AMERICAN PUBLIC POWER ASSOCIATION
Powering Strong Communities

PUBLIC POWER ENERGY STORAGE MATURITY MODEL

FRAMEWORK REPORT

DECEMBER 2023

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The American Public Power Association is the voice of not-for-profit, community-owned utilities that power 2,000 towns and cities nationwide. We represent public power before the federal government to protect the interests of the more than 49 million people that public power utilities serve, and the 96,000 people they employ. Our association advocates and advises on electricity policy, technology, trends, training, and operations. Our members strengthen their communities by providing superior service, engaging citizens, and instilling pride in community-owned power.

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EXECUTIVE SUMMARY

This report details the development of the Public Power Energy Storage Maturity Model (PP-ESMM or maturity model). The maturity model was developed as a tool to empower the public power community to effectively plan for and deploy energy storage projects. The maturity model was sponsored by the American Public Power Association under a cooperative agreement with the Department of Energy.

The maturity model comprises a set of interconnected tools, including predefined questions, cloud-based forms, and linked spreadsheets. These tools enable public power utilities to conduct assessments, which to date have been administered via facilitated, structured conversations, to determine the degree to which the utility is capable of successfully planning and executing energy storage projects. The results of the maturity model assessments offer insights to guide public power utilities toward implementing improvements in their energy storage planning, execution, and management capabilities.

Development of the maturity model began in November 2022. Its development, testing, and refinement have been performed in conjunction with the APPA Energy Storage Working Group. To date, ten assessments have been conducted across seven participating public power utilities.

Feedback received from participating utilities suggests that the maturity model is a useful tool that provides actionable insights to public power utilities with an interest in deploying energy storage technologies. Participants suggested a variety of means by which the assessment tool could be improved. The most significant suggestions have already been implemented into an enhanced version.

Moving forward, the maturity model will undergo further refinement to provide more actionable recommendations to utilities in response to the answers provided to key questions during the assessment. In addition, it is recommended that capabilities be developed to allow utilities to conduct assessments autonomously.

INTRODUCTION

The Public Power Energy Storage Maturity Model is a tool to assist public power utilities in planning and deploying energy storage projects.

Importance of Energy Storage for Public Power

Energy storage refers to the capture and retention of energy for later use. It plays a crucial role in modern energy systems, providing numerous benefits that contribute to a more sustainable, reliable, and efficient energy landscape. Public power grid operators responsible for generation, transmission, and/or distribution of electricity are increasingly looking to energy storage as a key element in supporting the transition to a clean energy future. However, those responsible for safe and reliable grid operations must first assess how prepared they are to adopt and fully maximize the benefits of energy storage as part of their operations. Maximizing the benefits of these investments is especially important for small or medium public power utilities, as smaller capital budgets require efficient expenditures.

American Public Power Association members are in the midst of implementing ambitious efforts to curb greenhouse gas emissions within the electric sector while preserving the affordability and reliability of electricity for customers. Public power utilities have already made significant strides in this effort, including embracing lower emission generating resources, investing in renewables, integrating distributed energy resources, and implementing energy efficiency programs. Moreover, they are actively championing transportation electrification by deploying charging infrastructure, offering electric vehicle rebates, and introducing rate structures that incentivize off-peak charging. Beyond this, some public power utilities are spearheading efforts to further reduce emissions by promoting the electrification of energy end-uses, such as water and space heating, which have historically been reliant on onsite fossil fuel combustion. These approaches underscore the commitment of the public power community to sustainability and reducing its environmental footprint, and energy storage can support the success of these efforts.

Energy Storage Benefits for Public Power

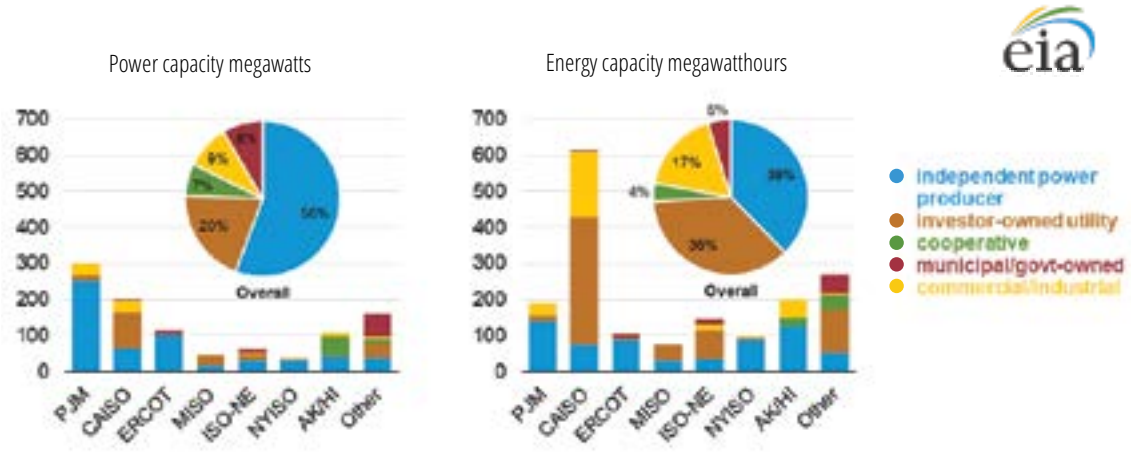
The potential benefits of deploying energy storage are numerous. The primary anticipated benefits include:

- **Grid Stability and Reliability:** Energy storage systems can store excess electricity generated during periods of low demand and release it during peak demand, thereby reducing strain on the grid. This helps to balance supply and demand, mitigate power fluctuations, and avoid blackouts or brownouts. Energy storage systems can contribute to critical grid functions such as black start, ensuring swift power restoration after blackouts; voltage support, maintaining consistent voltage levels; frequency regulation, responding to frequency deviations for stable electric distribution; and can serve as spinning and non-spinning reserves, providing immediate energy access to maintain grid reliability. By optimizing the use of energy storage systems, particularly in managing peak demand, utilities can potentially defer the need for immediate infrastructure upgrades to enhance the overall stability and reliability of the grid.
- **Renewable Integration:** Renewable energy sources like solar and wind often have intermittent or variable output, which can be challenging to manage, as the optimal times for production often do not coincide with peak demand. Energy storage allows for increased integration of intermittent renewable energy sources by storing any excess energy produced during times of high

production to be used when generation is low. Thus, storage systems enable a more consistent and predictable energy supply and allow for more value to be extracted from renewable sources. This promotes the widespread adoption of renewable energy and reduces reliance on fossil fuels, resulting in reduced greenhouse gas emissions and a cleaner energy mix.

- **Demand Management and Load Shifting:** By engaging in energy arbitrage, which involves storing electricity during off-peak hours (when prices are low) and discharging it during peak demand periods (when prices are high), energy storage systems can help optimize energy usage and reduce costs. These reduced costs translate into lower electric bills for customers. This approach, known as peak shaving or load shifting, can also alleviate strain on the grid during peak periods, leading to more efficient utilization of existing infrastructure.
- **Resilience in Withstanding Disruptive Events:** Energy storage also enhances the resiliency and reliability of decentralized energy systems. In remote or isolated areas, energy storage systems can provide backup power during outages or disruptions, ensuring continuous energy supply. They can also support microgrids, allowing communities or facilities to operate independently from the main grid if necessary. This improves energy security and allows for continued provision of critical services during natural disasters or other emergencies.
- **Promoting Clean Transportation:** Energy storage can support the growth of EVs by mitigating the demand for EV charging. By absorbing excess electricity from renewable sources and supplying it to charging stations, large-scale energy storage systems can help offset demand charges and minimize the necessity for extensive grid upgrades. Reliable charging experiences that minimize impacts on the rest of the grid encourage EV adoption, which in turn accelerates the transition to a cleaner transportation sector.

Figure 1. EIA Reporting on Energy Storage Deployments by Utility Type



Source: U.S. Energy Information Administration, 2019 Form EIA-860, *Annual Electric Generator Report*

The Benefits of an Energy Storage Maturity Model

A 2021 report by the United States Energy Information Administration (EIA) shows that energy storage deployments continue to exhibit rapid growth in the U.S.[1] Figure 1 shows that public power utilities collectively represented 5% of the energy storage projects deployed in the U.S. in 2019. Notably, this EIA data reflects energy storage by ownership and therefore does not capture public power energy storage projects executed through purchase power agreements. Historically, public power utilities could not take advantage of energy tax credits and therefore often partnered with third parties on renewable energy and energy storage projects.

APPA developed its Energy Storage Working Group (ESWG) to empower public power utilities in successfully deploying energy storage technologies. The maturity model is a tool to assist public power utilities in planning for storage projects, and in better understanding the potential impacts that storage projects may have on their organizations, on the electrical systems they manage, and on their organization's finances.

1 www.eia.gov/analysis/studies/electricity/batterystorage/pdf/battery storage_2021.pdf

Creating the Maturity Model

The PP-ESMM stemmed from discussions between APPA and the U.S. Department of Energy on the necessity of a tool that could assist the public power community in planning and executing energy storage initiatives. Consequently, APPA and DOE entered a cooperative agreement to support the development of this maturity model. The model was developed through a combination of an extensive analysis of literature reviews and research into strategies and technical innovations within the public power sector, including battery energy storage systems.[2–4]

The insights gained from this research informed the creation of the comprehensive maturity framework described in this report, ultimately facilitating informed decision-making for public power utilities at all stages of energy storage project development. A technical approach was employed, involving a review of maturity models in other industries and application areas, a review of published research on energy storage project development, and direct engagement with members of the ESWG to ensure the model's effectiveness and relevance to community-owned electric utilities.

2. www.dammaturitymodel.org

3. www.energy.gov/CESER/cybersecurity-capability-maturity-model-c2m2

4. https://trn.pnnl.gov

OVERVIEW AND DESCRIPTION

This chapter describes the structure of the public power energy storage maturity model, including the rationale for using a maturity model in public power and the various aspects of the tool.

Definition of a Maturity Model

A maturity model is a tool that assesses a set of characteristics, attributes, indicators, or patterns that represent capability and progression in a particular discipline. It provides a benchmark against which an organization can evaluate the current level of capability of its practices, processes, and methods and set goals for improvement. Using a widely applied model in a particular industry provides assessment results that can be anonymized and shared so that organizations can compare their operations with similar organizations. Likewise, with sufficient inputs, a maturity model can make inferences about the maturity of a group or class of industry members.

Importance and Benefits of a Maturity Model

The benefits of using a maturity model are numerous and can positively affect an organization's ability to achieve its goals. Key advantages include:

- **Assessment and Benchmarking:** A maturity model allows organizations to assess their current capabilities. It provides a structured approach to evaluating processes, practices, and performance, offering insights into strengths, weaknesses, and areas for improvement. By benchmarking against industry standards or best practices, organizations can identify gaps and develop strategies to enhance their performance.
- **Roadmap for Improvement:** A maturity model provides a clear roadmap for organizations to progress to a desired future state. The model's defined maturity levels act as milestones, guiding organizations through a logical progression of development. This roadmap helps prioritize improvement initiatives and facilitates informed and strategic decision-making, enabling organizations to effectively allocate resources.
- **Goal Setting and Alignment:** A maturity model assists organizations in setting specific, measurable, achievable, relevant, and time-bound (SMART) goals. By defining the desired maturity level and associated criteria, organizations can align their objectives with the model's framework. This alignment ensures that efforts are directed towards meaningful improvements and that progress can be tracked and effectively monitored.
- **Continuous Improvement:** A maturity model promotes a culture of continuous improvement within organizations. As they advance through the maturity levels, organizations are encouraged to regularly evaluate their processes, adopt best practices, and innovate. The model provides a structured approach to identify areas of improvement, fostering a mindset of learning, adaptability, and growth.
- **Communication and Collaboration:** A maturity model facilitates communication and collaboration within organizations. It provides a common language and framework for discussing capabilities, maturity levels, and improvement initiatives. This shared understanding fosters collaboration across teams and departments, enabling the exchange of knowledge, best practices, and lessons learned.
- **Stakeholder Engagement:** A maturity model can engage stakeholders at various levels within an organization. By involving key stakeholders in the assessment and improvement processes, organizations can create a sense of ownership, buy-in, and commitment. Stakeholders become

active participants in driving change and ensuring that improvements are sustained over time.

- **Performance Measurement:** A maturity model enables organizations to measure their progress and track their performance over time. By assigning specific metrics or indicators to each maturity level, organizations can quantitatively measure their capabilities and identify trends or patterns. This data-driven approach facilitates informed decision-making and enables organizations to demonstrate their progress to internal and external stakeholders.

Purpose of the Public Power Energy Storage Maturity Model

The PP-ESMM is a comprehensive assessment of the maturity and ability of community-owned utilities to implement energy storage projects. The model evaluates the readiness of utilities to effectively manage energy storage solutions throughout the entire lifespan of the assets. This entails a thorough examination of a utility's preparedness to adopt, implement, and oversee energy storage initiatives. The PP-ESMM provides a holistic view of the degree to which a utility demonstrates key aspects for a successful energy storage journey. It assesses not only the initial preparedness of the utility, but also the long-term sustainability of managing energy storage assets. This model allows utilities to better understand their readiness to plan, deploy, operate, and maintain energy storage assets and related programs..

Clarifying the Scope

The primary focus of the PP-ESMM is on the utility's organizational maturity, processes, and capabilities in adopting energy storage solutions. The PP-ESMM does not delve into the technical aspects of specific energy storage technologies, nor does it conduct a comparative evaluation of the various types of energy storage solutions available in the market.

User Expectations

When interacting with the PP-ESMM, users can expect an assessment of their utility's readiness to adopt energy storage solutions. This assessment highlights areas of strength and identifies gaps that may require attention. More importantly, the model offers actionable guidance, outlining specific steps and initiatives to effectively bridge these gaps. It equips an organization with a roadmap for improvement, allowing it to take informed actions to enhance energy storage capabilities.

Furthermore, the PP-ESMM is not a static assessment, but an evolving tool. It provides means for validation and reassessment as organizations progress on their energy storage journey. This approach ensures that maturity growth can be continually tracked, and necessary adjustments can be made over time, aligning organizational efforts with the dynamic energy industry. The PP-ESMM empowers organizations to embark on a transformative path toward energy storage adoption with confidence and a clear strategy for success.

Model Structure

The PP-ESMM is an analytical model that can be applied using a set of interconnected tools, including cloud-based forms and spreadsheets. This section of the report describes the model and the tools used to practically apply the model.

The Four Domains

The PP-ESMM evaluates maturity across four domains:

- Solution development
- System impacts
- Organizational changes
- Project economics

Table 1. The Maturity Model Framework

Structure of the PP-ESMM				
Domains	Solution Development	System Impacts	Organizational Changes	Project Economics
Structured Inquiries	Questions for Exploration Questions for Evaluation	Questions for Exploration Questions for Evaluation	Questions for Exploration Questions for Evaluation	Questions for Exploration Questions for Evaluation
Results	Maturity Level Assessments Recommendations for Improvement			

The model presents two sets of questions within each domain: questions for exploration and questions for evaluation. The exploration questions are designed to provoke verbal conversation among employees of a utility. After the conversation concludes, the employees then use a set of cloud-based tools to answer the questions for evaluation. The tools include embedded calculations that produce maturity level assessments for the utility, based on the evaluation responses provided by its employees. Table 1 shows the overall structure of the maturity model.

The maturity level assessments are provided on a scale that ranges from M1 to M4, as described in the Maturity Model Scale section. The maturity model produces a score for each of the four domains, and an overall score for the utility.

Structured Inquiries within the Maturity Model

The maturity model includes questions for exploration and for evaluation as a part of each domain. The exploration questions were designed to prompt focused discussion relevant to the important aspects of each domain. The assessment questions are designed to enable quantitative evaluation of the utility's maturity level, based on the responses provided by its employees.

Table 2 shows the inquiries developed for the **solution development** domain. These questions focus on why an organization is exploring the use of energy storage, and the plan it will implement for developing a solution.

Table 2. Inquiries Developed for Domain 1: Solution Development

Questions for Exploration	Questions for Evaluation
What problem are you seeking to resolve using energy storage?	To what extent does your organization have a clear and unified perspective on how energy storage will be used?
What other technical alternatives are available? In what ways are they similar / different? Better / worse?	To what extent has that perspective been communicated throughout the organization?
What benefits do you expect to receive from implementing an energy storage system?	To what extent does your organization possess a clear plan for realizing its energy storage vision?
What storage capacity do you require for your use case? What are the other critical operating parameters for your application?	To what extent does your organization's energy storage plan contain appropriate goals, metrics, targets, and timelines?
Which storage technologies are able to perform adequately for the use case that you intend?	To what extent does your organization possess a clear process for identifying energy storage solutions for relevant problems that emerge?
What companies / vendors / contractors are able to design, procure, install, maintain, and service the intended solution?	To what extent is energy storage embedded into your organization's technology roadmap (or equivalent)?

Table 3 shows the inquiries developed for the **system impacts** domain. These questions focus on the potential impacts that energy storage may have on the utility's broader electrical system, and the plan the utility has in place for understanding and addressing those impacts.

Table 3. Inquiries Developed for Domain 2: System Impacts

Questions for Exploration	Questions for Evaluation
Will implementation of the energy storage system (ESS) require you to make other upgrades or changes to your electrical infrastructure?	To what extent does your organization have a clear and unified understanding of the impacts of energy storage technologies on other electrical infrastructure that you own or operate?
Will implementation of the ESS require you to change the way you operate other parts of your system?	To what extent has that understanding of impacts been communicated throughout the organization?
Does energy storage asset ownership or management impact the way that you plan for the future of your electricity network?	To what extent does your organization possess a clear plan for addressing the impacts of energy storage on the broader electrical system?
Does it change the way you perform resource planning, system studies, or any other planning efforts?	To what extent does your organization's infrastructure impact plan contain appropriate goals, metrics, targets, and timelines?
	To what extent does your organization possess a clear process for incorporating energy storage system impacts into normal, periodic, infrastructure planning?

Table 4 shows the inquiries developed for the **organizational changes** domain. These questions focus on the potential impacts that an energy storage project may have on the internal structure and processes within the utility, including considerations for employment, training, leadership, and change management.

Table 4. Inquiries Developed for Domain 3: Organizational Changes

Questions for Exploration	Questions for Evaluation
In integrating ES into your organization, are there any workforce related changes that you need to make? This could include hiring employees, contracting with consultations, education and training initiatives, or other efforts.	To what extent does your organization have a clear and unified understanding of the impacts of energy storage planning, deployment, and management on its organizational structure and operations?
Will implementation of the ESS require any structural changes within your organization? For instance, creation of a new division or program, changes in leadership structure, etc.	To what extent has that understanding been communicated to all impacted parties?
Will changes be needed within your organization to ensure the long-term management of your ES assets?	To what extent does your organization possess a clear plan for addressing the anticipated organizational changes?
Who are the key stakeholders that need to be informed or aware of this effort as it progresses?	To what extent does your organization's change management plan contain appropriate goals, metrics, targets, and timelines
Who needs to provide approval? (e.g., local mayors, city councils, residents near our ESS project)	To what extent does your organization possess a clear process for incorporating energy storage system impacts into normal, periodic, organizational strategic planning?
Who within your organization will be involved in managing the various aspects of ES implementation?	

Table 5 shows the inquiries developed for the **project economics** domain. These questions focus on the potential financial impacts to the utility related to the deployment of energy storage. This section discusses potential costs, benefits, value streams, and financing considerations.

Table 5. Inquiries Developed for Domain 4: Project Economics

Questions for Exploration	Questions for Evaluation
Do you intend to use your ESS to participate in energy market operations? If so, can you describe how this will work?	To what extent does your organization have a clear and unified understanding of the financial implications of planning, deploying, and managing energy storage assets?
How do you intend to finance your energy storage project?	To what extent has that understanding of financial implications been clearly communicated to relevant and impacted parties?
Do you have access to any special programs, grants, or other mechanisms outside of your organization?	To what extent does your organization possess a clear plan for financially managing energy storage projects?
Do you expect your energy storage system to provide you with a positive economic return? If so, how have you modeled or projected this?	To what extent does your organization's energy storage financial management plan contain appropriate goals, metrics, targets, and timelines?
Do you plan to own, lease, or otherwise access the intended energy storage assets? What are the pros and cons of each scenario?	To what extent does your organization possess a clear process for incorporating energy storage financial planning into normal, periodic, budgeting and accounting?
Will any existing contracts or obligations (e.g., generation supply agreements) be impacted by your choice to implement an ESS?	

Maturity Model Scale

Table 6 describes the maturity level scales of the maturity model evaluation results. The maturity model assessment provides a score (M1 – M4) for each domain within the model, and also produces an overall score for each utility.

The maturity level definitions were updated over the course of the maturity model development effort. Originally, five maturity levels were included in the evaluation scale. The scale was redefined based on feedback from the ESWG members and the volunteers who participated in initial assessments. The Assessment Findings section of this report includes a comparison of the original and updated scales.

Table 6. Maturity Levels in the Energy Storage Maturity Model

Maturity Level	Description	Interpretation
M4	Very High Maturity Level	Activities are guided by policies. Responsibility, accountability, and authority are assigned. Effectiveness is evaluated and tracked.
M3	High Maturity Level	Practices are documented. Resources are provided to support practices.
M2	Low Maturity Level	Policies and practices are performed but may be ad hoc.
M1	Very Low Maturity Level	Policies are not in place. Practices are not performed. Procedures are not well understood.

MATURITY MODEL IMPLEMENTATION

Pilot assessments were conducted to test the effectiveness of the PP-ESMM in providing useful insights. APPA conducted outreach to members of its Energy Storage Working Group and identified several volunteer organizations to participate in these assessments.

Structure of the Assessments

Assessments were conducted as structured meetings with participating utilities. A total of seven utilities participated in seven separate meetings (one utility per session). Each utility volunteered a group of employees to participate in the meeting. Employees represented diverse aspects of the utility's business, including planning, finance, HR, and operations. An average of two utility employees attended each meeting, with up to four employees attending at most.

Each assessment was scheduled for 2.5 hours. The agenda was identical for each meeting, as shown in Table 7.

During each of the four 'domain discussion' sessions on the agenda, the meeting facilitator presented the relevant 'Questions for Exploration' to the utility personnel. All meeting attendees were provided an opportunity to give verbal feedback. The facilitator took notes on responses provided. The domain discussions provided a foundation for the evaluations.

Table 7. Agenda for the Initial Assessments

Schedule Item	Agenda (minutes)
Welcome and Overview	5
Introductions	10
Domain 1 Discussion	15
Domain 1 Evaluation	10
Break	5
Domain 2 Discussion	15
Domain 2 Discussion	10
Break	5

Schedule Item	Agenda (minutes)
Domain 3 Discussion	15
Domain 3 Evaluation	10
Break	5
Domain 4 Discussion	15
Domain 4 Evaluation	10
Break	5
Evaluation Results	5
Feedback	10

Using Cloud-Based Tools to Implement the Maturity Model

This section describes the cloud-based forms and spreadsheets used to collect responses from participating utility employees during assessments, and to enable automated scoring of maturity levels. The integration of cloud-based tools significantly streamlined the implementation process.

- **Electronic Form Templates:** Electronic evaluation form templates were developed using Google Forms. These templates were designed to capture all necessary information during the assessments. This shift to electronic forms simplified the data collection process.
- **QR Codes for Quick Access:** To further streamline access, a general QR code provided assessment participants with access to the evaluation form. A single QR code allowed all participants to access the needed evaluation form. By simply scanning the QR code with a smartphone or tablet, evaluators could instantly access and fill out the required forms. This approach eliminated the need for manual form distribution and retrieval.
- **Instructions for Evaluators:** To ensure proper use of the system, evaluators received clear instructions on how to access the evaluation form using the QR code. This included a brief tutorial on using the required cloud-based tools to complete and submit the form electronically. A user-friendly approach helped participants adapt to the process seamlessly.
- **Data Security and Privacy:** Emphasis on data security and privacy was paramount. Sensitive data, such as personal details, were stored securely within the cloud-based platform. Robust security measures and access controls were enforced to protect the confidentiality of participant data.
- **Real-Time Updates:** The cloud-based platform's features incorporated real-time updates, edits, and submissions. This ensured that assessments were evaluated quickly, making results available to utilities immediately upon submission by their employees. This also guaranteed that the latest version of the tool was always accessible.
- **Data Analysis and Reporting:** Leveraging the data analysis capabilities of the cloud platform, APPA generated reports and insights from the evaluation data. This data-driven approach allowed for a deeper understanding of the evaluation results, enabling informed decision-making and improvements.
- **Feedback Mechanism:** The evaluators were encouraged to provide feedback on the new cloud-based system and QR code access. This feedback loop drove continuous improvement, ensuring that the system remained user-friendly and aligned with the needs of the energy storage community.

Description of the Forms

The following section provides details on the major forms developed in implementing the PP-ESMM.

Utility Information Form

Prior to conducting an assessment, a representative from each participating utility was required to provide essential background information through the Utility Information Form. This information was crucial for gaining an understanding of the utility's context and characteristics. The questions within this form required short-answer, text-based responses, and covered:

- **Organization Name:** The official name of the utility/organization.
- **Location:** Details about the utility's physical location and service territory can include area in square miles, names of cities/towns served, latitude and longitude of service territory, or the utility's physical address.
- **Size:** Key metrics that define the utility's size, such as the number of employees, meter count, and annual revenue.
- **Customer Mix:** The composition of the utility's customer base, including the percentage breakdown of residential, commercial, and industrial customers.
- **Generation Characteristics:** The utility's generation capabilities, including installed capacity and the fuel or resource mix they rely on.
- **Non-electricity Services:** An outline of any non-electricity services the utility offers, such as gas, water, or broadband.

By collecting this foundational data, the Energy Storage Maturity Model ensures that the self-assessment process is tailored to each utility's unique context. This approach allows APPA to provide more targeted and actionable insights, ultimately assisting utilities in their journey toward effective energy storage adoption.

Participant Evaluation Form

During the scheduled assessments, evaluators were requested to provide essential information in the form of short answers. This information includes the evaluator's:

- Name
- Email address
- Organization
- Role within the organization
- Date
- Session number (assigned by the facilitator)

The Participant Evaluation Form also provided a mechanism for evaluators to answer the 'Questions for Evaluation' for each domain in the maturity model. The evaluation questions were slightly rephrased, to lend themselves to responses that adhered to the evaluation scale. Figure 2 is a screenshot from the evaluation form.

Figure 2. Screenshot from the Participant Evaluation Form

ASSESSMENT FINDINGS

This section reviews the major findings from conducting assessments using the PP-ESMM. These findings include recommended improvements to the model, some of which have already been implemented.

Table 8 shows the assessments conducted to test and validate the functionality and utility of the maturity model. Seven initial assessments were conducted. Based on the feedback received in these assessments and in meetings of the ESWG, improvements were made to the maturity model framework and implementation tools. After the changes were made, three reassessments were conducted to validate the new scoring method.

Table 8. Summary of Assessments Conducted

Session Number	Utility Name	Date	Time	Session Type
1	*Withheld for Privacy Purposes*	6/8/23	1030-1300MT	Initial Assessment
2	*	6/9/23	1200-1430CT	Initial Assessment
3	*	6/12/23	1230-1500ET	Initial Assessment
4	*	6/15/23	1230-1500CT	Initial Assessment
5	*	6/23/23	0930-1200ET	Initial Assessment
6	*	6/26/23	1400-1630ET	Initial Assessment
7	*	6/26/23	0900-1100ET	Initial Assessment
8	*	9/5/2023	1300-1330ET	Reassessment
9	*	9/13/2023	1100-1130ET	Reassessment
10	*	9/14/2023	1100-1130ET	Reassessment

Findings from the Initial Assessments

Table 9 shows the average scores from all seven of the initial assessments.

The scores for the initial assessments were produced using the original scoring framework, with five maturity levels, as indicated in Table 10.

In the original design, a maturity level of M3 corresponded to an evaluation response of 'Neither agree nor disagree.' However, reflections from evaluators revealed that individual respondents interpreted this response differently. Respondents were asked to provide an explanation for choosing this particular response.

Table 9. Results from the Initial Assessments

	Total Points Earned	Total Points Possible	Percentage Earned	Questions in Category	Maturity Level
Solution Development	18.25	30	60.83%	6	M3
System Impacts	14.00	25	56.00%	5	M2
Organizational Changes	16.50	25	66.00%	5	M2
Project Economics	18.00	25	72.00%	5	M3
TOTAL	66.75	105	63.57%	21	M2

Table 10. Original Maturity Level Scoring Methodology

Maturity Level	Interpretation	Corresponding Evaluation Response
M1	Very low maturity level	Strongly disagree
M2	Low maturity level	Disagree
M3	Moderate maturity level	Neither agree nor disagree
M4	High maturity level	Agree
M5	Very high maturity level	Strongly agree

Below is a list of reasons that they provided:

- I honestly have no idea how to answer this question.
- I do not believe that I am the right person to answer this.
- I don't have sufficient information to answer this question right now.
- It is not critical / important that I answer this question.

Given the variety of reasons provided, the interpretation of M3 became unclear. Given that public power, on average, resided at a maturity level of M3, it become difficult to properly interpret the results of the assessments and attribute accurate meaning. As a result, a feedback session with the ESWG and many of the evaluators that conducted initial assessments was used to update the maturity model framework.

Feedback and Recommendations

On June 27, 2023, APPA hosted a meeting of the ESWG that also included individuals who had participated in the initial assessments. During this meeting, APPA elicited feedback on the maturity model structure and the assessment methodology. Table 11 summarizes the feedback from the meeting.

Table 11. Summary of Feedback from the June 2023 ESWG Meeting

- Removal of the 3 would be helpful – forcing a choice above or below the midpoint would be useful.
- Some 3s reflected uncertainty. Could've unintentionally inflated the score. Scoring low is not a bad thing. It's better to know that upfront.
- Prepare organization to understand that scores of 1s and 2s are not a bad thing. Rating your organization can be an eye-opener. Some divisions are ahead of others. Not a bad thing – opportunities for improvement.
- We interpreted 3 as a positive step in the right direction.
- Facilitation was really helpful. Facilitation as an option would be helpful for everyone. Some sort of guidance or documentation.
- Facilitation really helped, instead of a self-guided assessment. Gave time to think and then answer questions. Would have scored higher without facilitation.
- Tool will be helpful as we move toward energy storage strategic planning, considering where it will be in our portfolio moving forward.
- The tool helped us in evaluating first principles; helped us answer the question 'is energy storage something we want to invest in moving forward?'
- Framework was helpful for understanding what to consider and walk through.
- Would be great to score some questions more specifically, based on tangible steps. Have we talked to finance agencies, vendors? Have we performed assessments?
- The perspective seems to assume storage has not yet been applied. Awkward if you have deployed storage already.
- In hindsight, would have liked to have had more input from senior management.
- Will look to circulate results internally to various departments.
- Expected to better understand where we are. Strategic planning groups are generally optimistic.
- We still have room for improvement and bringing more stakeholders into the mix.

Revisions Introduced

In response to the need for a more precise evaluation process, the maturity scale was thoughtfully revised to span from M1 to M4. This adjustment eliminates the previously ambiguous rating of M3 (the 'neither agree nor disagree' responses) and encourages participants to provide clearer and more accurate assessments. This refined scale ensures that the evaluation process yields more valuable and actionable insights for both participants and the broader public power community. The revised scale is reflected in Table 6: Maturity Levels in the Energy Storage Maturity Model.

This updated maturity scale enhances the precision and clarity of assessments, allowing for more targeted guidance and support to public power utilities as they navigate the complex energy storage landscape. By refining the approach, the PP-ESMM ensures that it continues to be a valuable resource for community-owned electric utilities, contributing to the successful execution of their energy transition strategies.

Reassessments and Validation

Reassessments were conducted to validate the new scoring method. Three of the seven utilities who participated in initial assessments volunteered to participate in reassessments, utilizing the updated scoring methodology. Each reassessment lasted an average of 30 minutes.

Participants were provided with an updated evaluation form, which is shown in Figure 3. In the updated form, the option for 'Neither agree nor disagree' was no longer available. Instead, respondents had the option to either select a response from the checkboxes provided or to write in a short explanation for omitting a response to a particular question.

When providing responses during the reassessment sessions, participants were asked to place themselves in the mindset of their original assessment. It was recognized that some utilities might have made significant progress related to their energy endeavors during the time between their initial assessment and their reassessment.

However, participants were encouraged to ignore these changes, and score their reassessments based on their original rationale. The reassessment scores were then compared to the original assessment scores. Drawing on the observed relationships, an approach was developed to reinterpret the results for all seven initial assessments, converting scores from the original scale to the revised scale.

Figure 3. Screenshot from the Revised Participant Evaluation Form

Reassessment Scores

Table 12 shows the scores from the three reassessments conducted. The scores shown are based on the revised maturity scale (M1 – M4).

Table 12. Results from the Reassessment Sessions Held

	Total Earned	Total Possible	Percentage Earned	Questions in Category	Maturity Level
Solution Development	14.00	24	58.33%	6	2
System Impacts	11.50	20	57.50%	5	2
Organizational Changes	11.25	20	56.25%	5	2
Project Economics	13.00	20	65.00%	5	2
TOTAL	49.75	84	59.23%	21	2

Modified Scores

Researchers calculated modified scores from the initial assessments, using the revised maturity scale, for the three utilities that participated in the reassessments. Table 13 shows the modified results of their initial assessments, averaged across the three organizations.

When comparing the modified scores to the reassessment scores, it is seen that the modified scores tend to overestimate the points received in each category by an average of 1.7%. The modification process is assumed to be fairly accurate, based on this result.

Table 13. Modified Scores for Utilities Reassessed

	Total Earned	Total Possible	Percentage Earned	Questions in Category	Maturity Level
Solution Development	13.67	24	56.94%	6	2
System Impacts	11.75	20	58.75%	5	2
Organizational Changes	10.83	20	54.17%	5	2
Project Economics	12.67	20	63.33%	5	2
TOTAL	48.92	84	58.23%	21	2

Table 14 shows the modified scores for all seven of the initial assessments. As shown, the modified scores indicate an overall maturity level of M2 across the seven participating utilities. However, it is quite possible that this result is also overestimated by up to 1.7%. More reassessments would be needed to eliminate uncertainty in the translation between the two scales.

Table 14. Modified Scoring for All Initial Assessments

	Total Earned	Total Possible	Percentage Earned	Questions in Category	Maturity Level
Solution Development	15.35	24	63.96%	6	2
System Impacts	11.78	20	58.88%	5	2
Organizational Changes	11.35	20	56.74%	5	2
Project Economics	12.60	20	62.99%	5	2
TOTAL	51.07	84	60.80%	21	2

RECOMMENDATIONS

This section describes recommendations for the future development of the PP-ESMM.

Web Presence

It is recommended that APPA create a page on its website explaining the maturity model and allowing parties interested in conducting an assessment to contact APPA. The webpage could communicate assessment findings, including generalized benchmarks concerning public power's energy storage maturity.

Versions of the Maturity Model

Feedback from participating utilities validated the use of a facilitated assessment. Remarks from participants indicated that the presence and leadership of a facilitator during the assessment sessions greatly enhanced the experience and improved the quality of the results obtained. When considering the eventuality of the maturity model, it may not be practical to assume that a facilitator can be present to conduct all future assessments. It is recommended that a plan be implemented to provide self-assessment tools to the public power community. In particular, it is recommended that three versions of the PP-ESMM be developed. Table 15 outlines these potential versions.

Table 15. Recommended Variations of the Maturity Model Assessment

Version	Description
Short Self-Assessment	Consists of 2 – 3 questions per domain. Can be completed in less than 15 minutes. Only requires one person from an organization to complete. Provides a very high-level maturity assessment with recommendations. Used to develop initial interest and to prompt users to take next steps and schedule a more thorough assessment.
Facilitated Assessment	Consists of questions for exploration and questions for evaluation in each domain. Requires a commitment of 2.5 hours with a trained facilitator. Requires participation from multiple people within an organization. Provides a detailed maturity assessment with specific recommendations. Used to guide organizational decision making.
Full Self-Assessment	Consists of questions for exploration and questions for evaluation in each domain. Can be implemented in a flexible way, allowing for multiple, shorter meetings over a defined period (e.g., two weeks). Does not require the presence of a trained facilitator. Requires participation from multiple people within an organization. Provides a detailed maturity assessment with specific recommendations. Used to guide organizational decision making.

Enhancing Cloud-Based Tools

A suite of cloud-based tools was developed to support the initial deployment of the PP-ESMM. Moving forward, the following enhancements would greatly improve the effectiveness of the tool:

- **Utility Login:** It would be helpful if each participating utility had the ability to login securely and see the results of their assessments. This would include the ability to review responses submitted by individuals within the organization, and to review maturity level scores and recommendations.
- **Tracking:** Upon logging in to a secure portal, it would be helpful to allow utilities to track improvements, to see the results of all assessments that they have completed over time, and to see trends of their results.
- **Dashboard:** APPA would benefit from having a secure dashboard that aggregates the maturity level of the entire public power community, both at a given time and over time. This can be useful in understanding the assistance that public power may need to grow its effective use of energy storage. APPA can use this insight to inform the development of support programs and additional tools for the community. In addition, APPA can use this dashboard to measure the impact of its programs.

Automating Recommendations and Assessment Reporting

Each participating utility received a report summarizing the outcome of the initial assessment. In addition to providing utilities with an overall maturity level and maturity level for each domain of the maturity model, these reports included recommendations for improvement that were specific to each participating utility organization. Although these reports were helpful in delivering insights to the utilities, they took significant time to create. To scale the impact of the maturity model, it would be helpful to develop a process for quickly generating the reports. It would be possible to develop an automated recommendation engine that directly utilizes a utility's scores in each domain, and by each evaluation question, to propose relevant recommendations to items that scored at maturity levels M1 or M2. The automated recommendations should be a core feature of the short self-assessment version of the maturity model, but could also be integrated into the longer, more in-depth versions of the tool.

Beyond the provision of recommendations, it is possible to automate the generation of a report each time a utility completes an assessment. It is recommended that APPA prioritize the development of this capability to further expand the maturity model's ability to impact a larger number of organizations within the public power community.

Periodic Publications

On a periodic basis, it is recommended that APPA generate a report on the state of energy storage maturity in the public power community. This report would be based on aggregated insights from the maturity model and has the potential to broadly disseminate top common recommendations for public power utilities interested in exploring energy storage. This periodic report (suggested to be released biannually) would indicate the domains and subtopics where public power utilities require the most support to find success in deploying storage technologies. The report could also describe the efforts implemented by APPA and the impact they've made since the last iteration of the report.

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