JUNE 23, 2021

Hybrid Integration Project

Patrick Lo
Sr. Manager Partnerships & Advanced Technology - Innovation, Research, & Development
Sasoon Assaturian
Sr. Advisor Partnerships - Innovation, Research & Development
Daniel Sohm
Sr. Engineer Advanced Technology Research - Innovation, Research & Development
Edward Arlitt
Supervisor Advanced Technology Research - Innovation, Research & Development

ieso
Connecting Today. Powering Tomorrow.

Webinar Participation (including audio)

- To interact, click the "Show Conversation" icon (message bubble symbol) to submit a written question or click on the "Raise hand" icon (hand symbol) at the top of the application window to indicate to the host you would like to speak
- Audio should be muted at all times. To unmute audio, click on the microphone icon at the top of the application window
- This webinar is conducted according to the IESO Engagement Principles

ieso
Connecting Today. Powering Tomorrow.

Webinar Participation (Connection Issues)

- If you experience issues logging in:
  - Disconnect from remote server connections (VPN) and try logging in again
  - Download the mobile app and join through mobile
- Need help? Contact Microsoft Office Support

ieso
Connecting Today. Powering Tomorrow.

Agenda

- Hybrid Project Updates
- Hybrid Projects Across North America
- Addressing Feedback from April Engagement
- Draft Questions for Hybrid Vision Phase
- Hybrids Research
- Questions to Stakeholders

ieso
Connecting Today. Powering Tomorrow.

Hybrid Project Updates

ieso
Connecting Today. Powering Tomorrow.

Hybrid Integration Project Updates

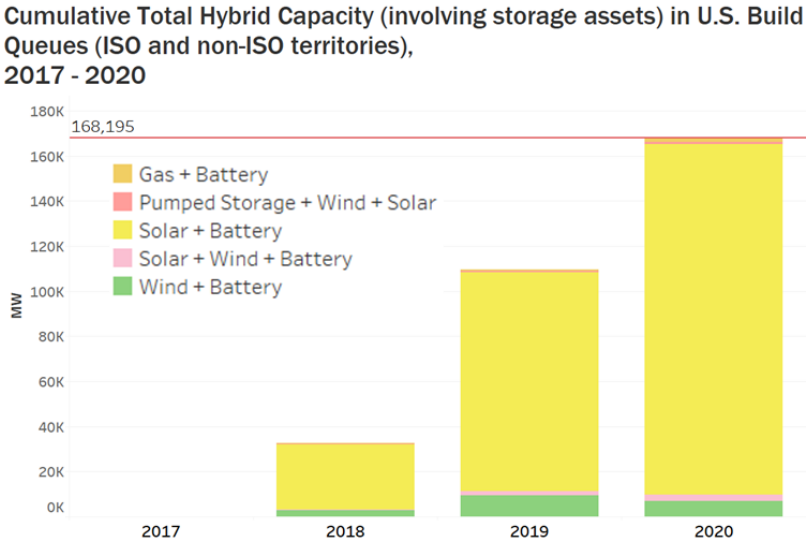
- IESO identifying a Foundational Participation Model for stakeholder feedback in August/September
- Grid Innovation Fund Call for Hybrids to be deferred to 2022 to align w/ outcomes of published Hybrid Vision Design

Hybrid Projects across North America

As of 2020, **168,195 MW** of Hybrid facilities in U.S. build queues.[1]

Configuration	% of build queues	Storage-to-generation ratio
Solar + battery	92 %	60%
Wind + battery	4%	35%

Note: Natural gas + storage ~ 1% of build queues capacity



1. Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As of End of 2020, Lawrence Berkeley National Laboratory

Hybrid Projects in ISO/RTO Build Queues

Deliverable	Hybrid Facility MW Generation in Build Queue As of 2020	Total MW of Generation in Build Queue as of 2020	% Hybrids In Build Queue as of 2020
AESO	1,531	17,493	9%
CAISO	46,840	122,434	38%
ERCOT	16,097	107,880	13%
ISO-NE	474	23,843	2%
MISO	12,219	92,057	13%
NYISO	935	61,867	1.5%
PJM	17,617	145,506	12%
SPP	8,526	96,306	9%

*sources: Lawrence Berkeley National Laboratory and AESO

ieso
Connecting Today. Powering Tomorrow.

Addressing Feedback from April Stakeholder Engagement

ieso
Connecting Today. Powering Tomorrow.

Feedback from April Engagement

The IESO sought feedback on four things:

1. Proposed definitions for co-located and hybrid facilities
2. Information required by developers to evaluate investment potential
3. Timelines and deliverables for the project
4. Engagement plan

ieso
Connecting Today. Powering Tomorrow.

Facility Definitions: Key Feedback + IESO Response

Common Themes/Input	IESO Response
General support for definitions	None
Clarity required re: do definitions include Dx-connected and behind-the-meter (BTM) facilities	Definitions intended for transmission (Tx) and distribution (Dx) connected facilities that participate in IESO markets only; Opportunities for DER aggregations will be addressed via DER integration work
Clarify which markets/services facilities would be able to compete in	Eligibility of hybrids to provide different services will be explored through visioning and design phases
Leverage definitions used by other system operators (SOs)	IESO has proposed a modified (less restrictive) version of what other SOs are using
Clarify which technology types (e.g. hydrogen) are included	Definition is intended to be technology agnostic; specifics about configuration will be determined through design phase
Deprioritization of implementing co-located or hybrid facilities	Should be determined through analysis work during the vision phase of the project; priority will be a simplified, least resource intensive solution

Information Required by Developers to Inform Investment Decisions: Key Feedback + IESO Response

Common Themes/Input	IESO Response
Clear understanding of system resource needs	To be provided by Annual Acquisition Report (AAR) and continued work on Annual Planning Outlook and Reliability Outlook documents
Clarity and certainty around procurement processes and plans	To be provided by AAR and details of future resource procurements
Clarity on revenue streams and compensation models	To be determined when participation models are developed and eligible market services are determined
Collaboration by OEB, IESO, Hydro One and LDCs on interdependent issues	Collaboration between all parties will be ongoing process throughout the Hybrid Integration Project

Timelines and Deliverables: Key Feedback + IESO Response

Common Themes/Input	IESO Response
General support for timing	See updates at outset of deck
Potential for pilot projects to maintain investor interest in Ontario given timelines	Through visioning process, the IESO will work with stakeholders to determine potential scope for Grid Innovation Fund hybrid call for proposals
Potential to advance simpler/lower effort solutions first	Will start by looking at the potential for a simplified, least resource intensive solution
Align timing of HIP deliverables with Resource Adequacy	Resource Adequacy timelines will be critical input to Enabling Resources work plan which includes Hybrids

Engagement Plan: Key Feedback + Response

Common Themes/Input	IESO Response
General support	None
Clarity of scope (behind the meter, feeder level aggregation)	Scope will include transmission (Tx) and distribution (Dx) connected facilities that participate in IESO markets only; Opportunities for DER aggregations will be addressed via DER integration work
Direct engagement with transmitters and distributors	As participation models are developed the IESO will engage with impacted transmitters and distributors

Draft Questions for Hybrid Vision Phase

ieso
Connecting Today. Powering Tomorrow.

Hybrid Integration Project Vision Questions

Answers "what and why" questions about hybrid integration

Problem statement

- How will participation of hybrids in the wholesale electricity markets be facilitated in order to contribute to ensuring that electricity needs are met reliably and economically?

ieso
Connecting Today. Powering Tomorrow.

Vision Design Outline

Key questions to be answered in the vision are focused on the need, context for participation, and analysis

- Need and Drivers: Why we need to enable hybrids
- Context: of hybrids and co-located resources for any participation model
- Analysis: of Hybrid Participation Model (opportunities and limitations)
- Key research questions

Vision for Hybrids: Need and Drivers

Questions around the need and drivers for Hybrid development in Ontario

Examples

- What is the system need and opportunity for hybrid participation in IESO-Administered Markets?
- What trends in the industry could become major drivers in Ontario's electricity sector?

Note: Expanded list in Appendix A

ieso
Connecting Today. Powering Tomorrow.

Vision for Hybrids: Context for A Foundational Participation Model

Questions that need to be answered for considerations of a foundational participation model

- What hybrid technology pairings are most likely to be built in Ontario, given the system needs?

ieso
Connecting Today. Powering Tomorrow.

Vision for Hybrids: Analysis of A Foundational Participation Model

Analysis: Questions determining how a participation model unlocks value for/from IESO-Administered Markets

- What are the market participation opportunities and constraints associated with the foundational participation model?
- How likely are potential hybrid developers to invest in Ontario under different market participation models? What else will impact investment decisions?

Vision for Hybrids: Research Questions

Research: Fundamental research questions that can be addressed through pilot projects, studies, and literature reviews

- What is the capacity value of hybrids compared to equivalent co-located facilities?
- What other ancillary services can reliably be provided by hybrids?

ieso
Connecting Today. Powering Tomorrow.

IESO's First Hybrid Research Project

ieso
Connecting Today. Powering Tomorrow.

Current and Future IESO Research Aims

Current/underway

- Understand the current hybrid growth phenomenon in the U.S. and what it means for the upcoming work of the IESO's Hybrid Integration Project
- Learn from early stage implementation efforts already taking place at U.S. system operators
- Conduct one or more proof-of-concept hybrid field studies in Ontario

Future

- Field testing of integration options from the Hybrid Integration Project
- Validate data from early-stage field research and examine scale-up implications with academic community
- Observational analysis of Ontario's hybrid fleet as it begins to enter operations for future design iterations and improvement

Hybrid Facilities Research – ATR Program

- The Alternative Technologies for Regulation Program at the IESO has been preparing for its first hybrid facility experiments which will commence soon
- These early stage experiments will examine potential new value streams including renewable smoothing and the potential impacts of different facility configurations

Alternative Technologies for Regulation (ATR)

Hybrid Facility Research Area
Facility registration and definition
Market Registration
Hybrid facility operations
Hybrid facility performance relative to existing market value streams
Hybrid facility – potential new value streams
Ancillary Services

Hybrid Facilities Research – GIF

- Future field projects could involve testing potential integration options developed through the Hybrid Integration Project

Grid Innovation Fund (GIF) and scale-up projects

Hybrid Facility Research Area
Facility registration and definition
Market Registration
Hybrid facility operations
Hybrid facility performance relative to existing market value streams
Hybrid facility – potential new value streams
Ancillary Services

ieso
Connecting Today. Powering Tomorrow.

Minto Hybrid Research Facility

- As part of the Alternative Technologies for Regulation Program, the Minto flywheel storage facility has been fitted with a small solar array on the roof to provide field data for a variety of potential experimental scenarios....

Image Source: NRStor Inc.

Minto Hybrid Research Facility (continued)

- In previous phases of the ATR program, the 2.5 MW Minto facility provided conventional regulation service and was the first facility in Ontario to provide fast regulation service

Image Source: NRStor Inc.

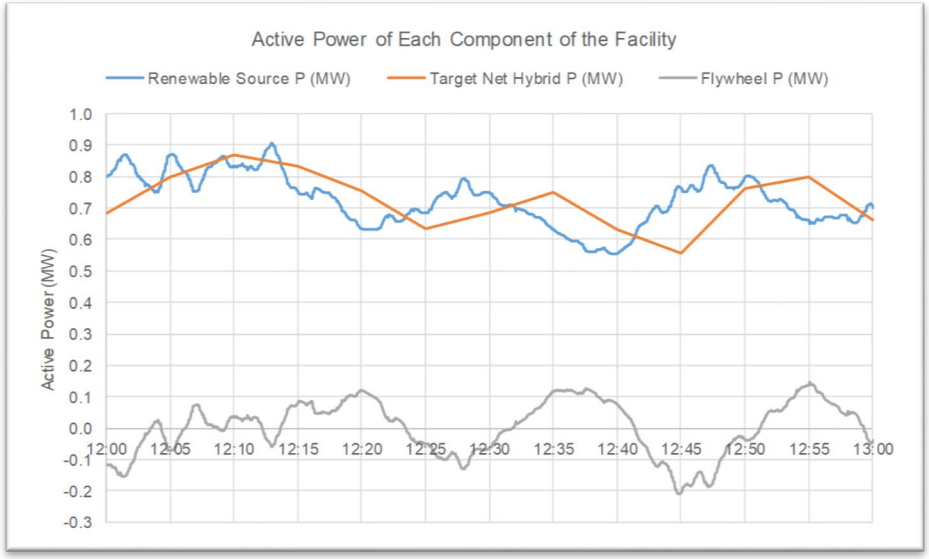
ieso
Connecting Today. Powering Tomorrow.

Image source: NRStor Inc.

Experimental Concepts (1)

Intermittent Linearization Service (renewable smoothing)

- The Minto facility affords the opportunity to test a potential new wholesale market product that recognizes the reliability benefit of co-locating storage resources at the province's renewable generation sites.
- Minto will begin with solar/storage pairings and a future wind/storage virtual pairing is also under investigation.



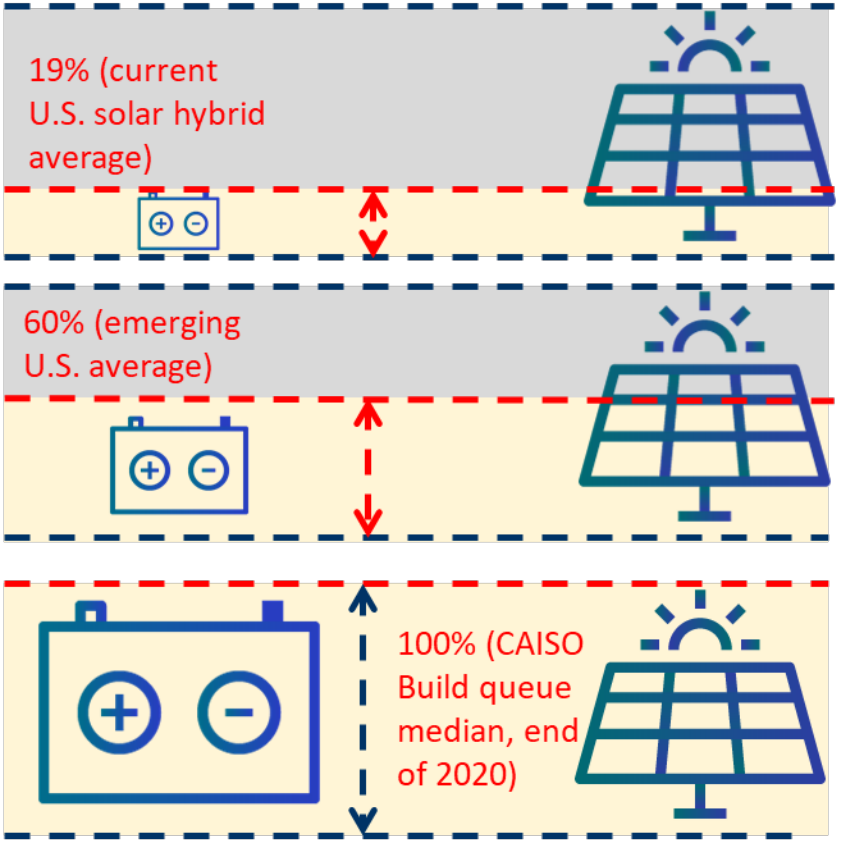
Simulated example of Intermittent Linearization Service

ieso
Connecting Today. Powering Tomorrow.

Experimental Concepts (2)

Optimal generation-to-storage ratios

- The Minto facility will allow the IESO to scale the active power signal from the solar panels and test the performance of different generation-to-storage ratios.
- Recent data from the United States shows that the different generation-to-storage ratios for hybrid facilities is trending dramatically upwards – particular for solar/storage hybrids.



ieso
Connecting Today. Powering Tomorrow.

Stakeholder Feedback

The IESO is seeking written feedback on the following:

- What types of Hybrid pairings (technology and storage-to-generation ratios) are most likely to be developed in Ontario? Why?
- Are the Vision questions appropriate given IESO's intent to pursue a foundational participation model? (Please see Appendix A for expanded list)

Please use the feedback form found under the June 23 entry on the Hybrid Integration Project webpage to provide feedback and send to engagement@ieso.ca by July 14, 2021

ieso
Connecting Today. Powering Tomorrow.

Appendix A: Expanded List of Draft Vision Questions

ieso
Connecting Today. Powering Tomorrow.

Vision for Hybrids: Need and Drivers

- What is the definition and difference between a hybrid and co-located facility?
- What is the system need and opportunity for hybrid participation in IESO-Administered Markets?
- What trends in the industry could become major drivers in Ontario's electricity sector?

ieso
Connecting Today. Powering Tomorrow.

Vision for Hybrids: Need and Drivers (2)

- How might hybrids impact system reliability?
- What are the general benefits that hybrids could achieve and which of these benefits are incremental to that which can be provided by an equivalent co-located facility?

ieso
Connecting Today. Powering Tomorrow.

Vision for Hybrids: Need and Drivers (3)

- What are the expected savings to project developers from adding storage to an existing facility? Will these savings lower costs for ratepayers?
- What is the expected timeline for an existing facility to be converted to a hybrid facility?
- What is the expected timeline for a new build hybrid to be built?
- What are the expected benefits to system operability and flexibility?

Vision for Hybrids: Need and Drivers (4)

- Are there material benefits to system reliability or affordability if hybrids operate with renewable smoothing control?
- What are the advantages and challenges of building a hybrid compared to building separate generation and storage facilities at two different locations?
- If a new-build storage facility is to be built, is it more economical to project developers to build it as a stand-alone facility or co-locate it at an existing renewable site?

Vision for Hybrids: Context for A Foundational Participation Model

- What is the definition and difference between a hybrid and co-located facility?
- What hybrid technology pairings are most likely to be built in Ontario, given the system needs?

ieso
Connecting Today. Powering Tomorrow.

Vision for Hybrids: Context for A Foundational Participation Model (2)

- What is the optimal storage to generation ratio for hybrids that are likely to be built, given the system needs?
- What is the potential capacity for hybrids in Ontario over the next decade?
- Where can hybrid capacity be built in Ontario over the next decade?

ieso
Connecting Today. Powering Tomorrow.

Vision for Hybrids: Analysis of A Foundational Participation Model

- What are the market participation opportunities and constraints associated with the foundational participation model?
- What are some of the key design questions that would need to be answered in the design phase?

ieso
Connecting Today. Powering Tomorrow.

Vision for Hybrids: Research Questions

- What types of renewable smoothing control can enhance value of hybrids?
- What is the impact to system reliability of facilities that have been converted to hybrids? Are new risks introduced?
- What lessons have been learned from other jurisdictions integrating hybrids?
- What other ancillary services can reliably be provided by hybrids?

Thank You

ieso.ca

1.888.448.7777

customer.relations@ieso.ca

engagement@ieso.ca

@IESO_Tweets

facebook.com/OntarioIESO

linkedin.com/company/IESO

ieso
Connecting Today. Powering Tomorrow.