NYS SmartGrid Consortium

Smart Grid Roadmap for the State of New York

September 15, 2010

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1 Introduction

Throughout its history, New York State has been a leader in the world of energy generation, distribution, discovery and innovation. With the rapidly evolving industry and the escalating strains being placed on the infrastructure through new technologies and increased consumer demands NY is in a position to be a pioneer in modernizing the electric grid.

New York is the proud home of key industrial smart grid players including GE and IBM, and it represents an epicenter of major energy research within academia, industry and government. As a world leader in global finance and media, NY is strategically positioned to finance the smart grid infrastructure, define its value and promote its importance on a regional, national and global level.

The New York State Smart Grid Consortium ("Consortium"), a unique public private partnership across the entire energy supply chain, was founded to align and leverage these unique resources. Its mission was to define an overall strategic smart grid vision, facilitate and enable timely, efficient and cost-effective smart grid developments and to serve as a model for the nation. The Consortium's unique, comprehensive and collaborative approach ensured a well integrated plan for smart grid implementation that meets the sustainable energy needs of the more than 7,930,000 electric customers across the state.

The collaborative spirit and commitment of the Consortium, combined with the expertise, capabilities and resources of its members, has successfully positioned New York State as a leader to successfully achieve this vision. To that end, KEMA/DeSola were commissioned to develop a Benefits/Costs whitepaper for smart grid deployment in the state. The purpose of the analysis was to assess the broad economic, customer and social impacts to NY as a consequence of an aggressive deployment of smart grid technologies.

Soon after sharing the initial Benefits/Costs findings with membership, work began on the development of a "Roadmap" for NY Smart Grid strategies that leveraged the integrated benefit/cost model to reflect the impact of future smart grid activities. This roadmap will help in the smart grid deployment decision-making process and help to prioritize investments needed to help maximize stakeholder value both in the short and long-term.

The purpose of the roadmap report is to assess the broad economic, customer and social impacts to NYS from the aggressive deployment of smart grid technologies. This unique statewide analysis factors in all practical smart grid technologies and applications, and considers all the potential consequences over the next decade. This roadmap has been developed to analyze the relative costs, benefits, and priorities of the various smart grid technologies, business models, and policies in some detail including how different types of customers and geographic regions benefit. The report describes all of the assumptions and calculations in the analysis of full statewide costs and benefits of a New York Smart Grid, including the use of an interactive model to assess the relationships between investments and savings. It analyzes savings to consumers that will accrue from direct impacts on T&D rates; on energy usage and on energy market peak prices; and from other economic benefits that directly flow to consumers. It also identifies less direct benefits such as environmental impacts and resulting economic development.

We strongly believe that this analysis[1] will help the Public Service Commission enhance its base of smart grid knowledge and enhance its ability to make well informed, critical decisions regarding investments in smart grid technologies moving forward.

It must be clearly understood that the data in this analysis originates in a number of published and unpublished works or in some cases was developed by the authors. The basic data on technology costs and overall anticipated benefits and the modeling methodology have been reviewed with a number of consortium members and their feedback incorporated. However, these analyses are not presented as being explicitly applicable to any individual state utility and should not be interpreted as such. None of these results have been "approved" by any consortium member as being explicitly applicable to their own service territories, filings, or plans. The New York State Smart Grid Consortium sponsored this roadmap development and has reviewed it prior to submitting it for PSC consideration as a valuable and informative analysis but is not representing that any individual consortium member's particular cases would closely mirror the data presented.

[1] Please note that while the NY PSC is a current member of the NYS Smart Grid Consortium, its directors or staff did not in any way review or participate in the drafting or finalizing of this report or were involved in the development of the Consortium's response to NY PSC CASE 10-E-0285.

2 Executive Summary

This report assesses the broad economic, customer and social impacts to New York State as a consequence of an aggressive deployment of the technologies and changed electric power operations and business models associated with Smart Grid technologies. While there have been many detailed analyses of the impact of major elements of Smart Grid on the economics of a single utility's business and their ratepayers, no state-wide assessment currently exists that factors in all practical Smart Grid technologies and applications over a period of a decade and which considers all the consequences.

When a utility develops a Smart Grid filing for a state utility commission, it typically analyzes the costs in great detail considering the state of its existing infrastructure and IT systems – using best known current costs of electronics, apparatus, and communications; and it analyzes in similar detail, the impact of new metering systems and automation on its operations and possibly on its long term capital investment needs. Such a filing can require 3-6 months of effort by a team of people to prepare.

When preparing this analysis for the New York State, we had to cover 5-10 times as much in terms of scope, plus analyze state wide economics not normally considered in a filing. The make-up of the trees in the forest is critical, but the details of counting and measuring every tree would overwhelm the reader as well as the team preparing the work. Consequentially, this analysis relies on a higher level methodology that translates "typical" cost and benefit data from sampled filings to metrics of $$ / MW of load. This methodology has been used in assessing national statistics from FERC Form 1 reporting of T&D investment levels, for example.

New York has (at least) three distinct utility environments: 1) a rural, sparsely populated set of regions, mostly upstate; 2) a number of densely populated suburban/urban areas characterized by traditional overhead or underground radial distribution circuits – but ones that are at higher voltages and heavier loading than rural circuits; and 3) a high rise urban environment characterized by electric service via urban underground secondary networks capable of carrying very high loads with outstanding reliability. The economic analysis in this whitepaper attempted to appropriately characterize the residential, commercial, and industrial customer load and Smart Grid costs and benefits for each of these environments.

The analysis shows that an investment of $7.2 billion by NY utilities over the next decade will result in annual savings and avoided costs to state ratepayers of $18.9 B over the period 2011- 2025. Overall benefits including jobs created are even greater over the same time period. This is a baseline analysis and scenarios of more or less aggressive Smart Grid deployments as well as variations in energy and infrastructure costs were explored as sensitivities. There are possibilities to achieve the same level of benefits at somewhat lower costs via policy and technology decisions that are also explored and explained in the document.

The major drivers in the cost benefits, as a result of Smart Grid, are as follows:

1. Economic Development benefits created by new jobs. The net gain of jobs is positive for full deployment, despite losing some jobs due to the increased automation.

2. Reductions in energy prices, especially at peak, as a result of peak shaving that originates with demand response programs and /or dynamic and time of use pricing programs that enable customers to more effectively manage their energy consumption given usage and energy prices. This analysis depended on published analyses by the Brattle Group and NY ISO, among others. Market peak price reductions ultimately benefit all consumers in the state as wholesale market expectations on peak pricing (and ultimately the fleet of peaking generation) will adjust to lower peak spot prices – and this will be reflected in all energy contracts and ultimately rates.

3. Lower costs in achieving state energy plan goals for renewable energy portfolio – the 15% by 2015 goal. Absent Smart Grid, more transmission has to be built, more wind generation may be curtailed at times, and the substitution of distributed generation for large wind farms is not as easy to

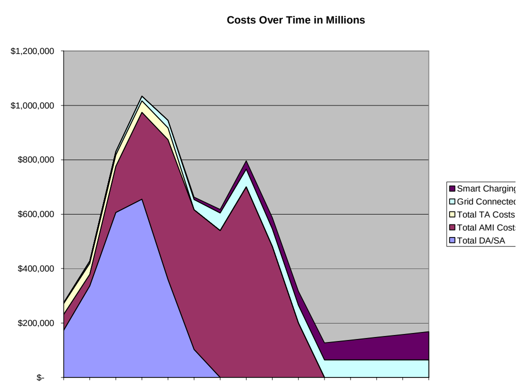
accomplish. The Smart Grid's ability to reduce/eliminate transmission congestion and to use storage to match renewable energy delivery to demand, are critical to realizing these benefits.

4. Significantly lower energy prices and distribution infrastructure capital costs associated with accommodating the state goal of 6% Electric Vehicle (EV) penetration by 2020. Absent Smart Grid and Smart Charging, EV will increase peak demand and spot prices, and will require "beefing up" of the affected distribution circuits.

5. Deferral of some distribution capital investment to accommodate general load growth by the exploitation of distributed energy resources.

6. Additional benefits associated with savings in utility operations, such as reduced losses and improved productivity that are also analyzed.

7. Our analysis of costs and benefits yielded a benefit to cost ratio of approximately 3 indicating these are sound investments. This is presented graphically in Figure 2.1 below:



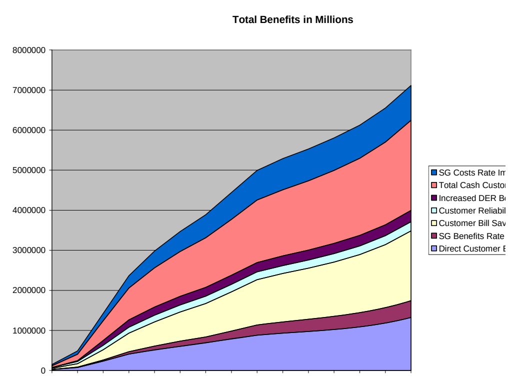


Figure 2.1 - Overall Costs and Benefits

Figure 2.2 displays another way to present this information:

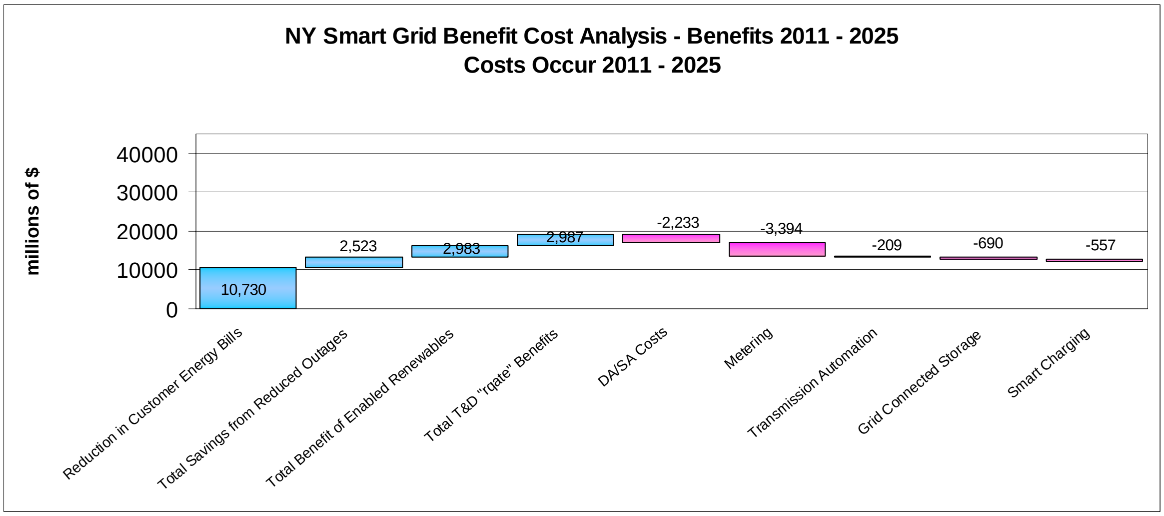


Figure 2.2 - Overall Benefit Cost Analysis

Beyond these quantifiable benefits, there are numerous less tangible benefits associated with the customer's ability to make informed choices about energy usage and to adopt new end-use technologies (such as smart appliances) some of which are hard to forecast. This report identifies these but does not attempt to quantify them.

Against these benefits, the cost of Smart Grid deployment must be assessed. The two major components are Advanced Metering Infrastructure (AMI) and Distribution Automation (DA) / Substation Automation (SA). AMI costs are estimated statewide based on existing filings from state and other utilities and incorporating projections of future costs at scale. DA/SA costs are estimated based on the three distribution circuit environments and translated to high level statewide estimates in terms of $$ / MW. Some of the state utilities have already deployed DA/SA to some extent but this could not be assessed, so in that regard, the costs estimated may be on the conservative side. Also embedded in these costs are those associated with transmission synchrophasor systems and operations / back office IT systems.

Other important Smart Grid technologies and applications are also considered including, e.g., Transmission Automation, Electric Vehicle Smart Charging, Electricity Storage.

What is new and different about this analysis is a year by year model of how penetrations of different technologies and policy decisions interact to impact state energy economics and downstream consumer and utility decisions about technology adoption – for instance with incremental penetration of Distributed Energy Resources such as rooftop Photovoltaic Systems.

Fully realizing the New York State Smart Grid vision will inevitably require that a number of policy issues be addressed. We have dedicated a section of this report to identify those policy issues which, if properly addressed, would be instrumental to achieving the vision and the identified benefits.

There are also some technology gaps in Smart Grid technologies today as compared with needs important to New York, especially to do with technologies that will gain flexibility in operating urban underground secondary networks. These are identified later in *Section 6 - The Smart Grid Roadmap* with recommendations on how to close those gaps.

3 The Consortium Smart Grid Vision

New York State has a vision for Smart Grid – where investments in Smart Grid infrastructure – Intelligence and communications – from the generator or wind farm to the consumer and the end use appliances – will produce substantial benefits to New York State consumers and businesses at many times the cost of those investments. The state will benefit by being able to achieve its Energy Plan – which includes increased renewable sources of energy and reduced carbon – at lower cost – and the state will enjoy improved power system reliability as seen by consumers and greater security of energy.

However, the electric grid as we currently know it, has for the most part, very much the same infrastructure that has been in place for the last 50+ years. It transports electricity from centralized points of large-scale generation sources over delivery transmission and distribution networks to consumers. The transmission system delivers electricity from power plants to distribution substations, while the distribution system delivers electricity from those substations to consumers. The flow of energy and information is predominately static and one directional, from the generators to the consumer, limiting the proactive participation of consumers. Grid-connected wind and solar resources, as well as distributed resources, create new challenges in planning, forecasting, monitoring, and managing the variability of resources that are inherently dependent upon the weather. The existing grid [see Figure 3.1 on following page] will be challenged by the need to integrate high levels of renewable resources - the successful development of a "Smart Grid" will dramatically enhance the way we interact and use energy moving forward.

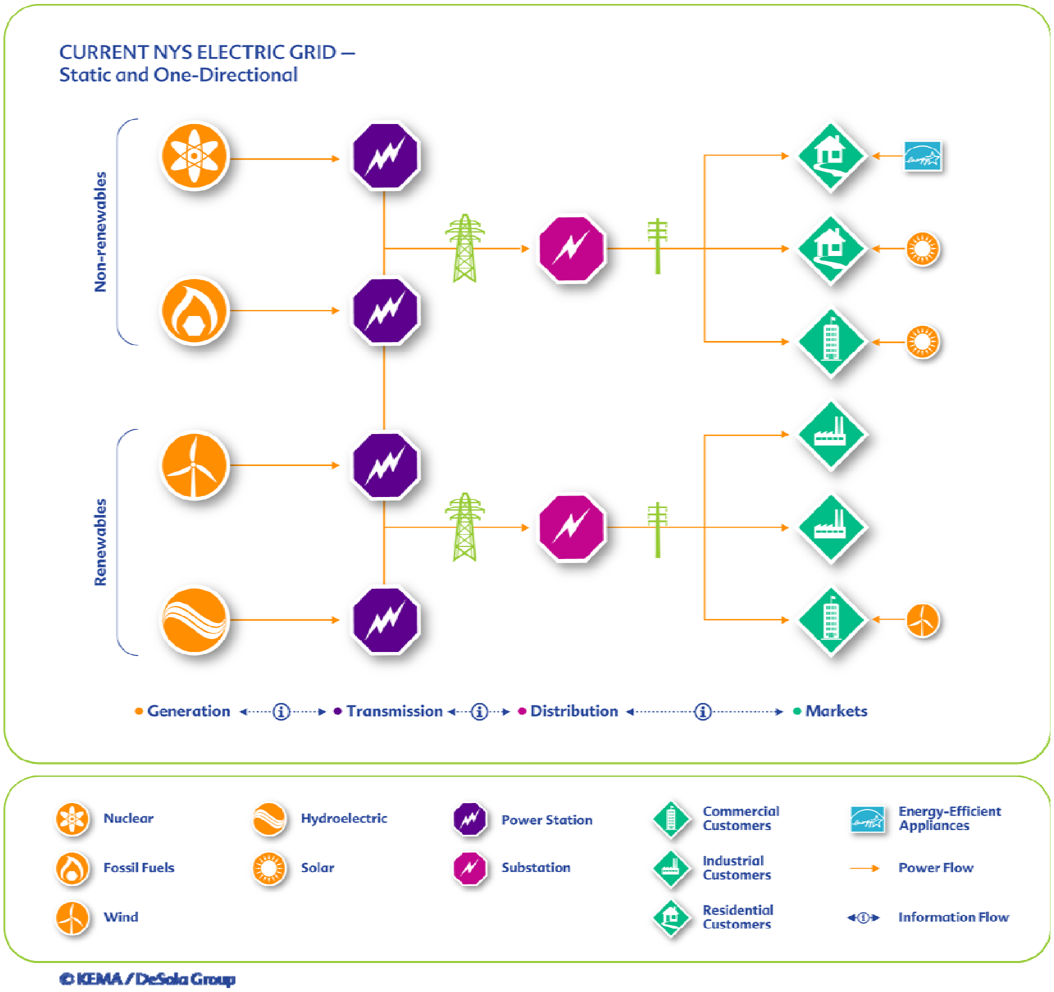


Figure 3.1 – Current NYS Electric Grid

Smart Grid means many things to many people today. It is not a "one size fits all" technology and must be adapted and configured for each region, state, and power utility. Smart Grid is a vision for the electric delivery system of the future. The Smart Grid envisions an entirely transformed electrical infrastructure. It will embody a network of devices as vast, interconnected, automated, and interactive as the Internet [see Figure 3.2 on following page].

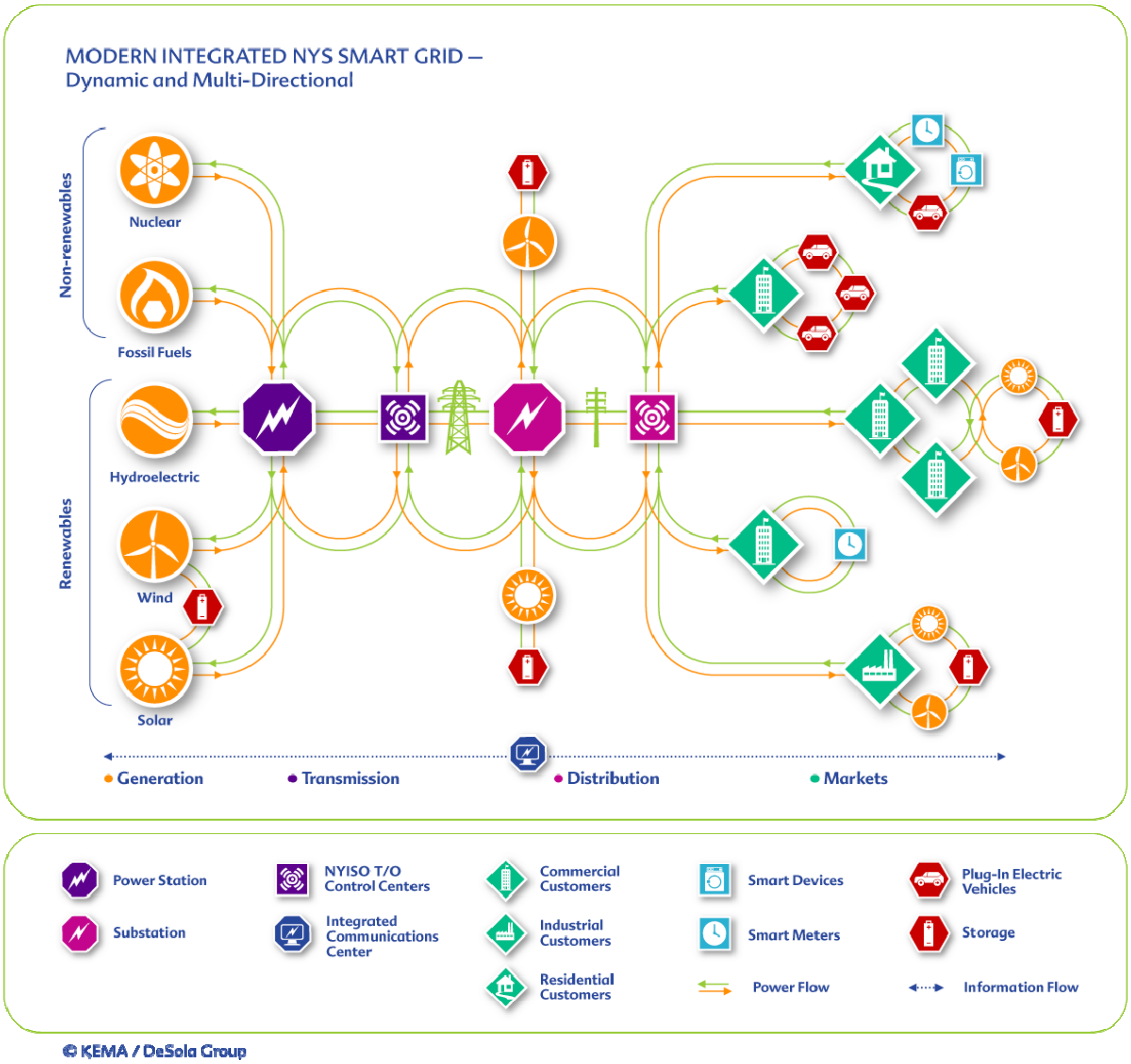


Figure 3.2 – NYS Smart Grid Vision

This Roadmap report presents an initial look at the potential benefits of Smart Grid to the State of New York in the year 2025. This starts with a definition of Smart Grid in context to New York State and a vision for Smart Grid purpose, functionality, architecture, and technology within the state.

Once we have defined that vision, we will articulate how the fully implemented and realized Smart Grid will benefit the state – the public as consumers, homeowners, rate payers, and employees; state businesses and institutions. One difficulty that utilities have faced in building a case for Smart Grid is that only a small subset of the benefits flow through the utility costs and rates. Smart Grid projects are often only marginally cost effective if viewed narrowly in terms of the cost impacts on traditional transmission and distribution operations. However, Smart Grid technologies will also result in avoided costs associated with accommodating distributed energy resources, renewable resources, electric vehicles, and other new technologies. An investment in a smart T&D and energy usage (behind the meter) capability enables a Smart Energy User to realize larger savings in energy costs.

Smart Grid is also a key to realizing a shift in energy resources from fossil fuels to renewable sources such as wind and solar. These latter resources are "variable" – they produce energy when nature dictates, not necessarily when people want it. Smart Grid enables us to adapt our energy consumption to match green power production to some extent and it allows us to store that green energy until we need it. It also will allow us to transmit the power from the renewable generation to the major load centers with less investment in new transmission capacity.

Another key element in the state plan is to shift a significant amount of the transport sector – buses, trucks, and cars – to electric or pluggable hybrid electric vehicles. These vehicles will use dramatically less gasoline and diesel fuel and will be cheaper to operate with electricity as the primary source of power. They will pollute less and our cities and towns will be cleaner. But converting large numbers of our vehicles to electricity will mean that at the end of the day, for instance, when commuters return home and plug in their cars, the demand for electricity will go up – way up. We can spend money beefing up the power system to support that increased demand, or we can manage the vehicle charging intelligently in conjunction with grid operations and save on major expansions of the power system infrastructure. Energy storage is a key element in managing a transition to renewable resources and electric transportation.

Storage will enable us to capture the wind and sun when they are available and to transfer that energy in time to the hours that consumers need to use it.

Many companies, anticipating Smart Grid, are developing new products for consumers and businesses that are anticipated to be "Smart Grid enabled" – able to make use of energy price and availability information to perform their purpose at lowest cost by interacting with the power system intelligently. These include clothes dryers, washers, microwaves, heat pumps, hot water heaters, and other devices. They also include a new generation of smart building automation systems that manage the HVAC and other systems in large buildings – these can act as miniature power system operators and energy traders, integrating in building distributed generation, energy storage, and energy usage for best comfort and economics.

No one knows today how these products will fare in the marketplace or what use customers will put them to – but they all signal a belief on the part of American industry in all quarters that the Smart Grid is here to stay and that it will enable all manners of customer choice – which in turn will lead to more product and business innovation. Nor do we know at this time exactly who will develop and sell these products to customers.

Smart Grid will, of course, also help utilities with the basics – reducing energy losses, managing their assets better, increasing work force productivity, improving service reliability, and saving money.

While the Consortium has focused most of its attention on modernizing the electric grid it believes that natural gas will play a significant role in the future of the smart energy grid. Natural gas is the cleanest fossil fuel, and there is an abundant domestic supply. Its use in reducing our dependence on imported oil, distributed generation, repowering of older generating plants and new combined cycle power plants for base load and to handle peaks and the intermittent nature of renewable resources as well as for combined heat and power systems will provide economic benefits to the consumer and provide environmental benefits as well. Smart Grid technologies such as Advanced Metering will provide operational benefits and information to gas utilities and customers just as will be the case on the electric side.

Finally, New York is already positioned to be a national and world leader in Smart Grid technology development and its business ecosystem. New York universities include world leaders in power systems and energy technologies. New York can boast of being home to the headquarters and research facilities of some of the world's leading Smart Grid technology innovators in GE, IBM, and others, and is also home to the Brookhaven National Laboratory. New York State agencies such as NYSERDA and NYSTAR are among the foremost state agencies in fostering energy R&D including Smart Grid related activities. New York utilities include major global energy companies, one of the world's leading urban utilities, and state agencies as large as any in the country. In short, the Smart Grid will create thousands of new high value jobs in the United States and NY should garner a healthy share of these.

This report will lay out the relationships between different aspects of Smart Grid – technologies and applications – and how they link to benefits to the utility and the consumer. Understanding the linkages is critical because the decisions the state and the utilities make about Smart Grid technologies and architecture have to be focused on supporting those linkages and realizing the direct and indirect benefits.

Quantifying these benefits to a level of detail that a single business would do in planning a new facility, or a utility in designing a new substation or IT system, is not practical. This analysis is for the entire state with multiple utilities each with varying situations. Instead, we will use recent analyses and studies to establish a likely range of benefits for New York as a whole from a state wide deployment of Smart Grid.

The New York State Energy Plan as developed in 2009 is the background for the vision and the benefits analysis. Key elements of the plan are how much energy will come from renewable resources; how many of the vehicles in the state will be replaced by electric / hybrid forms; and, what electric load growth will be in the future. We set the time frame for realization of the Smart Grid vision as 2025 as a realistic period during which to have made sufficient deployment so as to have realized significant benefits without resorting to crystal ball projections of future technologies.

The U.S. Department of Energy is focused on these same questions at a national level, and has established a Smart Grid clearinghouse to track the benefits of the ARRA funded Smart Grid investment and demonstration projects. There is no reason for NY to duplicate any of DOE's efforts. Because each utility's situation is unique, this report is not producing a cookbook of "how to evaluate your Smart Grid project." Indeed, there are several such available from DOE and the GridWise Alliance. What it does produce is an analysis of where the major benefits lie for New York along the path outlined by the state energy plan. Utilities can look to this when developing future detailed project plans to see how they can contribute to the major benefit categories identified herein.

4 Energy Plan Objectives and Smart Grid Priorities

The New York Energy Plan, which was finalized in December 2009, had the following policy objectives:

1. Assure that New York has reliable energy and transport sectors

2. Support energy and transportation systems that allow the State to significantly reduce greenhouse gas emissions

3. Address affordability concerns of residences and businesses caused by rising bills, and improve the State's economic competitiveness

4. Reduce the health and environmental risks associated with the production and use of energy

5. Improve the State's energy independence and fuel diversity by developing in State energy supply resources

The plan includes the following strategies which tie closely to the Roadmap presented in this report:

1. Produce, deliver and use energy more efficiently

2. Support development of in-state energy supplies

3. Invest in the energy and transportation sector

4. Stimulate innovation in the Clean Energy Economy

5. Engage others in achieving the State's policy objectives

Within these strategies are key components that tie directly to the Roadmap.

The Electric Grid for the 21st Century - Improving and upgrading the aging electric system infrastructure is a key component of the energy plan; this ties directly to distribution automation and substation automation.

Customer Enablement - Smart Grid has the potential to provide direct savings on bills from reduced usage, shifting of usage, as well as indirect saving from overall electric system savings.

Renewables - The investments in Smart Grid described in the Roadmap will increase the use of renewable energy and its integration into the Grid. The New York State Energy Plan calls for meeting 30 percent of new energy supply with renewables by 2015.

Energy Efficiency and Conservation - Energy efficiency and conservation are a critical component of the Energy Plan. Conservation is a significant potential benefit enabled by Smart Grid through giving customer time variant pricing. The New York Energy Plan has a goal of reducing usage by 15 percent below the 2015 forecast.

Electric Vehicles - EVs have the potential to save significant costs and greenhouse gases. Smart Charging is a critical component of Smart Grid Rollout.

Reduced Energy Costs - As shown in the subsequent sections of this report Smart Grid installations will provide significant savings in the long run.

5 Smart Grid Economics

Many recent studies of Smart Grid benefits and costs have been done as business cases for individual electric utilities. However, the economics of Smart Grid implementation are much broader and also need to include an assessment of the impacts on consumers, businesses, energy market participants and society as a whole. Some benefits of Smart Grid, along with the stakeholders that are impacted, are summarized in Figure 5.1 for what is defined as a "baseline" development scenario in this roadmap. In some cases, such as Increased Customer Satisfaction and Access to New Products and Services, the benefits are not easily quantifiable. However, in most cases, costs and benefits may be estimated based on results from recent studies, information available from utility filings, and industry expertise.

Anticipated Benefits	Direct Customers (rate payers)			In Direct Users	Electric Sector			Academia
	Residential	Commercial	Institutional	NY Residents	Utilities	Utility Shareholder	Other	Academia
Improved Cost Management and Customer Satisfaction	●	●	●	○	◐	◐	○	◐
Lower Customer Electric Bills	●	●	●	◐	◐	◐	◐	◐
Increased Customer Satisfaction	●	●	●	◐	◐	◐	○	○
Lower Market-Based Cost due to Price Response	◐	◐	◐	○	●	◐	◐	◐
Reduced Congestion Costs	●	●	●	◐	●	○	○	○
Access to New Products and Services								
Enhanced Power Quality & Reliability	◐	◐	◐	○	●	◐	◐	◐
Smart Grid devices on the T&D system	◐	◐	◐	○	●	◐	◐	◐
Asset Infrastructure Optimization								
Positive Societal/Environmental Impact	◐	◐	◐	●	●	◐	◐	●
Job Creation	◐	◐	◐	○	●	◐	◐	○
Enabling More Renewables And Storage	◐	◐	◐	○	●	◐	◐	○
Adoption of Electric Vehicles	●	●	●	●	◐	◐	◐	◐
Enhanced Quality of Life								

● Primary/Direct Beneficiary ◐ Secondary/Indirect Beneficiary ○ Not Applicable

Figure 5 1: Smart Grid Anticipated Benefits

As part of its work for the Consortium, KEMA developed a framework to assess the broad economic, customer and social impacts to NY from the deployment of Smart Grid technologies. This unique statewide analysis factors in all practical Smart Grid technologies and applications, and considers all the potential consequences over the next decade. By addressing the interactions between different components, and allowing input assumptions to vary, the model serves as a basis for considering different implementation scenarios. The timing of costs and benefits are linked, and reflects a reasonable prioritization. The benefits can be characterized in terms of overall uncertainty. The overall operational benefits are known and can be quantified easily such as the benefits of distribution automation. Other benefits are less certain such as reducing commodity costs and the potential savings from projected customer behavior. Societal benefits such as jobs are yet again at this point less know and hence less certain. The framework of the interrelationship of all these factors is shown in Figure 5.2. Because investments are made over time, benefits and related economics accrue/change over time. These interact with each other to produce synergistic effects in some cases. This framework captures important high level interactions.

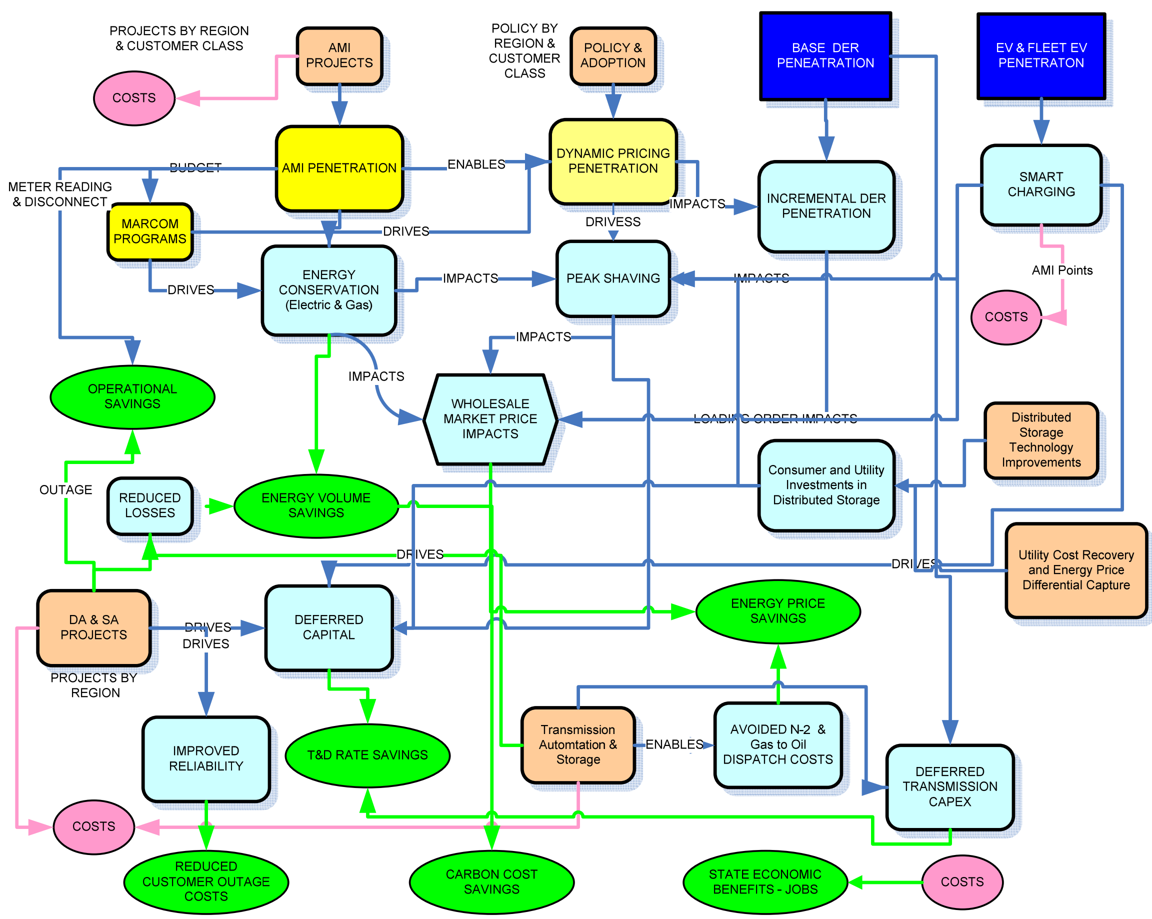


Figure 5 2 – Interrelationships

The Benefit Cost Analysis illustrates in a compelling way that many of the most significant benefits of Smart Grid accrue to customers via reduced energy bills – both from volumetric effects (conservation) and price effects (peak shaving). The price effects are a result of the market operations at the NY ISO and the dollar figures given are net savings in wholesale "LBMP" costs. (In effect, these are the production costs at market prices saved via the market clearing / dispatch process) These benefits do not in general flow through the regulated T&D utility rate structure. Benefit cost analyses that only consider the T&D rate impacts will usually be favorable, but only marginally so, for many Smart Grid technologies. However, when the energy bill impacts are considered the benefits become strongly favorable.

Some Smart Grid technologies can be implemented by 3rd party investors, consumers, or unregulated utility operations. The Roadmap discusses this and the general desirability of seeing market forces select technologies and individual consumers elect to make investments based on their own perceived benefits and costs. However, some Smart Grid technologies – especially ones with reliability implications such as Substation Automation and Distribution Automation – are the province of the T&D utilities. Investments in these have to be the domain of the utilities. It is important that the Commission understands the full benefits of these technologies even though they flow "around" and not "through" the utility rate structure.

5.1 Key Assumptions

There are many uncertainties associated with the future costs and benefits of Smart Grid implementations. However, in order to create an evaluation framework, estimates may be made of likely scenarios and financial parameters. For purposes of estimating benefits and costs, a number of assumptions were made. These assumptions are intended to reflect a conservative deployment of Smart Grid technologies over a reasonable time frame, allowing NY to learn from Smart Grid projects underway in other jurisdictions.

The key assumptions include:

1. The "end state" is a full statewide deployment of Smart Grid by 2025 as described below

2. NY State Energy Plan is used as a Baseline (load growth, renewables penetration, energy prices/costs)

3. Smart Grid Costs Reflect Current Filings, National Experience, and Forward Cost Projections

   a. Full cost of Distribution Automation (DA) roll-out assumed beyond estimated existing DA penetration. No underground secondary network automation beyond vaults.

   b. Substation Automation (SA) and Advanced Asset Management will be deployed at Majority of 345 kV and 230 kV stations and selected lower voltage stations

   c. Advanced Metering Infrastructure (AMI) is deployed with two (2) way communications. Remote connect/disconnect functionality is included in the cost estimates, but the use of remote disconnects is not claimed as an operational benefit to utilities due to current state policy.

   d. Gas Meters are assumed (gas Smart Grid) in order to accrue metering operational benefits and a very low gas conservation amount (1%) assumed (no data available on this subject in the US). No additional gas distribution system impacts are assessed, however.

4. Costs are incurred in 2011-2025 and benefits accrue as the technologies are deployed. Benefits after 2025 not considered.

5. 6% EV / PHEV penetration is assumed by 2025 (inferred from state plan). An estimate is made for fleet (commercial) EV development as well. This drives Distribution Capital Expenditures (CAPEX) and the need for Smart Charging. Fuel costs and environmental benefits of EV are not included. Avoided/deferred distribution CAPEX and Smart Charging benefits are included.

6. Reported utility Distribution Marginal Capital estimates are used to link Smart Grid peak load reduction impacts to deferred distribution capital expenditures which in turn favorably impacts consumer rates.

7. Congestion /locational reserve cost savings from a hypothesized ability to avoid N-2 dispatch (Hudson Valley) per discussions with NY ISO and Con Edison are included, as well as transmission loss reductions per NY ISO publications. Related savings from reductions in the "gas to oil fuel dispatch" followed in Con Edison and LIPA territories are also included. The gas to oil dispatch costs are the subject of a distinct tariff but for the purposes of this paper the cost reductions are treated as with the other wholesale energy savings.

8. Different penetrations of technologies are assumed for rural, suburban, and urban service areas with implementation staged over time.

9. Grid connected storage for congestion relief and renewables integration is costed and considered as one tool in achieving these benefits

These assumptions constitute the basis for the "base case" scenario along with large amounts of industry data on the underlying technology costs and the benefits to be garnered from various changes in system economics and utility operations as a result.

Additional scenarios of Smart Grid development and related policy development are explored as well so that the incremental benefits of different alternatives can be explored. These lead to the policy recommendations made in this roadmap that are backed up by the economic analyses of the possible gains from these choices.

5.2 Key Benefits of Smart Grid

The following are the key benefits associated with Smart Grid:

1. The jobs created from Smart Grid projects and state industrial development associated with Smart Grid technologies

    a. The impact of Demand Response or other new pricing options, namely conservation, price response and the associated energy and demand savings.
    b. Base cases assume Dynamic Pricing for C&I customers not already on such programs (using estimated net penetration today) but not residential customers
    c. Alternatives consider extension of Dynamic Pricing to all customers in different ways

2. An important alternative includes voluntary opt in for "Variable Pricing by residential customers using a penetration model that factors in expected savings and the benefits and costs of additional incentives in different levels as policy decisions.

3. Consumer benefits of improved reliability

4. Reduced distribution capital expenditures arising from various peak shaving benefits of AMI, Smart Charging, distributed storage, and DA/SA

5. Market price savings derived from peak shaving, distributed resources, distributed storage, conservation, and Smart Charging

6. Energy savings from consumer conservation as a result of better information (gas and electric)

7. Reduced utility operations expenses from AMI and Distribution/Substation Automation

8. Congestion reduction and reduction of special NY reliability dispatch provisions; specifically:

    a. N-2 contingency dispatch

    b. Gas to oil-gas contingency dispatch

    c. Impact on renewables

9. Reduced line losses

10. Increased penetration of Distributed Energy Resources (photovoltaic, for example) as the economics of dynamic pricing make them more attractive

11. Peak shaving benefits from distributed energy storage in the out years as costs improve

5.3 Smart Grid Costs

At this time, it is challenging to project what the actual total costs will be over a fifteen (15) year period since actual cost expenditures will be dependent upon a number of unknown variables, such as the products and services that will be accepted by the NYS consumer base, the speed of technology development and the market penetration of PEV/PHEV vehicles, the speed of technology development of and market penetration of distributed and micro generation and storage, the speed at which NYS chooses to deploy proven Smart Grid technologies and the availability of capital to invest in Smart Grid.

The key categories of costs include the technology and labor costs of:

1. Distribution Automation and Substation Automation

   a. In the base cases treated as separate new rate case investments for retrofit
   b. In an important variation treated as "Smart Asset Replacement" where the costs reflect the incremental costs of installation along with routine asset replacement

2. Advanced Metering Infrastructure

   a. In the base cases as projects covering 100% of a planned service area coverage including the cost of AMI communications
   b. In an important alternative a cost model that utilizes public common carrier communications at an annual tariff that is economical in light of the savings in meter reading costs. Meter deployment is still at 100% coverage as a model for installation on an "opt in" basis poses other difficulties.

3. Customer Education and Marketing

4. Transmission Automation

5. Grid-connected and Distributed Storage

6. Smart Charging facilities for Electric Vehicles

The details of the underlying cost data are available in the attached Roadmap PowerPoint document.

5.4 Results of Benefit / Cost Analysis

For each of the cost elements and quantifiable benefits of Smart Grid, projections were made for each of the years 2011-2025, and the total Net Present Value calculated. The results indicate that there are significant savings to be realized from Smart Grid, and a large positive relationship between total benefits and costs. Figures 5-3 and 5-4 show a high level waterfall chart of overall costs and benefits from Smart Grid on a Net Present Value basis over the period 2011 – 2025.

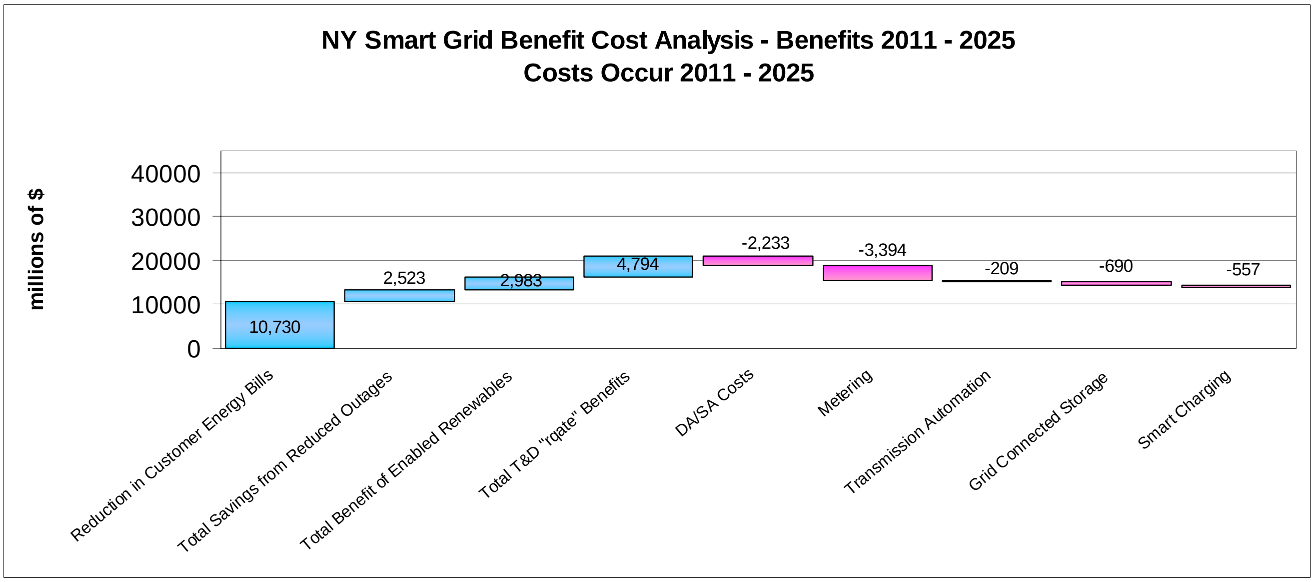


Figure 5.3 – Benefits 2011 – 2025 Cost Occur 2011 - 2025

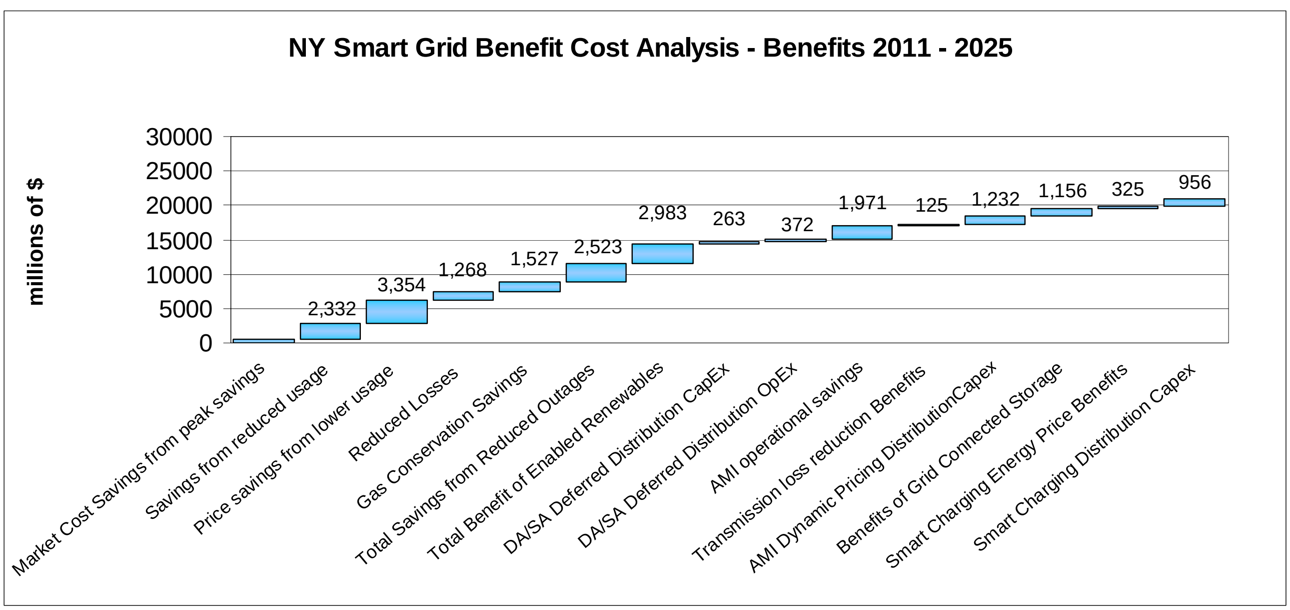


Figure 5.4 – Benefits 2011 - 2025

These benefits build up over time based on the different Smart Grid technology deployments in different hypothetical projects over time. Figures 5-5 to 5-7 show some of these costs and benefit buildups over the period.

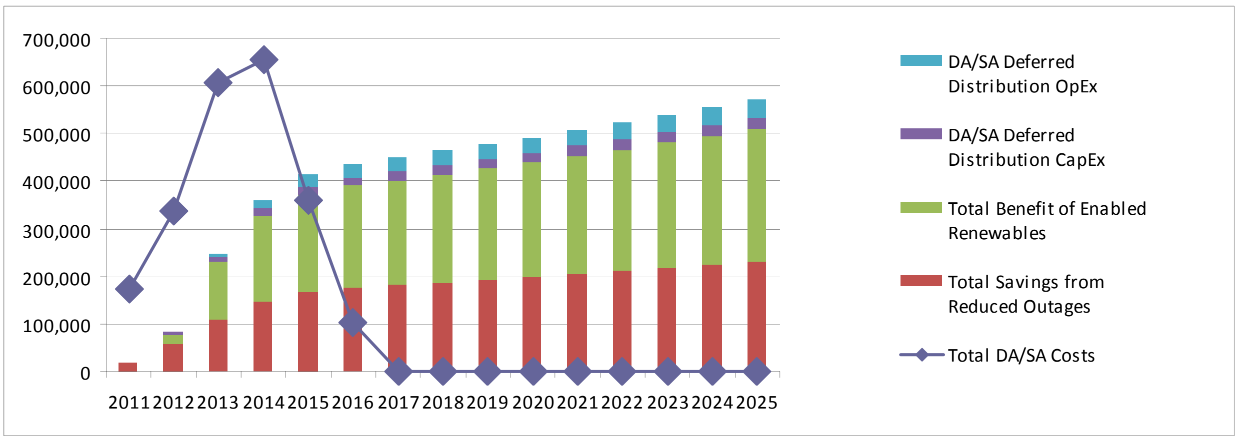


Figure 5.5 - Electric System Benefits over time

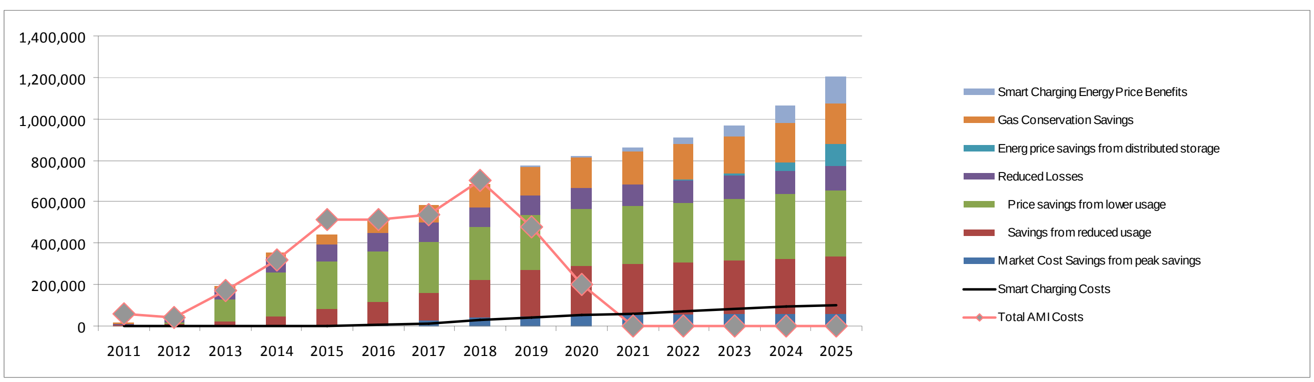


Figure 5.6 - Customer Benefits over time

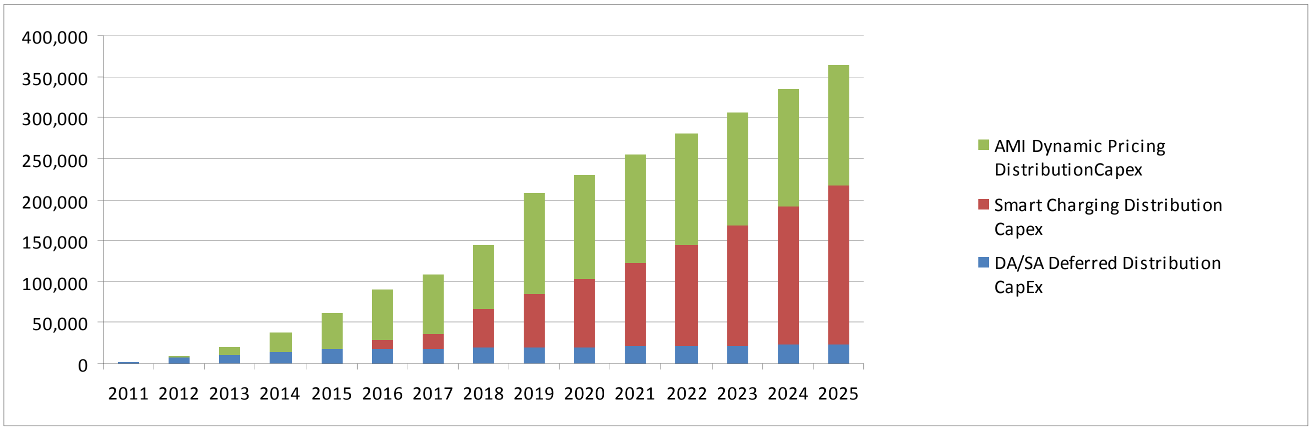


Figure 5.7 – CAPEX Reductions

The customer benefits are primarily in reduced energy bills and reduced increases in T&D rates, but also in reliability benefits and other indirect effects.

6 Smart Grid Roadmap

The Smart Grid Roadmap is designed to coincide with and support the achievement of the NYS Vision for Smart Grid outlined in section 3. The 'end state" is a full statewide deployment of Smart Grid by 2025. As such, the Roadmap outlines a near-term plan for years one (1) through five (5) and a longer-term plan for years six (6) through fifteen (15). Some considerations and assumptions made in the development of a roadmap for Smart Grid deployment include:

1. NYS recognizes it may be constrained on the amount of capital and personnel that are available to deploy on the implementation of Smart Grid. While there is broad support for Smart Grid, there may be capital and ratepayer impact constraints that impede the pace of the implementation of Smart Grid technologies. The greatest net benefit theoretically would come from the most rapid deployment of Smart Grid technologies state wide. However, this also greatly increases the immediate rate increases necessary to pay for the technology. The scenarios developed and analyzed in this document for the most part consider reasonable deferrals and staging of technology investments so as to allow a matching of benefits to costs with minimal adverse ratepayer impact in the early years. Some scenarios to demonstrate the rate and benefits impact of rapid full deployment are shown for illustration.

2. It may be a challenge for the State and its consumers to absorb too rapid a pace of change. As such, over the next five (5) years, the State should focus on those elements of Smart Grid that can significantly improve operations and reliability. During this time, the State should determine possible new products and services, which will be perceived to provide value to its consumer base, educate its consumer base on the value and benefits of Smart Grid, encourage utilities to make the business process and organizational changes necessary to reap the benefits of Smart Grid, educate and support its workforce through this major transformation, and implement the necessary core changes to IT systems.

3. Plug-in Electric Vehicle (PEV) / Plug-in Hybrid Electric Vehicle (PHEV) Charging – NYS will begin to see PEV/PHEV vehicles being deployed over the next five (5) years but, this is not expected to be a major factor in that time frame. However, NYS needs to support Smart Charging and develop tracking and billing systems for PEV/PHEVs since adoption will accelerate in years 6 – 15. Policies for how Smart Charging is integrated with AMI need to be established early so that utilities, ESCOs, parking system operators, and the automotive industry can adapt.

4. NYS will begin to see micro generation bear fruit over the next five (5) years but, it will not be a major factor. It is also estimated that the utility and consumer adoption of micro storage over the next five (5) years will be limited based on existing and forecast technology costs. Distributed storage becomes a factor in years 6-15 depending upon policy decisions over rate recovery and energy arbitrage allocations.

5. NYS will need to begin to support "early adopters" of HANs and smart appliances over the next five 5 to 7 years, though there will not be wide market penetration.

6.1 Smart Grid Roadmap Years 1-5 (2011-2015)

Over the next five (5) years, NYS should focus its Smart Grid efforts on providing a solid Smart Grid foundation in place and fully utilizing its capabilities. Key elements of a solid Smart Grid foundation include:

1. Key Regulatory And Legislative Actions
2. Customer Enablement
3. Modernizing The Grid
4. Diverse Supply Integration

5. Economic Development
6. Technological Development
7. Customer Research

6.1.1 Key Regulatory and Legislative Actions

In order to enable all of the benefits discussed in the previous section; New York will need to take a series of regulatory and legislative actions. This will include developing the regulatory mechanisms for utilities to deploy Smart Grid items. It will also include enabling customers to be able to respond to prices that change over time and reviewing all possible communications options for AMI. Specific actions include:

1. Provide cost recovery for utilities for cost effective Smart Grid installations including T&D investments in demand response and storage technologies that mitigate congestion and locational reserve costs. The benefits from these technologies could be greater as other targeted applications are identified, but technology and application development is needed to realize these proposed effects. These T&D automation investments, in particular, will reap large benefits in integrating renewable and distributed energy resources at lower levels of additional investment in basic infrastructure. They also will be invaluable in accommodating significant numbers of electric vehicles. Improvements in reliability that are well established benefits of these technologies have real economic benefits to consumers. These T&D automation investments include upgrades to Distribution, Transmission, and ISO control systems as necessary to exploit the new communications, monitoring, and control capabilities afforded by Smart Grid.

2. The Commission should examine Smart Grid business cases considering all the economic impacts to the state and ratepayers including several significant effects that do not accrue through the T&D utility rates, as indicated in the illustrative Benefit Cost Analysis submitted with this response.

3. Test key program design options with pilots to prove technologies and consumer value propositions.

4. Allow utilities to replace existing “dumb” equipment with “smart” equipment as part of normal asset replacement. This reduces the deployment cost of substation and distribution automation as well as reducing forward risks of stranded assets. An estimate of the value of this direction is on the order of $650-700M over the 15 year period as compared with investments in distribution and substation automation not linked to routine asset replacement.

5. Research the possibility of using public networks for AMI. There are significant cost and business model savings to be had, but policy (communications tariff) and technical (security and performance) issues must be addressed. An estimate of the potential savings from this direction, in urban and suburban but not as likely rural areas, is on the order of $350-400M over 15 years.

6. Explore voluntary dynamic pricing for all customer classes on an "opt in" basis linked to planned installation of AMI infrastructure in their locale. The benefits/cost analysis used an estimate that 80% of the benefits of AMI and dynamic pricing for all classes can be obtained when 30% of the customers able to save the most decide to opt in. (This is a calibration for a more sophisticated non-linear model that relates peak shaving amounts and savings to opt-in penetration) This estimate is consistent with some reports from various pilots but should be taken as an illustrative example for the overall computations. All customers benefit as peak load and prices are reduced for all; some of the broader savings can be used to fund additional incentives for customers that opt in accelerating the process and increasing the overall benefits. How varying the incentives can affect opt in penetration and overall net benefits after the cost of incentives is explored and presented in the report.

7. Ensuring that commercial and industrial customers reduce peak load to the maximum feasible and consistent with their commercial objectives and processes is a key to obtaining benefits. Extending mandatory hourly pricing to as low a threshold of peak load as possible should be investigated.

8. Develop programs including outreach for Electric Vehicle Smart Charging and alternatives to additional AMI points. Smart Charging has a potential savings to New York in the order of $ 1.0 B over the period 2011 – 2025.

6.1.2 Customer Enablement

Enabling the customer represents an important aspect of developing the New York State Smart Grid. Providing the customer with adequate and timely information and options will encourage them to make informed decisions. The options will come in the form of pricing that more closely reflects the cost to deliver energy (Demand Response, time of day, variable), simple, interoperable equipment (AMI, smart devices, DG, storage, PHEV) and network automation to manage their energy costs. These decisions will benefit customers and be aligned with state energy policy goals. In essence, the customer becomes an active participant within the grid instead of being a passive user of electric services. Key benefits from customer enablement are the bill reductions from conservation impacts and the shifting of peak load which will benefit all consumers. Another benefit will be increased flexibility in the use of on-site renewable energy which supports the NY State Energy Plan goals for renewables.

1. All commercial and industrial customers should have AMI and should have access to time differentiated prices.

2. AMI for these customers should be implemented as cost effectively as possible including the possible use of public networks where coverage is All

commercial and industrial customers Utilities and other providers will provide commercial and industrial customers with options to take advantage of time differentiated prices.

3. Suburban residential customers with average and above average usage should have AMI. Use of the public internet for AMI communications for these customers has potential economic benefits in reduced costs provided that security and performance requirements can be met.

4. Residential customers should have access to time differentiated prices on an opt-in basis.

5. Utilities and other providers should provide residential customers with options to take advantage of time differentiated prices.

6.1.3 Modernizing the Grid

The grid connects the customer to generation, transmission and distribution in the electric power system. As the aging infrastructure is upgraded, it will provide significant opportunities to improve cost and reliability through advanced sensors and controls (e.g., PMU) designed to limit outages (self-healing, islanding), linked by integrated communications networks and managed by intelligent advanced systems and operations. As grid enhancements provide a reliable supply of electricity at reasonable costs, they elevate security risks (cyber and physical) and the importance of managing them. Standards that are being developed by National Institute of Standards and Technology (NIST) with support from the GridWise Architecture Council will enable the safe and efficient operation of the Smart Grid. The key benefits of upgrading the grid are increased reliability and reduced losses. DA and SA are highly cost effective and are just the start. This is an area where there will be significant technological change over time.

The following are actions that will be needed to ensure the Smart Grid in New York will modernize the grid:

1. Implement Distribution Automation throughout the power system in NYS as part of ongoing utility planning and engineering.

2. Implement and/or enhance Substation Automation throughout the power system in NYS on a similar basis.

3. Provide cost recovery for these investments both as part of major rate case projects but also as part of normal asset replacement programs and targeted reliability improvement programs.

4. Continue to monitor new technologies as they become available to make the Grid even more efficient.

6.1.4 Diverse Supply Integration

The energy supply portfolio will continue to evolve and several types of renewable generation (wind, solar) tend to be intermittent and less predictable. Incorporation of renewable energy sources into the electric power grid will require a combination of solutions including storage, demand response, and integrated control of distributed resources. This integration will facilitate a timelier and lower cost achievement of renewable portfolio standards.

The following are actions that will be needed to ensure the Smart Grid in New York provides for diverse supply integration:

1. Continue to support the development of large scale and customer side renewables plus other advanced distributed generation as technologies are proven

2. Explore utility ownership and or utility programs to promote customer side renewables

3. Pilot storage technologies in combination with demand response and renewable technologies.

4. Test use of public networks for AMI including testing cyber security and information / privacy aspects that can provide necessary monitoring of Distributed Energy Resources on a cost effective basis.

5. Explore the economic linkage between dynamic pricing and increased distributed solar penetration.

6. Address recovery mechanisms and incentives for utilities to invest in distributed storage; in particular how utilities can realize the time value gains from energy stored in distributed facilities and benefit consumers from the overall solution.

7. Plan for Automatic Demand Response via Smart Buildings and Virtual Power Plants (integrated load side resources of distributed generation, storage, and demand management) as part of an overall solution, via utilities, aggregators, large end users, or on a fully autonomous basis responding to NY ISO price signals and able to supply ISO ancillary services and other new products as may evolve in the future.

8. Plan for Electric Vehicle Smart Charging as a key component in providing increased demand response, and ancillary services.

6.1.5 Economic Development

New York will be a national leader in the implementation of Smart Grid and Smart Grid industries will cluster in New York providing significant economic benefits. This will attract additional industry. The universities of NY will become national leaders in the field of Smart Grid.

The following are actions that will be needed to ensure the Smart Grid in New York provides customer benefits:

1. Continue to support the collaboration between universities, industrials, and utilities at the New York Smart Grid Consortium.

2. Add curriculum as needed at NY universities to train the Smart Grid workforce.

3. Develop the research Nexus

6.1.6 Technological Development

Work within the NY Smart Grid Consortium Nexus, the Smart Grid Innovation Center, and other state R&D organizations to reduce the costs of all technology related to grid automation and customer enablement.

1. Design and test interfaces building on the experience of state entities with Smart Grid interface testing. (example, National Grid STC 2009 testing program)

2. Build demonstration homes and businesses with these technologies that are capable of being linked to utility, aggregator, and ISO market systems for demonstration and evaluation

3. Establish open source Smart Grid testing program

4. Encourage and support participation in available DOE ARPA-e and other R&D initiatives as appropriate by utilities, academic institutions, and manufacturers within the state.

5. Develop mechanisms to cross fertilize state R&D activities and commercialize promising technologies

6. Encourage utilities to develop R&D budgets and allow appropriate cost recovery for R&D costs.

6.1.7 Customer Research

The analysis conducted in this study clearly illustrates the large potential benefits of time based pricing and other related customer activities. The research on this topic is not conclusive. Specific areas to explore include:

1. Role of enabling technologies such as displays or behavioral programs

2. Test new rate options and different ways of opting in. (as well as opt-out)

3. Explore the role of dynamic pricing in encouraging adoption of distributed renewable generation and other distributed resources.

4. Research on the future potential roles of retailers and other non regulated firms in developing services related to AMI and Demand Response as participants in real time energy and ancillaries markets in addition to today's capacity markets. Also analyze closely the differences in adoption, practicality, and effectiveness of aggregator based operations versus autonomous price response by consumers.

5. Research on the actual pricing options large C/I customer receive from retailers and what that actually means as it relates to the impact of AMI for these customers.

6. Additional research to confirm the estimates of benefits suggested by this report.

6.2 Smart Grid Roadmap Year 6-15 (2016-2025)

During years 6-15, a number of Smart Grid-related technologies should have matured by this time and NYS should have had the opportunity to determine the products and services that its consumer base views as providing value to them. In addition, NYS should have been able to learn valuable lessons from the more aggressive Smart Grid projects other jurisdictions have undertaken. It is anticipated that during years 6-15 NYS should focus on:

1. Deploying advanced products and services that provide perceived value to its consumers.
2. Continuing the deployment of advanced Smart Grid technologies to fully realize the “self-restoring” goal of Smart Grid.
3. Continuing the deployment and support of PEV/PHEV vehicle infrastructure.
4. Continuing the deployment and support of HAN and Smart Appliances infrastructure.
5. Continuing the deployment and support of commercial-scale distributed generation and storage infrastructure.
6. Continuing the deployment and support of micro generation and storage infrastructure.

6.3 Technologies Over Time

As presented here the evolvement of the base case will include increased penetration of the technologies discussed in this white paper. The figures below show respectively:

- Cumulative “ Smart Meters” over time
- Cumulative Distribution and Substation Automation by area type over time
- Electric Vehicles over time

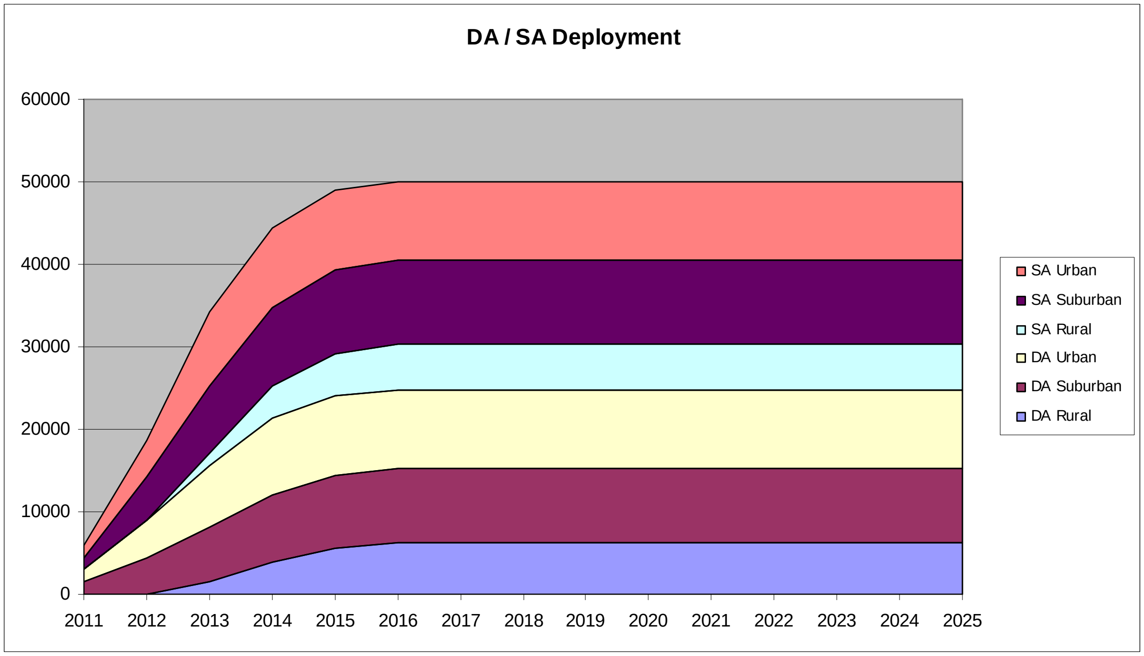


Figure 6.1 – DA/SA Deployment

These figures are the deployments over time that are used in the base case scenario presented in this roadmap and from which variations are drawn in the different scenarios. Variations on them can be easily analyzed with the model that KEMA developed for the consortium, and the "base case" is not presented as the ideal outcome; indeed the alternatives of "smart asset replacement" and "use of common carrier communications" are preferred. These deployments also reflect a philosophy that DA and SA needs to be a priority to avoid increased stranded asset / retrofit costs and that AMI for residential customers can be deployed on a more measured basis.

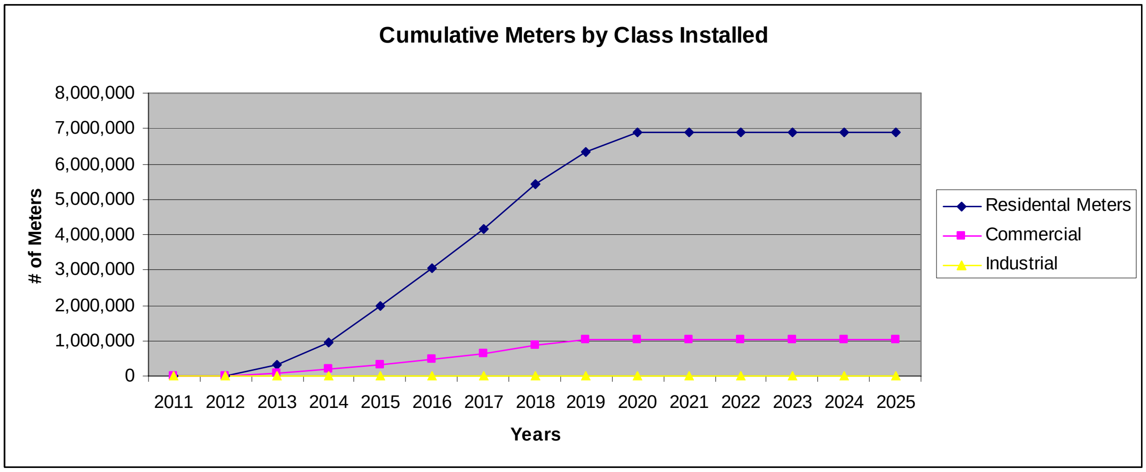


Figure 6.2 – Cumulative Meters by Class Installed

Other technology penetrations used in the scenario development and analysis have built in forward cost assumptions – especially for distributed storage and for photovoltaic generation. Both of these are new technologies that are experiencing rapid technology development and cost-performance data in future years is highly uncertain – breakthroughs are not out of the question. These technologies and their penetration rates need to be monitored closely to see if acceleration of related Smart Grid technologies needs to be considered in years 5-10.

EV penetration is based on an assumption. The future penetration of Electric Vehicles by fleet operators and consumers is highly uncertain and will be influenced by oil prices, public policy, and battery costs. The scenario that examines a doubling of the projected EV penetration – to 12% by 2025 which is not impossible at all – shows the financial impact of Smart vs. Dumb Charging to be on the order of $1B more than the 6% EV penetration in the base case – so preparing for Smart Charging before the vehicles are purchased and in garages is clearly prudent policy.

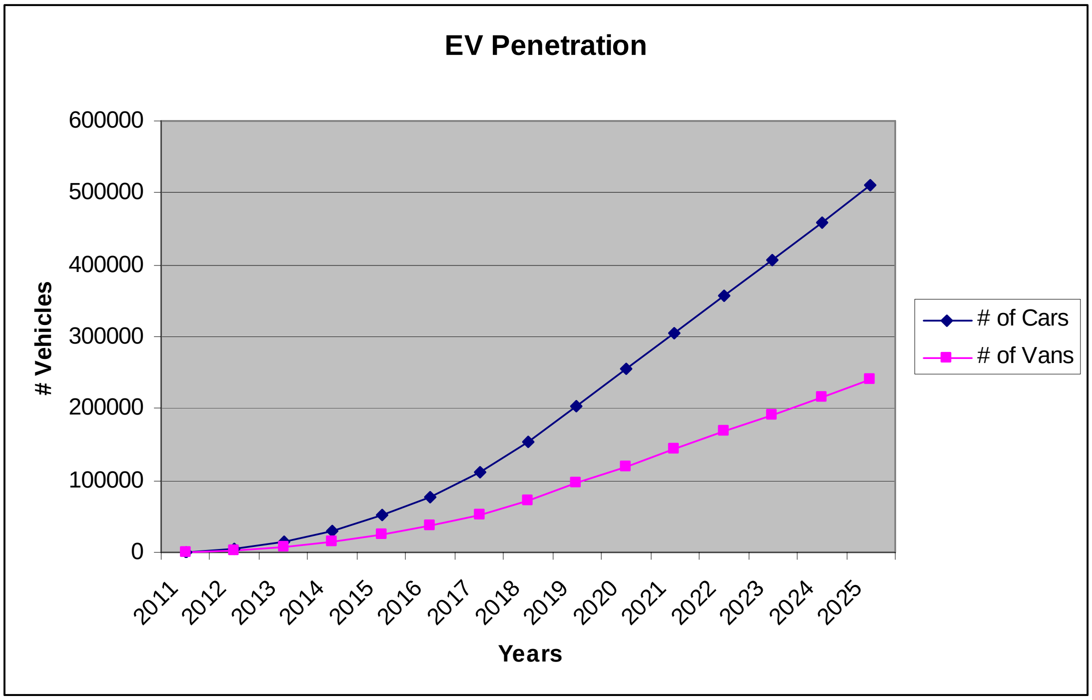


Figure 6.3 – EV Penetration

7 Smart Grid R&D Needs

The roadmap suggests strongly that public common carrier communications (e.g. the Internet via cable, fiber, DSL, or wireless) be used to support AMI communications. This has great economic benefits but requires that information security and consumer privacy are adequately secured, and that the communications reliability, latency, and general performance are acceptable for AMI purposes. This concept should readily extend to other Automatic Demand Response resources including EV Smart Charging, Smart Building integration with the grid, and monitoring and even control of Distributed Energy Resources. We believe that broadband internet today provides adequate performance for AMI and ADR purposes. However, some investigation is required to validate that belief as well as to assess what Smart Grid performance using the internet might be during times of very heavy usage – as could occur, for instance, in a period of major disruption of public services or the like when the grid might well need ADR capabilities.

Cyber security of Smart Grid internet usage will require that communications be routinely encrypted. This should not be a major technical or cost challenge today but again validation is required.

The roadmap suggests that combinations of fast storage and ADR can be used to mitigate N-2 contingency dispatch and other contingency dispatch protocols that increase congestion costs. This has been validated in conversations with industry experts but needs validation and quantification by, for instance, NY ISO staff performing more rigorous dispatch studies which would include validating the performance requirements of grid connected storage and ADR for the purpose.

The estimates of the impact of Smart vs. Dumb EV charging are based on a few market projections and electricity market projections. Fortunately, there is time available to address this problem but continued investigations into EV adoption rates, driving usage and charging demand, and the impact of managed charging are required. An ongoing evaluation of EV charging load and potential Smart Charging impacts on an annual basis would be an idea worth considering.

The roadmap clearly identifies the impact of altered consumer energy consumption patterns as the greatest single benefit of Smart Grid, via a number of mechanisms. It also demonstrates that getting the level of opt-in incentives and consumer outreach "right" is critical. While the quantitative figures used in the roadmap are of an order of those reported in other studies, the amount of hard information about how consumers of different classes will react is quite limited. That consumers will behave differently based on geography, climate, lifestyle, and the like is certain. Therefore, design of these programs requires solid research and analysis of pilot program data on an ongoing basis and it is likely that a "one size fits all" approach in as diverse a state as NY will be far from optimal.

The T&D benefits of Smart Grid were assessed in light of today's commercially available technology and best practices. However, there are a number of R&D efforts underway around the nation aimed at developing lower cost / better sensors for use in T&D asset condition assessment. Some of this research is being conducted in New York and should be followed up appropriately by state agencies and utilities.