Research and Development Plan for Advanced Transmission and Distribution Technologies

Respectfully submitted by the Joint Utilities of New York,

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EXECUTIVE SUMMARY

On January 20, 2022, the New York Public Service Commission (Commission) issued its Order on Power Grid Study Recommendations (the "Order"), directing the Joint Utilities and Commission Staff to establish a group tasked with addressing "the challenge of identifying and removing barriers to the deployment of new technologies."[1] The Advanced Technology Working Group (ATWG) has come together to serve as the working group directed in the Order.

This report describes a Research and Development (R&D) plan related to the deployment of advanced technologies in electric transmission and distribution (T&D) systems to help support the achievement of objectives of the Climate Leadership and Community Protection Act (CLCPA) and the Accelerated Renewable Energy Growth and Community Benefit Act (Act).

In the Order, the Commission directed the working group to focus on three high-priority technology areas that the Joint Utilities had identified in their November 2, 2020 report: dynamic line ratings (DLR), power flow control (PFC) devices, and energy storage for transmission and distribution services.[2]

The plan presented in this report is focused on two near-term goals:

1. Establish a sustainable working group and R&D program that can support the achievement of CLCPA goals; and
2. Identify and remove barriers to deploying technologies from the three high-priority areas identified by the ATWG.

The report is organized in four parts plus appendices.

- Section 1 summarizes the objectives and background for the ATWG and the R&D plan.
- Section 2 presents a proposed approach for R&D designed to accelerate the development of T&D technologies and their deployment in New York.
- Section 3 provides background on recent and ongoing technology R&D in New York within the three high-priority technology areas.
- Section 4 presents a high-level R&D road map and plan for the ATWG, focusing on the near term (2022-2023).

[1] Case 20-E-0197, *Order on Power Grid Study Recommendations*, State of New York Public Service Commission, January 20, 2022.
[2] Utility Transmission and Distribution Investment Working Group Report, November 2, 2020, p. 253.

Acknowledgments

This plan and report were developed by the Joint Utilities of New York, working in consultation with multiple organizations, including:

- Electric Power Research Institute;
- Long Island Power Authority;
- New York Independent System Operator;
- New York Power Authority; and
- New York State Energy Research and Development Authority.

1 BACKGROUND AND OBJECTIVES

Meeting the clean energy and climate mandates set by the Climate Leadership and Community Protection Act (CLCPA) will involve adding thousands of megawatts of renewable generation and energy storage throughout the New York electric T&D systems. These additions will require expanded T&D capacity to ensure that renewable energy can serve customers. In response to direction from the New York Public Service Commission (the "Commission"), the Joint Utilities have sought to use advanced technologies to help increase transfer capabilities of certain grid facilities and access to renewable generation.

In its January 2022 Order on Power Grid Study Recommendations (the Order),[3] the Commission directed the Joint Utilities to create a group that brings together utilities, grid operators, and research organizations that will focus on accelerating the deployment of advanced technologies that can increase the delivery capability of T&D infrastructure, and in doing so, help support the objectives of the Accelerated Renewable Energy Growth and Community Benefit Act (the Act) and the Commission's initiating order in this proceeding.[4] This document presents a research plan designed to accelerate the testing, evaluation, and deployment of advanced technologies in New York's electric transmission and distribution system, as directed by the Order. The Joint Utilities prepared the plan, working in conjunction with the Advanced Technology Working Group (ATWG), which includes representatives from the Long Island Power Authority (LIPA), the New York Power Authority (NYPA), the New York Independent System Operator (NYISO), the New York State Energy Research and Development Authority (NYSERDA), and the Electric Power Research Institute (EPRI).

This research plan is designed to support two near-term objectives:

1. Establish a sustainable working group and approach focused on accelerating the deployment of advanced technologies for New York's electric T&D systems; and
2. Identify and remove barriers to deploying dynamic line rating (DLR) and power flow control (PFC) technologies and use energy storage for T&D services.[5]

Following the filing of this research plan, the Joint Utilities, working as members of the ATWG, intend to commence work to achieve the near-term objectives. As required by the Order, the ATWG plans to file a progress report by January 20, 2023.[6]

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[3] Case 20-E-0197, Order on Power Grid Study Recommendations, January 20, 2022.

[4] Case 20-E-0197, Order on Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act, May 14, 2020.

[5] The NYISO treats storage as a resource and not as transmission, has no mechanism to treat storage as transmission in its tariffs, and would need to understand further what transmission function storage is performing before it could do so.

[6] Order at 39.

2 PROPOSED APPROACH FOR R&D

R&D is typically not performed with the expectation of immediate success but is expected to contribute to a company's long-term sustainability. R&D may lead to discoveries, patents, and new products. For utilities, R&D represents activities to improve or address complex problems or challenges. These activities can include studying and learning about the issue at hand, formulating solutions never tried before in the company, piloting solutions to evaluate their applicability and performance, and deploying innovative solutions if the pilots are successful.

Because R&D projects are risky, with far from any assurance of success, utilities often find it difficult to allocate money from operations to spend on R&D activities unless the money is funded in rates. Also, not every utility has the same R&D funding capability and, more importantly, adequate financial resources to take on the R&D activities contemplated in this research plan without rate relief or governmental financial support.

Pooling resources from multiple utilities can reduce the inherent risks of R&D projects in certain circumstances. Projects best suited to mutual support might be focused on pure research, the development of standard evaluation tools, or laboratory demonstrations. By contrast, piloting a technology on a host utility system might be impractical for joint R&D, except where multiple utilities could play technical advisory roles. These are essential considerations for the ATWG as we develop our plans.

The ATWG recommends three related activities for developing advanced T&D technologies and accelerating their deployment in New York (Figure 1).

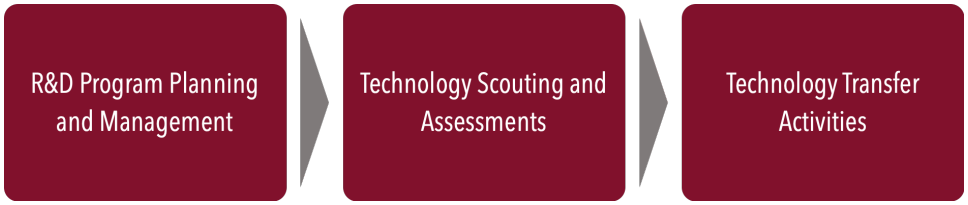

Figure 1. Overview of recommended approach for the ATWG

2.1 R&D Program Planning and Management

2.1.1 Program Objectives

The ATWG seeks to establish a sustainable working group and R&D program to help ensure that the T&D systems in New York can support the achievement of CLCPA goals. The ATWG will work to:

- Accelerate the deployment of underutilized T&D technologies,
- Foster innovation to improve the functionality and cost-effectiveness of emerging or advanced technologies,

- Develop standardized tools and techniques for evaluating the suitability and application of all T&D technologies and solutions, and
- Facilitate information sharing and collaboration among all interested stakeholders in New York.

We recognize that multiple factors can limit the adoption of new technologies in the electric utility industry, some of which may have nothing to do with the technical efficacy of those technologies. The ATWG proposes to craft an R&D program that addresses four critical barriers:

1. Technical – ensure that technologies offer the capabilities and functionality needed.
2. Process – assist utilities with evaluating, adopting, and operationalizing new technologies.
3. Regulatory/Legal – enable deployment, ownership, and operation of advanced technologies alongside traditional solutions.
4. Benefit/Cost – improve the cost-effective deployment of new technologies by monetizing stakeholder benefits, reducing cost, and increasing customer value.

2.1.2 Organization and Governance

The following is based on the ITWG Governance document.[7] These governance terms will be reviewed and refined by the ATWG as part of establishing the working group following the filing of this report.

Mission

The ATWG aims to identify, discuss, and resolve technical barriers and challenges associated with developing and deploying advanced technologies on the New York electric T&D systems. ATWG's goal is to ensure that the necessary policies, procedures, and standards exist to address technical, process, regulatory, and economic concerns related to modern and innovative technologies.

Membership

The ATWG shall consist of member representatives from each group, with titles and roles outlined in Table 1. Members should have a technical background and experience in electric power T&D planning, operations, engineering, or technology R&D. If needed, specific utility and industry technical experts can be invited to support working group discussions or activities (see Task Forces).

[7] NYS Interconnection Technical Working Group Mission, Governance & Operations, Interconnection Technical Working Group, New York State Department of Public Service, January 2021, https://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/def2bf0a236b946f85257f71006ac98e/$FILE/70950409.docx/ITWG%20Governance%20Jan%202021.docx

Table 1. ATWG membership

Sector	Representatives
New York State Entities	(1) Representative - Department of Public Service (1) Representative - NYSERDA
Investor-Owned Utilities	(1) Primary and (1) Secondary Representative from each of the Joint Utilities • AVANGRID (NYSEG and RG&E) • Central Hudson Gas & Electric (Central Hudson) • Con Edison (CECONY and ORU)[8] • National Grid The utility group shall designate a Liaison for the group amongst the selected primary representatives
Power Authorities and Grid Operators	(1) Primary and (1) Secondary Representative from power authority or grid operator • LIPA and/or PSEG-LI • NYPA • NYISO

Leadership – The ATWG will designate a Chairperson responsible for leading meetings and acting as a point of contact for the group. The ATWG will also designate a Secretary responsible for meeting coordination, documentation, and management of information developed or maintained by the ATWG. The ATWG may choose to reassign the chairperson and secretary duties from time to time through reelection, rotation, or other means as determined by the ATWG.

Alternate Members - Each primary member of the group from the electric utility industry may designate an alternate (secondary) to represent itself or its Company.

Membership Changes - Modifications to the ATWG membership composition shall be discussed at meetings.

Technical Consultants – Technical consultants often participate in the ATWG meetings to provide their expertise on specific topics and address technical issues within the group.

Responsibilities of Members

Non-Member Participation & Representation - Only core ATWG members shall engage in meeting discussions unless a non-member has been invited to present or speak as a subject matter expert (SME).

Attendance - ATWG representatives and alternates will attempt to attend all Working Group meetings, be on time, and review all documents disseminated before the meeting. If a representative or the representative's alternate cannot participate in a meeting, the

[8] Consolidated Edison Company of New York (CECONY) will represent itself and Orange and Rockland Utilities (ORU).

representative should let the Chairperson know before the meeting (by telephone or e-mail).

Information Dissemination - It is the responsibility of the ATWG representatives and alternates to keep their organizations and other organizations in their clusters informed of developments in the Working Group process.

Subcommittee Operations - The ATWG may designate subcommittees on specific topics. These subcommittees will be charged with bringing suggestions, ideas, and draft deliverables back to the ATWG for discussion. These subcommittees may include additional members or SMEs as required.

Agenda Setting – Setting agendas for meetings is the responsibility of the Chairperson and Secretary. Members can submit ideas for upcoming meetings to the Secretary at any time. Each agenda should include time for discussing potential items for future meetings.

Establishment of Task Forces

From time to time, the ATWG may wish to establish one or more task forces to explore specific types of barriers, technologies, or R&D questions. Task forces will likely require SMEs from within ATWG member organizations. Task forces may also invite participation from non-ATWG member organizations with expertise and experience that supports the task force's objectives. Task forces will choose members responsible for the leadership and report to the ATWG as necessary.

Decision-Making Processes

1) Seek Consensus – The goal of the process will be to make substantive decisions by consensus of the ATWG members, where consensus shall mean that all the representatives (or their alternates in the representative's absence) are at least willing to accept a decision and choose not to dissent. If unable to consent, a representative will be expected to explain the reason for dissenting and offer a positive alternative. Representatives are responsible for voicing their objections and concerns.

2) Technical Consultancy Support – The ATWG may request that a technical consultant evaluate options and provide a recommendation on a specific technical subject with differing opinions. The technical consultant shall elaborate on industry-wide best and/or emerging practices and experience.

3) Final Analysis & Non-Consensus Process – The ATWG's Final Analysis to the Department of Public Service at the end of the process will identify all areas of consensus and will describe the alternative approaches preferred by Working Group representatives if and where agreement is not reached. In the case of non-consensus issues, the ATWG Chairperson will have time allotted to deliberate the subject matter until consensus is reached.

2.1.3 Funding

The ATWG will require funding for the next three years to support activities related to program support, studies and analysis, and laboratory testing as needed (see Table 2). The

ATWG will develop a detailed budget for these activities as part of program development and support in the next 6-12 months. The Working Group will also identify potential demonstration projects as part of longer-term R&D plans. Additional funding may be provided by NYSERDA for demonstration and pilot projects as recommended by the ATWG and approved by NYSERDA.

Table 2. ATWG activity types and examples

Activity Type	Examples	Timeframe	Preliminary Budget
Program Support	• Program administration, facilitation, and reporting • Develop guidance documentation • Technology Scouting and Assessments for Beneficial Technologies	2022 - 2026	$2 million (NYSERDA)[9]
Studies and Analysis	• EPRI study to identify and develop analytical tools for energy storage valuation • System modeling	2023 - 2026	
Laboratory Testing	• Use of NYPA Advanced Grid Innovation Laboratory for Energy (AGILe) • University or national laboratory testing	2023 - 2026	
Demonstration Projects	• Long-term energy storage demonstration • Thermal energy storage demonstration	2023 - 2026	$15 million (NYSERDA)[10]

In the near term, the ATWG will focus on projects best suited to joint R&D that benefit New York. Pilots and demonstrations involving individual utilities may be done through solicitations with funding support from NYSERDA, the United States Department of Energy, technology vendors, or host utilities. We anticipate that the ATWG will be involved in identifying and prioritizing the R&D questions and helping to set the objectives of independent utility demonstration programs. Utilities will evaluate these demonstration projects, and funding needs to adopt the most successful technologies. Utilities will share the insights and lessons learned with the ATWG.

2.2 Technology Scouting and Assessments

The ATWG will develop and use a common approach to scout and evaluate technologies that can be applied to addressing various existing and anticipated future challenges across

[9] NYSERDA has estimated program support funding at $2 million through 2026.

[10] NYSERDA has estimated funding for pilot and demonstration projects at $15 million. These funds may be supplemented by project partners including technology vendors, utilities, or other research organizations.

the electric T&D systems in New York. We anticipate exploring hardware, software, techniques, and tools that could improve performance in a variety of areas, including:

- T&D planning,
- T&D operations,
- T&D infrastructure,
- T&D asset management, and
- Energy systems integration.

Technology scouting and assessment is typically a multi-stage process that begins by identifying and characterizing the functionality, capabilities, or attributes desirable for addressing a challenge. These factors become parameters for surveying existing and emerging technologies and screening them for potential fit. In stage two, promising technologies can be evaluated and compared to traditional solutions to determine the potential value of developing and deploying each technology in various applications. Finally, experts can develop evaluation and application guidance to help planners and engineers deploy technologies and solutions in locations that will deliver the most significant benefits at the lowest cost (best value). Figure 2 illustrates the three-stage approach.

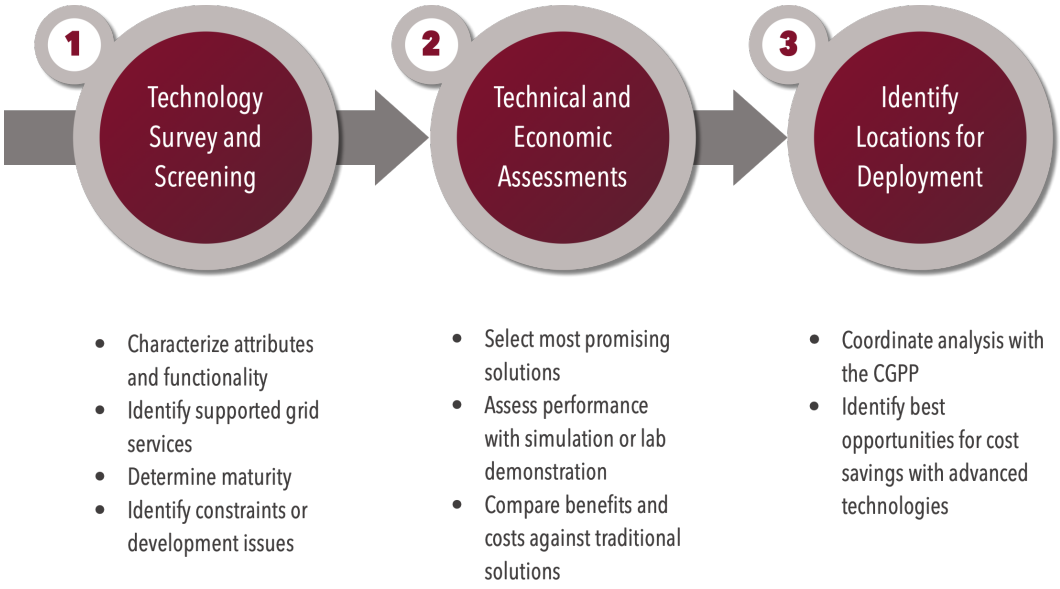

Figure 2. Three-stage technology scouting and assessment approach

The near-term priority for the ATWG will be the identification and evaluation of DLR, PFC, energy storage technologies, or other grid enhancing technologies (GETs) that improve the performance of the T&D system consistent with the Commission's directions in the Order. These technologies all address transmission capacity bottlenecks that may constrain the utilization of renewable resources. In addition, there are emerging concerns regarding the ability of the T&D system to host and support the interconnection of large numbers of

inverter-based resources.[11] Present system planning protocols and software tools cannot adequately address these issues. Future work of the ATWG can be to initiate or support research and development that addresses the technical problems of high inverter-based resource penetration and the study tools and procedures needed to provide a secure system while meeting the CLCPA goals.

2.2.1 Technology Survey and Screening (Stage 1)

The ATWG will develop survey and screening criteria consistent with its program objectives described in Section 2.1.1. Our initial focus will be to develop and deploy technologies and solutions that:

> *(a) alleviate T&D system bottlenecks to allow for better deliverability of renewable energy,*
>
> *(b) unbottle constrained resources to allow more renewable hydro and/or wind imports and reduce system congestion*
>
> *(c) optimize the utilization of existing transmission capacity and rights-of-way, and*
>
> *(d) increase circuit load factor.*[12]

Technologies can consist of both hardware and software, which helps monitor and improve the performance of the hardware. The ATWG recognizes that the maturity of technologies varies within each category. For example, PFC technologies range from the most mature phase angular regulators (PARs) to flexible alternating current transmission system (FACTS) devices to inverters with grid-supporting capabilities. This initial step of surveying and screening the technologies of focus also includes tabulating for each technology/product the following details:

- Technology readiness level (TRL),[13]
- Commercial maturity, including where they have been installed (preferably in New York) or other Independent System Operator (ISO) or Regional Transmission Organization (RTO) control areas in the US,
- Grid services (or ancillary services) it provides and their typical range (MW and MVAR),
- The typical range of capital and annual O&M costs, preferably shown in unitized costs, $ per MW or all-in $/MW-yr., which would take into consideration the economic life of the technology, recognizing that modern technologies often have shorter economic lives compared to traditional solutions, and

[11] Almost all emerging renewable and storage resources utilize inverter technology.
[12] Order at 34.
[13] The ATWG plans to utilize the TRL approach developed by the US Department of Energy and used by NYSERDA in other program areas. NYSERDA typically focuses on "applied" R&D with a TRL of five or greater.

- Any constraints and issues that will need to be considered before deploying.

Potential Technology Scouting Services

An excellent repository to start the search for technology innovations and emerging technologies is EPRI's Tech Portal.[14] The portal contains information on companies innovating on energy storage, grid modernization, emerging technologies, sensors, data analytics, and modeling, among many topics pertinent to the goal of seeking out technologies that can enhance the existing grid to provide additional capacity without adding new lines and allow for increased utilization. Some New York utilities are members of EPRI and thus have access to the complete EPRI Tech Portal.

EPRI also runs annual innovation challenges through their Incubatenergy Labs, which engages early-stage companies to conduct accelerated demonstrations of innovative solutions to address the needs and challenges of the participating utilities. Through EPRI's Incubatenergy Labs, participating utilities have engaged companies offering innovative solutions, including DLRs, PFCs, energy storage, and supporting software applications.[15]

2.2.2 Technical and Economic Assessments (Stage 2)

Using the results from the Surveying and Screening stage, the ATWG will recommend two or three products from each technology area (DLR, PFC, energy storage) for evaluation in a simulation or laboratory demonstration. The ATWG anticipates working with NYPA's AGILe lab, universities, or other technical evaluation facilities to conduct testing and performance evaluation.[16] We expect that technologies or commercially available products will be assessed under a range of conditions from normal operation to extreme ends of possible operating modes. Both technical and economic assessments of the product will be made using the performance results. The technical evaluation will include identifying any limitation of the use of the product and optimal range(s) of operation. The economic evaluation will consist of a benefit-to-cost analysis where the benefit will be the avoided cost of a comparable traditional solution, for example, reconductoring or adding a new line. Because the economic lives of advanced technologies and traditional solutions will mostly be different, both the benefit and cost in the benefit-to-cost analysis will be annualized, for example, in the form of levelized costs or annual revenue requirements.

2.2.3 Identify Locations for Deployment (Stage 3)

This stage should be closely coordinated with the Coordinated Grid Planning Process (CGPP), which will work towards identifying viable T&D solution sets. For example, whatever databases and assumptions are used in this stage for simulation and analyses should be consistent with those used in the CGPP. In principle, the potential areas for implementing advanced or traditional solutions should be electrically close to key transmission interfaces or regions where the need for "on-ramps" or "off-ramps" have been

[14] https://techportal.epri.com/

[15] Representatives from Con Edison, Fortis, National Grid Partners, and NYPA are advisors to Incubatenergy Labs. https://labs.incubatenergy.org/en/page/advisors-en

[16] See Appendix C for details on the capabilities and services of AGILe.

identified in New York State. Figure 3 illustrates how the ATWG and CGPP could coordinate an analysis.

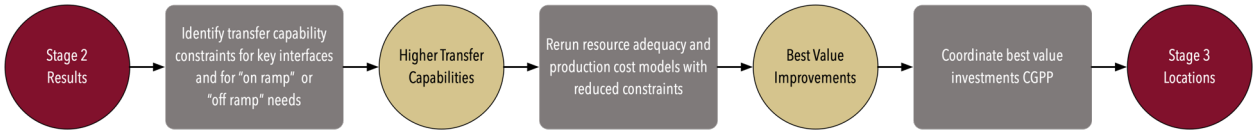

Figure 3. Example coordination between ATWG and CGPP in Stage 3

Potential Analysis Tools

Identifying and assessing the potential deployment locations of the T&D solution sets will require analytical tools to perform steady-state power flow and dynamic analysis, transient analysis, resource adequacy, operational reliability, cost-benefit analysis, and production cost studies. Such tools are widely used by the New York utilities, NYISO, and other parties in New York and are likely adequate for evaluating the impact of DLRs and PFCs on the grid and identifying where to locate these solutions.[17] To the extent that any of these tools are used in the CGPP, the ATWG will coordinate with the CGPP to ensure consistent input assumptions are used. However, good analytical tools for energy storage are less mature and will require further investigation and use to determine their suitability. One such potential tool for further research is EPRI's Distributed Energy Resources Valuation Estimation Tool (DER-VET), which uses time-series simulation to analyze the cost-effectiveness of energy storage. DER-VET supports energy storage grid services covering the full scope of the electric system, including generation, T&D, and customer premises. According to EPRI, DER-VET can save significant effort in identifying high-potential energy storage use cases before running full-system production cost simulations.

Live field demonstrations can be costly and may introduce reliability risks to T&D systems. Real-time simulators can provide accurate and comprehensive representations of the New York State electric power grid and the input/output interfaces needed to test the performance of equipment such as DLRs, PFCs, and energy storage. Capabilities for technology evaluation include:

- Real-time simulation;
- Hardware-in-the-loop testing;
- Communications testing;
- Cybersecurity testing; and
- Production cost modeling and analysis (economic analysis).

These capabilities are available at NYPA's AGILe lab and can supplant the need for live field demonstrations. The AGILe Lab has plans to create a comprehensive digital twin of the New York State T&D grid to support a common approach to equipment testing. The AGILe lab

[17] Examples of these tools include Siemens PSS/E (Power System Simulator for Engineering), DNV Synergi, CYME, DEW/ISM, PSCAD (Power Systems Computer Aided Design), EMTP (Electromagnetic Transients Program), GE MARS (Multi-Area Reliability Simulation) and GE MAPS (Multi-Area Production Simulation.

can also evaluate economic impacts using a small-scale high-performance computing (HPC) implementation of production cost simulation software (GE-MAPS).

2.3 Technology Transfer Activities

2.3.1 *External Communications and Engagement*

The ATWG plans to communicate and engage with a broad and diverse group of stakeholders to be as openly collaborative as possible, as this is a fundamental R&D tenet. Stakeholders will include the ATWG members, consultants, industry research groups, national laboratories, academic institutions, T&D equipment manufacturers, project developers, and technology start-ups and innovators. The ATWG expects New York-based stakeholders to be well engaged, for example, the State University of New York (SUNY) colleges, Brookhaven National Laboratory, and the New York Battery and Energy Storage Technology (NY-BEST) Consortium.

Communication and engagement will involve regular information exchange meetings (e.g., at least once per quarter) and a website. The information exchange meetings can include discussing pertinent topics, existing and new projects, and knowledge transfer among ATWG members and guest attendees. The website will provide meeting announcements, meeting documentation, and a forum for public comments.

2.3.2 Coordination with the Coordinated Grid Planning Process

The Joint Utilities of New York filed a Coordinated Grid Planning Process (CGPP) proposal with the Commission in December 2021. In early 2022 the JU expanded the scope of the Planning Coordination Working Group, which was renamed the CGPP Working Group, to focus on developing and refining the CGPP proposal. The goal of the CGPP is to identify opportunities to reduce local T&D constraints that may limit the ability to integrate and deliver renewable energy. Reducing such conditions will help New York State meet its clean energy goals. Given the strong alignment between the CGPP and the ATWG, it will be essential to coordinate activities and timing.

The CGPP follows six stages to be completed over two years. The ATWG anticipates coordinating closely with the CGPP Working Group and the development of the CGPP. CGPP Stage 3 involves a local system assessment that considers Non-Wire Alternatives and the use of advanced technologies as options that will be compared to traditional wired solutions. Assuming approval of the CGPP in 2023, the ATWG foresees that the output of the Technology Scouting and Assessment process could be needed as early as the end of 2024. Figure 4 shows the potential coordination between the ATWG and CGPP.

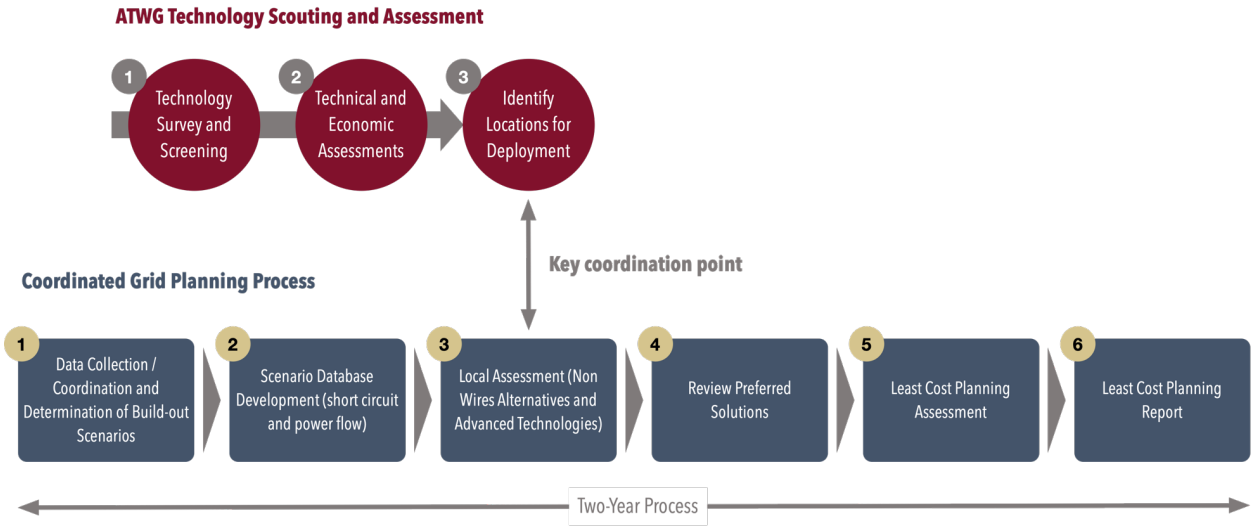

Figure 4. Coordination of the ATWG and CGPP processes and timelines

Guidance Documents for T&D Planning

Consistent with the charter of the ATWG, a key deliverable of this research plan is to provide a consistent approach for New York utilities to identify and assess various GETs for potential use in their system. This consistent approach is spelled out above in the technology scouting and assessment methodology discussion. If this approach were adopted and implemented, the ATWG would be conducting studies identifying beneficial GETs and their potential use cases, with results documented in the form of guidance documents to help utilities with T&D planning, accounting for their regional differences and including the integration of renewable power to help meet the goals of CLCPA. The layout of these guidance documents is still yet to be determined. Still, one possibility is to have the results from each of the three stages of the Technology Scouting and Assessment as a guidance document – one for each step.

Development of the guidance documents should take approximately twelve months, including the necessary analyses. However, this twelve-month period may not be continuous, especially if stage 3 needs to be coordinated with the CGPP. Guidance documents will require periodic updates (e.g., every two to three years) to keep pace with new and improved technologies.

3 TECHNOLOGY R&D IN NEW YORK TODAY

3.1 DLR Technologies

3.1.1 Background

Transmission line ratings are critical operating limits used by reliability coordinators, transmission system operators, and planning authorities to ensure that transmission line flows do not increase the likelihood of reliability events and equipment failure. Several factors, including line clearance, thermal rating limits, and contingency conditions, contribute to the overall rating of a transmission line.[18] Generally, thermal transmission line ratings are reduced for higher ambient temperatures and solar radiation but increase with higher wind speeds. In addition, conductor temperatures often depend upon conductor material properties, diameters, and surface conditions.

The North American Electric Reliability Corporation (NERC) Reliability Standard FAC008-3 requires each transmission owner to have a documented methodology for determining transmission line ratings. Rating methodologies have evolved from fully static conductor thermal ratings with no adjustment for changes in ambient conditions to real-time ratings. Recent approaches have moved to short-term forecasts where the thermal rating is obtained 1 hour, 4 hours, 24 hours, or more in advance.

In December 2021, the Federal Energy Regulatory Commission (FERC) issued Order 881, establishing mandatory ambient adjusted hourly ratings, and as of June 2022, is opening an investigation into DLR. These efforts have increased industry focus on understanding the potential range of DLR methods.

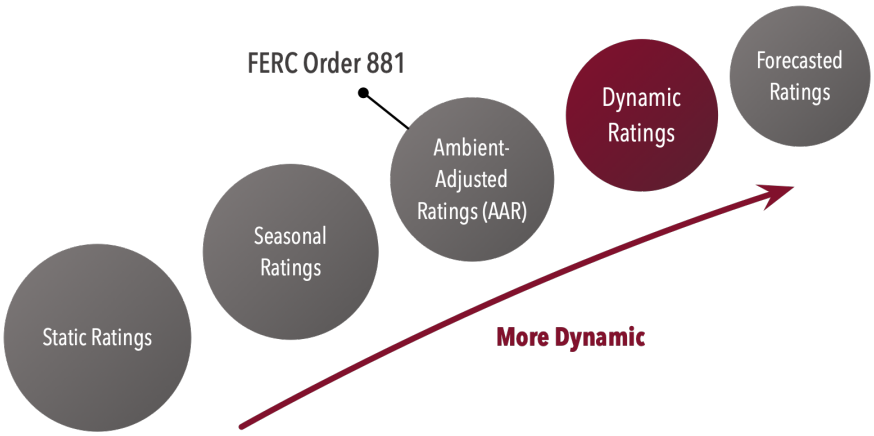

Figure 5. Progression of line rating methods

[18] In practice, this pertains only to overhead transmission lines. Underground transmission is negligibly affected by real-time ambient conditions, except where the constraining element is an above-ground termination.

Static ratings are simple to implement and use but typically set lower capability limits than other approaches. This is because static ratings assume worst-case forecasts and do not account for conditions that change over time. The static rating for a transmission line might remain fixed for years or never change. Most transmission owners that apply multiple sets of ratings make seasonal distinctions (i.e., summer and winter). Seasonal ratings account for the significant differences in ambient conditions such as temperature and wind speed.

Ambient-adjusted ratings (AAR) are more dynamic than static and seasonal ratings, and their values change more frequently (e.g., hourly). Ambient air temperature forecasting and solar line heating are critical to using AARs. DLR incorporates similar ambient conditions as AAR, such as ambient air temperature and solar irradiance, but adds additional local weather conditions, line tension, photo-spatial sensors (e.g., LIDAR), and line sensors installed on or close to the monitored line. DLR-determined ratings are also updated frequently depending on the characteristics of the DLR monitoring equipment.

Recent DLR schemes leveraging machine learning and weather forecast data can provide short-term forecast ratings. Case studies and available literature show that most utilities would gain delivery capability between 80% and 99% of the time. The increase depends on real-time weather conditions. Although DLRs can potentially provide benefits, their applications may be limited and less likely for widespread deployment.

New York utilities will be required to implement AAR by July 2025 in accordance with FERC Order 881. The ATWG should develop an approach for analyzing DLR's incremental costs and benefits over AAR for specific projects. This will help identify opportunities where DLR could offer higher value for T&D systems and customers.

3.1.2 Recent or ongoing R&D projects and related activity

Numerous research and development efforts are currently underway in New York in connection with utilities and state entities, including the following projects:

- AVANGRID DLR Challenge in coordination with NYSERDA evaluating transmission lines in the New York Southern Tier region.
- Central Hudson DLR evaluation project of a radial transmission line in collaboration with EPRI using an optical camera to evaluate the impact of a DLR system on the line rating.
- NYPA exploration of direct SAG measurements with results transmitted to the data center. Additional Wind-Vision pilot in coordination with NYSERDA exploring congestion challenges.
- National Grid will install eight DLR monitors on two lines and eighteen DLR monitors on a third line, including any work required for access, the necessary modifications to integrate the line ratings into the EMS, and five years of service with LineAware and LineVision.[19]

[19] National Grid project will install eight (8) DLR monitors from LineVision on the Laona - Moon Rd LN173 and Moon Rd - Falconer LN175 lines in New York, including any work required for access. This project will

- Con Edison and LIPA/ PSEG LI applications of DLR technology on underground transmission with promising initial results.

The ATWG will consider best practices for applying different DLR technologies, benefit-cost analysis (BCA) factors, project financing, and potential investment recovery mechanisms. Initial efforts by this group will attempt to answer these business questions while aligning with the strategic and business objectives of the transmission owners.

3.2 PFC Technologies

3.2.1 Background

As the amount of intermittent, non-dispatchable resources grows on the New York electric grid, there will be a need to improve system flexibility across the remaining dispatchable resources and the power delivery system to ensure system reliability. Going forward, traditional transmission projects will be needed for most grid expansion. There are also innovative solutions like coating technologies that could increase transmission capacity by approximately 20%.[20] Still, new transmission technologies that offer increased operating flexibility can potentially increase transmission path throughput while utilizing existing rights of way.

Portable, distributed, and scalable devices such as modular flexible alternating current transmission system (M-FACTS) devices have the potential to be effective options to improve the flexibility and adaptability of transmission networks. These technologies can be installed in smaller increments based on changing system conditions, unlike conventional assets like lines and substations that are large-scale lumped solutions. Such technologies and more mature FACTS technologies could be deployed in various applications depending on the need. Comparing capabilities and costs among different FACTS technologies can help increase deployment in high-value cases.

A far-reaching advantage of incorporating flexible assets in the planning process is the possibility to defer major conventional projects until the need for such investment is fully established. Flexible assets can be used as interim solutions until information regarding system evolution is available and concrete solutions can be devised. These devices can be installed relatively quickly and relocated to other parts of the system if they are no longer needed in their original location.

Further study of this technology will help evaluate the applicability of PFC technologies within or as a replacement to T&D solutions in New York. The ATWG should: (1) focus on applying available technology solutions for specific problems; and (2) use research to accelerate the development of less proven or emerging technologies. As detailed in the R&D

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also include the necessary modifications to integrate the line ratings into EMS. National Grid project will install eighteen (18) DLR monitors from LineVision on the McIntyre - Colton #8 line in New York, including any work required for access. This includes five (5) years of service with LineAware and LineRate systems from LineVision.

[20] Prysmian is working with Exelon to pilot its advanced coating technology. See https://www.youtube.com/watch?v=TnDDbf73R5I.

Roadmap section of this report, ongoing work by NYSERDA and EPRI can be leveraged for this purpose.

3.2.2 Recent or ongoing R&D projects

Several utilities are exploring PFC technologies in New York through the following programs:

- Phase Angle Regulator (PAR) technology is currently being implemented by several utilities in New York state.
- Central Hudson is currently conducting a pilot test of SmartValve technology and anticipates commercial deployment in 2023.

Additional review by utilities and New York State entities in this area is focused on evaluating traditional and new types of PFC technologies, including unified power flow controllers, series compensation, and variable frequency transformers, among other technologies.

Many traditional PFC technologies are mature compared to DLR and energy storage technologies. As a result, coordinating their integration into the T&D system should be focused primarily on established studies to determine the most suitable applications and opportunities for integration. This could include technical studies conducted by institutions like EPRI, the utilities, or those undertaken by NYPA around low-frequency AC and SEN transformers. However, there are emerging forms of PFC technologies involving power electronics, superconducting materials, and distributed deployments which should also be included in this research.

Low-frequency technology can potentially increase power flow but is currently highly exploratory and costly. SEN transformers can simultaneously control real and reactive power, and NYPA is developing prototypes. These transformers could provide value if deployed to any location with real power control needs and voltage concerns.

PFC solutions compete with traditional T&D upgrades on cost. Comparisons should include maintenance and adjustment costs for PFC technologies over the project's life. The economic viability of PFC solutions may require a pricing scheme that accounts for the value of avoided congestion. For example, Central Hudson's integration of Smart Valve technology is designed to prevent thermal overload and avoid costly transmission upgrades, but additional benefits of avoiding sub-synchronous resonance and expensive protection schemes were also significant considerations. Experience with this technology shows that utilities should consider multiple benefits when evaluating a PFC solution.

An initial R&D approach for PFC technologies might explore specific applications with tailored BCA approaches that account for avoided congestion benefits and consider integrating PFC information into existing operation technologies and systems like energy management systems (EMS) or distribution management systems (DMS). A comprehensive study of PFC technology and applications could pave the way for additional pilot programs by alleviating concerns of risk and feasibility held by transmission owners with obligations to prioritize reliable service.

3.3 Energy Storage for T&D Applications

3.3.1 Background

Battery energy storage systems (BESS) have gained support in recent years for their role in promoting renewable energy development and achieving decarbonization goals. BESS costs are still too high for many applications. However, experts anticipate that cost reduction will make BESS more viable over time. BESS has the flexibility and capability to provide varied services and systems that are becoming modular and mobile, which allows for easy relocation and fast deployment. This versatility expands the potential applications for BESS exponentially and currently includes:

- Deployment for disaster and emergency response;
- Local and municipal siting;
- Reduction of transmission line congestion;
- Improved hosting capacities in the distribution system;
- Grid support in areas that will see increased renewable integration;
- Supports electrification associated with electric vehicle deployment and gas conversions;
- Improved efficiency over diesel generators; and
- System upgrade deferrals.

In concert, these varied services help in strengthen grid operations and improve reliability.

3.3.2 Recent or ongoing R&D projects

There are several utility energy storage projects for T&D applications:

- Orange & Rockland Utilities is developing co-located storage with new distribution substations.
- AVANGRID's ongoing utility study includes proposals for energy storage projects and analysis, including NYISO market participation, of the potential transmission connected battery energy storage projects, submitted in response to the NYSEG and RG&E Bulk Power Energy Storage Request for Proposal using DER-VET™ using newly developed customized input templates to automate the process.
- Con Edison is advancing the Fox Hills 30 MWh Energy Storage Project, which will provide substation load relief, assist with system ramp-up associated with solar intermittency (PV-duck curve), and participate in the NYISO market services.
- Con Edison developed and installed the Ozone Park 2 MW/10.5 MWh BESS system as part of the Brooklyn Queens Demand Management (BQDM) program to provide distributed peak reduction and substation/sub-transmission feeder load relief.

- National Grid and Convergent Energy+Power completed a solar-plus-storage system that combines 10MW/40MWh energy storage with 15 MWdc of solar generation to provide a non-wires alternative to customers in Cicero, New York.
- National Grid is exploring an RFP for a 20 MW bulk storage project to alleviate n-1 or outage situations on the T&D system.
- National Grid recently put two 2MW/3MWh energy storage systems into service at East Pulaski and North Troy to support distributed peak reduction, wholesale market participation, and power quality.

3.3.3 Research Questions

R&D strategy for storage technology in a T&D setting should focus on identifying high-value applications, including reduced curtailment of renewable resources, energy time-shifting for solar, pumped hydro, and wind, and a role in reducing transmission congestion. BESS can also provide capacity services for resource adequacy and capital investment deferral, mitigate peak temperature on underground cables through load leveling and provide ancillary services for voltage, frequency, reserves, and black start capability.

Additional research questions for BESS applications should be directed at how to most effectively site storage projects in the context of standard T&D operations and New York-specific geographic considerations related to weather, population centers, and existing transmission infrastructure. An appropriate storage solution may vary in technology type and scale based on its location's geographic or infrastructural characteristics.

3.3.4 Resources

As New York adopts advanced technologies, various resources will assist in evaluating, screening, and preparing for widespread use through pilots and demonstrations. Coordination with utility planning groups and other utility groups associated with deploying and operating these advanced technologies, such as procurement, legal, regulatory, and processes, will need to learn about these new, innovative technologies.

Resources that expedite and facilitate technology adoption include Technology Training, Guides, Modeling Tools, and Templates and Test Protocols. Others are expected to be identified and developed over the timeframe of the ATWG.

Technology Training

Energy storage technology training sessions for various utility departments are essential for implementing energy storage at the utility and in New York. Topics ranging from applications, deployment, safety, operations, and end-of-life are must-know for safe, reliable, and proper use of energy storage. NY-BEST has regular and periodic virtual training sessions, and EPRI has ES101 available for free on their website, StorageWiki.[21] EPRI provides other training sessions tailored to specific audiences. Training assists in understanding and assessing emerging technologies.

[21] StorageWiki, https://storagewiki.epri.com/index.php/Energy_Storage_101

Guides

A planning engineering guide that outlines a screening methodology and identifies best practices to evaluate energy storage technologies and associated applications would benefit New York utilities.

Modeling & Analysis Tools

To design and evaluate transmission and distribution solutions that incorporate the capability of various technologies, appropriate analytical methods and tools for optimization and simulation analysis are needed. Congestion analysis of production cost studies performed by NYISO and NYPA can inform this resource.

EPRI has developed a software application (CPLANET for Controlled Planning Network) that helps identify optimal solutions for mitigating thermal overloads in a power system under various operating scenarios. The optimum solution is determined from a given set of candidate projects that may include power flow controllers (Phase-shifting transformers, M-FACTS, and fixed series reactors), energy storage, and traditional expansion projects such as new and upgraded transmission lines and substations. For power flow controllers and energy storage, the software determines the location and size of the devices and their control settings for the given operating scenarios. The software uses a mix-integer optimization engine to identify the least-cost solution for the specified conditions. Even though CPLANET is a valuable tool to help planners identify transmission solutions, it does not exploit all salient characteristics of these transmission technologies in its current version.

EPRI has another tool that has screening capabilities, the Distributed Energy Resources Value Estimation Tool; DER-VET™. DER-VET is an open-source platform for calculating, understanding, and optimizing the value of energy storage and other distributed energy resources (DER) based on their technical merits and constraints. DER-VET supports site-specific assessments of energy storage and other DER technologies—including solar, wind, demand response, electric vehicle charging, internal combustion engines, and combined heat and power—in single, hybrid, and other configurations as microgrids. It uses load and other data to determine optimal size, duration, and other characteristics for maximizing benefits based on site conditions and the value extracted from identified use cases. Customers, developers, utilities, and regulators across the industry can apply this tool to inform project-level decisions based on sound technical understanding and unbiased cost-performance data. DER-VET was developed with funding from the California Energy Commission and is a free, publicly available modeling website tool.[22]

Tools at NYPA's AGILe lab can verify use cases for which the new technologies, including DLR, PFC, and energy storage, are intended to be used by interfacing them with the New York State model and digital twins. A variety of different use cases can be verified in the context of the New York State electric power grid, including but not limited to transmission lines congestion management, low-frequency oscillation damping, frequency response support, and frequency regulation.

[22] DER-VET website, http://www.der-vet.com

Templates and Test Protocols

Many resources are available to assist New York in meeting its energy storage deployment goals. They have been developed by standards organizations, the U. S Department of Energy, National Lab, and EPRI, among others. In 2013, EPRI pulled together many of these organizations and established the Energy Storage Integration Council (ESIC) to advance the deployment and integration of energy storage systems through open, technical collaboration. There are working groups that work to develop and publish relevant documents and online resources. These publicly available guides, tools, and templates support energy storage integration and deployment. They are designed with the collective input from industry stakeholders participating in ESIC and are periodically updated based on user feedback. The documents include the following and are available to download from the ESIC website:[23]

- A Guide to ESIC: The Energy Storage Integration Council
- ESIC Energy Storage Implementation Guide
- Summary of Energy Storage Control Performance Metrics
- ESIC Energy Storage Operation and Maintenance Tracking Tool
- ESIC Energy Storage Request for Proposal Guide
- ESIC Energy Storage Technical Specification Template, v3.0
- ESIC Energy Storage Test Manual
- Electrical Energy Storage Data Submission Guidelines, Version 2
- ESIC Energy Storage Reference Fire Hazard Mitigation Analysis
- ESIC Energy Storage Safety Incident Gathering and Reporting List
- ESIC Energy Storage Modeling Bibliography
- Standard
- ESIC Energy Storage Commissioning Guide
- ESIC Energy Storage Cost Template and Tool v2.0
- Energy Storage Safety: 2016
- DERVET and supporting documentation
- StorageVET and supporting documentation

[23] ESIC website, https://www.epri.com/pages/sa/epri-energy-storage-integration-council-esic

4 R&D ROAD MAP AND PLAN

4.1 Objectives of the R&D Plan

The near-term objective of the ATWG is to establish a sustainable working group and R&D program to help ensure that the T&D systems in New York can support the achievement of CLCPA goals. The ATWG will leverage its R&D program to create a standard approach for technology R&D that will focus on DLR, PFC, and energy storage technologies in the near term and extend into other areas over time in aligning its objectives with those of the State (Table 3). The working group acknowledges that solutions are commercially available in each of these areas and may have the potential, in specific applications, to help unlock additional capacity from delivery infrastructure while maintaining grid reliability. The most significant near-term challenges will be assisting utilities in identifying the use cases for these technologies and cost-effective applications.

In each area, the capabilities of the technologies have been demonstrated, and commercially available technologies indicate the potential for adoption in targeted applications. However, experience has shown that comparing the performance and functionality of different technologies and configurations can be challenging. Some technologies are better suited to specific applications where they are cost-effective. We see this challenge in DLR, PFC, and energy storage technologies.

Since these technologies can increase the capacity and utilization of existing T&D infrastructure, they may be considered alternatives or complementary to investments in new infrastructure. Existing planning, investment, market, and recovery models may need to be adjusted to evaluate the use of these new technologies.

Table 3. Objectives

New York State Objectives	ATWG Objectives
• Develop and integrate GW of renewable energy. • Maximize existing transmission capacity by reducing or eliminating T&D capacity bottlenecks that limit the generation and use of renewable energy. • Increase T&D system utilization and throughput (reduce congestion).	• Encourage a streamlined approach to technology adoption. This includes understanding the functionality and capabilities of each technology and how best to apply different solutions. • Support the evaluation and comparison of different technologies and solutions. • Facilitate information sharing, collaboration, and standardization among New York stakeholders that reduces duplication of effort and accelerates learning and deployment. • Focus on areas where T&D are integrated or must be coordinated. • Align with the CGPP and its recommendations.

4.2 Timeframe

We envision the longer-term roadmap covering the next ten years (Table 4). However, the initiatives identified in this plan are scheduled to occur in the near-term and medium-term.

Table 4. Timeframe for activities and objectives

Period	Activities and objectives
Near Term (2022-2023)	• Establishment of the ATWG R&D program • Development of business case, application guides, integration best practices for priority technologies
Medium Term (2024-2026)	• Pilots and demonstrations for emerging and innovative technologies
Longer Term (2027-2031)	• Acceleration of technology deployment at larger scales

Utilities will continue to evaluate and adopt advanced technologies under existing programs in parallel with ATWG R&D activities. The ATWG will look for opportunities to coordinate its activities with member utilities where appropriate.

4.3 Near-Term R&D Program Initiatives

R&D initiatives presented here are focused on establishing the ATWG R&D program, supporting program management and reporting, and beginning work on technology scouting and assessment related to the top priority technology areas. The near-term (2022-2023) focus of technology scouting and evaluation will be on DLR, PFC, and energy storage technologies. The ATWG may elect to continue work in these areas in 2024 and beyond and expand into other advanced technology areas in need of R&D. The following are initiatives that the ATWG expects to pursue in the next three years. We will refine these plans later in 2022 and create a supporting budget.

Table 5. R&D program initiatives and milestones

Initiatives	Timeframe
Establish program governance and funding	Q3-Q4 2022
Program management and reporting	Ongoing
Technology Scouting and Assessment (DLR, PFC, energy storage)	Q3 2022 – Q4 2023
Establish AGILe technology evaluation approach	Q3-Q4 2022
Develop “Challenge” solicitations for DLR, PFC, energy storage	Q3-Q4 2023
Develop GET compensation models	Q3-Q4 2023
Milestones	**Timeframe**
R&D Plan Report submitted	Q3 2022
Coordinate and align with CGPP	2023 - 2024
Program Review	Annual

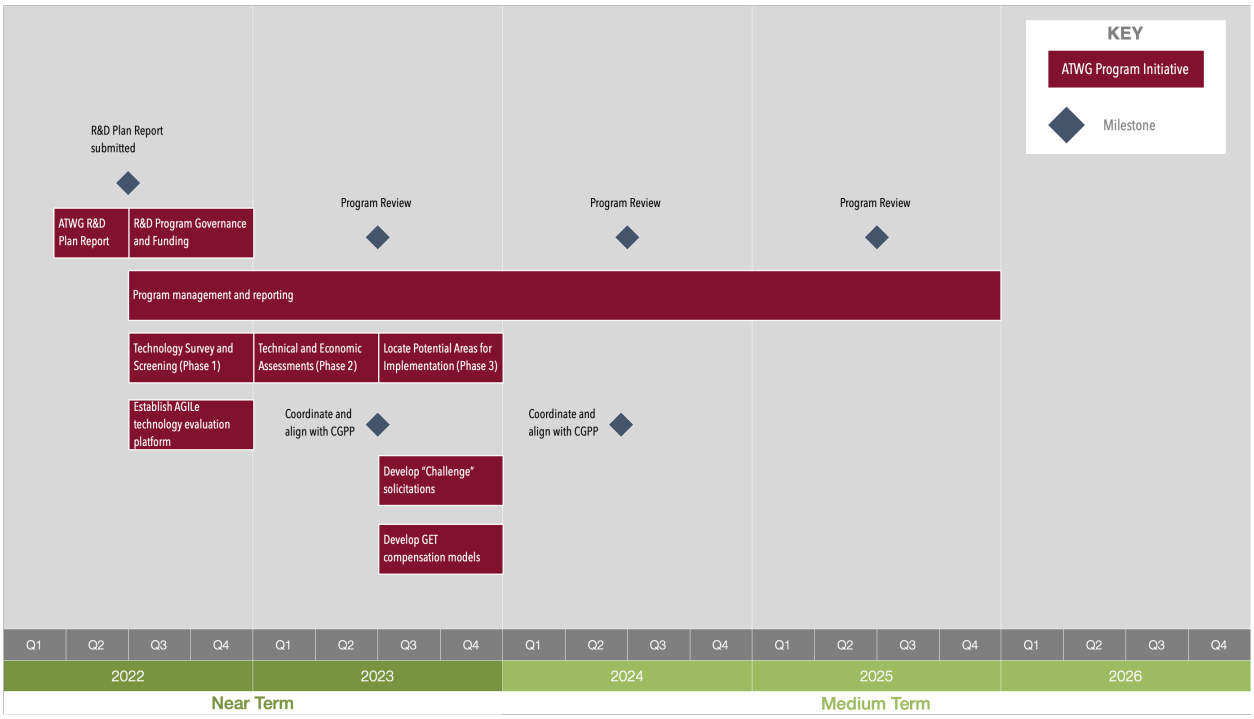

Figure 6. 5-year roadmap – ATWG Program Initiatives

APPENDIX A – PROJECT DETAILS

ATWG Program Development and Support

Project Name	**ATWG 1.0** - R&D Program Governance and Funding
Objectives	Establish a sustainable R&D program that can achieve strategic objectives over the next ten years
Activities	Develop program governance model with review and acceptance by ATWG members Develop funding model and budget with review and acceptance by ATWG members
Team	TBD
Timeframe/Duration	6 months
Deliverables	Governance agreement; Funding agreement
Input Projects	None
Output Projects	ATWG 2.0

Project Name	**ATWG 2.0** - Program Management and Reporting
Objectives	Ensure that program activities are prudently managed, and that progress toward program objectives are clearly documented and reported to funding organizations and program stakeholders
Activities	• Coordinate ongoing program activities • Develop periodic progress reports including project and program status and budgets • Facilitate stakeholder engagement and inputs, including participation in periodic program reviews
Team	TBD
Timeframe/Duration	Ongoing
Deliverable	Status reports and program review materials
Input Projects	ATWG 1.0
Output Projects	None

Technology Scouting and Assessments

The ATWG recommends a three-stage approach for identifying beneficial emerging technologies that could be applied to reducing T&D constraints. The outcome of this approach is to deliver technology evaluation and application guidance for T&D planners and engineers as they consider alternative solutions. This activity would be coordinated and aligned with the ongoing CGPP in New York. All three technology focus areas are involved (DLR, PFC, and energy storage).

Project Name	**ATWG 3.1** - Technology Survey and Screening (Stage 1)
Objectives	Understand the technology landscape and the best opportunities to advance Grid Enhancing Technologies (GETs) in each focus area
Activities	• Tabulate the attributes for each GET • TRL, commercial maturity • Grid services the GET can provide • Capital and O&M costs • Any constraints or issues need to be considered?
Team	Consultant
Timeframe/Duration	3-6 months (Q3-Q4 2022)
Deliverable	Report
Input Projects	None
Output Projects	ATWG 3.2

Project Name	**ATWG 3.2** - Technical and Economic Assessments (Stage 2)
Objectives	Identify the most technically and economically feasible solutions
Activities	• Select top 2 to 3 products from each GET type (DLR, PFC, energy storage) for evaluation • Assess performance through simulation or lab demonstration (e.g., AGILe) • The economic assessment compares the annual requirement of GET solutions versus that of traditional solutions
Team	Consultant; AGILe
Timeframe/Duration	3-6 months (Q1-Q2 2023)
Deliverable	Report
Input Projects	ATWG 3.1
Output Projects	ATWG 3.3

Project Name	**ATWG 3.3** - Locate Potential Areas for Implementation (Stage 3)
Objectives	Identify high value locations in which priority solutions can be demonstrated
Activities	Use the transmission solution set in Final CGPP Report Identify greatest opportunities for production cost savings and revenue requirement savings
Team	Consultant; production cost simulation
Timeframe/Duration	3-6 months (Q3-Q4 2023)
Deliverable	Report
Input Projects	ATWG 3.2
Output Projects	ATWG 5.0

AGILe Evaluation Platform

Project Name	**ATWG 4.0** - Establish AGILe technology evaluation platform
Objectives	Create a testing and demonstration facility where grid technologies can be evaluated
Activities	Establish NYPA's AGILe lab as a testing and demonstration facility where advanced technologies are vetted and evaluated before they are selected and deployed in the field.
Team	NYPA AGILe and other organizations as necessary
Timeframe/Duration	3-6 months (Q3-Q4 2022)
Deliverable	Report
Input Projects	None
Output Projects	ATWG 3.3

Pilots and Demonstrations

Project Name	**ATWG 5.0** – Develop "Challenge" solicitations
Objectives	Solicit multi-year pilots and demonstrations with host utilities
Activities	TBD
Team	NYSERDA; Consultant (?)
Timeframe/Duration	3-6 months (Q3-Q4 2023)
Deliverable	Report
Input Projects	ATWG 3.3
Output Projects	Pilots and demonstrations for DLR, PFC, and Energy Storage

APPENDIX B – ELECTRIC POWER RESEARCH INSTITUTE (EPRI) SUPPORT OF ATWG

EPRI conducts research, development, and demonstration projects to benefit the public. As an independent nonprofit organization for public interest energy and environmental research, it focuses on electricity generation, delivery, and use in collaboration with the electricity sector, its stakeholders, and others to enhance the quality of life by making electric power safe, reliable, affordable, and environmentally responsible. The EPRI team has a broad set of skills directly applicable to the primary objectives of the ATWG, including expertise in T&D modeling and simulation, application of advanced technologies, and technology assessment. The ATWG and NYSERDA engaged EPRI in 2020 to support the "Utility Transmission and Distribution Investment Working Group" report issued in November 2020. EPRI developed potential solution summaries for the highest prioritized technology categories, including an overview of their technologies, key application considerations, commercial readiness level, vendor landscape, and field/lab testing experience.

EPRI has been a technical resource to the Interconnection Technical Working Group (ITWG) since its creation in 2016, providing significant experience with a working group similar in structure to the planned ATWG. Although the scope and stakeholder group of the ATWG will be different from the ITWG, the ITWG approach can be leveraged in building the ATWG, as the Order noted. In general, it is envisioned that EPRI will support the ATWG in a broad set of areas during both the implementation of the R&D plans and while the plan is executed:

- Actively participate in meetings and facilitate the connection with ITWG activities.
- Provide documentation and presentations on relevant past and ongoing research.
- Perform assessments of current modeling practices and identification of modeling gaps/needs.
- Support the performance of laboratory experiments in conjunction with AGILe and other venues.
- Perform steady-state, dynamic, and transient T&D system studies that help identify future needs and prioritize the R&D efforts
- Conduct EPRI member surveys to understand current technology state of the art
- Support the engagement with commercial vendors that allows for critical evaluation of technology solutions
- Provide unbiased evaluations of technology solutions
- Develop modeling techniques and tools that enable both technical and economic evaluation of advanced technology solutions

To further demonstrate the applicability of the ATWG effort to recent and ongoing EPRI activities, below are several EPRI past and ongoing activities relevant to the technologies specifically called out in the DPS Order.

- EPRI is actively involved in assessing the impacts of DLR technologies and the impacts of FERC Order 881
- EPRI has a current NYSERDA project involving an EPRI-developed tool (CPLANET 2.0) that evaluates the costs and benefits of PFC technologies in the 2035 New York system with 9 GW of offshore wind.
- EPRI recently completed a study with a New York utility that identified locations of value for energy storage deployment. Storage "use cases" were identified for transmission deferral, wind curtailment mitigation, and market services.
- EPRI has developed planning tools (DER-VET) and methods for evaluating energy storage applications in electric T&D systems
- The EPRI Integrated Strategy System Planning (ISSP) Board initiative aimed at developing an end-to-end integrated planning process covering expansion planning to distribution system modeling. The New York system is being used as a case study to prove out the process.

APPENDIX C – NYPA AGILE CAPABILITIES

Advanced technologies typically include an inherent risk of not meeting expectations or even failure. Therefore, their results and effectiveness are not guaranteed until thoroughly tested and evaluated. A crucial impediment to adopting new technologies in the electric power industry lies in the difficulty of deploying them in the field, as this is typically time-consuming, complicated, and risky. Thus, given reliability constraints, electric utilities are reluctant to implement pilots, let alone broader deployments, unless the technology is proven and mature. At the same time, most academic research and development is typically performed using simplistic models and synthetic data. Therefore, a disconnect exists between what is theoretically developed by research entities and what is applied in practice, leading to long lead times for a new idea to find its way to commercial implementation.

The current analytical and off-line simulation tools cannot precisely assess the impact of advanced technologies on the operation of the electric power grid. To help remove this barrier, NYPA's Advanced Grid Innovation Laboratory for Energy (AGILe) has built and maintains accurate and realistic models of the electric power grid of New York and creates testbeds researchers can use to demonstrate their technologies under conditions that are as close as possible to actual field conditions, without the time, complexities, costs, and risks of actual field implementation. This approach de-risks such new technologies for the electric utilities, which can now more confidently proceed to field pilots and field installations after having set up and extensively tested new apparatus and algorithms in a realistic lab environment.

AGILe's collaborative model with the engagement from all New York utilities and the NYISO, as opposed to the single-entity lab model, provides a unique opportunity for achieving such goals. AGILe also focuses on two other vital capabilities: modeling and simulation of communication systems and cyber security events and production cost modeling and analysis. The first is implemented via a commercial-grade network emulator and provides a versatile environment that allows a more realistic representation of cyber-physical systems. It enables the evaluation and testing of grid monitoring and control schemes considering the performance of the supporting communication network by co-simulating the network along with the power grid. The latter depends on a small-scale high-performance computing (HPC) implementation of production cost simulation software and is intended as a means of economic evaluation of new technical solutions, allowing AGILe to assess not only the engineering but also the economic impact of new technologies on the grid.

AGILe is also equipped with more traditional offline grid simulation and data analysis tools providing cutting-edge capabilities for research, analysis, and development in the electric power industry. AGILe is being operated in close collaboration with the Electric Power Research Institute (EPRI) and is being leveraged as a resource by several EPRI projects. In addition, AGILe has established partnerships with a variety of academic institutions, both in New York and nationwide, other research organizations and laboratories (such as National Labs, including the Brookhaven National Lab and the National Renewable Energy Lab), as well other utilities and vendors (e.g., EirGrid and ESB of Ireland).

AGILe is participating in active research projects with all these partners. Electric utilities increasingly view research labs as valuable assets for helping to plan and prepare for the fast-changing landscape of the electricity industry. AGILe's vision includes more than a lab's technical and engineering aspects. It also seeks to create a collaborative research environment that brings people from utilities, academic institutions, technology vendors, and research organizations together to work on shared challenges and opportunities to improve the electricity grid's performance, effectiveness, and efficiency.[24]

Since its establishment, AGILe has not only successfully allowed engineers to test emerging technologies on a digital grid model before putting them into the real world, but the lab has also fostered many industry-first collaborations.

In sum, the value of AGILe lies in its vision that the lab can:

- Support specialized grid studies with powerful modeling and simulation tools, which are not typically done as part of routine processes.
- Offer a variety of modeling, simulation, and analysis tools, including leading real-time grid simulation systems (RTDS and OPAL-RT) for realistic hardware- and software-in-the-loop testing and equipment demonstration before field deployment.
- Utilize actual data and models to provide realistic and flexible test beds to accelerate the development, adoption, and commercialization of new technologies at both transmission and distribution levels or within microgrids.
- Present an industry and collaborative academic environment to leverage technical capabilities and expertise from diverse participants.
- Offer "one-stop shopping" for external entities (including researchers, vendors, or other technology providers) with participation from all New York stakeholders for accelerated research, development, and deployment opportunities in New York.

[24] [https://www.nypa.gov/news/press-releases/2020/20200203-agile-simulations-ensure-grid-reliability] [https://www.nypa.gov/news/press-releases/2019/20190313-agile] [https://transformers-magazine.com/tm-news/nypas-agile-lab-speeds-up-smart-grid-innovation/] [https://www.utilitydive.com/news/nypa-to-create-realtime-simulation-model-of-new-yorks-transmission-system/532589/] [https://www.tdworld.com/grid-innovations/smart-grid/article/21133342/nypas-agile-lab-speeds-up-smart-grid-innovation] [https://www.publicpower.org/periodical/article/nypa-with-epri-test-digital-grid-technology-laboratory] [https://cfes.rpi.edu/news/07252019-1836/nypa-and-rensselaer-lab-collaboration-research-cleaner-grid-technologies] [https://www.automation.com/en-us/articles/november-2020/clarkson-university-ny-state-effect-wind-farms]