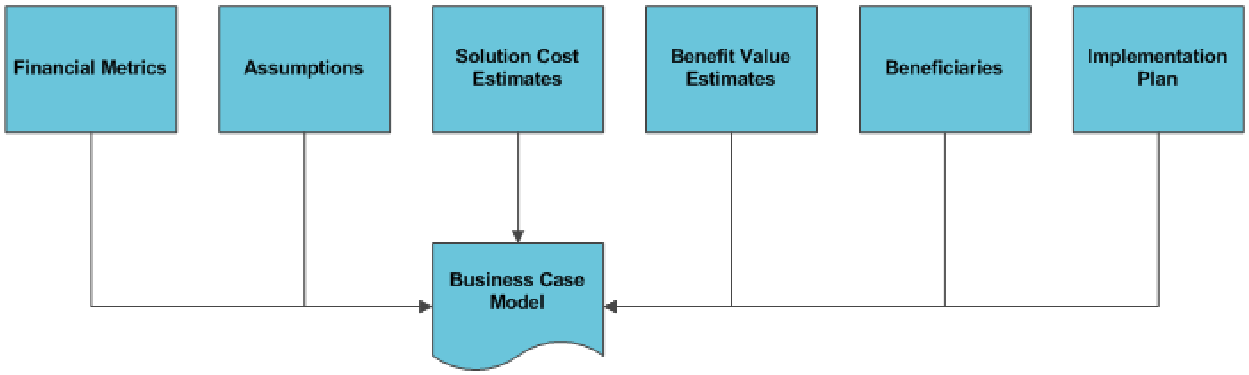

Figure 5: Performing the business case analysis

The fundamental inputs to the business case model are depicted in Figure 5 above. Each of these elements is discussed below.

Financial Metrics

The financial metrics to be used for the business case should be based on what is needed by the overall smart grid decision-making process. Some suggested metrics include net present value, benefit-to-cost ratio, and payback period.

Assumptions

A list of assumptions and their values and bases should be identified up front and listed on a specific worksheet of the financial tool. Later, these assumptions can be varied to determine how sensitive the end results are to the uncertainty of the assumption(s). Outputs from modeling and simulation tools can be used to reduce the uncertainty of the more sensitive assumptions.

Solution Cost Estimates

The initial run of the business case model should apply the solutions selected during the gap analysis phase. Capital investment costs, as well as the annual O&M costs for each solution, are estimated. The timing, sequencing, and penetration levels of the solutions are identified in the implementation plan phase. The business case will be optimized iteratively by adjusting the implementation plan timing, sequencing, and quantities to get the best financial result.

Benefit Value Estimates and Beneficiaries

The goals defined in the desired future-state assessment form the basis from which the regional-specific smart grid benefits are determined and their values estimated. For example, if one goal is to improve reliability by 30% relative to the BAU reference then that goal implies a specific reduction in the number and frequency of outages and perhaps an improvement in power quality. The challenge is then to estimate the value of these specific benefits from the perspective of the primary beneficiaries the utility, the consumer, and society. Specific financial data needed to support the monetizing of benefits can be obtained from the utilities or from Internet research.

Although the goals established in the desired future-state assessment section drive the overall benefit expectations, additional benefits may be identified when the solutions identified from the gap analysis are considered collectively.

Some specific benefits of the smart grid broken down by primary beneficiary are listed below. Their value depends on the conditions in the specific region where they are realized.

The Beneficiaries

A win-win proposition for all stakeholders will be required to create the traction needed to move smart grid implementation forward; therefore, smart grid business cases should be developed in a way that defines the value proposition from each beneficiary's perspective. As mentioned earlier, the primary beneficiary groups are utilities, consumers, and society in general.

Utilities

The term "utility" is used in this context as a general label for all grid operators, including investor-owned utilities, public power, municipals, cooperatives, etc. Cost recovery is different among and within these groups due to their various structures and regulatory policies. Generally speaking, the benefits and general costs associated with this beneficiary include:

Benefits

- Return Of and On Investment
- Operational Benefits
- Improved Customer Satisfaction
- Improved Relations with Regulators
- Improved Environmental Image

Costs

- Risk of Cost Recovery

The utility group is the engine for smart grid investment and without its involvement, the transition to the smart grid will not occur. If the risk of cost recovery for smart grid investments is eliminated, reduced, or clearly defined, the utilities will be more likely to move forward with investments that advance the smart grid and increase shareholder value.

Consumers

Each of us as individual residential consumers is interested in what the smart grid will do for us as individuals. The consumer value proposition answers the question, "What's in it for ***me***?" Some of the consumer benefits and costs include:

Benefits

- More reliable service.
- Potential bill savings.
- Transportation cost savings—plug-in hybrid electric vehicles (PHEVs) vs. conventional vehicles.
- Information, control, and options for managing electricity.
- Option to sell consumer-owned generation and storage resources into the market.

Costs

- Smart grid costs passed on to consumer.

How compelling are these benefits? Let us look at two of the specific benefits listed above—potential bill savings and transportation costs savings—to get a general idea for the magnitude of the value proposition for each benefit.

Potential bill savings

Let us use some rough numbers, starting with an average residential electric bill of around $100 per month. Next, we will assume consumers who participate in Energy Efficiency (EE) and Demand Response (DR) programs will achieve around 10%–15% savings on their bill each month. The benefit in bill savings is then $10–$15 per month. If we assume the increase on their bill to pay for smart grid investments is $5–$10/month, the net benefit is $0–$10/month. This is a positive proposition but not one that is very compelling.

Potential Bill Savings	
Estimated residential bill/month	$100
Expected reduction from EE/DR	10%–15%
Potential savings/month	$10–$15
Assumed bill increase to pay for SG/month	$5–$10
Net consumer value/month	$0–$10

Figure 6: Potential bill savings

Potential fuel cost savings from PHEVs

At current electricity prices, the cost to drive PHEVs using kilowatt-hours (KWh) as fuel is significantly less. Again, using some rough numbers, we can estimate what the value proposition is for PHEV drivers enabled by the smart grid. We begin by assuming consumers drive an average of 10,000 miles per year. Next, we calculate that if the traditional vehicle achieves 25 miles per gallon and the cost of gasoline is $2.50 per gallon then the fuel cost for operating with gasoline is 10 cents per mile. As the fuel economy goes down and the cost of gas goes up, the cost per mile will go up. So, let us assume a fuel cost range of 10–15 cents per mile.

The fuel cost for operating a PHEV is less straightforward and obviously depends on the cost of electricity. Some researchers project the cost of operating a PHEV to be about 3 cents per mile when electricity prices are 10 cents per KWh, so we can assume a fuel cost range of 3–5 cents per mile.

Using these fuel cost ranges, the annual cost for operating a vehicle with gasoline is $1,000–$1,500 and the annual cost for operating a PHEV is $300–$500, resulting in a potential annual savings of $500–$1,200. This benefit is more significant than the bill savings benefit discussed above; however, we must not forget the premium of $4,000–$10,000 to purchase the PHEV so that these benefits can be realized. Yes, this value proposition is more compelling, but is it enough to encourage consumers?

Potential Fuel Cost Savings	
Assumed miles driven/year	10,000
Fuel cost (gas)/mile	10–15 cents
Fuel cost (PHEV)/mile	3–5 cents
Annual fuel cost (gas)	$1,000–$1,500
Annual fuel cost (PHEV)	$300–$500
Potential fuel cost savings/year	$500–$1,200
Premium to purchase PHEV over gas	$4,000–$10,000

Figure 7: Potential fuel cost savings from PHEVs

These examples suggest that the consumer value proposition, while positive, may not be compelling enough to motivate wide spread acceptance of the smart grid by individual residential consumers. The benefits that the smart grid could bring to society, however, might provide the necessary incentive to motivate us all.

Society

The societal value proposition answers the question, “What’s in it for *us*?” The smart grid is expected to provide opportunities in a number of societal areas, some of which include:

Benefits

- Downward pressure on electricity prices.
- Improved reliability reducing losses that impact consumers and society.
- Increased grid robustness improving grid security.
- Reduced emissions.
- New jobs and growth in gross domestic product.
- Transformation of the transportation sector leading to a reduction in U.S. dependence on foreign oil.

Cost

- No incremental cost.

Further work is needed to quantify these opportunities, but they are expected to be quite large. Taken together, the consumer and societal value proposition is compelling and both should be included in consumer education programs and smart grid business cases.

Business Case Modeling

Business modeling is performed from an overall view to determine if the smart grid meets the financial hurdles. The values of the assumptions should be varied to determine the sensitivity of each. Additional analysis will be required to reduce the uncertainty of any assumptions that significantly impact the end result. Specific views from the perspectives of the primary beneficiaries should also be done to illustrate the value proposition for each group.

IMPLEMENTATION PLAN AND OPTIMIZATION

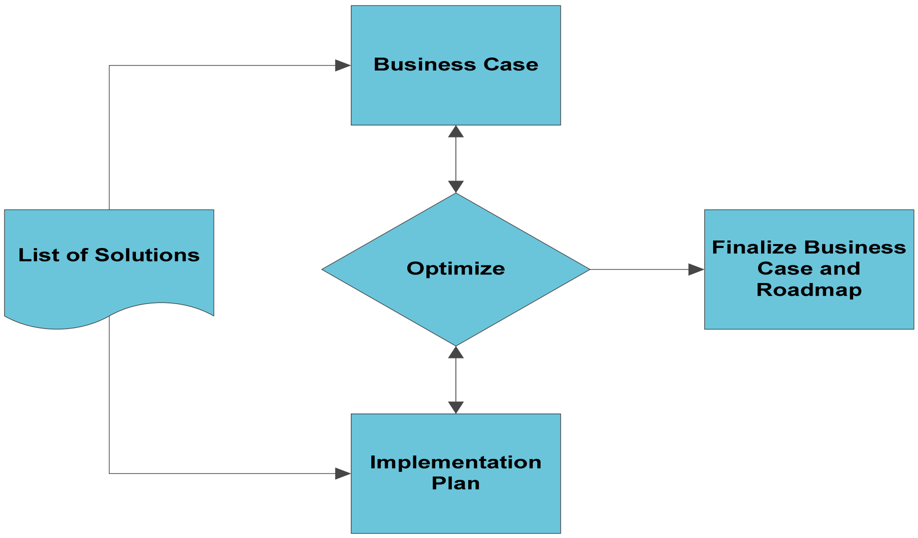

Figure 8: Implementation planning and optimization

The gap analysis process produces the initial solution set but does not define the sequence and depth of deployment or the specific timing for implementation. The initial quantities, sequencing, and timing for deploying the solutions are defined in the initial implementation plan. The corresponding benefits are then appropriately linked to these deployments.

The business case analysis is performed based on the initial implementation plan and the results analyzed. The business case is then optimized by adjusting the implementation parameters (quantities, sequence, and timing) to determine the most optimal implementation plan based on the financial results. For example, the placement of distribution automation switches, both their location and quantities, might be varied along with the resulting costs and benefits (i.e., reliability) to determine the optimal configuration. Engineering judgment and other analytical tools may be used to assist in this optimization process.

It is important to note that the business case and implementation plan are based on the assumption that the solutions are rolled-out in a coordinated fashion rather than independently. Treating the solutions as separate cases would increase the cost and reduce the benefits to the consumers and society.

The optimization process is repeated until the desired level of optimization is achieved.

Finalization

Once the optimization process is complete, the results of the business case analysis can be used to determine if the regional smart grid is viable. Additionally, the value proposition for each of the primary beneficiaries can be determined. These value propositions, if compelling, can create the motivation for moving forward.

SUMMARY

The implementation plan and business case created from this process is intended to produce the level of detail needed to support a business-level decision-making process for moving forward with a regional smart grid. Additional work will be needed to define the specific functional requirements for each of the solutions, build the project schedule, and conduct the design, build, test, and operate phases.

The Modern Grid Strategy team continues to work in this area of smart grid implementation. The next steps include plans to develop a business case financial model, consistent with this process, and specific tools to help in estimating the values of many of the benefit categories. Visit the Modern Grid website periodically to take advantage of these tools when they are available. http://www.netl.doe.gov/moderngrid/

For more information

This document is part of a collection of documents prepared by the Modern Grid Strategy team. Documents are available for free download from the Modern Grid website.

The Modern Grid Strategy

http://www.netl.doe.gov/moderngrid/

info@TheModernGrid.org

(304) 599-4273 x101

BIBLIOGRAPHY

1. "Modern Grid Strategy," NETL, 2009, http://www.netl.doe.gov/moderngrid/.
2. Power Delivery System of the Future - A Preliminary Estimate of Costs and Benefits, Report #1011001, EPRI, July, 2004, http://mydocs.epri.com/docs/public/000000000001011001.pdf
3. Software Engineering Institute, Carnegie Mellon, 2009, http://www.sei.cmu.edu/smartgrid/.
4. U.S. Department of Energy - Advanced Vehicle Testing Activity, PHEV Field Test Plans and Testing Results, DOE PHEV Annual Review Meeting – Washington, D.C., June 2007.

APPENDIX A: GENERAL SMART GRID SOLUTIONS

The general smart grid solutions categorized by the fundamental smart grid milestones are described below. Smart grid milestones group the solutions based on their value in the following areas:

- Consumer
- Distribution system
- Transmission system
- Asset Management process

Consumer

The Consumer Enablement (CE) milestone will empower consumers by giving them the information, control, options, and education they need to utilize the new options provided by the smart grid effectively. Additionally, this milestone provides grid operators new options for engaging the consumer as a resource. Solutions include:

- Smart meters that record interval energy usage, power quality parameters, other system operating parameters, and are equipped with remote connect/disconnect capability.
- Two-way integrated communication system with adequate bandwidth and speed to support the exchange of data and information among consumers, other smart grid users, and all appropriate smart grid processes, technologies, and applications.
- Consumer portals that support a home area network (HAN) and in-home display that enables consumers to set preferences easily, control their smart devices, understand their consumption, and interface with the smart grid.
- Meter data management system that intelligently processes the vast amount of data produced by the smart meters, converts the data to information, and integrates with other smart grid processes and technologies.
- Time-of-use prices that reflect the real cost of electricity provided to consumers at frequencies needed to support market transactions.
- Upgrades to utility legacy processes, technologies, and applications needed to support the integration of other smart grid applications. For example, legacy Customer Information Systems and Information Technology architectures might need modification to support the increased transactional load and cross-functional nature inherent in the smart grid vision.
- Customer educational programs to help consumers understand the benefits of the smart grid and how they can take advantage of the new opportunities and options it provides to them.

- Demand response programs that incentivize consumers to participate in demand reducing activities.
- Consumer-owned distributed generation and storage resources that are grid connected, dispatchable by grid operators, and provide financial incentives to the owners.

Distribution system

The Advanced Distribution Operations (ADO) milestone is primarily aimed at the utility side of the smart grid and will improve reliability and enable self-healing. It supports effective and efficient operation of extensive distributed generation and storage of all types and sizes including perhaps millions of PHEVs and various types of micro-grids. Solutions include:

- Ubiquitous deployment of smart sensors that monitor distribution system operating parameters at all key locations.
- High level of granularity of smart switches, enabling the distribution system to be sectionalized into optimal size parts when needed.
- Distribution Management System (DMS) equipped with advanced analysis and control algorithms and devices to enable two-way power flow on the distribution system. DMS is used to take advantage of the ubiquitous system information and control capability to optimize operation and provide self-healing capability.
- Distribution Automation that automatically reconfigures the distribution system to minimize the impact of disruptions.
- Advanced Outage Management System, which integrates ADO with CE to detect and diagnose local outages, leading to a rapid dispatch of crews to repair the trouble. Customer calls to report trouble will no longer be needed to determine location and source of the trouble.
- Geographic Information System (GIS) to provide the "where" dimension needed to support ADO and CE.
- Micro-grid operation tools integrated with DMS and consumer HANs to identify when micro-grids should be operating in parallel with the grid or in an islanded mode.
- Advanced protection systems that adapt and support two-way power flow.

Transmission system

The Advanced Transmission Operations (ATO) milestone is primarily aimed at improving transmission reliability and efficiency by integrating the distribution system's smart grid features, both the CE and ADO milestones, with Regional Transmission Organization (RTO) applications to improve overall grid operations and reduce transmission congestion. Solutions include:

- Substation automation that collects information and control capabilities at each substation and communicates with other substations to ensure that broader system conditions are optimized among these assets.

- Integration with RTOs and their processes to ensure linkage among ATO and ADO, and ultimately with CE.
- Wide Area Measurement System (WAMS) that is integrated with transmission operation centers to increase operator's situational awareness. WAMS will also reduce the time needed for key transmission algorithms to solve, giving operators new tools to better understand existing and projected conditions.
- Ubiquitous deployment of smart sensors that monitor transmission-system operating parameters at all key locations.
- Modeling and simulation tools to enable operators to perform "what-if" scenarios and understand future operating risks.
- Advanced materials and power electronics devices to improve asset utilization, voltage management, power quality, and flow control of large blocks of power.
- Advanced protection systems that adapt to system operating conditions and can utilize WAMS's instantaneous information to provide wide-area protection.

Advanced asset management process

The Advanced Asset Management (AAM) milestone will integrate the grid intelligence acquired in achieving the other milestones with new and existing asset management applications. This integration will enable utilities to reduce operations, maintenance, and capital costs and better utilize assets during day-to-day operations. Additionally, advanced asset management will significantly improve the performance of capacity planning, maintenance, engineering and facility design, customer service processes, and work and resource management. Solutions include:

- Ubiquitous deployment of smart sensors that monitor asset condition and health for all critical assets.
- Dynamic ratings of assets to optimize their utilization.
- Condition monitoring algorithms that determine when assets should be removed from service for maintenance, maximizing their useful life.
- Integration of smart grid intelligence with key asset management processes, including system planning, maintenance, engineering, customer service, work, and resource management.