New York Independent System Operator

Control Center Needs Assessment Study

Prepared by KEMA Inc.

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1. Executive Summary

The New York Independent System Operator (NYISO) is responsible for operating and maintaining the reliability of the bulk power system and administering the wholesale electricity markets in New York State. The grid and markets in New York State are among the most complex in the country and pose unique operational and reliability challenges. The NYISO operates the grid and administers the markets in New York State from its Primary Control Center at Carman Road and its Alternate Control Center at Krey Blvd.

The NYISO engaged KEMA, Inc. (KEMA): (i) to review the adequacy of its Carman Road Control Center and Krey Blvd Control Center for accommodating the NYISO's existing and imminent new responsibilities to ensure reliable grid operations and efficient market administration, and (ii) to make recommendations regarding any necessary modifications or improvements to the NYISO's control centers in keeping with industry best practices.

KEMA makes the following key findings and recommendations regarding the adequacy of the NYISO's existing control centers:

- Between 2011 and 2015, the NYISO will be required to meet expanded operational responsibilities and reliability requirements to ensure reliable grid operations and efficient market administration – the "Expanded NYISO Responsibilities" discussed in Section 3 of this report.

- The NYISO's control centers accommodate the NYISO's existing responsibilities. However, the NYISO must address shortcomings in its control centers to implement the Expanded NYISO Responsibilities. Allowing the shortcomings to continue or adapting partial fixes places NYISO's ability to implement the Expanded NYISO Responsibilities at risk and could compromise the NYISO's ability to reliably perform core functions.

- Both the Carman Road Control Center and the Krey Blvd Control Center have shortcomings in their layout and capacity to accommodate additional operating staff.

- KEMA weighed alternative approaches for the NYISO to resolve the shortcomings in its control centers, and recommends that the NYISO construct a new Primary Control Center at Krey Blvd and convert the Carman Road facility into a viable and sustainable Alternate Control Center.

- KEMA also recommends that, if the NYISO accepts this recommendation, it initiate planning and construction as soon as practicable, as the work on the centers, estimated to take 24 to 36 months, must be complete before the staff and technology requirements to support the Expanded NYISO Responsibilities exceed the capabilities of the existing facilities.

KEMA makes these key findings and recommendations on the basis of the following general findings, which are discussed in greater detail in this report.

Expansion of Operational Responsibilities and Reliability Requirements

The NYISO, along with the entire electric utility industry, is facing significant changes to the power system and to their operational responsibilities. The NYISO's ability to implement the changes specific to the New York and neighboring region and presented in this report as the Expanded NYISO Responsibilities, will hinge on:

- Developing additional information capture and presentation capacities in its control centers to enhance situational awareness.

- Increasing control room staff to manage additional operational tasks. The NYISO has identified that it will need at least two, and likely more, control room positions to support the Expanded NYISO Responsibilities.

KEMA assessed the adequacy of the existing control centers to accommodate both current operational responsibilities and reliability requirements and also the Expanded NYISO Responsibilities. The Expanded NYISO Responsibilities include:

- Implementation of the Broader Regional Market initiatives. These initiatives address complex seams issues, market inefficiencies, and reliability challenges. More generally, these initiatives will improve inter-regional Independent System Operator coordination. The NYISO expects the implementation of these initiatives will save approximately $200 million annually in wholesale electric power costs in New York.

- Incorporation of Smart Grid technologies. The NYISO is in the early stages of a Department of Energy project to add phasor measurement units (PMUs) across the New

York State power system and to display the data collected from the PMUs to operators to enhance situational awareness[1] within New York and throughout the broader region.

- Incorporation of intermittent, renewable generation resources. There are currently approximately 7,000 MW of wind projects in the NYISO's interconnection queue and the currently available tools to manage a substantial amount of intermittent, renewable resources may not be adequate. The NYISO must improve its ability to manage substantial additions of intermittent generation.

- Compliance with evolving reliability requirements. The North American Electric Reliability Corporation (NERC) and other reliability standards that are applicable to the NYISO continue to evolve, and the Federal Energy Regulatory Commission (FERC) has directed NERC to update and revise its standards in multiple respects.

The NYISO will be required to assume the Expanded NYISO Responsibilities between 2011 and 2015.

Assessment of the Carman Road and Krey Blvd Control Centers

KEMA identified the following pressing issues with the existing design and infrastructure of the NYISO's control centers that could compromise the NYISO's ability to implement the Expanded NYISO Responsibilities:

- Space constraints at the Krey Blvd Control Center. The control room at Krey Blvd is approximately one-half the size of the Carman Road control room. The addition of the anticipated new operating positions will exceed the design capacity of the room. Visibility to key operating data is compromised by the long and narrow form of the room.

- Older technology wall displays at the Carman Road Center. North American ISOs and RTOs have replaced or augmented old technology wall displays with large-format video displays. While the Krey Blvd Control Center has a video wall, the Carman Road Control Center does not have this technology.

[1] Situational awareness refers to the ability of system operators to continuously keep the system in an "analyzed state" so that system contingencies can be managed without violation of reliability standards or cascading outages.

- Aging infrastructure at Carman Road. The Carman Road center, at over 40 years of age, is the oldest center among ISOs and RTOs. Much of the infrastructure – emergency generators and their fuel tanks, electrical switch gear, the roof, and other pumps and motors – are near the end of their life and must be replaced.

- As concluded by KEMA in another study, the Carman Road Data Center should also be redeveloped.

These issues must be addressed if the NYISO is to continue to provide reliable and efficient service. Allowing the issues to continue or adapting partial fixes could compromise the NYISO's ability to implement Expanded NYISO Responsibilities**.**

Analysis of Alternatives

The constraints imposed by the conditions of the existing facilities and the requirements for reliable operations limit the alternatives to resolve the control center issues:

- The NYISO can operate with only a single center (while the other center is planned out of service) for a limited time – no more than a few hours.

- The needed renovations at Carman Road are extensive and, depending on the approach, the construction schedule could extend 24 to 36 months. During this time, the center may not be available for operation as a primary or alternative control center for a significant period.

- The adequacy of the Krey Blvd Control Center to support operations over the long term will lessen over time as the control room staffing increases. Current staff planning would at least reach, if not exceed, the design capacity of the Krey Blvd Control Center within the next calendar year.

- The Krey Blvd Control Center cannot be meaningfully expanded due to limitations imposed by the building design and construction.

These constraints would necessitate development of an interim alternate control center during the renovation of the Carman Road Control Center. KEMA cannot recommend this approach, as it would provide an incomplete solution for the long term and entail significant stranded costs.

KEMA finds that construction of a permanent facility is the best available alternative. Developing a new control center on the Krey Blvd campus has several benefits beyond addressing the shortcomings of the existing centers.

A cost study of a new control center is being prepared by Energy Initiatives Group, LLC. Preliminary analysis from the current draft of that report shows a positive cost benefit comparison to the development of a new control center on the Krey Blvd campus and redevelopment of the Carman Road facility as an alternate control center – the same plan recommended by KEMA. This Control Center Needs Assessment Study report will be updated when a final cost report is available.

2. Background and Introduction

The NYISO is responsible for reliably operating the bulk power system and administering the wholesale electricity markets in New York State, including the New York metropolitan area ─ the largest urban area of the United States and one of the leading international centers of business, finance, and the arts. The grid and markets in New York State are among the most complex in the country and pose unique operational and reliability challenges. In large part, this is because the New York metropolitan area consists of a series of islands fed by highly congested transmission corridors that are susceptible to lightening strikes and other contingencies.

The NYISO operates the grid and administers the markets in New York State from its Primary Control Center at Carman Road in Schenectady, NY and its Alternate Control Center at Krey Blvd in Rensselear, NY. The Primary Control Center began operation in 1969 under the NYISO's predecessor, the New York Power Pool, and is the oldest ISO/RTO control center in North America[2].

The NYISO engaged KEMA (i) to review the adequacy of its Primary Control Center and Alternate Control Center for accommodating the NYISO's existing responsibilities and expanded NYISO Responsibilities to ensure reliable grid operations and efficient market administration, and (ii) to make recommendations regarding any necessary modifications or improvements in keeping with industry best practices.[3]

[2] KEMA conducted an informal survey of ISO and RTO control centers during this study. The construction dates for those ISO/RTOs responding follow (organization names are not listed by request).

- ISO/RTO1 – 2006 (primary center); 2008 (backup center)
- ISO/RTO2 – 2006; 2008
- ISO/RTO3 – 2010; 2007
- ISO/RTO4 – 2002; 2010
- ISO/RTO5 – 2006; early 1980s
- ISO/RTO6 – 2003; 2007
- NYISO – 1969; 2005

[3] The scope of KEMA's assignment did not include cost benefit analysis; however, this report references the findings of a cost benefit analysis performed by Energy Initiatives Group, LLC (EIG). Any additional discussion of cost in this report must be understood to be qualitative, based solely on KEMA's extensive experience with electric utility operations and control and data center design and construction.

2.1 Methodology

KEMA consultants met with the NYISO staff to review the current state of the Carman Road Control Center and the Krey Blvd Control Center. A first draft of the report was delivered and reviewed by the NYISO, errors in fact corrected, and the findings discussed. The findings of this assignment remain entirely those of KEMA.

The final report represents the situation at both the Carman Road and Krey Blvd Control Centers as of the date of publication on the front cover, including consideration for growth projections and business evolutions.

2.2 Experience and Qualifications of the Consultant

N.V. KEMA of Arnhem, the Netherlands is internationally recognized for technical and management consulting, testing, inspection, and certification for businesses in the energy and energy consuming industries, assisting more than 500 clients in more than 70 countries. KEMA employs more than 2,000 full-time professionals and leading experts in many facets of the energy utility industry. Founded in 1927, KEMA serves the complete spectrum of participants in the energy marketplace and offers a full complement of services supporting generation through to the consumer side of the meter. KEMA, Inc, the North American unit of the company participated in the development of all of the North American ISOs and RTOs.

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3. Expanded NYISO Responsibilities

The adequacy of the existing control centers must be assessed not only against current operational responsibilities and reliability requirements, but also against likely future responsibilities and requirements – the "Expanded NYISO Responsibilities". The assessment must consider the lead time necessary to develop new control center facilities or to renovate existing facilities before the NYISO's responsibilities surpass its capabilities. For this reason, the NYISO and other entities in the electric power industry continually review the adequacy of the power system, forecast future developments, and evaluate the adequacy of the system to support those developments. The Expanded NYISO Responsibilities that form the basis of this assessment of the adequacy of the NYISO's control centers include:

- Implementation of the Broader Regional Market initiatives.
- Incorporation of Smart Grid technologies.
- Incorporation of intermittent, renewable generation resources.
- Compliance with evolving reliability requirements.

It should be noted that, whole some of these responsibilities are unique to the NYISO, The incorporation of Smart Grid technologies and intermittent, renewable generation and compliance with evolving regulatory requirements affect the electricity power industry as a whole. In fact, the Smart Grid and renewable generation requirements are being implemented around the globe.

3.1 Evolving Responsibilities and Requirements

Broader Regional Markets

The NYISO, in coordination with its neighboring ISOs and RTOs, is implementing a set of related market enhancements, collectively the Broader Regional Markets initiatives. These initiatives will improve the NYISO's ability to address complex seams issues, market inefficiencies, and reliability challenges that result from the circulation of electric power around Lake Erie. More generally, the initiatives will improve inter-regional Independent System Operator efficiencies through the availability of enhanced market and ISO-to-ISO coordination. These market enhancements are planned to be incorporated by 2013:

- Buy-Through of Congestion - Cost allocation to and recovery of constraint management costs from the parties responsible for creating the system congestion through the identification of the sources of loop flow.

- Market to Market Coordination - Redispatch of generators within a neighboring control area to address transmission constraints when that dispatch is more cost effective than the dispatch of generators within the control area experiencing the constraints.

- Interface Pricing Revisions – Improvement of the pricing of energy sales between individual grid operators (ISOs and RTOs) to allow for more efficient regional power transfers.

- Interregional Transaction Coordination - Flexible transaction scheduling provisions to improve market and operational efficiency by allowing transaction schedules to adjust to the ever-changing system conditions and to respond to system contingencies.

These market enhancements are designed to reduce uplift costs associated with congestion and real-time event management, to improve the capability to incorporate intermittent resources, and, thereby, to lower total system operating costs. The NYISO expects the Broader Regional Market initiatives to enhance reliability through regional dispatch and to save approximately $200 million annually[4] in wholesale electric power costs in New York.

Integration of Smart Grid Data

The NYISO is in the preliminary stages of a Department of Energy-funded project, along with the New York Transmission Owners, to implement a network of phasor measurement units (PMUs) on the New York power grid and to integrate the data collected from the PMUs to provide greater situational awareness[5] for NYISO dispatchers. This project is scheduled to be implemented by 2013. The NYISO intends to integrate PMU data with NYISO systems in its

[4] *Analysis of the Broader Regional Markets Initiatives*, Joint NYISO-IESO-MISO-PJM Stakeholder Technical Conference on Broader Regional Markets, September 27, 2010, http://www.pjm.com/~/media/committees-groups/stakeholder-meetings/brmjsg/20100927/20100927-analysis-of-the-broader-regional-markets-initiatives.ashxr

[5] Situational awareness refers to the ability of system operators to continuously keep the system in an "analyzed state" so that system contingencies can be managed without violation of reliability standards or cascading outages.

Carman Road and Krey Blvd Control Centers. The applications PMU technology will support include:

- Wide-area visualization and monitoring.
- Phase angle and frequency monitoring.
- Inter-area oscillation detection and analysis.
- Proximity to voltage collapse.
- Dynamic model validation.
- Fast frequency regulation.
- Optimization of capacitor operation for reliability and loss reduction.

In the long-term, the NYISO's PMU network will interoperate with PMU networks in New England, the Mid-Atlantic, the Midwest, and Ontario to create broader situational awareness in the NYISO's control centers and in control centers throughout the Northeast, and to facilitate rapid responses to system disturbances that will help avoid major system disturbances such as the 2003 Northeast regional blackout, which resulted in significant costs[6].

These capabilities, along with the actions being taken by the NYISO to understand and manage future Plug-in Electric Vehicle ("PEV") charging demand, will require state-of-the-art monitoring and control capability to address reliability concerns resulting from the use of Smart Grid technologies and the anticipated demand requirements associated with significant use of PEVs.

Incorporation of Renewable Resources

The electric power industry, as a whole, lacks the tools to efficiently and under all conditions manage large amounts of wind and other intermittent resources. As greater amounts of wind resources are brought online in New York[7] and elsewhere, today's technology for managing wind resources may not be adequate to handle certain wind related events. Specifically,

[6] For the United States alone, costs estimates resulting from the 2003 blackout ranged from $4 to $10 billion. *U.S. Canada Power System Outage Task Force, Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations* (April 2004)

[7] There are currently approximately 7,000 MW of wind projects in the NYISO's interconnection queue.

reliability concerns arise from ramp events that must be managed. Wind plant ramp events occur during sudden drops in wind speeds or when wind speeds approach cut-out levels that cause sudden large drops in wind output levels. The industry, and the NYISO, must improve the tools to manage wind ramp events. The NYISO must be able to receive and process real-time data regarding wind speed and direction, requiring state-of-the-art monitoring capability.

In addition, new limited energy storage technologies are being developed, such as flywheel and large scale battery technologies, to compliment the variable output of renewable resources. The NYISO is also studying the charging demands of Plug-in Electric Vehicles and how they would affect the overall dispatch. These new technologies will have to be integrated into the NYISO's dispatch operations.

Considerable research is being applied to the problems of coordinated management of intermittent resources, storage, and PEV charging; but until that time when appropriate automated tools are ready for production use, the NYISO may have to add staff to the control room floor to manually manage the resources.

Additional Reliability Requirements

The NYISO recognizes that mandatory North American Electric Reliability Corporation (NERC) and other reliability standards that are applicable to the NYISO will continue to evolve. The Federal Energy Regulatory Commission (FERC) has directed NERC to update and revise its standards in multiple respects. The NYISO control centers must contain sufficient physical space and flexibility to incorporate new control center technologies and additional staffing to enable the NYISO to maintain compliance with evolving reliability requirements. It is widely expected that FERC will soon expand the definition of Bulk Electric System facilities, so that NERC standards apply to many additional transmission facilities 115 kV and above. If FERC takes this action, the NYISO would require an additional control center position to comply with the mandatory NERC standards.

The NYISO control centers should also contain sufficient space to accommodate additional staff needed during events that threaten reliability, such as during adverse weather conditions.

3.2 Effects on Control Center Needs

The NYISO's ability to realize the desired and expected benefits of the Expanded NYISO Responsibilities will hinge on the capability of its infrastructure to gather, assemble, and deliver the necessary information on system conditions both within New York State and regionally and

the ability of NYISO personnel to act on the information. The NYISO will need to accommodate the following capabilities in its control centers to implement the Expanded NYISO Responsibilities:

- Include additional information capture and presentation technologies in its control centers to enhance situational awareness.
- Accommodate additional control room staff to manage the related monitoring and coordination functions.

The NYISO will need to appropriately manage the workload of control room and support staff to reliably implement the Expanded NYISO Responsibilities. New functionality will entail new tasks and processes that, when added to the existing workload within the control room, will require additional staff to monitor and manage the grid.

Enhancing Situational Awareness

The NYISO's control centers will require improvements in information capture and presentation capabilities in the areas of:

- Regional wind and solar power production, forecast conditions, and intermittency expectations.
- Existence and prediction of regional transmission system constraints.
- Review and validation of system flows and the identification of the sources of these impacts.
- PMU data and the results of the applications analyzing the data.

Current conditions, short term predictions, and, most critically, changes to those conditions will need to be understood in real-time.

The NYISO can enhance operator's situational awareness via advanced video display technology and a significant dedicated area of video wall display (a dedicated large format display), which require space in both the NYISO's control centers.

The report on the August 2003 blackout[8] pointed to a lack of situational awareness by utility operators as a key element in the events leading to the blackout. While the report does not recommend or endorse large format video displays as a remedy for this problem, most of the industry's efforts in developing advanced visualization tools have focused on video presentations, both small format (on the operators' desks) and large format (video walls)[9].

Additions to the Control Room and Operations Support Staff

The NYISO will also need to augment control room staff to manage the Expanded NYISO Responsibilities. The NYISO has identified, and planned for, the inclusion of the following additional control room positions:

- The Broader Regional Markets initiatives will add new workload to:
    - Establish and validate schedules with each of the NYISO's four neighboring regions as often as every five minutes, rather than on an hourly basis as is currently done.
    - Market-to-Market coordination requires setting up and validating redispatch action for, and from, neighboring control areas to ensure efficient resource utilization and satisfaction of reliability criteria.
    - Buy-Through of Congestion requires active monitoring for and identification of parallel flow impacts on NYISO constrained facilities to minimize unrecovered constraint management costs.

  The NYISO plans to add one additional control room staff position to implement the intra-hour scheduling. The NYISO will evaluate the addition of further control room staff positions as the workload of the Broader Regional Markets initiatives is better known.

- The development of Smart Grid technologies is accelerating and the integration of these technologies into the grid is increasing. Renewable generation resources are being built

[8] *U.S. Canada Power System Outage Task Force, Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations* (April 2004)

[9] For examples of recent investigations, see: http://www.oe.energy.gov/our_organization/rnd.htm; http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19103.pdf; http://www.wrldc.com/docs/VHPSO_FINAL.pdf

and connected to a grid not designed for them. Control centers must manage reliability concerns identified by PMUs and other Smart Grid technologies. The NYISO is prudently preparing for increasing amounts of renewable resources, the output of which is often difficult to forecast and control, by planning for enhanced situational awareness technology, changing market rules, and considering adding a control room position assigned to the management of Smart Grid and renewable resources. As with the transaction scheduling position, this staffing requirement could very easily increase.

- If FERC decides to expand the definition of Bulk Electric System facilities, so that NERC standards apply to many additional transmission facilities down to 115 kV, the NYISO expects to add one additional transmission operating position in the control room to address this change in NERC's standards.

4. Carman Road Control Center Assessment

The Carman Road Control Center, located in Guilderland, NY, was purpose-built as a control center in 1969 by the predecessor of the NYISO – the New York Power Pool – which used the building for offices and a control center from that date. The Carman Road Control Center is the oldest of the North American ISO and RTO centers[10].

The control room is approximately 8650 square feet, with a ceiling height of almost two and one-half stories. The dominant feature of the control room is a curved tile mapboard 22 ft high and 95 ft long (2090 ft^2). The mapboard displays the NYISO transmission grid, down to 115 kV lines (details of some lower voltage lines are omitted, trading off completeness for clarity). Chart recorders presenting Phase 1 data[11] are mounted below the mapboard. Supplemental LCD video displays are mounted within and around the board, showing lightning strikes, weather, news, and other information of interest to the operators. Five consoles face the mapboard. Operations support staff occupy offices surrounding the control room, with direct access to the control room.

The layout and construction of the Carman Road Control Center presents challenges to the continued reliable and efficient operation of the New York state electric grid. This is particularly true when considering the Expanded NYISO Responsibilities described in Section 3 of this report. The deficiencies that should be remedied in the near future to ensure continued reliable operations can be grouped as follows:

- Control Center layout.
- Infrastructure deficiencies.
- Future expansion requirements.
- Cyber and physical security.

[10] Ibid. footnote 2.

[11] Phase 1 data is telemetered directly from substations to the chart recorders and is monitored and alarmed independently of the Energy Management System. The operators consider the Phase 1 data as the most reliable source of critical operating information, as it is available even when the EMS is out of service.

4.1 Carman Road Control Center Layout

While the NYISO and the New York Power Pool have maintained and renovated the Carman Road Control Center over its life, there are several problems with the current layout and infrastructure that cannot be resolved without major construction.

Mapboard

The existing tile mapboard performs very well in presenting a “big picture” overview of the transmission system in real time. The large format of the mapboard affords reasonable visibility throughout even a large control room.

However, most ISO control centers have implemented video display walls in place of or supplemental to mapboards. While mapboards have advantages in operating costs and legibility (due to higher resolution), the set of data presented on a video wall and the form of presentation can be changed moment-to-moment and the technology allows for the rapid deployment of new presentations of data. These capabilities will help realize the full value of the Broader Regional Markets initiatives, Smart Grid technologies, and the integration of renewable resources.

Video displays also allow the same data to be presented wherever needed in the control room. This will provide a significant advantage as the control room area and operator complement grow and the distance from the furthest operator to the wall displays lengthens.

NYISO must consider control room enhancements to accommodate video displays. The existing hard-wired mapboard should be replaced, in total or in part, with video displays. This will be a major construction effort and cannot be done while the room is occupied.

Chart Recorders

Currently, the CRT chart recorders showing Phase 1 data are mounted in the support structure below the mapboard itself. The real value of the chart recorders and the associated alarm and annunciation panels is that they are a base level of information directly connected to the field.

In conjunction with upgrades to accommodate video display technology, the chart recorders should be removed and the Phase 1 data displays incorporated into the video display recommended above. The data can still be received directly from the field devices. Rather than display the data at just one location in the room, the information could be made available on the

room wall displays as well as at each separate position on displays at the operating position consoles.

Console Layout

The control room has five consoles, each facing the mapboard, with the Shift Supervisor occupying the center position. Operations personnel have indicated that efficient operations require them to be within easy visual and voice communication with each other and the mapboard. As more positions are added, this need will be more difficult to realize. This is particularly true if the single wall display of critical operating information is retained as a design principle. As the room is upgraded to accommodate video displays, the consoles will need to be rearranged for better visibility as well as communication between operators. Relocating the consoles and adding consoles will be a major task, involving relocating communications and power cabling as well as dismantling, moving and re-assembling the consoles themselves. While this can be done while the room is occupied, it will be distracting to the operators and could present a risk to reliability.

4.2 Infrastructure Deficiencies

The Carman Road Control Center currently supports reliable and efficient power system operation. However as a result of the facilities' age, there are problems that need to be addressed in the near future to ensure continued reliable operations.

- The existing 600 kW emergency generators are over 30 years old and are nearing end of life. Two new 1500 kW generators have been purchased as replacements. Before the new generators can be installed, there will have to be a substantial reconfiguration of the building power distribution system. Reconfiguration of the building power system will replace much of the switchgear.

- The existing power distribution and UPS equipment are protected by manual fire extinguishers, and the area is not suitable for the installation of a gas-based fire suppression system. An automated fire suppression system is highly desirable as fires have proven to be one of the most probable risks to control centers. This could reasonably be accomplished during the installation of new generators and switchgear.

- The in-ground diesel fuel tanks for the emergency generators are nearing end of life and will need replacement to mitigate the risk of fuel leakage.

- The building roof is nearing end of life and must be replaced to prevent further deterioration and possible equipment damage due to water leaks.

- Many of the pumps, switchgear components, and mechanical systems are original to the building and nearing end of life. These systems will need to be replaced or rebuilt to ensure reliable operations.

With careful planning each of the above items can be corrected, but with some disruption to operations at Carman Road. Importantly, changes to the electrical system will require outages of some duration and longer periods with reduced redundancy.

Work has already begun to address those facility deficiencies that were deemed to be most urgent. However, during the time when the redundant systems are down there will be a higher risk to power system reliability. During outages at the Carman Road Control Center, operations can be conducted from the Krey Blvd Control Center. However, as discussed in Section 5 of this report, shortcomings of the Krey Blvd Control Center will increase the risks to reliable and efficient power system and market operation if the Krey Blvd Control Center is used for an extended period of time.

4.3 Future Expansion

The existing Carman Road and Krey Blvd Control Centers meet current reliability needs. In the near future both control centers will need to be expanded to implement the Expanded NYISO Responsibilities. The NYISO has already initiated work to add three consoles to the current complement, producing a total of eight control center positions.

Given that it is reasonable to expect that additional operating positions may be needed beyond those now planned, any renovation of the control centers should include space for additional positions beyond the three identified new positions. The Carman Road Control Center control room is large enough to accommodate the identified expansion to eight consoles, but will require construction to incorporate further consoles, particularly in conjunction with the redevelopment of the existing wallboard with video technology. If the NYISO were to renovate Carman Road as the primary control center, construction could take 24 to 36 months. The NYISO would need to operate from the Krey Blvd Alternate Control Center for some of the construction time. As presented later in this report, the Krey Blvd Control Center is not presently suitable for long-term operation.

4.4 Physical and Cyber Security

Physical access to and throughout the Carman Road Control Center is aligned with good industry practice and meets all industry and government security requirements. KEMA is not aware of any changes to requirements that could not be satisfied by the existing Carman Road Control Center, but certain temporary measures taken to meet existing standards could be improved with a facility designed to meet present day security requirements.

The lack of office space at Carman Road has resulted in locating a number of operating support staff behind the mapboard. While NYISO manages these employees as essential personnel, a "best" solution would have them located outside the control room security perimeter.

KEMA is currently auditing NYISO's cyber security procedures and practices under a separate contract. At this early stage of that work, KEMA is not aware of any cyber security issues that can be attributed to shortcomings of the Carman Road Control Center. The authors of this report will review the final findings of cyber security audit and will issue an amendment to this report if issues are found with the Carman Road Control Center.

5. Krey Blvd Control Center Assessment

In 2005 NYISO purchased an office building on Krey Blvd in Rensselaer, NY to consolidate the majority of its staff into a single location. As part of the renovations and retrofits to the building, a new data center and a new alternate control center were constructed within the building. The relocation of the alternate control center was primarily driven by the NYISO's need to resolve certain security risks regarding the location of the then-existing alternate control center that had been identified by several security studies by U.S. agencies and the NYISO's internal audit staff.

The Krey Blvd Control Center is located on the second floor of the Krey Blvd facility, and occupies an area of approximately 4000 ft². The Krey Blvd Control Center has seven consoles facing a projection display wall configured as a 12 wide x 2 high matrix of video projection display cubes (512 ft^2 of display area). An enclosed conference room, work areas for market and scheduling staff, and one supervisory office are located within the control room's secure area.

The Krey Blvd Control Center currently provides a reliable alternate control center, as required by NERC. However, the layout and construction of the Krey Blvd Control Center present challenges to continued reliable and efficient operation of the New York State electric grid. This is particularly true when considering the Expanded NYISO Responsibilities. The deficiencies that must be remedied in the near future to ensure continued reliable operations can be grouped as follows:

- Krey Blvd Control Center layout.
- Infrastructure deficiencies.
- Future expansion requirements.
- Cyber and physical security.

5.1 Krey Blvd Control Center Layout

While the Krey Blvd Control Center has served NYISO well since its development, there are problems with the current layout that cannot be easily resolved.

Room Configuration

The Krey Blvd Control Center control room is a shallow rectangle, 80 ft wide and 44 ft deep (to the front of the video display wall). While the Carman Road Control Center has adequate space within the control room security zone, the Krey Blvd Control Center space is very limited. The floor area is less than half that of the Carman Road Control Center and includes work areas for operations staff who are located outside the control room in the Carman Road facility.

There are seven consoles; four in the row closest to the video wall and three in a second row. Because of the shallow room depth, the operating positions at the ends of the room are outside of the optimum viewing angles of the video wall; therefore a considerable fraction of the video wall is not useful from these operating positions. The compromised view of the information presented on the wall could lead to misinterpretation of the operating conditions, increasing the risks to reliable operation.

If the NYISO is to operate from the Krey Blvd Control Center for more than a few days, arrangements must be made to move personnel from the offices surrounding the Krey Blvd Control Center to make room for the required operations support personnel from the Carman Road facility. If the Carman Road Control Center is uninhabitable for more than a few weeks, approximately 75 employees would need to move to the Krey Blvd Control Center. Business continuity plans provide for temporary relocation, but, over time, efficiency of operations will suffer if the relocation of staff is required for a longer period of time. These 75 employees do not include approximately 10 management and administrative staff who would also be relocated if operations were to move to the Krey Blvd Control Center for more than a few days.

Video Display Wall

The Krey Blvd Control Center video display wall is a two-high by twelve-wide matrix of projection cubes, installed into the front wall of the control room. This display area of 512 ft^2 is less than 25% of the Carman Road Control Center wallboard size (2090 ft^2). The two-high column of projectors on the left side of the wall is used to display chart recorder data, and the remaining screens show the transmission one-line diagrams. The Phase 1 data is presented in the chart recorder space, but the data at Krey Blvd is not considered as reliable as it is dependent on equipment at the Carman Road Control Center. If the Carman Road Control Center is out of service, the Phase 1 data will not be available at the Krey Blvd Control Center.

The size of the video wall is limited by the length of the room and the low ceiling height of 8 ft 3 in (further discussed in Section 5.3). While this video display wall is adequate for the current

level of operations, it will not be adequate for the expansion required to meet the Expanded NYISO Responsibilities. This is particularly true when considering the video display requirements of incorporating Smart Grid technologies and the technologies for the incorporation of intermittent, renewable resources.

The considerable differences between the wall displays at the Carman Road and Krey Blvd Control Centers are not commensurate with best practice. Ideally, the presentation of operating information would be identical at both the Carman Road and Krey Blvd Control Centers. In the ideal scenario, there would be no distinguishing characteristics between the operating floors at the two centers. The extreme difference is wallboard space (2090 ft2 versus 512 ft2), the different technologies (tile board versus video display), and the different presentation of information stemming from these differences is a shortcoming that compromises both short- and long-term operations from the Krey Blvd Control Center.

5.2 Infrastructure Deficiencies

If the Krey Blvd Control Center is to continue as a reliable alternate control center for even the near future, shortcomings of the power supply need to be addressed. The Krey Blvd building is fed from a single substation; uses a single generator for non-critical load and another single generator for critical loads. The supply to critical loads is configured for a second generator that has not yet been installed. There are no provisions for sharing or transferring loads between the two generators or for selective load shedding.

The reliability of the Krey Blvd power supply is on the order of 97.5%, compared to 99.9% for Carman Road[12]. This is acceptable for its current use as an alternate control center, but not acceptable if it is to be considered a viable long-term primary control center.

5.3 Expansion Requirements

The Krey Blvd Control Center meets current reliability requirements. However, in the near future both control centers will need to be expanded, replaced, or renovated to support the requirements identified in Section 3.

[12] This comparison assumes the complete loss of utility power and reflect the industry norms for the difference between a single emergency generator and an ‘N+1’ configuration.

One additional console position could possibly be added in the Krey Blvd Control Center, bringing the total up to eight positions, by eliminating some of the office space. However, the view of the video display from that console would be severely compromised with the acute angle to the screens, exacerbating an already marginal situation. Expansion of the room itself is limited by its placement within the building; it is bordered on three sides by fixed walls. The only available space for expansion would be to the operators' left into the adjacent office space. Expanding into this space would further compound the problem with viewing angles because of extended width in relation to the shallow depth of the room.

The critical problem will be expanding the video display as required to enhance situational awareness. The ceiling height is limited by the ceiling structure, which cannot reasonably be altered. This limits the video displays to 5' high, given the 3' height from the floor to the first row of screens required for visibility. This severely limits the amount of data that can be shown on the screens.

5.4 Physical and Cyber Security

Physical access to and throughout the Krey Blvd Control Center, is aligned with good industry practice and meets all industry and government security requirements. KEMA is not aware of any changes to requirements that could not be satisfied by the existing Krey Blvd facility.

KEMA is currently auditing NYISO's cyber security procedures and practices under a separate contract. At this early stage of that work, KEMA is not aware of any cyber security issues that can be attributed to shortcomings of the Krey Blvd Control Center. The authors of this report will review the final findings of cyber security audit and will issue an amendment to this report if issues are found with the Krey Blvd facility.

6. Carman Road Data Center Assessment

The NYISO separately engaged KEMA to review the adequacy of the Carman Road Data Center to support operations. The objective of that study was to review the current state of the data center at the Carman Road facility while accounting for growth projections in the area of power consumption, platform expansion, and identified business evolution, and to provide an assessment of current adequacy and a plan for expansion.

The report was submitted to the NYISO in September 2010. The following is a synopsis of that report.

NYISO has realized good value from the Carman Road Data Center. Over its forty-year life the Carman Road Data Center has been expanded, augmented, and renovated as needs and technology have changed. Deficiencies of the center have been reasonably worked around and the center has given the NYISO reliable service.

The Carman Road Data Center is not without problems. None of these issues in isolation is sufficient to necessitate replacing the center. However, taken in total and recognizing the age of the building, consideration of a new data center is warranted.

Determining the critical time when the Carman Road Data Center can no longer satisfy the NYISO's needs is difficult. That moment must be identified some time in advance, at least eighteen months, to allow for the design and construction of a replacement. It is reasonable to expect that the Carman Road Data Center will remain useful over the next eighteen months, but sometime beyond that time, further work-arounds or replacement will become necessary.

Considering the age of the building, the numerous compromises made to achieve the current lifetime, and the ongoing compromises to be made if the building is to continue as the primary control center, KEMA endorses a decision to begin work to construct a new data center. This determination is based on engineering principles. But there are other viewpoints that reinforce the desirability of a new data center.

The Carman Road Data Center is an inefficient design. While our estimate of the cost of this inefficiency - $100,000 to $200,000 per year – is not enough to by itself justify a new facility, the savings over the lifetime of a new data center can offset some of the construction cost. The sooner these benefits could be realized, the greater the payback.

There also is the value to the NYISO in developing “green”, or at least “greener”, facilities. Other organizations such as Syracuse University, have constructed energy efficient data centers. Syracuse has constructed a data center that operates with effectively no power from the electricity grid (http://www.syr.edu/greendatacenter). While operating off the grid may not be realistic for the NYISO, positioning the company as environmentally proactive is appropriate for this day and age.

Finally, the near-term plans for the IT infrastructure reinforce our findings. The NYISO refreshes the IT infrastructure over multi-year cycles, targeted at three years. Four projects now underway could benefit from installation directly into a new data center (as opposed to installation into the existing center and subsequent movement to a new center):

- Replacement of the current-generation Ranger servers.
- Replacement of the tape silo data backup system.
- Replacement of the backbone networking hardware.
- Inclusion of systems associated with the DOE Smart Grid project.

The benefits, although not quantified as part of this report, would include reduced costs (labor and shorter project cycles) by avoiding the work to relocate the new hardware from the existing center to the new center and reduced risk of outages for the same reason.

As found in the Carman Road Data Center report, while we cannot declare the state of the Carman Road Data Center to be in crisis, we fully support a decision to begin construction of a new data center. We believe a greater benefit will be realized the sooner this activity is started, in terms of realizing operating cost benefits, avoiding the stranded cost of partial solutions, and earlier mitigation of the risks endemic to the design compromises in the existing data center.

7. Analysis of Alternatives

As described throughout this report, both the Carman Road Control Center and the Krey Blvd Control Center have shortcomings in their layout, infrastructure, and their capacity to accommodate the expected new functionality and additional operating staff required to implement the Expanded NYISO Responsibilities. The most pressing issues with the existing control centers are the space constraints at the Krey Center, the out-of-date wall displays at the Carman Road Control Center, and the aging infrastructure at Carman Road. As concluded in another study (and summarized in this report), the Carman Road Data Center should also be redeveloped.

The constraints imposed by the conditions of the facilities at the Carman Road Control Center and the Krey Blvd Control Center and the requirements for reliable operations limit the effective alternatives:

- The NYISO can only operate from a single center (while the other center is planned out of service) for a limited time – no more than a few hours.
- The needed renovations at Carman Road are extensive and, depending on the approach, the construction schedule could extend 24 to 36 months. During this construction time, the center may not be available for operation as a primary or alternative center for a significant period.
- The adequacy of the Krey Blvd Control Center to support operations over a long term will lessen over time as the control room staffing increases. Current staff planning would at least reach, if not exceed, the design capacity of the Krey Center within the next calendar year.
- The Krey Blvd Control Center cannot be meaningfully expanded due to the building design and construction.

The constraints clearly mandate development of an interim alternate control center during the renovation of the Carman Road Control Center. This center would need all of the current operational capabilities of the Carman Road Control Center to maintain compliance with FERC and NERC requirements. Establishing this control center will be no small task. Even with the construction of an adequate temporary alternate control center, the adequacy of the Krey Control Center for use as a primary control center over a long construction period is

questionable. Furthermore, a temporary alternate control center would be without long-term value. For all these reasons, we do not recommend this alternative.

If a third control center must be developed during renovation of Carman Road, we recommend construction of a permanent facility. Developing a new center on the Krey Blvd campus has several benefits beyond addressing the shortcomings of the existing centers:

- The new center can be designed with capacity for the known staff complement and for growth beyond that size.
- The technology and arrangement of consoles and wall displays can be rethought, enhancing situational awareness.
- Assuming that Krey Blvd would become the primary site, staff time travelling between corporate headquarters and the primary control center would be eliminated. Locating the primary control center on the campus would bring the key operating staff more fully into the NYISO corporate culture.
- Under the same assumption, the Carman Road Control Center could be redeveloped into the alternative site – a role more commensurate with its remote location.
- Location of the primary control center at the Krey Blvd site makes it immediately accessible to senior management during power system upsets.
- The eventual decommissioning of the current Krey Blvd Control Center would free up valuable office space.

A cost study of a new control center is being prepared by Energy Initiatives Group, LLC. Preliminary analysis from the current draft of that report shows a cost benefit to the development of a new control center on the Krey Blvd campus and redevelopment of the Carman Road Control Center as an alternate control center – the same plan recommended by KEMA. This Control Center Needs Assessment Study report will be updated when a final cost report is available.

8. Summary and Recommendation

The NYISO has realized full value from the Carman Road Control Center. Over its forty-year life the Carman Road Control Center has been expanded, augmented, and renovated as needs and technology have changed. The Carman Road and Krey Blvd Control Centers have together enabled the NYISO to perform its operating responsibilities and meet reliability requirements. However, NYISO's ability to implement the Expanded NYISO Responsibilities will be at risk without replacement or expansion of the existing control centers to provide for additional staff and enhanced situational awareness.

KEMA has examined alternatives for redeveloping the control centers to provide for the additional staffing and technology required to maintain the reliable and efficient operation of the power grid in New York State and the administration of the wholesale electricity markets. For the reasons set forth in Section 7, KEMA recommends that the NYISO construct a new Primary Control Center at Krey Boulevard, and convert the Carman Road Control Center into a viable and sustainable alternate control center.

KEMA also recommends that, if the NYISO accepts this recommendation, it should initiate planning and construction as soon as practicable, as the work on the control centers, estimated to take 24 to 36 months, must be complete before the staff and technology requirements to support the Expanded NYISO Responsibilities exceed the capabilities and capacity of the existing facilities.