NEW YORK INDEPENDENT SYSTEM OPERATOR

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November 1, 2010

Smart Grid RFI
U.S. Department of Energy
Office of Electricity Delivery and Energy Reliability
1000 Independence Avenue, SW
Room 8H033
Washington, DC 20585

Re: Smart Grid RFI: Addressing Policy and Logistical Challenges

In response to the Department of Energy's (DOE) Request for Information regarding smart grid implementation listed in the September 17, 2010 *Federal Register*, the New York Independent System Operator, Inc. (NYISO) offers the attached white paper entitled "Envisioning a Smarter Grid for New York Consumers." This white paper, issued by the NYISO in September 2010, was filed at the New York Public Service Commission (NYPSC) in response to a call for comments in its Smart Grid Proceeding.[1]

The NYISO would also like to bring to the DOE's attention a white paper prepared by the New York State Smart Grid Consortium, entitled "Smart Grid Roadmap for the State of New York," which was filed on September 16, 2010 at the NYPSC. A link to the NYS Smart Grid Consortium paper on the NYPSC website follows: http://documents.dps.state.ny.us/public/Common/ViewDoc.aspx?DocRefId={76A8E242-B300-44A0-BED1-60794D06738A}

Respectfully submitted,

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[1] *Order Instituting Inquiry Into Smart Grid*, Case 10-E-0285 & Case 09-M-0074 (July 16, 2010) ("Order").

Envisioning a Smarter Grid for New York Consumers

A New York Independent System Operator White Paper

September 2010

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I. Introduction

The development and integration of smart grid technologies offer potentially significant benefits for New York consumers by empowering electricity consumers, reducing power costs, improving the reliability of the power system, and facilitating integration of renewable resources. More specifically, smart grid technologies have the potential to:

- **Lower costs to consumers and expand consumers' understanding and control of their electricity use;**
- **Enhance the reliability and efficiency of the power system by improving grid operators' situational awareness and control; and**
- **Assist the growth of renewable resources and complementary energy storage resources.**

This document outlines the NYISO's vision for smart grid development in furtherance of the objectives set forth in the New York State Energy Plan. It describes how New York's wholesale electricity markets and bulk electric grid operations can take advantage of smart grid capabilities to realize the benefits identified above in a manner that is sensitive to the fact that consumers will bear the ultimate cost of implementation. It identifies technology, market, and policy developments and questions that should be addressed to enable optimal implementation of smart grid in New York State.

II. The NYISO Vision for Smart Grid Development in New York

The NYISO's vision for smart grid development in New York is a collaborative effort by the PSC, policy makers, industry, and academia to develop and integrate smart grid technologies and business models: (i) to provide consumers with more control over their energy use and opportunities for energy costs savings, (ii) to enhance grid reliability, security, and efficiency, and (iii) to improve the management of intermittent resources and other non-traditional resources within the grid. The NYISO envisions that this process will be accomplished in a methodical manner that is sensitive to the fact that consumers will bear certain implementation costs, that provides clear benefits to consumers, and that does not mandate consumer participation. The NYISO's vision emphasizes that, to the maximum extent possible, the development and implementation of smart grid technologies and business models should be accomplished through private investment encouraged by market structures that send the right price signals to consumers to install equipment and participate in programs that will help consumers use energy more efficiently and cost effectively. In this manner, certain implementation costs and risks will be borne by private investors and voluntarily participating consumers, rather than ratepayers generally. The achievement of this vision will require policy changes, public awareness, and consumer options. Smart grid includes an array of advanced energy technologies and innovative business models that will be valuable in meeting the objectives of the New York State Energy Plan. Smart grid development should be planned and prioritized to help accomplish key state goals for more affordable power, increased use of renewable energy, reduced carbon emissions, and electrification of the transportation sector.

Notably, the NYISO's vision anticipates the increased deployment in New York of distributed variable resources, such as solar and wind resources. The intermittent nature of such resources creates operational challenges for the system operator. As described in detail below, the NYISO envisions that the use of smart grid technologies will enhance its system operator's management of distributed variable resources by (i) improving the dispatch of flexible conventional generation, such as hydropower, to balance the intermittent nature of variable resources, (ii) utilizing new technologies, such as energy storage, to balance the intermittent nature of variable resources, and (iii) enhancing the use of load-side management programs. Such load-side management programs include large consumer's direct participation in demand reduction programs, the use of dynamic pricing to facilitate lower peak load amounts and flatter load profiles, and the aggregation of smaller consumers for participation in demand reduction programs. The NYISO anticipates that some combination of these approaches for managing distributed variable resources will be required, but recommends that the market be allowed to identify the most efficient combination for managing such resources.

The end results of the NYISO's vision are as follows:

- **The "Smart Energy Consumer" will be an empowered energy consumer** with access to enhanced information about electricity markets and innovative products and services that provide new ways to manage energy use and control electricity bills;

- **The power system will be made more reliable, secure, and efficient** by optimal deployment of smart grid technologies; and

- **Smart grid technologies will help meet the challenge of reliably connecting renewable energy resources to the grid and economically integrating them into the wholesale energy markets.** Through the capabilities of smart grid technology and dynamic pricing, consumers will be able to provide energy storage, regulation and reserve services to the power grid and lower their electricity costs in the process.

Achieving the objectives of the New York State Energy Plan will challenge the electric system's transmission and distribution (T&D) infrastructure in multiple ways: Generation from renewable facilities in remote locations will have to be brought to load centers, potentially requiring new transmission capacity. Distributed resources will require new approaches to distribution system planning, engineering, and operations and at high penetrations may require coordination with wholesale markets and grid operations. The goal of reducing carbon emissions may lead to growth in overall electric energy consumption, fed by fuel switching away from carbon-based usages. These developments would normally require attendant increases in the T&D infrastructure to support them. Smart grid technologies will help meet these challenges.

Smart grid alone cannot eliminate needed growth in T&D infrastructure. Consistent with the aims of the State Energy Plan, public policies and regulations should be reviewed to consider changes in retail access programs and rate design in retail tariffs that enable consumers to change their usage patterns to follow the availability of the most economic resources to meet the needs of total loads in the New York Control Area. Such changes can reduce the need, and ultimately the costs consumers bear, for additional T&D facilities.

Smart grid can reduce the costs associated with increased T&D capacity in several key ways:

- It can increase the productivity of existing infrastructure by allowing better monitoring and improved controllability.
- Smart grid can potentially provide locational reserves less expensively than conventional generation, via technologies such as automatic demand response, smart charging, and grid-connected energy storage. This reduces the cost of guarding against failures of transmission and generation assets.
- T&D utilities can expect to extend the life of existing assets through condition monitoring and reduce the level of unplanned outages and replacements. The life extension of existing assets gives more flexibility to T&D planning and engineering and will allow for smarter asset replacement over time. Reducing and deferring capital investments needed for grid reliability lessens consumer-rate impacts.

III. Markets Can Help Smart Grid Technologies Benefit Consumers

The NYISO recommends that market forces be allowed, to the maximum extent possible, to drive the development and success or failure of smart grid technologies and business models. Markets create valuable signals about 1) the relative value of different energy products and services; and 2) the costs of limitations on the amounts or the delivery of those products. Allowing market forces to dictate the development and timing of smart grid technologies and business models will allocate the costs to those investors and interested consumers that anticipate benefits from such technologies and models and will also place risk on such investors rather than ratepayers in general. When investors are able to use market-based price signals to make investment decisions and then to harvest a share of the market improvements via innovative offerings, the consumer benefits as well as the investor. Transparency of information and open access to markets are essential to this fundamental and beneficial function of New York's electric system.

Where electricity markets are transparent and accessible, there are already examples of investors bringing innovative technologies and business models to market. The development and growth of demand response in the New York electricity markets is a case in point. Demand response resources in the NYISO markets have grown from fewer than 300 end-use locations providing about 700 MW in 2001, to more than 4,000 end-users providing nearly 2,400 MW of demand-response resources in 2009. Traditional, regulated utilities have expanded their demand-side services, and new energy services companies have increased the array of demand response programs and services in New York State.

Likewise, the design of NYISO markets has evolved to enhance the integration of windpower with the creation of a state-of-the-art wind forecasting system. A centralized system enables the NYISO to better utilize and accommodate wind energy by forecasting the availability and timing of wind-powered generation. The NYISO was also the first grid operator to dispatch windpower, fully balancing the reliability requirements of the power system with the use of the least costly power available via economic dispatch.

More recently, New York's marketplace for electricity has seen private investor-funded development and deployment of energy storage technologies to provide regulation service. Over time, developments like these will lower the costs of regulation as well as provide "better" regulation response, which will benefit system reliability, market economics, and the consumer.

Many smart grid investments are likely to be made by the individual utility. Some, like digital protection and substation automation, cannot realistically be made by any other party or process. The utility is, however, in the position of making an investment that will benefit the energy component of the customer's energy bill – thus the policy decision to make this investment on behalf of the customer increases regulated delivery rates on the promise of reduced energy bills. On one hand, those benefits need to be accounted for in policymaking. On the other hand, any uncertainties in the relative benefits are better left to individual investors and consumers whenever it is possible and practical to do so. Innovative technologies that offer new business models provide opportunities to rethink the boundaries between regulated cost recovery and investor at-risk domains.

IV. Consumers Can Benefit from Smart Grid

Consumers can also benefit from smart grid development through enhanced access to market information and electricity pricing. Smart grid technologies can bridge the gap between retail and wholesale electricity markets. Today, consumers can exercise a choice about whether and when to use electricity, but they generally do not see the economic impacts of their decisions. Instead, the supply side adjusts to consumer choices through wholesale markets, and the costs of those choices are passed on to consumers in their bundled retail electric bills—but without any transparency or indication of how their individual decisions affect prices. Except for large industrial customers participating in the wholesale electricity markets, individual consumers do not receive the full benefits of wholesale-market-driven energy prices.

With appropriate retail rate designs, flexible smart grid implementation can allow customers to realize the economic benefits of their choices. The NYISO views such rate design as one of the key policy decisions the PSC will need to make in these proceedings. Smart grid policy development and its resulting technology implementation should be planned around the most appropriate applications of different price signals to different customers for different purposes. There are several ways that price signals can be relayed to consumers, including time-of-use rates and variable hourly wholesale-market price pass-through.

- Time-of-use and critical peak-pricing programs use regulated tariffs that establish time-varying rates for customers, usually on an off-peak/on-peak basis. As such, they have the benefit of being predictable as opposed to varying from day-to-day. They are less than perfect at adapting load to supply, are not fully transparent with wholesale market costs, and cannot enable consumer participation in ancillary markets. Their primary applications to date have been aimed at shifting consumption away from peak load periods and reducing the need for generation capital investments to meet a few hours of annual-peak or daily-peak load. And while peak shaving produces valuable benefits, it does not help to balance variable renewable production beyond the basics of helping align diurnal cycles with peak demand.

- One key element in reducing electricity prices is to have consumer price elasticity factored into electricity market behavior as fully as possible. This may be accomplished in a variety of ways, including aggregator forecasting of price elasticity and/or smart grid technologies that allow end users to automatically react to prices. Aggregators may use price signals or direct controls to manage end usage and energy price risk. Consumers may elect to use devices or home/building automation systems. "Behind the meter" smart grid technologies will be developed by appliance manufacturers, building-automation suppliers, aggregators, Internet software developers, and other entrepreneurs.

- Real-time dispatch pricing is only usable by load that is capable of fast, automatic reaction to changing prices (currently, prices can change every five minutes). End-use loads that are not adversely affected by cycling on this rapid basis, or that can be aggregated into larger numbers to achieve the same results, are candidates for real-time price response or demand response in the real-time market. Some loads, by nature of process, cannot be cycled in this manner. Electric vehicle charging is potentially attractive for real-time dispatch demand response. The needed vehicle charging controls are technically feasible today and are not prohibitively expensive. Other end-use equipment and appliances offer similar potential as flexible loads. These include thermal storage systems ranging from conventional electric hot water heaters to advanced ice storage systems.

- Expansion of renewable resources is expected to increase the amounts of regulation service needed to balance supply and demand on the electric system. While there appears to be sufficient load-following capability available from conventional generators, the cost of using these resources to follow increased renewable ramping may increase overall wholesale market costs. Some conventional generators, especially combustion turbines, will be displaced from merit order dispatch when renewable production is high. Their operators will have to recover the fixed costs of these units across fewer operating hours, so it is reasonable to expect their supply offer prices to increase when they are required for renewable balancing. Opening up real-time dispatch and ancillary services markets to demand response can assist to moderate costs. *(This topic is currently being deliberated by stakeholders in the NYISO's shared governance process).*

Another major benefit of allowing consumers to participate in the wholesale markets by taking advantage of hourly variable pricing is that the true economics of distributed renewable resources will be visible to consumers, encouraging increased consumer adoption of more efficient distributed resources. At one level, consumers can "passively" realize these benefits through the higher value of demand-correlated renewable production. At another level, aggregators will develop services to increase the value of distributed renewables through monitoring, control, and linkage to demand response and energy storage. For example, there is a high correlation between rooftop photovoltaic (PV) production and peak load periods. The value of investment in PV-produced power is more accurately assessed when the cost of that investment can be readily compared to electricity market prices. Over time, this can increase consumer adoption of PV systems, which in turn could reduce peak demand at the wholesale level and lessen the need for costly investments in transmission capacity to bring remote renewables to market. Smart grid technologies also provide better monitoring and potentially better control of distributed resources such as PV systems, which can facilitate grid integration, forecasting, and market operations.

PEV smart charging also offers the potential for significant distributed resources. PEV penetration at significant numbers can create a considerable evening peak load, with major adverse consequences for market prices and the T&D infrastructure. Not all PEVs will require charging at their maximum rate (potentially 6 – 8 kW) for an entire evening. Depending upon the vehicle and the owner/operator's usage, a vehicle's charging can be spread out over the course of the night, thus avoiding the evening-peak phenomenon. This can be accomplished with controls technology in the vehicle or the charging station. Further incorporation of communications and monitoring equipment—smart grid technologies—can enable PEVs to be used as energy storage resources.

In addition to rate-base-funded investments by utilities, smart grid development should be driven as much as possible by private investments spurred on by market opportunities. Aggregators and consumers will make innovative investments in technologies and business models at a rapid rate if the market facilitates their decision making and investments. Competition is a great driver of innovation, and competition among aggregators for retail consumers and for chances to sell ancillary services to the markets and to participate profitably in real-time markets will drive great innovation and customized consumer marketing, enabled by smart end-use devices and the Internet. Competition throughout the energy value chain guarantees shared savings with consumers as opposed to leaving excess margin with suppliers. Utility smart grid investments should be seen as the enabler of these innovative and private-market investments, driven by competition and customer needs that will not require ratepayer investments. This is the most effective model for investment risk taking and decision making and the one with the greatest benefit to consumers. As long as basic reliability, market information, and interaction needs are met, this aspect of market development should be encouraged to be innovative and entrepreneurial.

Some smart grid technologies are best deployed on the distribution system rather than behind the meter. Examples include photovoltaic systems with multiple homeowners as system owners—but installed to take advantage of the best solar exposure—or community storage technology, which benefits all the consumers on a given distribution transformer. Today, such deployment is the province of the regulated utility. Some concepts such as virtual-net metering can facilitate some of these desirable variations; others require additional creativity and flexibility. Regulatory constructs and business models allow consumers and third parties to address some of these opportunities, or allow utilities to do so on a targeted basis, either as regulated or unregulated assets or as a mixture, as desirable ways to facilitate additional innovations in distributed resources.

The key principles of such constructs are common to those relating to behind-the-meter or smart-charging cases. They include:

- Providing consumers access to wholesale energy and ancillary services market prices;
- Meeting reliability minimums for measurement and control of resources appropriate to the market product provided;
- Implementing wide-scale increase in behind-the-meter resources in accordance with electric system reliability and public safety standards.
- Allowing investors and consumers to realize all the gains (reduced energy costs and/or enhanced reliability) associated with the investment; and
- Recognizing and rewarding the unique capabilities and contributions of new technologies with market design flexibility.

As noted earlier, there are various examples of innovations in New York's marketplace for electricity that are achieving results for new energy services and technologies.

Consumers will benefit from the market's flexibility in assessing risks and rewards and subsequently making investment and purchasing decisions. In particular, different smart grid pricing schemes, as described earlier, should not be forced on consumers in a top-down fashion without a way to achieve consumer buy-in. California pilot projects have shown, for instance, that 30% of customers provide 80% of the time-of-use pricing benefits. By allowing customers to opt in or out of different pricing schemes, the customers most able to benefit from a given mechanism will opt in, and those unable to benefit from it or possibly disadvantaged by it will opt out. As a result, customer acceptance will be high and frustrations will be better tolerated since the decision to "opt in" is a matter of customer choice. However, and most importantly, all customers benefit from the actions of customers who choose to opt in. The opt-in customers will reduce the costs of renewables integration, lower wholesale-market peak prices, and lessen the need for costly infrastructure investment.

In general, markets are most efficient when a) rules provide level playing fields and do not restrict innovation to protect incumbents; and b) when quality information is widely available in a timely fashion to allow all participants to make good decisions in the same time frame. To date, electricity markets have been able to provide information to relatively large consumers. Smart grid has the potential to empower all consumers.

Areas of research, development, and demonstration focus for market operations under smart grid include:

- Better forecasting of mid-term (day-ahead) and short-term (hour-ahead and intra-hour) renewable production. The NYISO has already developed sophisticated wind forecasting tools to help facilitate wind integration into the markets. The long-term ideal would be to forecast renewable production as accurately as load can be forecast today. There is a market impact from expected inaccuracies in renewable forecasts that appears in the form of additional reserves and other product procurements. Improved forecasting will improve market prices and reliability.

- Better understanding of consumer demand elasticity; how it changes with new technologies and how it varies with ambient environmental conditions. Today, load forecasting is a mature science in terms of understanding the sensitivities of demand to weather and economic activity. However, as consumers are exposed to day-ahead, hour-ahead, and real-time prices, how they will react to price information—and how that interaction will link to weather and other factors— will become an important element in forecasting demand for reliability and market operations.

V. Smart Grid Can Enhance Reliability at Transmission and Distribution Levels

Smart grid technologies will lead to important bulk power system enhancements. One of the most important smart grid technologies is the advent of phasor measurement units or PMUs. By providing near instantaneous measurement and observation of bulk-power-system phase angles at strategic locations across the system, PMUs are expected to increase the NYISO's (and transmission owners') interconnection-wide awareness of the system's state and its vulnerabilities in real time. The NYISO and transmission owners are deploying PMUs with the assistance of the U.S. Department of Energy, American Recovery and Reinvestment Act (ARRA) funding. The NYISO will be developing and installing advanced visualization displays to enable operators to interpret and use PMU data. This will provide operators another way to identify grid situations as they develop, and respond accordingly. PMU data can also be fed into new direct-state-estimation algorithms that will provide similar, near-instantaneous visibility of grid flows in real time.

Calculating line ratings more precisely in real time will allow greater transmission throughput. PMU data will allow the real-time calculation of changes in line impedance from conductor lengthening as it sags under higher temperatures. This will allow more specific and timely estimation of line sag for use in establishing real-time ratings. Since high wind speed both drives wind production and cools lines, this will hopefully result in higher ratings for the transport of wind power when it is most beneficial.

Transient stability problems on the bulk power system develop in milliseconds and are not subject to operator intervention: they are subject only to avoidance. Most renewable resources, especially wind turbines and photovoltaic systems, are inverter based and lack physical inertia. Thus, at high levels of renewables production, the system will have less overall inertia and may be more vulnerable to transient stability problems. Nevertheless, very high-speed monitoring devices such as PMUs, coupled with high-speed energy resources like fast energy storage or other high-speed inverter-based systems, could lead to stability-enhancement systems that further increase transmission productivity. Today, the NYISO manages transmission congestion by a) preventing the basic generation dispatch from overloading transmission lines and transformers or violate stability limits and b) in the event of a contingency (loss of a generator or transmission asset), correcting any resulting overloads within a time frame appropriate to the overloaded asset by utilizing locational reserve management. For instance, overhead transmission lines can be loaded to a four-hour rating without damage provided the loading is reduced to continuous limits within that time frame. Contingency dispatch or locational reserve management adds to wholesale energy costs. There are various examples of reliability considerations affecting wholesale energy costs in the NYISO's current tariffs, including thunderstorm alert and oil/gas fuel switching protocols.

Smart grid technologies offer the possibility of reducing these kinds of reliability costs. Demand response, smart charging, and energy storage can change the resource mix available for reliability purposes and, hopefully, offer lower economic costs than conventional generation re-dispatch. As a hypothetical example, fast energy storage in conjunction with demand response could provide a highly capable and low-cost contingency relief mechanism and mitigate contingency dispatch costs, provided that the technical questions around "certainty" and performance can be addressed. Best of all, this demand response application would provide benefits every day, or at least every peak day, but impact users only when a (relatively infrequent) contingency happens.

As noted above, market design rules can increase the penetration of renewable distributed energy resources. However, high levels of distributed energy resources penetration can also create grid and market integration problems. Fortunately, smart grid technologies may provide practical solutions to some of these problems.

Smart grid systems such as advanced metering initiatives (AMI) and pervasive distribution-feeder monitoring will allow monitoring of distributed resources' production, such as photovoltaic, in real time. Such monitoring will allow the utility and the system operator to know how much photovoltaic production is present in near real time as well as to validate estimates of installed capacity from direct observation. This will have several benefits:

- The utility and the system operator will be able to differentiate from load on the feeder versus the net load that includes distributed energy resource production.
- Forecasting will be improved as a result of the feedback from observations.
- The system operator would be able to forecast the impact of sudden cloud cover on distributed energy resource production and the impact on feeder net load at the take-out points.

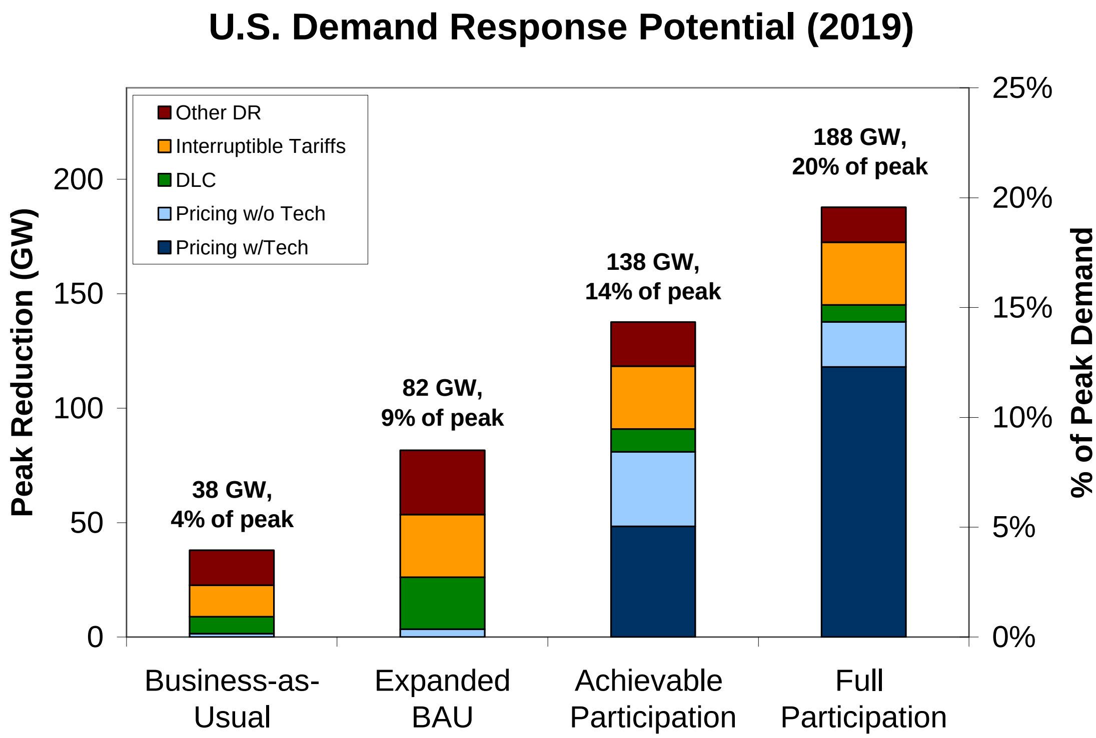
VI. Facilitating the Deployment of Demand Response and Distributed Variable Resources

A. Development of Demand Response

Development of additional demand response and distributed energy resources to operate alongside conventional generation resources **offers additional approaches to reducing carbon emissions**. Viable mechanisms include autonomous price response by consumer loads, directly or through aggregation; automatic- and manually-operated demand response on a pre-planned basis via aggregation; and directly controlled demand response acting as a provider of ancillary services. Demand response can also be used to balance the production of distributed resources on a local basis. These mechanisms can be utilized in conjunction with local resources, including distributed generation and local storage, to mitigate electricity demand

"The largest gains in demand response impacts can be made through pricing programs, particularly when offered with enabling technologies," according to an assessment of demand response potential by the staff of the Federal Energy Regulatory Commission[1]. That study found that deployment of advanced metering infrastructure and dynamic pricing could increase the potential impact of demand response by 68 percent. (*Illustrated by the difference between "Expanded Business as Usual" and "Achievable Participation" in the following table.*)

[1] *A National Assessment Of Demand Response Potential, Federal Energy Regulatory Commission Staff Report, June 2009.*



SOURCE: *A National Assessment Of Demand Response Potential, Federal Energy Regulatory Commission Staff Report, June 2009.*

Consumer acceptance will be essential to the further development of demand response programs. Notwithstanding the technical and business process potential of the approaches described above, significant levels of demand response participation will have an impact on commercial and residential customers. Successful development of demand response programs will require continued innovation driven by careful attention to customer input. The NYISO will continue to drive innovation in its demand response programs through the sustained evolution of its markets, in collaboration with stakeholders working in the NYISO shared governance process.

Markets benefit from demand response as a resource for reliability and control services such as spinning reserve and regulation. To realize these very significant benefits, the demand response program design and underlying smart grid technologies must be capable of meeting the technical requirements (e.g., response, certainty, measurement) for demand response as a source of reliability services. These challenging technical requirements should not be overlooked in smart grid architecture and design, as ancillary and reliability capabilities are too significant to lose. Furthermore, demand response cannot jeopardize the system by failing to meet ancillary performance requirements.

B. Challenges of Distributed Variable Resources

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. Managing renewable energy resources economically and reliably can encompass various approaches, including:

- **Flexible conventional generation**, such as hydropower projects (including pumped storage) and gas-fired combustion turbines, **can be used to manage the variability of wind and solar power production**.

- **Advanced technologies for grid-connected energy storage**, which are drawing increasing attention and should be technically and economically feasible, **can be used for some renewable-integration applications in the near term**.

- **The load side of the supply-demand balance can be managed to adapt demand to the variable levels of renewables' production.** For example, effectively managed plug-in electric vehicles (PEV) charging load can serve as a flexible demand resource for integrating renewable energy sources and managing their variability. Overnight PEV-charging could take advantage of peak production periods of wind generation resources. Absent effective management of PEV-charging load, there could be adverse reliability and market impacts.

- **Improving communications infrastructure will enable demand response resources to address bulk power system resource and reliability** needs even more quickly and efficiently than today.

There are pros and cons to each of these paths, and the best solution for New York will be a combination of options developed and operated for the best outcomes.

The use of conventional resources has the advantage of requiring little new development in markets or technology, but is the least attractive path from a carbon-reduction viewpoint. Also, cost variation with fuel price volatility has major implications for the future portfolio of conventional generation.

In addition to New York's existing hydropower pumped storage resources, new energy storage technologies are emerging. There are projects proceeding in New York involving the use of flywheels, compressed air energy storage, and advanced batteries for system regulation.

Energy storage is a fast developing field and the best mix of technologies will evolve as market forces dictate.

Smart grid can reduce the cost for monitoring and control of distributed (variable) resources. Today, distributed energy resources such as rooftop photovoltaic are invisible to grid operations. This invisibility is not a serious issue when PV contributes less than 10% of the load to a particular feeder. Likewise, when the total system PV contribution is only a small percentage of total generation, it is equally non-critical. However, PV penetration generating thousands of megawatts will create difficulties for utility distribution operations and will also make forecasting and scheduling for the NYISO more difficult unless integrated smart grid communications and data collection can be used to capture distributed energy resource status and production to optimize T&D and NYISO operations. Again, this requirement can be overlooked in AMI-only architectures and designs. Cost-effective distributed energy resource monitoring will be a requirement for successful grid operations and smart grid implementations should accommodate such monitoring. Advanced metering infrastructure should have provisions for gathering distributed energy resource production in near real time so that it can be aggregated for T&D and NYISO operations.

Improved monitoring of distributed energy resource production is a specific example of a general benefit of smart grid. Advances in the scope and array of new generating technologies will bring new technical issues when integrating with grid and market operations. While it may not be possible to anticipate all of these issues today, it is possible to develop monitoring and grid control strategies to address new generation resources.

VII. Research, Development and Demonstration – Areas of Focus

The research, development, and demonstration needs for reliability applications of smart grid include:

- Advanced analytics to use PMU information to enhance stability and reduce congestion. These may include new adaptive protection systems or centralized high-speed adaptive control algorithms and systems for stability enhancement.

- Improved dynamic-line ratings to increase transmission productivity and reduce congestion costs. The New York Power Authority ("NYPA") is conducting a pilot project on the use of PMU data to calculate line impedance in real time and then extrapolate line sag. Other new technical solutions may already exist that use advanced sensors and analytics. Improving line ratings directly improves transmission throughput and is one of the earliest tangible benefits of smart grid applications.

- Utilization of new technologies such as fast response storage technologies to alleviate post contingency loadings and reduce contingency dispatch costs.

VIII. Smart Grid Technology Considerations

A. Interoperability of Systems

– Smart grid interoperability is currently a key issue. The development of interoperability standards is being led by the National Institute for Standards and Technology (NIST) and supported by other standards bodies representing many domains. Continued collaborative development of standards with other ISOs/RTOs via the ISO RTO Council (IRC) and NIST is an ongoing priority for the NYISO. Smart grid business cases that drive protocols and interoperability standards are under development for market and grid operations functions such as demand response, bulk storage, and PEV integration.

– In a future with high distributed energy resource penetration and high demand response usage in markets, distribution systems and distributed resources must interoperate with transmission systems. Resources on the distribution network will increasingly provide support for transmission operations and reliability. The NYISO must consider those applications that will be required to facilitate such interoperability, including any effects on smart grid architecture and performance. Some of these issues were described in the discussion on distributed energy resources and T&D reliability above.

– Continued integration of market products across ISO/RTO borders. The NYISO is advancing broader regional markets initiatives with the grid operators serving the Mid-Atlantic, Midwest and New England regions of the United States and the Canadian province of Ontario. The ability to share reliability products across borders, to procure regulation across borders, and to share renewables integration products across borders will benefit regional energy costs and reliability. These efforts will become more and more important as renewables penetration increases.

– New technologies and third party product introductions will pave the way for novel aggregation technologies. One such real-time example includes the development of virtual net metering to allow for aggregation of multiple behind-the-meter distributed energy resource installations into one net metering supply resource. Another example includes the aggregation of multiple smart buildings, CHP, and distributed energy resource installations into a "virtual power plant" for the purposes of grid and market integration. In the future, Internet-based services such as Google Power Meter and similar offerings from other large IT and Internet businesses will be important. To facilitate PEV charging by providing easy consumer interaction that is location independent, providing a "meter-on-the-car" concept may have merit. Industry and regulatory processes need to be as receptive as possible to these new concepts and not allow rigid smart grid standards and business models to create obstacles to innovation.

  - Storage, ramping, and regulation technology introductions. As new technologies are developed and are commercially available, market participants and utilities will seek to bring them to market. Working with policymakers and its stakeholders, the NYISO will work to develop and introduce new market products and services aimed at facilitating the integration of renewables and making the optimum use of new resources such as smart charging and automatic demand response in its operations. The NYISO will be doing this in conjunction with other grid and market operators around the U.S. to learn from other innovations and experiments.

- Related Infrastructure needs

  - Smart grid deployment will require enhancements and new deployment of related infrastructure, some of which are discussed in this paper. Utility smart grid architecture typically requires new telecommunications capabilities. Consideration must be given to the interoperability of telecommunications systems across ownership boundaries – for example, potential interaction between the NYISO and distributed energy resources. There may also be benefits in making telecommunications systems usable for related domains such as gas and water.

  - The use of common carrier communications (*e.g.,* cable, fiber, Internet, cellular) for smart grid applications is potentially interesting and valuable. Especially for communications to consumers and end use devices, the economics and ease of integration with consumer technologies are attractive. Serious investigation into the security, performance, and reliability aspects of these systems, if applied to different smart grid applications, is a high priority. Use of common carriers for AMI and smart charging may pose one level of difficulty while use for distribution automation might present greater technical problems. Where existing or funded infrastructure can be exploited, it avoids the need for ratepayer-funded investments. This goal has to be balanced against the critical performance and security needs of system operations and control.

  - Utility control centers and the ISO control center will ultimately require upgrades in applications, visualization, performance and, potentially, facilities as part of full smart grid deployment. Utility smart grid cost recovery mechanisms usually recognize this and incorporate, for instance, advanced distribution management systems as part of smart grid development. Transmission operations systems such as energy management systems will similarly require upgrades in time.

- "Smart" Information Systems Infrastructure

  - Smart grid deployment requires the development of agile, highly adaptable and highly available information systems architecture in order to support the "real-time" and "near real-time" business nature of smart grid applications.

    - Real-time systems have traditionally been localized to energy management (and SCADA) systems supporting utility/ISO control centers; and remaining core applications and systems were either operations oriented or event-driven (Outage Management Systems (OMS), Mobile Work Force Management, Geographical Information System (GIS), etc.), or transaction-driven (Customer Information System (CIS) Billing; Market Settlements; Financial Systems; etc.). As the introduction of AMI and demand response moves normal utility operations to a "real-time"/"near real-time" business environment, interoperability and integration of traditional T&D, and Asset Management systems with multiple new market products and applications to both mid-office and back-office IT systems of a smart grid require the complete IT infrastructure to be dynamic and flexible. Coupled with organizational process changes, smart grid deployment requires transforming a utility/ISO organization into a "real-time"/near real-time" enterprise.

    - With high volume throughput, performance and frequency of data collected and transmitted as part of a smart grid deployment, more focus and emphasis will be needed on data management, data integration, data storage and archival, data analytics and reporting.

    - Coordinating events and transactions, along with interoperability and integration with "real-time" and "near real-time" applications and data transformations, requires a robust enterprise information systems architecture be implemented in a coordinated fashion. The development of a Smart Grid Reference Architecture (SGRA) will provide the blueprint to dynamically leverage existing IT applications and systems investments while taking advantage of newer smart grid enabled application and data capabilities.

- Utilities and the NYISO will need to assess their "smart" information technology infrastructure readiness for a smart grid deployment. It should develop and implement a Smart IT Roadmap to close any gaps and evolve to an agile, highly adaptable, and highly available IT infrastructure in parallel with process and organizational transformation.

B. Cyber Security

Cyber Security is the process by which any organization deploys and manages information assets to assure that the security tenets of confidentiality, integrity, and availability are maintained. This process is founded on a risk-based methodology, coupled with an assessment of the importance of the assets being managed to the overall mission of the organization. When cyber security is applied to the implementation of smart grid technologies, there are several factors that need to be considered:

- The implementation plans for any new technologies need to be assessed to derive potential operational impacts on existing infrastructure. The ongoing operation of these new technologies will necessitate changes within monitoring, change management, and testing procedures.

- An ongoing risk-based assessment, complemented by an impact assessment of implementation and operational plans for smart grid technologies should serve as the basis for comprehensive security architecture to support any smart grid deployment.

- Security components selected for use in smart grid projects within the initial implementation phase need to be continuously evaluated to ensure that they provide for adequate protections against known and perceived threats to the infrastructure.

- Interoperability and adherence to evolving industry standards are challenges that will need to be factored in during any product selection process as well as within the continual operational processes that smart grid technology deployments will impact. Security architecture and component selections will need to account for, and accommodate, a changing environment. Participation and communications with the standards development efforts will enable utilities to stay abreast of these changes and better plan for the smart grid initiatives they are undertaking.

- Communication networking components are vital design elements in any roadmap for smart grid technology deployments. Projecting bandwidth and latency needs for smart grid enabled applications is a universal challenge confronting the deployment of smart grid enabled applications and functions. The potential use of common carrier or public internet pathways will need to be assessed to determine if adequate security mitigation strategies can be implemented based on the criticality of the assets and applications that are being deployed. Assurance that both adequate protections of data in transit and network access control measures are present within all network interfaces is an important measure to assure the reliability and integrity of smart grid functions. The cost and effort of deploying a dedicated, private network to gain deterministic benefits and enhanced security need to be weighed against the operational costs and risk mitigation measures that would be required to secure a common carrier or public internet design.

- The data being collected and transmitted as part of any smart grid deployment will need to be protected accordingly to assure that it can be used within the context of the operational procedures for which it is envisioned as well as to ensure the integrity of its use or impact on wholesale market functions. As smart grid applications involving data connections to/from individual consumers are deployed, privacy concerns will likely drive additional security requirements for both the devices being deployed in homes as well as within the design and implementation of communications pathways that are deployed to support these efforts.

- Software solution vendors will need to be carefully scrutinized to ensure the integrity of any application source code provided for, or being developed as part of, a smart grid initiative. Hardware vendors need to be scrutinized about the components that are being provided within their products to assure that their mitigation or testing procedures account for threats that could be inherent within their production processes or supply chain. A structured approach to acquire a consistent and thorough vendor evaluation would be a valuable component within any procurement phase of deploying smart grid technologies.

C. T&D Modernization

- In addition to smart grid technologies such as PMUs, dynamic ratings, and substation and distribution automation, basic T&D infrastructure will also require modernization. While not traditionally considered as part of the smart grid, the following are important to consider in planning:

    - Re-conductoring and re-powering the transmission system to utilize higher current ratings and higher voltage levels, and realize greater throughput from the same right of way and towers.

    - New transmission technologies such as FACTS devices, active reactance control, supercapacitors, and other technologies.

- Beyond simply providing for cyber security of smart grid technology deployments, the NYISO and the NYTOs must consider the physical security of key assets, especially substations. For instance, when substations are automated, provisions for advanced intrusion detection can be incorporated.

IX. Role of the NYISO in Ongoing Smart Grid Planning in New York

When the federal and state governments opened access to the grid and restructured the electric utility industry in the 1990s, the NYISO was assigned the task of reliably operating the bulk electricity grid, as well as designing, administering, and monitoring wholesale electricity markets in New York State. In collaboration with its diverse array of stakeholders, the NYISO has continued to evolve grid operations and market design to reflect the dynamic nature of the electric system and the technology that serves it. NYISO was given the responsibility for reliability planning by FERC in 2004, which was subsequently expanded in 2008 to include economic planning in accordance with FERC's Order No. 890.

The NYISO's shared governance system, featuring an independent board of directors and stakeholder committees, has been key to the successful evolution of grid operations and market design. Stakeholder committees are comprised of representatives of market sectors that include transmission owners, generation owners, other suppliers, end-use consumers, public power, and environmental parties.

There are a number of potential opportunities for the NYISO to contribute to smart grid planning in New York that could make use of its collaborative system of governance, and its extensive expertise, capabilities, and infrastructure. Examples of these follow:

- There will be a need for ongoing market forecasts and analyses as renewables, distributed energy resources, and PEV penetrations increase. This is an existing responsibility of the NYISO and a core competence today, and the ISO would expect to continue to perform these analyses.

- The NYISO will lead in the identification of needs/opportunities stemming from increased integration of renewable resources, PEV charging, and related developments. The NYISO will necessarily be involved in developing concepts and designs for new market products around ancillary services, firming, forecasting, and aggregation, and ultimately in establishing the technical requirements, tariffs, and protocols for any that are implemented. Similarly, the integration of automatic demand response into market and grid operations will require the NYISO's close involvement.

- Transmission planning, integrated with long-term load and resource forecasting and scenario analysis, is a primary NYISO responsibility today. There will be a need for improved planning tools to accommodate the analysis of advanced transmission, generation, and technologies that are likely to be facilitated by the implementation of smart grid devices.

- Energy risk management under uncertainty will be an important factor in market operations, given the variability of renewable resources.

- All of the new resources and technologies introduce higher levels of uncertainty into grid and market operations across time scales ranging from multi-year planning to intra-hour dispatch. The methodologies in use today generally deal with uncertainty and risk in straightforward ways such as N-1 and N-2 planning and dispatch. It is expected that the industry as a whole will be investigating the use of more sophisticated risk management mathematics and methodologies and ultimately may incorporate them into grid and market operations as appropriate. The NYISO will play a key role in these developments in New York.

X. Areas for Policy Decisions

An array of policy decisions will be required in the near term to enable planning and deployment of smart grid technologies, and to enable the New York power system to best incorporate new resources.

- Smart charging policy is needed before PEV adoption grows to significant levels. Smart charging has been identified as having major benefits in terms of peak market pricing, avoided T&D infrastructure spending, and ancillary services in support of renewables integration. Policies that enable smart charging technical capabilities and business processes are essential so that aggregators and utilities can plan on systems deployment, and so that consumers are well informed about smart charging as it becomes a lifestyle. The PSC should consider whether changes in regulations will be needed. A technical conference on the subject may be the most effective means to address the details.

- Net metering rules may need to be revisited to see if further changes to encourage distributed renewable resources' participation in markets and operations are desirable. Topics such as virtual net metering should be explored. Virtual net metering addresses not only the tariffs and market integration of distributed energy resources (allowing the virtual aggregation of distributed resources that are "close" to each other on a given distribution circuit but are not "behind" just one single meter) but also associated monitoring. The PSC should consider these topics before the relevant smart grid systems are deployed or distributed energy resource penetration reaches high levels.

- Some new technologies are inherently mixed purpose, capable of performing market-based services such as ancillary services as well as providing reliability services. In general, smart grid systems are viewed today as regulated assets that are acquired, installed, and operated by electric utilities. Several related technologies, such as energy storage and distributed energy resources, are connected to the distribution feeder but not technically on consumer premises. There are no current provisions for third-party investment in, or operation of, assets that are connected to the distribution system directly other than for primary service customers, typically industrial users. This is an area worthy of investigation.

- The benefits of consumer participation in energy markets on various bases are potentially very large. However, mandating uniform customer participation in markets for all customers regardless of their circumstances poses large risks in terms of consumer dissatisfaction. From a consumer viewpoint, voluntary participation or opt-in/opt-out is a desirable path. The PSC is in a good position to investigate this structure and to explore development of further services and tariffs for common carrier support of smart grid deployment that will facilitate voluntary consumer participation. As noted above, this is a complex topic that involves issues of coverage, stranded cost, technical performance, security, and reliability.

XI. Public Awareness

Successful smart grid planning and implementation in New York will require attention to public awareness and understanding of the technologies, public policies, and consumer impacts. The NYISO is prepared to use its existing stakeholder processes, workshops, forums, conferences, and other capabilities to support these efforts. In particular, the NYISO can support training on smart grid impacts on markets, reliability, and the integration of renewables. As New York State develops stakeholder and consumer outreach and education programs and collateral, the NYISO is prepared to provide support through its resources and programs that include:

- Market Training
- Stakeholder Conferences
- Working Groups
- Industry Engagements
- Academic Linkages
- Regulatory Information Support

XII. Workforce Development and the Role of State Academic Institutions

The smart grid will result in significant job creation during its development and deployment and will transform the nature of many jobs in the electric power industry. Lower skilled positions will be replaced by jobs that require advanced engineering training in power systems and in the new energy and Communications, Command, and Control (CCC) technologies. New York has a number of well-respected institutions of higher education with strong engineering departments. Continued and increased interaction between the electric power industry and academic institutions is highly desirable to foster cooperation and convey to the entering students that this is a viable and attractive career area. Electric power industry activities in power program research and development support, co-operative training and internships should be encouraged and allowed as reasonable operating costs in the ratemaking process.

XIII. Conclusion

Successful integration of smart grid into New York's electric system will require consideration of myriad technologies and involvement of an extensive array of parties ranging from government and industry to academia and the individual consumer.

The NYISO commends the Public Service Commission (PSC) on its measured approach to determining the most effective way to capture the potential benefits of smart grid technologies, and stands ready to offer its expertise, capabilities, and existing infrastructure to support smart grid planning in New York State.