Transmission and Distribution System R&D Plan for New York State

Final Report 06-13
November 2006

New York State
Energy Research and
Development Authority

NYSERDA

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TRANSMISSION AND DISTRIBUTION SYSTEM R&D PLAN FOR NEW YORK STATE

FINAL REPORT

Prepared for the

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

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Executive Summary

The results of an effective R&D program in the area of transmission, distribution, and power markets can lead to a broad range of benefits to the utilities, businesses, and citizens of New York State. Such a program can improve power reliability, quality, and security; reduce the cost of energy; help protect the environment, worker safety, and public safety; improve quality of life; and stimulate economic productivity.

The purposes of this report are 1) to document the key issues that New York State faces in the transmission and distribution (T&D) area, and 2) to propose an R&D plan for New York State that addresses these issues. This report identifies the following five critical needs: transmission reliability, distribution reliability, diverse needs from upstate to downstate, regional issues, and power system operation and planning. Today, New York faces a range of issues that threaten to reduce power system reliability, voltage, and dynamic stability, potentially imposing a real cost to businesses and consumers in New York State. These issues include lack of transmission investment that can adversely impact reliability; difficulty in obtaining new (or expanding existing) transmission rights of way; as well as space constraints, aging equipment, and maintenance difficulties in high load density areas. Distribution issues also pose reliability concerns in New York; over 90 percent of minutes lost during power outages are typically attributable to distribution events. In New York, these issues include the need for fault current management, improved fault location capabilities, and others.

New York also faces a range of issues that affect the entire northeastern region and in some cases, much of the Eastern Interconnection. These include shifting wholesale power transfer patterns that have resulted from industry restructuring, an increasing need for reactive power reserves and voltage support, and a need for improved power system integrity protection. Power system operational issues, such as the need to improve situational awareness of operators, also cut across New York's boundaries. Further, the Federal Energy Regulatory Commission (FERC) has entrusted independent system operators (ISOs)/regional transmission organizations (RTOs) such as the New York Independent System Operator (NYISO) with significant regional planning responsibilities.[1] The Energy Policy Act of 2005 has also made fundamental changes to the investment incentives related to many types of energy resources and the T&D infrastructure. The importance of maintaining high T&D system reliability will increase with the formation of the ERO (Electricity Reliability Organization), which will have legal authority. As the industry continues to change, this research plan must adapt to the changing conditions.

This report includes the ideas discussed at a stakeholder meeting on March 4, 2005. Prepared for the New York State Energy Research and Development Authority (NYSERDA), this R&D plan is designed to help address these needs in the T&D area for all of New York State. In addition to needs that are specific to New York State, the plan

[1] After transmission developers obtain approvals from the NYISO, these developers must also apply for approval from the New York State Public Service Commission under Article VII of the Public Service Law [1].

addresses regional issues that also affect New York. Within the state, the plan addresses the unique issues of both low load density and high load density areas. Projects in the plan span a range of both technology development/deployment efforts and policy/business/regulatory projects.

The key advantage of R&D collaboration is to draw on the expertise and the experiences of multiple utilities, research managers, and researchers, and collectively focus them on problems that are too large for any single entity to tackle alone. This approach multiplies the potential benefits of the financial investment in solving problems that are critical and common to multiple entities. An important criterion for designing a collaborative portfolio of projects is that they complement and build upon the completed, ongoing, or planned work of other research organizations, rather than duplicating other work. In particular, the EPRI IntelliGrid Consortium has a vision and a scope that are quite synergistic with the New York R&D objectives. In the recommended list of projects in this document, the Fast Simulation and Modeling project is also in EPRI's IntelliGrid Consortium. If the New York stakeholders of this R&D plan select this project, EPRI recommends that NYSERDA collaborate with EPRI on the scope of the projects on both sides. Accomplishing this industry-wide collaboration would require coordination or information sharing among the major research organizations in the electric power industry. Still another criterion is that the selected projects are unlikely to be developed by commercial entities alone, yet pose high potential value. With these criteria in mind, the New York R&D program will fill a major gap in the development of T&D solutions, with specific public benefits accruing to New York State.

The next step in moving towards implementation of this R&D plan is to obtain feedback from the key stakeholders in New York's power industry. New York stakeholders consensus and approval of the R&D plan, and their continued involvement in the R&D planning process as it evolves, is crucial to the success of the R&D program. To help achieve this, an advisory council and set of task forces will be established, consisting of representatives from relevant stakeholder groups. The R&D program will be periodically updated as additional R&D needs emerge, new technologies become available, stakeholders learn from ongoing projects, and additional or substitute project areas are recommended for consideration.

Section 1
Introduction

While this R&D plan is tailored to the needs of the stakeholders of New York State, many of the issues that New York faces are part of a broader, national concern. In its Grid 2030 report published in 2003, the U.S. Department of Energy eloquently captures this concern:

> "America's electric system, the supreme engineering achievement of the 20th century, is aging, inefficient, and congested, and incapable of meeting the future energy needs of the economy without substantial capital investment over the next several decades [2]."

While this concern presents a major problem to be solved, it also represents an enormous opportunity—the opportunity to realize a broad range of benefits for all involved stakeholders by upgrading the power system. An enhanced T&D system will increase the capacity of networks; improve power reliability, quality, and security; reduce the cost of energy; help protect the environment, worker safety, and public safety; improve quality of life; and stimulate economic productivity [3].

The concern that DOE expresses cannot be addressed, nor can the corresponding opportunity be fully exploited, without a firm commitment to research and development in the T&D area. Experience has repeatedly shown that major infrastructure improvements cannot be effectively completed without simultaneous technological advance. In the U.S., this has been found to be true during the great projects of rural electrification; establishment of an interstate highway system; construction of a network of dams for electrification, irrigation, and flood control; and a host of other accomplishments. In other countries, this concept has been demonstrated during the construction of the Channel Tunnel, the great flood control system of the Netherlands, and many others.

There is another reason why the time is right for increased research and development in the T&D area. As shown in Figure 1, construction expenditures on the power transmission infrastructure across the U.S. have just begun to increase after two decades at lower levels [4]. This rise in transmission expenditures is a welcome trend. Such transmission investment has not yet risen in New York State for a number of reasons discussed below. But it clearly must increase, in order to mitigate fundamental capacity limitations for power transfer between the northern and southern portions of the state. The fundamental premise of this R&D plan for New York State is the following: coupling this needed rise in T&D system investment with technological advancement in T&D technologies will ensure realization of the highest economic, social, environmental, and other benefits.

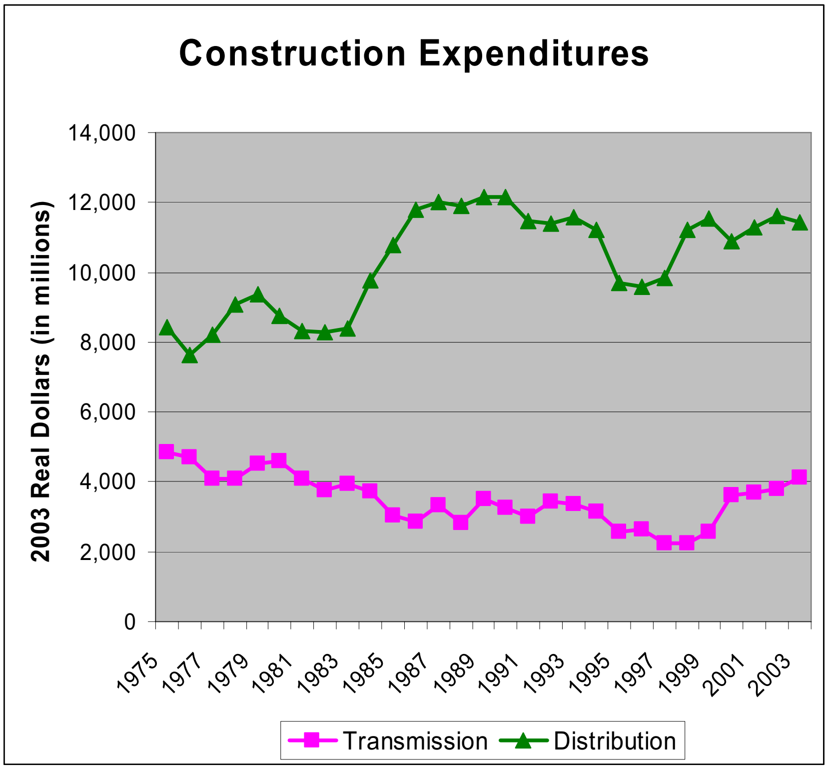

Figure 1
Construction expenditures on the power transmission and distribution infrastructure from 1975 to 2003

This coupling of investment and technological advance makes sense. Installing state-of-the-art equipment will clearly lead to more efficient operation, better use of resources, and other benefits, compared with installing less advanced equipment.

The Energy Policy Act of 2005 has also made fundamental changes to the investment incentives related to many types of energy resources, T&D infrastructure, and advanced transmission technologies. The importance of maintaining high T&D system reliability will increase with the jurisdiction of the Electricity Reliability Organization (ERO), which will have legal authority. As the industry continues to change, this research plan must adapt to the changing conditions. Taking advantage of this critical time in the history of the electric power infrastructure in New York State is the focus of this R&D plan.

Section 2
New York State's Five Critical Needs

2-1. Transmission Reliability

In New York State, the number one issue in the T&D area is the sustained lack of transmission investment and its potential impact on reliability, voltage, and dynamic stability. Only a few new transmission facilities have been constructed in New York in the last decade (e.g., the Cross Sound Cable, which faced legal challenges but is now operational, and the advanced power electronic-based transmission controller—the Convertible Static Compensator—installed at Marcy by NYPA). The lack of transmission capacity is a potentially costly situation for residents of New York State. According to a May 2004 report by the NYISO, "transmission limitations constrain the ability of New York's [power] markets to reduce consumer costs. This transmission 'congestion' can have a real cost to New York consumers [5]." The NYISO goes on to say that New York "has made very little progress…in strengthening its transmission infrastructure…[which]…has potential negative implications both for future system reliability and consumer costs [5]." According to New York ISO 2004 State of the Market Report, congestion charges in New York amounted to about $629 million in 2004 [6]. The report then hastened to caution that "these costs do not represent the net benefits of eliminating all congestion in New York, which has been estimated to be less than $100 million." In other words, reducing congestion costs requires transmission investments that may not be economically justifiable.

However, according to the New York ISO, a congestion cost metric defined as the difference in production cost between the transmission-constrained and unconstrained unit commitment and dispatch is a "measure of the economic inefficiency introduced by the existence of transmission bottlenecks. In a sense, this is the societal cost of transmission congestion." This may be one metric for measuring the effectiveness of a research and development program. Other metrics should include the reliability performance and utilizations of transmission facilities.

New York is not alone in this regard. Transmission congestion is increasing in the eastern interconnection as a whole. Various entities in this area, which includes all of the U.S. east of the Rocky Mountains excluding Texas, manage congestion in different ways. The PJM Interconnection, NYISO, New England ISO, and Midwest ISO use "security-constrained unit commitment and dispatch" inherent in the computation of locational marginal pricing (LMP).[2] Transmission Loading Relief (TLR) is also used when the LMP

[2] LMP (Locational Marginal Pricing) is the procedure for determining the prices of electricity (both supply and demand) at each node of a transmission grid, based on the bid prices by scheduling the optimal supply sources, subject to keeping all power flows within all transmission limits. LMP is therefore a simultaneous, near real-time, procedure to solve the market dispatch and congestion problem.

approach is not sufficient. The remainder of the interconnection uses TLR.[3] The number of calls for TLR is a measure of transmission congestion in a region. For the Eastern Interconnection, of which New York is a part, calls for TLRs of level 2 or higher have risen from 305 in 1998 to 2312 in 2004, according to the North American Electric Reliability Council (NERC) [7]. That represents more than a seven-fold increase. Concerned about increasing congestion, FERC recognizes the problem of inadequate investment return for transmission, explaining: "Providing regulatory certainty for the industry and investors in order to build needed infrastructure is a critical need facing the energy industry and requires Commission action [8]."

To address this challenge, New York needs to be able to identify and evaluate the potential of various market-based and/or institutional mechanisms for increasing certainty of return on investment in transmission. Methods of determining the optimal portfolio of investment projects are also needed. At the same time, investments in generation capacity must be coordinated with investments in transmission capacity. These and other needs must be met with an eye towards relieving short-term congestion problems, as well as a long-term view.

2-2. Distribution Reliability

Compared to the transmission system, the greater complexity, exposure, and extent of distribution systems generally (e.g., more miles of wire and more poles or conduits) result in inherently lower reliability, reduced power quality, and greater vulnerability to disruptions of any kind. However, due to the criticality of the supply of electricity to New York City, a higher standard of reliability is needed there. Consolidated Edison Company of New York (Con Edison) has adopted such a reliability standard. Figure 2 shows that about 1200 distribution customers are interrupted per 1000 served per year (national average). This means that on average, each distribution customer suffers about 1.2 outages per year. Conversely, the number of New York City customers interrupted per thousand per year is significantly lower. Distribution reliability in New York State as a whole is also significantly better than the national average.

[3] TLR (Transmission Loading Relief) is the procedure to reduce transmission loading on specific transmission facilities by computing and curtailing those bilateral wholesale power transactions that contribute to such congestion above a minimum threshold, in order of transmission priorities. In contrast to LMP, TLR is an after-the-fact, rather than a near real-time, procedure.

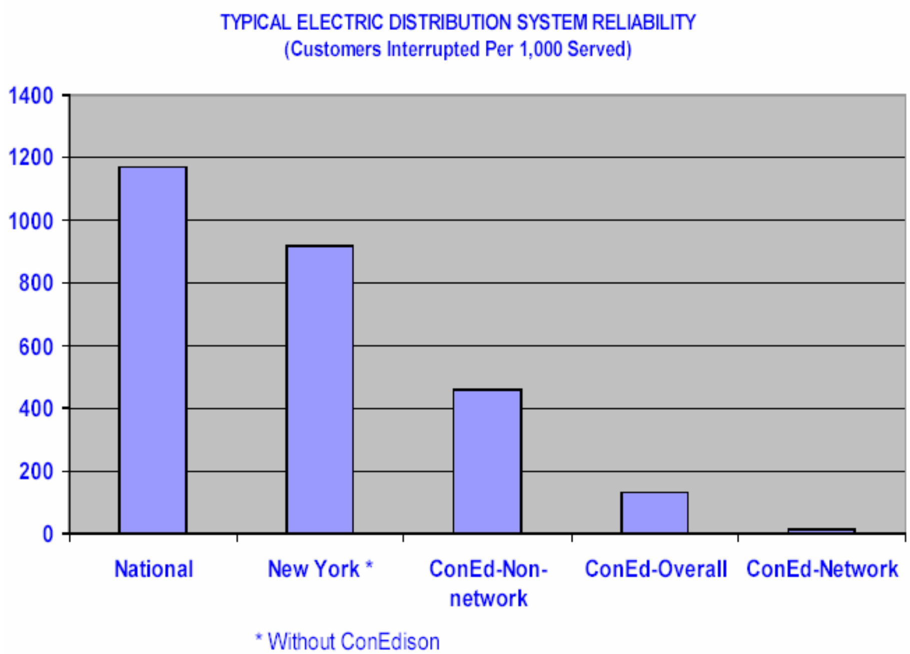

Figure 2
As measured by customers interrupted per year, New York State boasts a more reliable distribution network than the national average. Due to Con Edison's use of a network, rather than radial, distribution system designed to withstand two simultaneous contingencies, the utility has been able to further increase distribution reliability [9].

Distribution system characteristics and performance primarily affect the number and duration of power disturbances that consumers experience. Reliability performance is often measured as the average total duration of interruptions (i.e., "minutes lost") experienced by a consumer in a year. Using this measure, over 90 percent of the minutes lost for consumers are attributable to distribution events. Hence, investments in the distribution system are required to achieve higher levels of reliability and quality.

Specific distribution system needs discussed at the recent workshop include superconducting cables, fault current management, improved fault location capabilities, higher capacity distribution cables, distribution automation capabilities, effective integration of distributed resources into the distribution system, worker and public safety, environmental excellence, cost reduction, and reliability. Various utilities in New York are already conducting a substantial amount of work in these areas. The New York State R&D plan for T&D should complement this work.

2-3. New York State's Diverse Needs

New York State's wide variety of load densities (i.e., primarily high load density in the heavily populated urban centers in downstate New York, and the primarily low load density in upstate New York) pose unique challenges. To be effective, this R&D Plan must address issues that concern all areas of New York State.

Utilities and other stakeholders in low load density areas of New York, for example, face the difficulty of increasing the capacity of long overhead transmission lines. Obtaining new rights of way (or expanding existing rights of way) is problematic. Upstate New York entities and consumers also face issues of equitability and fairness in power markets. The availability and the eventual market-based distribution of low cost generating capacity outside of high density urban centers raises concerns about fair allocation of that power so that *all* power market participants benefit.

Conversely, high load density areas must address the limited amount of space available for new generation and T&D capacity. The routing of large amounts of power into a smaller area also causes fault current problems in these areas. The extensive use of underground transmission and distribution equipment in high load density areas complicates maintenance access as well as fault detection and location.

In addition, the New York State Public Service Commission (NYS PSC) has instituted a proceeding that established a renewable portfolio standard (RPS). The goal of the RPS is to procure 25 percent of electricity consumption from renewable energy sources within ten years. About 17 percent of electricity consumed in New York is currently generated using renewable energy sources. The T&D R&D plan must address the intermittent nature of renewable energy sources and the need for transmission capacity to bring the renewable sources to the load centers. Metrics for measuring success in this category of R&D needs include the fuel diversity in New York, the penetration of renewable resources, and demand portfolios.

2-4. Regional Issues

Currently the NYS PSC is fully committed to developing an efficient regional market that includes all of the surrounding ISOs. Hence, many of the issues that New York faces involve the state’s role in the northeast region, and more broadly, in the entire Eastern Interconnection. The NYISO maintains significant transmission interconnections of at least 1000 MW with each of four neighbors—the Independent Electricity System Operator of Ontario to the northwest, Hydro Quebec to the north, ISO-New England to the northeast, and the PJM Interconnection to the south [5].

Figures 3 and 4 show the shift in the pattern of wholesale power transfers (in MW) between New York and its neighbors by comparing two recent years (2001 and 2003). These plots show, for example, that many power transfers in 2001 involved New York export of power, while far fewer such transfers were present in 2003. The potential impacts of these shifting patterns, that had accompanied power industry restructuring, are not well understood, but may lead to unforeseen problems if the different patterns trigger unstudied instability modes. At the same time, there is insufficient “visibility” of power flow conditions over the entire region. ISOs/RTOs in the northeastern region need larger and more comprehensive real-time regional and interconnection-wide power flow models for anticipating changing flow patterns and the formation of new transmission bottlenecks. In general, improvements in coordination, communication, and control of the power system on a regional basis is needed.

A second regional issue area involves management of reactive power (VAR) reserves. A general lack of monitoring and control of reactive reserves in the region and adjacent regions leads to the possibility of inadequate dynamic VAR support available from generators, which in turn may lead to voltage instability and cascading outages.

Improved regional system protection is also needed. One key area is improved control schemes (e.g., enhanced under-voltage or voltage-instability load shedding). Other needs include automatic "safety nets" for power system operation, and advanced special protection schemes (e.g., adaptive islanding of the grid). Each of these areas can benefit from the integration of information gathered and processed by wide area measurement systems (WAMS). Another area involves improvement in the protective relay itself—its proper placement, settings, reliable operation, and performance.

Another regional issue that is emerging in New York and New England is the concern about global warming and the effect of power plant emissions of greenhouse gases. Any implementation of state-wide or region-wide processes to limit greenhouse gases from power plants, whether a "cap and trade" mechanism or a "carbon tax," will significantly impact the overall electricity supply picture in the entire region. New York is participating in the Regional Greenhouse Gas Initiative (RGGI). The state is coordinating with all New England states to develop a CO_2 "cap and trade" program, which may have a significant impact on generation cost and development. The R&D plan will address the need to understand the implications of this program for the T&D system.

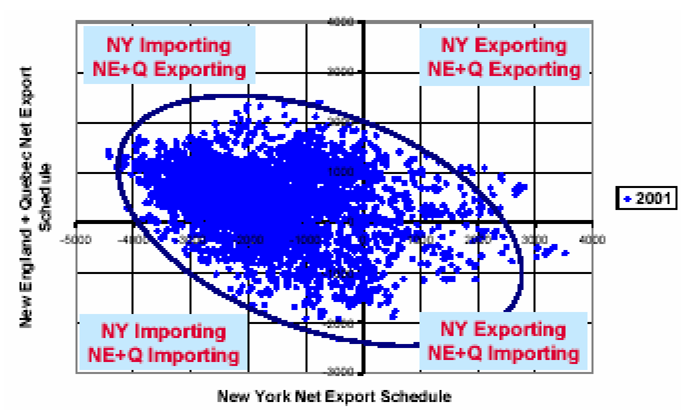

Figure 3
Wholesale power transfer patterns (in MW) for May through October 2001 (New York State both imported and exported power in the summer of 2001)

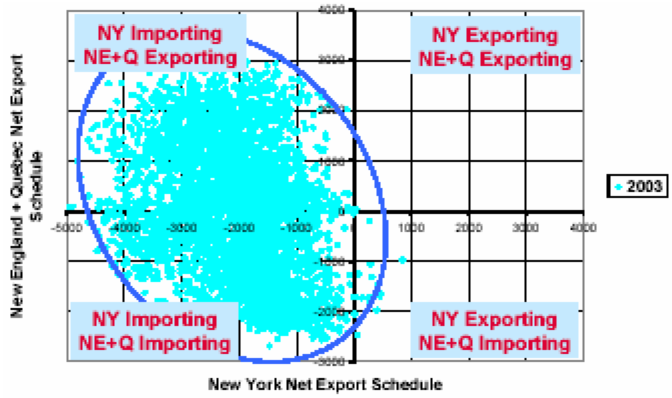

Figure 4
Wholesale power transfer patterns (in MW) for May through October 2003
(New York State primarily imported power in the summer of 2003)

2-5. Power System Operation and Planning

The needs that New York faces in the areas of power system operation and planning are not unlike those within most regions in the Eastern Interconnection. The desire to enhance situational awareness of power system operators within the region heads this list. These operators require improved ways of recognizing patterns in data relayed to them from regional phasor measurements, better power system modeling, and faster simulation of contingencies on the power system. Satisfying these requirements will help operators better monitor the grid for potential cascading failures, locate disturbances, and enhance reliability. At the same time, operators need tools and methods for enhancing infrastructure and cyber security. To do this, these same operators also seek better ways to visualize problems on the grid, manage the flood of alarms that are generated at critical times, and effectively and quickly restore the system to a stable operating state in the event of a system failure.

In the planning area, FERC has entrusted ISOs/RTOs such as the NYISO with significant regional planning responsibilities. This poses challenges that New York shares with system operators throughout the Eastern Interconnection. Regional planning must address the efficient integration of sustainable generation and transmission resources with New York's power markets. This process must consider modeling uncertainties, integration of particularly large generation resources as well as decentralized ones, and power generation emission limits.

The NYISO is making substantial progress on initiatives to coordinate planning in the Northeast Region. These efforts include development of a Comprehensive Planning Process and entering into an agreement on a Northeastern ISO-RTO Planning Coordination Protocol [5]. R&D activities in the area of regional planning will complement these efforts.

Section 3.0
R&D Plan Objectives and Approach

3-1. Objectives

The objective of this R&D plan is to establish a short-term (five-year) plan for collaborative R&D that benefits the stakeholders of New York State, as well as helps move toward a long-term (10+ years) vision for the future T&D system in the state.[4] This long-term vision can be viewed as a T&D system that provides a broad range of benefits to customers, the public, and other stakeholders. At the recent workshop, Niagara Mohawk Vice President Marc Mahoney proposed the following list of R&D objectives [10]:

- Increase network efficiency and throughput
- Improve reliability
- Enhance security (i.e., detect and protect against threats)
- Ensure public and worker safety
- Reduce environmental impacts
- Reduce O&M costs commensurate with reliability requirements
- Promote capital efficiencies
- Improve customer service
- Enable demand response, distributed resources
- Enable value-added services
- Improve training aids for employees

3-2. Collaboration

A "collaborative" R&D program can be defined as one in which financial resources and technical experiences are brought together from multiple participants to solve issues that face all of them and produce results that are mutually beneficial. While this approach does not address unique problems that may affect a particular company, the collaborative approach enables the participants to focus their collective knowledge and expertise on problems that are too large for a single company to tackle alone. This approach multiplies the potential benefits of the financial investment in solving problems that are critical and common to multiple entities.

In addition, by collaborating with other research organizations outside the state, New York can address problems that are larger than New York can solve on its own and multiply the benefits of its financial investment far beyond what its residents can expect to receive by only in-state funding. These approaches also typically result in solutions that are broadly applicable to stakeholders within the state. Existing industry-wide funding sources for transmission and distribution R&D include the following:

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[4] For more information on the vision of the T&D system of the future for North America, refer to "Electricity Technology Roadmap: 2003 Summary and Synthesis, Power Delivery and Markets," EPRI report 1009321, November 2003 [11].

- Utility funding of R&D organizations such as EPRI and university research consortia
- State-mandated research programs funded by utilities or ratepayers
- Government funding (e.g., DOE's Office of Electricity Delivery and Energy Reliability, national laboratories, the Department of Homeland Security, the Department of Defense, and state research programs)
- University funding
- Private sector (e.g., manufacturer) funding of internal R&D.

In particular, the EPRI IntelliGrid research program has a vision and a scope that are quite synergistic with the New York R&D objectives. In the recommended list of projects in this document, the Fast Simulation and Modeling project is also on the EPRI IntelliGrid program. If New York stakeholders of this R&D plan select this project, EPRI recommends that NYSERDA collaborate with EPRI on the scope of the projects on both sides. In the same spirit of collaboration and leveraging of research funding, EPRI also recommends that NYSERDA collaborate either directly or through the IntelliGrid Consortium with research efforts undertaken by the U.S. Department of Energy's Office of Electricity Delivery & Energy Reliability in the areas of Grid-Wise/Works, GridApps, and Modern Grid.

3-3. Project Management

The collaborative R&D program that meets New York's needs should be defined by the stakeholders of the system, including owners, operators, regulators, and science and technology experts from New York and around the world. This can be accomplished by establishing a two-tier structure that includes an advisory council and various task forces. The advisory council would consist of a group of advisors who guide broad R&D directions, as well as specific emphasis on individual projects. This council addresses a combination of project conception, operational feedback, and longer-term strategic planning. In two annual meetings, the council would review project results and status reviews, discuss new projects and priorities, define deliverables, approve R&D projects and portfolio, and discuss and approve multi-year plans. The council would also identify the metrics to be used to gauge project performance and success (e.g., reduced costs, improved reliability, etc.). Examples of metrics include congestion costs, frequency and duration of customer interruptions, power quality indices, customer cost of electricity, environmental impacts, and others.

The task forces would consist of a group of representatives from stakeholders who have hands-on experience, expertise, or interest in a particular topic. These task forces would provide more detailed input and feedback on specific R&D projects. Task force representatives would discuss day-to-day operational issues of a project and make decisions including conception, definition, scoping, marketing, and tracking.

The New York program should heavily leverage the expertise of those entities in the state with a core business in T&D areas via program oversight, governance, and implementation. More generally, this R&D plan is committed to using New York State resources (e.g., contractors, universities, and other New York-based entities) as appropriate.

3-4. Project Selection Criteria

An important criterion for designing a collaborative portfolio of projects is that they complement and build upon the completed, ongoing, or planned work of other research organizations, rather than duplicate other work. Accomplishing this requires coordination or information sharing among the major research organizations in the electric power industry. Conversely, a project should not duplicate nor reinvent work that has already been accomplished. Instead, it should add to the scope of the research effort, accelerate its schedule, speed up prototyping and demonstration in New York, and obtain valuable experiences for New York participants.

Further, the R&D program should consider the interplay of commercial risk, technical risk, and value (see Figure 5). The interplay of risk and value is central to any attempt at R&D planning efforts. Commercial entities should handle high value, low risk projects. Conversely, low value, high risk projects are best avoided. Hence, the best fit for the New York R&D plan is a portfolio of relatively high risk, yet potentially high value projects. While the potential payoff to the stakeholders of these projects in the form of increased reliability and other benefits is high, significant effort may be required to develop them and overcome or mitigate their inherent commercial and/or technical risks. The difficulty of managing these programs stems from the need to understand which candidate technologies to pursue and which to defer or remove from consideration. This consideration of risk and reward is at the core of candidate project evaluation.

With these considerations in mind, the criteria for considering candidate projects for inclusion in the R&D plan for New York State include the following:

- Offers value in a manner that is consistent with the long-term (10 years+) vision of the T&D system of New York State
- Provides benefits to a broad range of New York stakeholders, including customers and the public
- Focuses collective knowledge and expertise on problems that are too large for individual participants to tackle alone
- Meets a short-term and/or long-term need that affects a large portion or all of New York State
- Complements and leverages existing or planned work by others, rather than duplicating or supplanting such work
- Offers potential high value to New York stakeholders, while posing significant commercial and/or technical risk

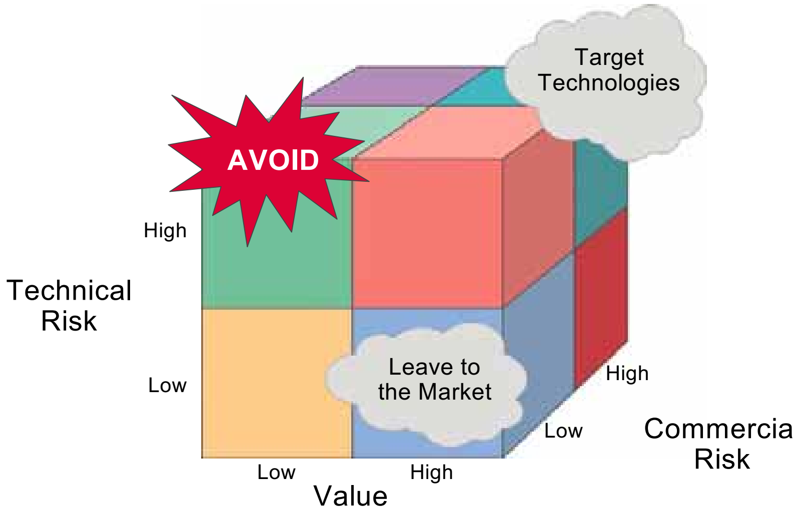

Figure 5
The interplay of risk and value is at the core of candidate project selection for a collaborative R&D plan

3-5. R&D Planning Process

With this approach in mind, representatives of New York utilities, NYSERDA, universities, EPRI, and others met in Albany on March 4, 2005 to begin the process of identifying critical R&D needs for New York State. In general sessions and six breakout sessions, participants identified these needs in a wide range of areas. This report represents the continuation of the R&D planning process by documenting a proposed R&D plan.

Beginning of the actual project work will not signal an end to the R&D planning process. The R&D program will be periodically updated as the vision evolves, new technologies become available, stakeholders learn from ongoing projects, and additional or substitute project areas are recommended for consideration. In this way, this plan will be a living document.

3-6. Summary of R&D Planning Results – A Balanced Portfolio of R&D Endeavors

In addition to adhering to the established project criteria, each of the projects proposed in this R&D plan responds to one or more critical R&D needs that New York State faces. Table 1 maps the proposed projects, grouped according to subject area, to meet these critical needs. This table shows that the recommended projects address all of the critical needs to varying degrees, with some projects responding to more than one need.

Based on the needs that the projects address, perceived potential value of the projects, and other considerations, Table 2 presents a preliminary listing and prioritization of the proposed projects. Once approximate project costs are determined for each project and the total available funds for the R&D program can be relatively accurately estimated, this table can be used to determine a "cut-off" line. Projects above this line can be funded in the R&D program, whereas projects below the line cannot be immediately funded. The latter projects can be considered for funding at later dates, based on the availability of overall funding.

Section 4
Conclusions and Recommendations

This report significantly moves forward the process of initiating a collaborative R&D program for New York State in the areas of transmission and distribution and power markets. The next step in the R&D planning process is to enhance this plan according to feedback to be received from New York stakeholders at the next meeting on this topic. New York stakeholder consensus and approval of the R&D Plan, and their continued involvement in the R&D planning process as it evolves, is crucial to the success of the R&D program.

The goal of this process is to develop an R&D plan, and then initiate an R&D program, that is responsive to New York's critical needs in the T&D and markets area. At the same time, the process should move New York closer to realizing the long-term vision of a T&D system that offers improved reliability and power quality, enhanced security, lower electricity costs, reduced environmental impacts, improved customer service, and other benefits.

Table 1
Proposed R&D Projects Meet Critical R&D Needs in New York State

Critical R&D Issue Project name	Transmission Reliability	Distribution Reliability	Diverse Needs: Low load density needs	Diverse Needs: High load density needs	Regional issues	Power system operation and planning
Fast simulation and modeling	X	X	X	X	X	X
Pinpointing the initiating location of a disturbance	X		X	X	X	X
Fault anticipation and notification system for the New York State distribution system		X	X	X		X
Fault current limitation	X	X		X		X
Public/private business model for sustainable investment in T&D infrastructure	X	X	X	X		
Regional pattern recognition project for New York State	X		X	X	X	X
Intelligent islanding to maintain NY power system integrity during external cascading failures	X		X	X	X	X
Replacement of secondary networks by a new technology		X		X		X
Transformer asset performance database and fleet management	X	X	X	X	X	X
Intelligent monitoring and diagnostics of power electronics-based controllers	X		X	X	X	X

Table 2
Preliminary Prioritization of Proposed R&D Projects for New York State
(highest priority =1)

Priority	Project Name
1	Fast simulation and modeling
2	Pinpointing the initiating location of a disturbance
3	Fault anticipation and notification system for the New York State distribution system
4	Fault current limitation
5	Public/private business model for sustainable investment in T&D infrastructure
6	Regional pattern recognition project for New York State
7	Intelligent islanding to maintain NY power system integrity during external cascading failures
8	Replacement of secondary networks by a new technology
9	Transformer asset performance database and fleet management
10	Intelligent monitoring and diagnostics of power electronics-based controllers

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Section 5
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Section 6
Project Descriptions

This section provides summary descriptions of each of the proposed R&D projects for New York's R&D Plan in the areas of transmission and distribution, and power markets.

6-1. Project Title: Fast Simulation and Modeling

Benefits of Project

The Fast Simulation and Modeling (FSM) project is designed to provide the mathematical underpinning and look-ahead capability for a self-healing grid for New York State—one capable of automatically anticipating and responding to power system disturbances, while continually optimizing its own performance. "Fast" means the ability of the computation to simulate a time period, of say 20 seconds, for hundreds of scenarios in less than a few seconds so that when the power system moves forward in real time, a complete assessment of reliability or stability can be completed before the system changes. It will provide a tool to aid in decision-making by permitting an operator to obtain an accurate state estimation of the grid in real time. This will allow the grid operator to optimize grid operations, as well as predict grid behavior based upon historical and real time data. This project will result in an operating tool for grid operators in New York.

Project Description

The FSM project will apply an open platform for software. Figure 6 shows the concept of a distributed hierarchical system for implementing an advanced control system architecture of the future. On the vertical dimension, the integrated messaging or data communication network is shown connecting the different hierarchies. The substation level is shown at the bottom. At each substation, the function F1 (e.g., voltage stability) is implemented with an intelligent functional agent at that substation, which is capable of actuating a control action through the actuator. This intelligent agent interacts with the next hierarchy (control area) through the messaging system. The intelligent agent at a substation also interacts with other intelligent agents at other substations. Likewise, the intelligent agents at each hierarchy interact with other agents at the same level and at other hierarchies as well. Above the control area level is the region level. Finally, at the top is the level of the interconnection.

The steps follow the normal requirements-design-development-testing phases as specified by EPRI's IntelliGrid Consortium. Future work done in this project will not duplicate prior work. It will instead draw benefits from previous works and apply the knowledge gained to a specific demonstration project for New York.

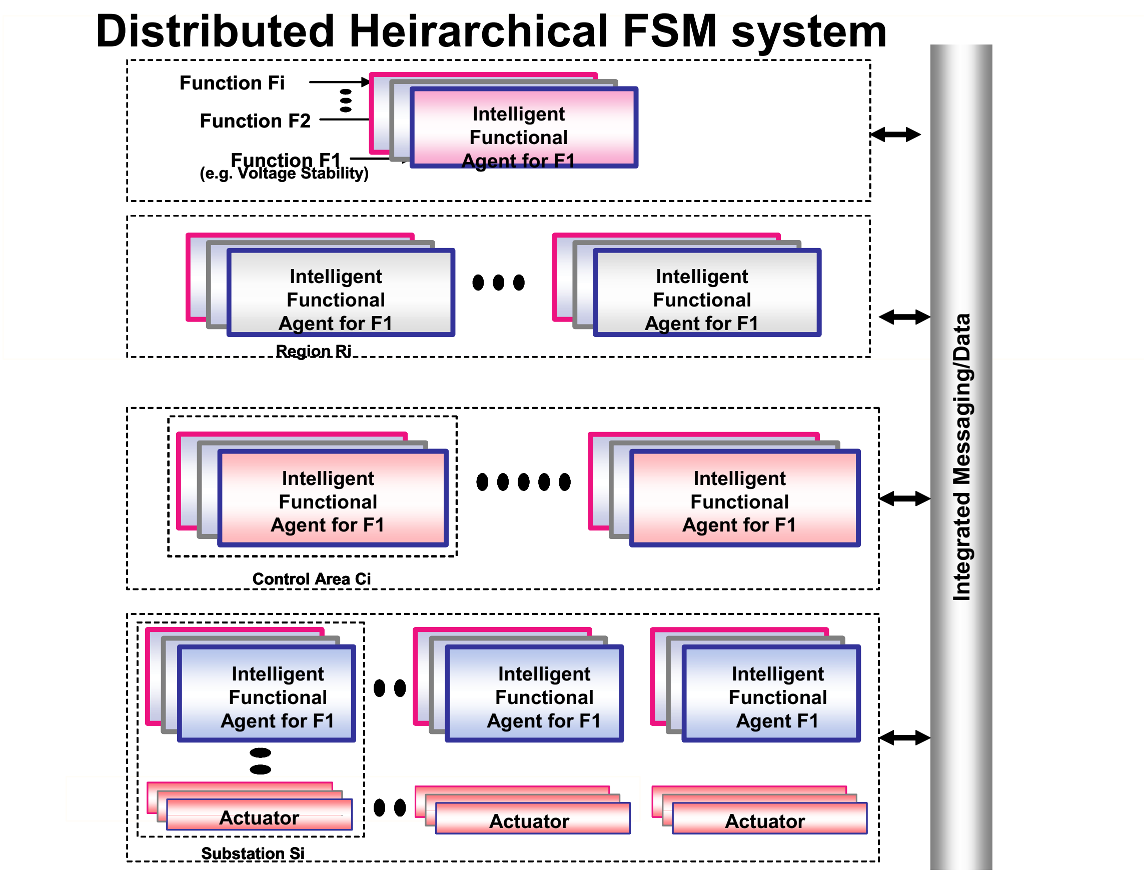

Figure 6
A distributed hierarchical FSM system for implementing an advanced control system architecture

Transmission-Fast Simulation and Modeling, T-FSM, is the focus of FSM on transmission applications. To date, the project team has developed general architectural requirements and detailed functional requirements, and validated the tool based on industry peer reviews for one important specific application—Voltage/VAr Management of Transmission Power Systems. The computing architecture is based on hierarchical distributed intelligent agents as shown in Figure 6. The focus of this project for New York will be on voltage stability. In a recent 2004 study report by the NYISO for the study year of 2009, the voltage collapse limits of Dysinger-East and West Central are lower than previous reviews as a result of load growth and generation retirement. As loads continue to grow, it is possible that voltage instability will be an increasing concern.

Work Plan for Project

The plan for this project is to develop software at each level of the hierarchy that examines the voltage stability issues for New York State. The application software would attempt to detect voltage stability problems in advance and recommend or take actions to prevent cascading blackouts. The software would be integrated into a simulator that would model the New York State system and surrounding areas. At the end of 2006 or early 2007, the simulator would take real-time data and demonstrate to operators the control actions that the FSM system would recommend. This would build confidence in the technology. Table 3 below shows each of the milestones for the FSM project.

Milestones

Table 3
Fast Simulating and Modeling (FSM) Project Milestones

Milestone Description	**Milestone Year (from Project Start)**	**Deliverable Type**
Design and develop voltage stability applications for the hierarchy -- initial focus on applications for New York.	Year 1	Software
Integrate results of voltage stability simulations into the Operator Training Simulator (OTS) and test using data representing New York State grid	Year 2	Software Technical report
Integrate FSM simulator with real time measurement from EMS system at NYISO or New York State utilities and evaluate FSM control action recommendations	Year 3	Software Technical report

6-2. Project Title: Pinpointing the Initiating Location of a Disturbance

Benefits of Project

Recently, industry professionals have determined that the location of a disturbance on the electric power grid affecting the New York State electrical system can be accurately pinpointed through use of multiple devices that accurately measure the frequency of the grid. The EMS does not record or measure some changes on the high voltage grid, particularly if they occur in neighboring interconnected electrical systems. As a result, New York State grid operators need to know what has occurred during the disturbance, understand if the grid has been weakened, and continue to provide reliable power to New York State load centers. A detection system that can be deployed independently of the control center computers would greatly improve the situational awareness of the grid operators when hardware or software problems plague the control center computers during emergency situations.

Project Description

When a line or generator trips, then the frequency changes in the electrical grid. Since this change in frequency propagates quickly over the entire system from the point of origin to the entire Interconnection, it is now possible to detect the change in frequency with highly accurate monitors and back-propagate to determine the location of the disturbance.

From the replay snapshots, observations show that as time progresses, the dots spread out gradually at a speed much less than the speed of light (typically spreading over the Eastern Interconnection in seconds) or in the form of electromechanical wave propagation in the system. If there are enough measurement units in the system, this propagation may be viewed in greater detail as traveling “waves.” Rapid communication may even allow a real-time display, as the travel time is measured in seconds. The time delays seen at different observation points in the system provide the opportunity for a number of applications to study the speed of propagation and to use the time difference for triangulation of location.

Pinpointing the initiating location of a disturbance is useful as a supplement to a topology estimator or state estimator and may actually be faster. In addition, if a change occurs outside the measurement area, it is difficult to determine the cause or location of the disturbance using simply a state estimator or topology estimator.

Methods to Determine the Location of a Disturbance

Recently, a U.S. university has installed a number of low cost frequency detector devices on the distribution network to detect and accurately time stamp the measurements using global positioning satellite (GPS) time stamps. More of these devices need to be introduced in and around the New York State electrical grid. With more devices deployed around the grid, the potential ability to accurately pinpoint the location of a disturbance would increase.

In addition, algorithms need to be developed to back-propagate from the measurements to the location of the disturbance, either using time and distance or Fast Fourier Transform methods. The results would be a determination of the type and location of the problem that caused a frequency disturbance on the electrical grid in or near New York State.

Milestones

Table 4
Project milestones for pinpointing the initiating location of a disturbance

Milestone Description	**Milestone Year (from Project Start)**	**Deliverable Type**
Deployment of low cost frequency detection devices and design and development of back propagation program	Year 1	The deliverables will include the deployment of frequency detection devices in and around New York State. Software program to back propagate the frequency disturbance to the location of the disturbance Technical report
Testing of back propagation program using results from frequency detection devices	Year 2	Technical report Updated software
Deployment of location of disturbance software at New York State utilities and/or NYISO	– Year 3	Final report Updated software

6-3. Project Title: Fault Anticipation and Notification System for the New York State Distribution Power System

Benefits of Project

A fault anticipation and notification system in the New York State distribution power system would offer a number of benefits. This system would provide advanced incipient fault identification and notification warning to electric utility operations and maintenance personnel that failure of distribution system components (e.g., transformer, voltage regulator, in-line switch, cables, or capacitors) is imminent. This enables preventive action to take place, avoiding costly outages, including potentially catastrophic cascading outages. In addition, the life expectancy of these various components in the New York State distribution power system would be increased through the early identification and detection of equipment failure, thereby reducing operation and maintenance costs and increasing reliability.

The fault anticipation and notification system would also provide warnings of vegetation intrusion on distribution lines, potentially avoiding system outages. With this system in place, outages and downtime on the distribution system could be avoided and distribution system operator errors could be minimized. This advanced notification of incipient faults would provide operational personnel more time to take action in a proactive mode than a reactive mode.

Project Description

The distribution fault anticipator (DFA) is a system developed to better use measured electrical signals to determine when power system equipment is deteriorating, enabling utility companies to anticipate faults and take corrective action to prevent adverse consequences to the system and to their customers. Prototype systems are currently installed and monitoring 66 circuits at 11 utility companies. Incipient failure precursors detected by these systems have included lightning arrestor failure, voltage regulator failure, LTC controller failure, oil switch failure, and numerous failures and operational problems with capacitor banks. Early warning of these problems will enhance service quality and reliability by reducing forced outages and the costs associated with them. The concepts and systems also are readily extensible to transmission and sub-transmission circuits as well.

This project will be a large-scale deployment of DFAs on New York State circuits to anticipate the occurrence of faults and failures such as those outlined above. The DFA also can provide information on optimum vegetation management cycles, thereby providing tremendous cost savings and outage reduction. The anticipatory feature of the DFA also could facilitate the implementation of an Advanced Distribution Automation (ADA) system within New York State, reducing system restoration times and thereby shortening the duration of customer interruptions.

The costs for such large-scale implementation of DFAs will consist of hardware and software for acquiring precursor signals and for analysis and reporting. These costs are estimated to be around $5 million. Table 5 below shows each of the milestones for the DFA project.

Milestones

Table 5
Distribution fault anticipator project milestones

Milestone Description	Milestone Year (from Project Start)	Deliverable Type
Design and build DFAs	Year 1	Technical report on design and development of DFAs
Design and build DFAs	Year 2	Technical report on design and development of DFAs
Installation of hardware, firmware, and software for data collection	Year 3	Technical report on initial testing of data acquisition systems
Data collection and algorithm development	Year 4	Technical report on data collection and analysis
Validation of fault identification system and hand over to utilities	Year 5	Final report and tech transfer to utilities

6-4. Project Title: Fault Current Limitation

Benefits of Project

This project will develop capabilities to limit fault current in distribution systems. This is a high-priority need identified at the NYSERDA workshop on March 4, 2005. These capabilities will improve system reliability and reduce operating costs by lessening the extent of damage to equipment that may be caused by excessive fault currents. Additional operating cost savings would result from mitigating the extent of outage propagation that may be triggered by a fault. The public would benefit from the higher level of system reliability and the containment of operating costs associated with fault current problems. The project results are expected to benefit all utilities in New York State.

Project Description

The fault current limitation (FCL) project would entail the following steps:

Phase 1: Requirements Definition
The standard requirements definition phase is normally performed prior to committing larger resources to actual development work in a research and development program. The common causes of fault currents will be examined to determine the nature of the fault currents involved. The project team would then determine the likely magnitudes of fault currents in important classes of distribution circuits. Options for limiting fault current by adding suitable control in existing distribution equipment will also be analyzed. Finally, options for limiting fault current by developing a new controllable device for distribution circuits will be examined. In all cases, the team will consider both the capabilities needed for sensing the level of fault current and then limiting the fault current.

The team will select a preferred option for development in subsequent phases of the project. In the remainder of Phase 1, the requirements for development of the chosen FCL concept will be developed. The feasibility of developing the chosen concept will be assessed in terms of technical and economic prospects for success, and an appraisal of the feasibility will be provided. Next, a cost/benefit analysis for adopters of the new technology will be performed, and a statement of benefits to all stakeholders will be developed.

Lastly, a detailed plan for the development of a widely applicable FCL technology will be developed. The plan will include the scope of work, budget requirements, contractor and other skill requirements, deliverables, final product description, and a schedule. Table 6 shows a preliminary description, schedule, and budget estimate for Phases 2 to 4, which will be clarified and refined in the requirements definition phase.

Phase 2: System Design

For the chosen concept, a detailed system design will be performed. This phase will require partnering with a vendor. The team will conduct a design analysis using suitable simulation tools to insure the integrity of the design. Both the technology and associated software, if any, needed in the new FCL device will be determined in the design phase. The design will be developed in sufficient detail to provide a blueprint for the development work in Phases 3 and 4, undergoing revisions and iterative analyses until sufficient integrity is achieved. The team will determine whether a family of FCL devices of different ratings for different distribution system applications is needed.

Table 6 shows that Phases 3 and 4 are each estimated to require 18 months to complete. . Based on the results of Phases 1 and 2, a more precise determination of the schedule requirements for Phases 3 and 4 will be established, along with the possibility of overlapping the schedules for Phases 3 and 4.

Phase 3: Development of Laboratory Bench Model

A bench model of the new FCL device will be developed and tested in the laboratory. Following any required design refinements to correct any problems identified in laboratory testing, the design will then move to the field prototype phase. At that time, packaging requirements for the field prototype will be established.

Phase 4: Development and Testing of Field Prototype

In Phase 4 of the FCL project, a field prototype of the FCL device will be developed and tested in actual utility systems. The test results will be compiled and analyzed to determine what is needed to finalize the FCL device into product form. Specifications for the product version of the device will be written and released for industry implementation.

Table 6 shows the four phases as project milestones, along with their anticipated timeframes.

Milestones

Table 6
Fault current limitation project milestones

Milestone Description	**Milestone Timeframe in months (from Project Start)**	**Deliverable Type**
Requirements definition	12 months	Technical report
Design completion	24 months	Design report
Laboratory bench model of new FCL device	42 months	Bench model development and test report
Field prototype of new FCL device	60 months	Field prototype development and test report and final product specification

6-5. Project Title: Public/Private Business Model for Sustainable Investment in T&D Infrastructure

Benefits of Project

Sustaining economical investment in the T&D infrastructure in New York will provide tremendous benefits to New York in the areas of electricity supply reliability, low electricity costs to all classes of customers, and state-wide economic growth. T&D infrastructure is the critical link between sources of electricity and the users of electricity. Without adequate T&D investments, T&D bottlenecks will result in the inefficient and non-economic dispatch of electric generation, even if it is inexpensive and plentiful. In addition to increasing the cost of electricity to those customers in the T&D-constrained service areas, under severe conditions, brownouts, rotational blackouts, or sudden blackouts may occur.

Project Description

This project will perform research in developing a public/private business partnership model that will sustain economical investments in T&D infrastructure.

The project will conduct a comprehensive review of all factors that impede the sustainability of T&D infrastructure investment in the New York State. The factors include financial risks and incentives, federal and state regulatory processes, cost recovery mechanisms, alternative mechanisms, and environmental and health issues. Additional factors include the Not-In-My-Backyard (NIMBY) syndrome, availability of new rights-of-way, feasibility of expanding existing rights of way, availability and risks of advanced T&D technologies, engineering impediments for allocating costs based on actual T&D usage, and public understanding of complex T&D issues.

With the Energy Policy Act of 2005, many of these factors are changing. It is necessary to assess whether the regulatory and incentive provisions in the Energy Policy Act of 2005—with subsequent rules by FERC—will be sufficient to induce and sustain an adequate level of unbiased T&D investment and provide the economic decisions needed for New York. Such an assessment will be included in this project.

In addition, the project team will investigate innovative forms of public/private business models. Some examples of such ideas have recently been proposed in the technical community. [1,2] These include the following:

- Tier 2 pricing for externalities as a means of consensus negotiation and cost benefit to overcome NIMBY oppositions and automatic transmission toll collection so users pay for actual T&D usage.
- Holistic transmission planning for consensus on long term transmission backbone investments
- Tier 2 pricing for greenhouse gas incorporated into electricity prices to induce correct investments in energy technologies

The research methodology will include extensive interviews with stakeholders with an interest in this subject (e.g., federal and state regulators, non-governmental organizations, legislators, consumer groups, transmission companies, NYISO, investment advisors, independent transmission project investors, and others). These interviews will work to uncover all potential impediments to the sustainability of T&D investment and to solicit ideas on how a public/private business model may be developed.

The team will develop a report for this project and present the draft report in a public workshop to solicit comments. The revised final report containing public comments will then be published at the project's conclusion.

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2. Stephen T. Lee, "Transforming Transmission Companies into Market-based Regulated Businesses", presented at the IEEE PowerTech 2005 Conference, St. Petersburg, Russia, June 27-30, 2005.

Milestones

Table 7
Project milestones for public/private business model for sustainable investment in T&D infrastructure analysis

Milestone Description	Milestone Year (from Project Start)	Deliverable Type
Draft report	Year 1	Technical report
Public workshop	18 months	Workshop
Final report	Year 2	Technical report

6-6. Project Title: Regional Pattern Recognition Project for New York State

Benefits of Project

When the power system becomes weak due to a number of transmission lines or generators out of service, the system may be approaching the point of collapse. In some cases, the grid operator may not be aware of the proximity of the grid to collapse. The effect of large cascading outages on the economy of New York State can be large, as demonstrated by the August 2003 outage. Running simulation programs and examining all possible contingencies are too slow to be useful for operations use. New solutions are needed to provide early warning of potential weaknesses in the grid to system operators.

Project Description

Many real-time measurements (e.g., voltage, power, and phase angle) are performed today as part of the Energy Management System (EMS) control system and Phasor Measurement Units (PMUs). The operator needs experience to interpret this data, determine the state of the grid, and identify how to adjust operation to reduce the possibility of outages. Some operators have not encountered a sufficiently broad range of situations to enable understanding of their potential consequences. This project will give operators advanced warning of emerging conditions that may signal the approach of a cascading blackout.

The Regional Pattern Recognition project will use historical information (e.g., phasor measurement data) from New York State (NYS) and calculated information from control centers. It will use contingency analysis and voltage stability and dynamic stability simulators to model the NYS electrical grid to supplement these measurements. From these measurements and simulated data, the methodology will develop key indices that relate to the health and reliability of the NYS electric power grid. Then, the method will use a pattern recognition system to quickly determine in real-time if the NYS electrical grid is weak or strong, and will display the indicator to a NYS grid utility operator.

Before a pattern recognition system can be used, it needs to be trained on a variety of historical and calculated information so that it can easily recognize a similar situation.

Information for Training Pattern Recognition Program

Information for training the pattern recognition program could originate from a variety of sources. One source would be by simulating a variety of single or multiple contingencies and calculating the values of power, voltage, and phase angle at buses that are normally measured. A stability index also indicates the proximity of the system to voltage or transient instability by examining the stability margins.

Historical measurement data could also be used for both stable and nearly unstable real-time situations along with the stability index. The latter would be based on proximity to a contingency that would cause major problems (see Figure 7). This information could include years of historical data with different configurations, market information, and real-time measurements. A pattern recognition program, such as a neural network or cluster analysis, can be trained using this historical information and adapted each day using new information as well.

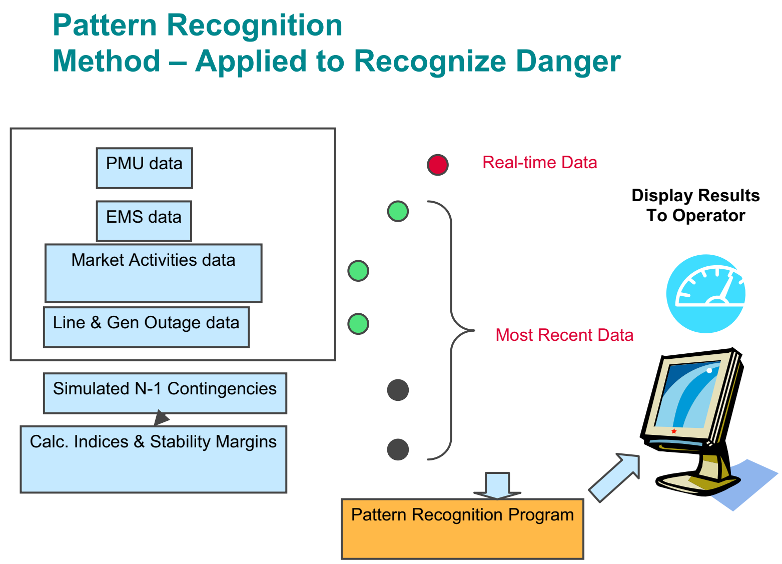

Figure 7:
Training the pattern recognition program using historical data

Pattern Recognition Method Applied To Recognize Danger

After the pattern recognition program has been trained, it can then process real-time data from the EMS system and PMUs from the New York State area and surrounding region and quickly classify the grid health as strong, weak, or in danger (see Figure 8). These results can be quickly displayed to the operator to provide warnings that the system is in danger and that corrective actions are needed.

Benefits of Project

The regional pattern recognition program would be able to quickly classify a large electric power grid, such as the NYS electrical grid, to its proximity to instability. This could be accomplished much faster than running many contingencies—the typical procedure used to obtain this information. This will provide additional input to the system operators and allow them to quickly understand the situation and identify possible corrective actions. Table 8 shows each of the milestones for the pattern recognition project.

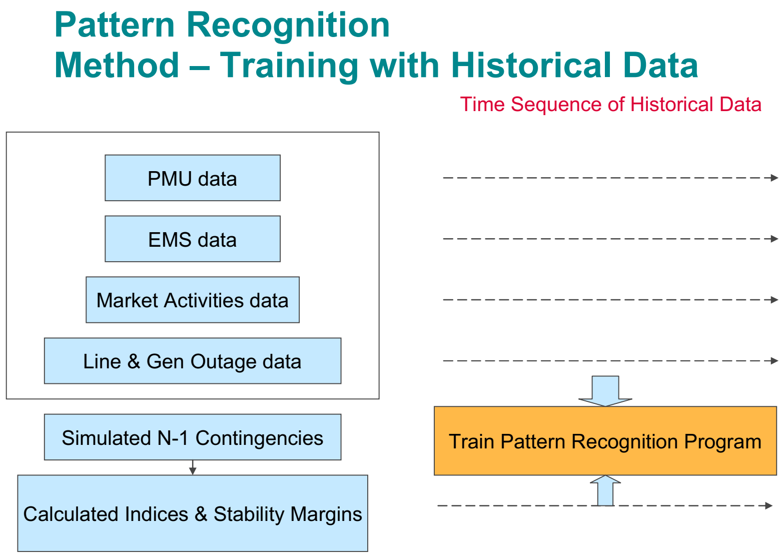

Figure 8
The pattern recognition method applied to recognize danger

Milestones

Table 8
Project milestones for pattern recognition

Milestone Description	**Milestone Year (from Project Start)**	**Deliverable Type**
Design and development of pattern recognition software.	Year 1	Technical Report Software
Testing of regional pattern recognition software using data from real-time system measurements.	Year 2	Technical report on tests Updated Software
Deployment of regional pattern recognition software at New York State utilities and/or NYISO	Year 3	A Software Program, and a report showing the results obtained

6-7. Project Title: Transmission Assets Performance Database and Fleet Management

Benefits of Project

This project will provide all of the New York utilities with data and information resources not currently available to each individual utility. This will help utilities develop a repair/refurbish/replace strategy for their aging transmission assets, using the transformer fleet as the initial application. This project will also work to achieve the goal of reducing unplanned outages and increasing the reliability of electricity supply to individual customers and businesses in New York State.

Operating transformers to or beyond their typically assumed design lives is an increasingly important benefit for many utilities. However, it is not the physical age of the transformer that is important but rather, the actual condition. Installing condition assessment monitoring equipment and performing diagnostics to develop an understanding of transformer condition is prohibitively expensive across a utility's entire fleet, and is generally not the chosen option. This project will benefit the individual New York utilities by utilizing the pooled condition-related data from all of their neighbor utilities to help assess the actual condition of their own fleet and provide risk-informed operational strategies.

Further benefits from this project include consistent and automated reporting between utilities and regulators, the ability to provide a defendable justification for maintenance budgets and perform risk-informed decision-making, and enhanced collaboration between New York State utilities.

Project Description

Most utilities have adopted the assumption that transformer failure and replacement rates experienced in the past will continue in the future. If the distribution of transformer ages is uniform and if the ages are in the flat portion of the failure rate "bathtub curve," this would be a valid approach. However in the real world, utilities have adverse demographic distributions (i.e., a bulge of units in the 40, 50, and over age categories) and significant numbers of transformers at the back end of the "bathtub curve." As a result, existing asset management methods are not adequate for the effective management of the "boomer" generation of aging transformers.

Developing a repair/refurbish/replace management strategy for significantly aged populations and the rational basis for the strategy is a critical need. In order to achieve such a strategy, the asset manager needs to be able to quantitatively relate the various options at their disposal to project failure and replacement rates and the associated costs and impacts. A key to optimizing maintenance activities and predicting future failure rates is sharing information across utilities to provide more statistically-valid models and information.

This project will develop a standardized database structure for transformer performance analysis and benchmarking, and will populate the database with data from all New York

State utility transmission transformers. The database will use the Common Information Model (CIM) structure and will consist of a local database at each utility that contributes filtered, non-business sensitive data to a pooled database on a remote server. Examples of entries in the database will include nameplate data, operational history, maintenance history, design, and if the transformer has failed, details of the failure type.

The project will develop innovative methodologies and tools to support the identification of practical transformer investment strategies based on specific family, make, model, application, and age. Specifically, tools will be developed to interrogate the databases for fleet management purposes for the identification and tracking of performance problems within groups (e.g., design type or age bracket) due to the larger sample size. The tools and methodologies will also aid in developing a risk-informed strategy for operating and maintaining the transformers as well as the impact on reliability. In addition, these strategies are expected to provide benchmarking across companies matching “apples to apples” and support “what-if” optimizations of maintenance and asset management using data reflecting various O&M practices. The new methodologies and tools developed will also encourage standardized terminology, trouble reporting, and the support of the CIM in the T&D arena.

Table 9 summarizes the project milestones over the course of a four-year period. LIPA has begun some initial research and development in this area. However, to be effective, it requires more collaborating partners to raise the value of the information.

Milestones

Table 9
Project milestones for transmission assets performance database and fleet management

Milestone Description	Milestone Year (from Project Start)	Deliverable Type
Database structure	6 months	Report
Unpopulated database installed on a server	1 year	Hardware and software
Populated databases at each utility	2 years	Software
Asset management tools to interrogate the databases	3 years	Software
Final report on implementation of the asset management tools with results and case studies over a one year period	4 years	Report

6-8. Project Title: Replacement of Secondary Networks by a New Technology

Benefits of Project

This project provides a new technology to replace secondary networks in power distribution systems. This new technology will provide increased system reliability in delivery of power to consumers and greater system security, resulting in less vulnerability to sabotage, terrorism, and operator error. This critical need identified at the workshop is principally applicable to the urban load centers, but some of the concepts developed may be more universally applicable. The obvious public benefit is increased reliability and security in electric power service.

Project Description

The project would entail the following steps:

Phase 1: Requirements Definition

The project team will assess the current state-of-the-art technology in secondary networks, determine the functionality provided by the networks, and identify additional desired functionality. The problems and limitations for today's secondary networks will also be established, and a few candidate systems to replace secondary network systems will be conceptualized. The team will perform an examination of the candidate systems' pros and cons to determine the need for new equipment and possibly software. Other parameters include the suitability of the system concept for use in new distribution circuits in new areas and retrofit in existing secondary networks. The team will also consider the cost and time requirements for the full development cycle.

The project team will select a preferred concept for development in subsequent phases of the project. Alternatively, two different concepts could be chosen, if the budget allows. However, the budget estimate shown below applies to development of one new concept in the subsequent project phases. In the remainder of Phase 1, the requirements for development of the chosen concept will be developed. The feasibility of developing the chosen concept will be assessed in terms of technical and economic prospects for success, and an appraisal of the feasibility will be provided. The team will perform a cost/benefit analysis for adopters of the new system concept and develop a statement of benefits to all stakeholders.

A detailed plan for the development of the system concept, including new components, will be developed. This will include the scope of work, budget requirements, contractor and other skill requirements, deliverables, final product description, and schedule. Table 10 shows the preliminary description, schedule, and budget estimate for Phases 2 to 4, which will be clarified and refined in the requirements definition phase.

Phase 2: System Design

For the chosen concept, a detailed system design will be performed. This will include both distribution circuit layout and control system design. Using off-the-shelf components wherever possible should minimize the cost and schedule requirements associated with new component development. Essential component technologies and software that are not available off-the-shelf, and will be requiring development in Phase 3, will be identified, and specifications will be written for that development.

The team will perform system simulation work to analyze the integrity of the design in terms of electrical component ratings, short-circuit duties, stability, protection coordination, load handling, response to contingencies, and control algorithms. The design will be refined and iteratively reanalyzed until sufficient integrity is achieved. The system simulation work may involve digital simulation and use of an analog network analyzer as appropriate.

Table 10 shows that Phases 3 and 4 are each initially estimated to require 18 months to complete. Based on the results of Phases 1 and 2, the team will more precisely determine the schedule requirements for Phases 3 and 4, with possible partial overlap of the schedules for Phases 3 and 4.

Phase 3: Development of New Components (and Possibly Software)

The team will develop new components needed for the chosen system concept. These components will be developed in partnership with appropriate equipment vendors. The components will be bench model tested in laboratories and field-tested in actual utility systems. The goal is to have working versions of these components, suitable for trial use in the system prototyping in Phase 4. Preliminary component specifications will be produced.

The team will finalize the components into product form in parallel with the system prototyping in Phase 4 in an effort to keep the overall project schedule to a five-year period. Given the short time available for Phase 3, no major new component technologies will be developed. The system concept chosen in Phase 1 must address the fact that limited time and resources are available for component development. More significant component technology development could be addressed in a follow-up second-generation system on a longer project time schedule.

Phase 4: System Prototype Testing

The chosen system concept to replace secondary networks will be prototyped in an actual utility system. Care will be taken to choose a host utility with a back-up traditional secondary network to avoid major disruptions in consumer service if a problem arises in testing the prototype system concept. The project team will compile and analyze the test results to determine what is required to finalize the new system concept to replace the secondary networks. The team will then write specifications for the final system concept and release them for industry implementation. The component specifications will also be finalized.

Table 10 summarizes this five-year project and shows the planned milestones for each level of the secondary network replacement work.

Milestones

Table 10
Project milestones for replacement of secondary networks by a new technology

Milestone Description	Milestone Year (from Project Start)	Deliverable Type
Requirements definition	12 months	Technical report
Design completion	24 months	System design report and specification for new equipment development
New equipment development completion	42 months	Report on new equipment development, including preliminary component product specification
System prototype completion	60 months	Report on system prototype testing, including final component product specification and final system specification

6-9. Project Title: Intelligent Monitoring and Diagnostics of Power Electronics-Based Controllers

Benefits of Project

This project aims to develop an intelligence-based monitoring and diagnostics work station for the most advanced and sophisticated power electronic-based transmission controller, the Convertible Static Compensator (CSC). Installed at the Marcy 345-kV substation in Utica, New York, CSC is one of the world's most advanced and versatile controllers, controlling voltage and power flow. The CSC is eliminating a major transmission bottleneck in the New York Transmission System, enabling an increase of power transfer capability from the north and east to the major load area in the south by about 240 MW. This is approximately enough electricity for more than 200,000 homes.

The successful development and implementation of the project will increase the availability and reliability of the Marcy CSC while avoiding unplanned outages of the Marcy CSC. This project will also investigate the congestion cost savings resulting from the installation and the reliability improvements due to this project.

Project Description

The objective of the project is to develop an intelligence-based monitoring and diagnostic tool that is capable of providing early warning of potential impeding of power electronics-based transmission controllers. By monitoring key operational and environmental parameters, comparing them to the designed normal ranges for these parameters, and correlating deviations with potential failures, the power electronics-based transmission controllers' owner/operator will be able to take corrective actions before equipment malfunction.

The project will first select an existing power electronics-based transmission controller—the Marcy CSC—as a pilot development and demonstration project. The next step will be an assessment to determine which critical components of the controller should be monitored, what type of the needed sensors are available or need to be developed, and what form of data acquisition system should be employed. The goal will be to gather information necessary to assess the real-time condition or health of the controller.

Measured data will include recorded state data, inspection-based data (e.g., visual, acoustic, and other inputs), calculated performance data, and environmental factors such as ambient noise levels and ambient temperature. Changes in the latter parameters may signal a change in controller performance. For example, an increase in ambient noise could signal the onset of some unwanted component vibration that if unchecked, could worsen and lead to component failure.

The work on the project will leverage experience gained in development, installation, and commissioning of a several power electronics-based controllers. These include the Static Synchronous Compensator (STATCOM) at Tennessee Valley Authority's Sullivan substation and the Unified Power Flow Controller (UPFC) at American Electric Power's

Inez substation. The work on the project will also leverage the experience gained in related condition monitoring environments, including nuclear power plants.

The scope of this project will include the potential application of power electronics-based transmission controllers to other locations in New York, by identifying situations and locations where they will be beneficial. Workshops will also be conducted to provide technology information to power system planners and operators in New York. Table 11 shows each of the milestones for the intelligence-based project.

Milestones

Table 11
Project milestones: Intelligent monitoring and diagnostics of power electronics-based controllers

Milestone Description	Milestone Year (from Project Start)	Deliverable Type
Documenting the conceptual design of the Intelligence-Based Diagnostics Work Station	Year 1	Technical report
Detailed description of the pilot implementation of the selected Power Electronics-based Controller	Year 1-2	Technical report
Documentation of the development, application, and experience results	Year 2	Technical report

Appendices

Appendix A: March 4, 2005 Workshop Agenda

Time	Agenda Item	Speaker
9:00 am	Welcome and Introduction	Peter Smith (President and CEO - NYSERDA)
9:05	NYSDPS T&D Overview	Paul Powers (Executive Deputy – NYSDPS)
9:15	R&D Needs on T&D from Wide-Area New York Perspectives	Mark Mahoney (VP Transmission – National Grid)
9:45	R&D Needs on T&D from Urban Load Centers' Perspectives	Louis Rana (Sr. VP Electric Operations - ConEd)
10:15	The Electricity Technology Roadmap and EPRI's Power Delivery Program	Wade Malcolm (VP Power Delivery and Markets – EPRI)
10:45	Critical Mid- and Long-Term R&D Needs on T&D – Perspectives Learned from Industry at Large • Topic 1: Wide-Area System Protection, Under-Voltage or Voltage Instability Load Shedding, Automatic Islanding, Reactive Power Management • Topic 2: Monitoring of Potential Cascading Failures, Disturbance Locator, Pattern Recognition with Phasor Measurements, System Modeling, Fast Simulation, Infrastructure and Cyber Security • Topic 3: System Restoration and Operator Assistance Tools, Advanced Alarm Management and Visualization • Topic 4: Long Term Integrated and Sustainable Generation and Transmission Planning with Markets • Topic 5: Advanced Hardware Technologies for T&D Applications – FACTS, Superconductor cables, Fault-current management, Storage, High Voltage AC/DC transmission • Topic 6: Impact of Distributed Resources and Demand Side Management on Transmission and Distribution Networks	Steve Lee (Technical Executive, Power Delivery and Markets – EPRI)
11:45	T&D Market Impacts	Bernie Neenan (President – Neenan & Associates)
Noon	Lunch Speaker: IGC Superpower	Phil Pellegrino (President - IGC Superpower)
1:00	Breakout Groups 1, 4, and 5 • Group 1 – Wide-Area Grid Control • Group 4 – Long Term Planning • Group 5 – Advanced T&D Hardware Technologies	Group 1 – Peter Hirsch, Steve Gehl Group 4 – Pei Zhang, Frank Goodman, Steve Lee Group 5 – Aty Edris, Steve Eckroad, Ray Lings
2:10	Breakout Groups 2, 3, and 6 • Group 2 – Tools for Situational Awareness • Group 3 – Tools for Restoration and Operator Assistance • Group 6 – Impact of Distributed Resources on Transmission and Distribution Networks	Group 2 – Pei Zhang, Steve Lee Group 3 – Peter Hirsch, SteveGehl Group 6 – Frank Goodman, Steve Eckroad, Ray Lings
3:10	Reports by Group Leaders and Discussion	
4:15	Closing Remarks	NYSERDA

Appendix B
March 2005 Workshop Attendee List

1. John Adams	New York Independent System Operator
2. Raj Addepalli	NYS Department of Public Service
3. Roger Anderson	Columbia University
4. Roger Avent	NYSERDA
5. Diane Barney	NYS Department of Public Service
6. Albert Boulanger	Columbia University
7. Peter Cappers	Neenan Associates
8. James Castle	New York Independent System
9. Allen Chieco	National Grid
10. Joe Chow	Rensselaer Polytechnic Institute
11. Frederick Coppersmith	Con Edison
12. Tammy Cunningham	NYSERDA
13. Gary Davidson	NYS Department of Public Service
14. Juan de Bedout	General Electric Global Research Center
15. Paul DeCotis	NYSERDA
16. Robert Delmerico	General Electric Company
17. Robert DeMello	New York Independent System Operator
18. Kevin DePugtt	New York State Electric & Gas Corp.
19. David Devendorf	Niagara Mohawk Power Corporation
20. Brian Dimisko	Central Hudson Gas & Electric Corp.
21. Stan Doe	EPRI
22. Frank Doherty	Con Edison
23. Peter Douglas	NYSERDA
24. Thomas Duffy	Central Hudson Gas & Electric Corp.
25. Steven Eckroad	EPRI
26. Aty Edris	EPRI
27. Paul Elston	Columbia University
28. James Gallagher	NYS Department of Public Service
29. Timothy Garvin	Orange and Rockland
30. Stephen Gehl	EPRI
31. Frank Goodman	EPRI
32. William Gould	EPRI
33. Pradeep Haldar	Albany NanoTech
34. Harvey Happ	NYS Department of Public Service
35. Michael Hervey	Long Island Power Authority
36. Peter Hirsch	EPRI
37. Steven Keller	NYS Department of Public Service
38. Vinod Kotecha	Con Edison
39. Arthur Kressner	Con Edison
40. Sunil Kumar	Clarkson University
41. Bill Lamanna	New York Independent System Operator
42. Don LaVada	NYSERDA
43. Stephen Ting-Yee Lee	EPRI
44. Ray Lings	EPRI
45. Marc Mahoney	National Grid
46. Wade Malcolm	EPRI
47. James Marean	New York State Electric & Gas Corp.
48. Luis Martinez	Natural Resources Defense Council
49. Parker Mathusa	NYSERDA Board Member
50. Timothy Mount	Cornell University

51. Bernie Neenan	Neenan Associates
52. Thomas Ortmeyer	Clarkson University
53. Jim Parmalee	Long Island Power Authority
54. Nag Patibandla	NYSERDA
55. Phillip Pellegrino	IGC Super Power
56. Pragasen Pillay	Clarkson University
57. Paul Powers	NYS Department of Public Service
58. Charlie Puglisi	NYS Department of Public Service
59. Louis Rana	Con Edison
60. Susan Rapaport	NYSERDA
61. John Reese	NYS Department of Public Service
62. A. Ralph Rufrano	New York Power Authority
63. William Saxonis	NYS Department of Public Service
64. Lydia Scholle-Cotton	Neenan Associates
65. Edward Schrom	NYS Department of Public Service
66. Peter Smith	NYSERDA
67. Jack Spath	NYSERDA
68. Robert Strauss	New York State Electric & Gas Corp.
69. Karl Tammer	New York Independent System Operator
70. Howard Tarler	NYS Department of Public Service
71. James Tarpey	Orange and Rockland
72. Robert Thomas	Cornell University
73. Mark Torpey	NYSERDA
74. Mani Venkata	Clarkson University
75. Gunnar Walmet	NYSERDA
76. John Watzka	Central Hudson Gas & Electric Corp.
77. Thomas Welsh	KeySpan
78. Jerry Whooley	PJM
79. Michael Worden	NYS Department of Public Service
80. Shalom Zelingher	New York Power Authority
81. Pei Zhang	EPRI

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Transmission and Distribution System R&D Plan for New York State

Final Report 06-13

State of New York
George E. Pataki, Governor

New York State Energy Research and Development Authority
Vincent A. DeIorio, Esq., Chairman
Peter R. Smith, President and Chief Executive Officer