DER Potential Study

Stakeholder Session 2:
Draft Detailed Project Plan

In partnership with:

November 23 2021

Executive Summary

This session (the second of three stakeholder engagements planned for the DER Potential Study) is intended to present to stakeholders the draft detailed study plan:

- **Pre-Assessment Update:** Final list of DERs to be considered in the study
  - The pre-assessment, presented in October 2021, identified DER technologies considered most relevant to Ontario
  - Comments were received from stakeholders, and adjustments to the approach and outcomes were made in response
  - The final output of the pre-assessment is the list of 'Assessed DERs', which will be modeled in the study
- **Study Approach**: Today's presentation will review the proposed approach for assessing DER potential:
  - Technical potential represents the theoretical maximum potential for DERs in Ontario and their grid service capabilities, based on the market size and the impacts of each measure. The technical potential does not account for interactive effects between measures, and therefore the results are not additive on a system-wide basis.
  - Economic potential represents the cost-effective potential for DERs to contribute to different grid services. Cost-effectiveness is first assessed on a measure-by-measure basis, and then optimized market-wide potential is assessed by stacking measures and considering interactive effects.
  - Achievable potential represents the system services that can be provided by DERs considering real-world adoption of measures and their expected participation in the market. Achievable potential is assessed under several scenarios that reflect different market, technology and system outlooks.
- **Next steps:** Feedback from stakeholders is requested over the coming three weeks to help finalize the study plan:
  - Proposed technical, economic, and achievable potential assessment approach
  - Input on study scenarios (e.g. factors considered, assumptions for these factors, etc.)
  - Approach for regional segmentation of study results and DR participation barriers

Speakers

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AGENDA & MEETING OBJECTIVES

1. **Recap**
   - Overview of study objectives and scope
2. **Pre-Assessment Results**
   - Final list of DERs to be considered in the study — Q&A
3. **Proposed Approach**
   - Technical, economic and achievable potential — Q&A
4. **Key Study Parameters and Inputs**
   - Review key study parameter and inputs
5. **Wrap-up & Next Steps**
   - Timelines and discussion — Q&A

1. Recap

- Study Context and Objectives
- Timelines

Study Context and Objectives

Study Context:

- There is increasing adoption of DERs by customers, grid operators, and service providers (at least 5,000 MW* of DERs deployed in Ontario to-date)
- DERs can provide benefits to customers and the electricity system
- By enabling DERs to provide wholesale services, system costs can be reduced and opportunities for customers and investors can be increased

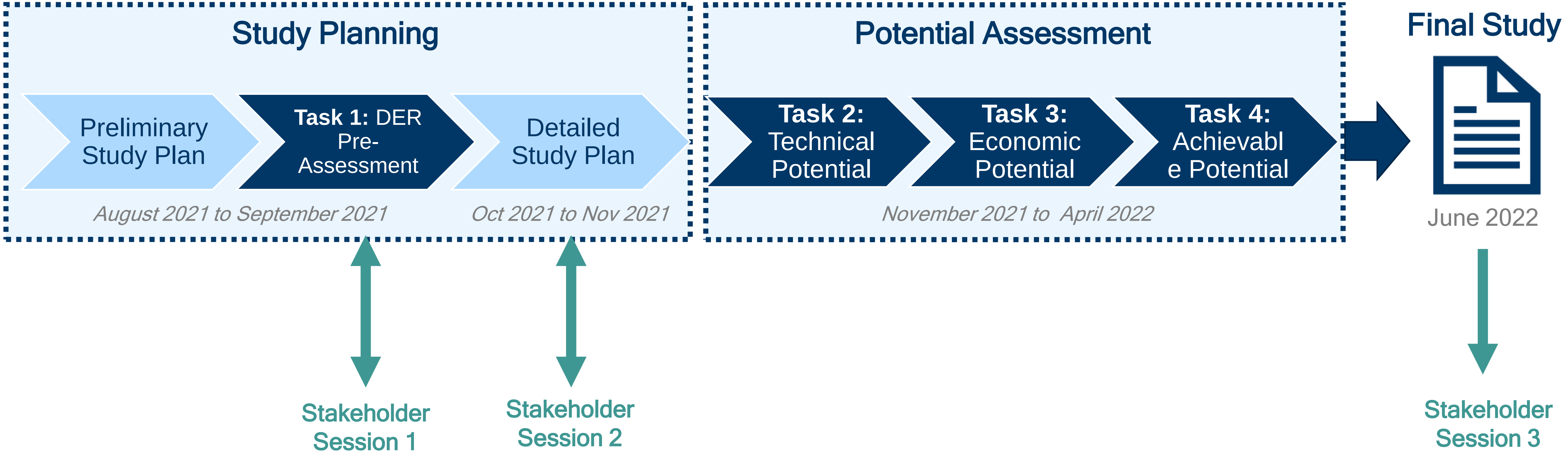
Study Objectives:

- Identify the key DER technologies most relevant to the Ontario context and their corresponding use-cases
- Assess the technical, economic and achievable potential for these DERs over the next 10 years
- Develop recommendations on focus areas, priorities, timing and key considerations for DER integration efforts in Ontario

***That IESO has visibility to as a result of markets, procurements, programs, and the Industrial Conservation Initiative

Timelines: Overview

- **Study Planning:** August 2021 to November 2021
- **Potential Assessment:** November 2021 to April 2022
- **Final Report:** June 2022



Timelines: Stakeholder Sessions

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Stakeholder Session 1: Preliminary Plan & DER Pre-Assessment (September 22)

- Introduce project team
- Share overview of the context and objectives of the study
- Share and solicit feedback on Preliminary Project Plan
- Share and solicit feedback on DER Pre-Assessment
- Solicit input to inform the development of key study parameters

Stakeholder Session 2: Detailed Study Plan (November 23)

- Present detailed study plan, highlighting methodology, key inputs and assumptions
- Solicit feedback from stakeholders on detailed project plan
- Solicit input to inform the development of key study assumptions

Stakeholder Session 3: Final Results Presentation (June, exact date TBD)

- Present final results and recommendations to stakeholders
- Solicit input on recommendations and areas for further study

2. Pre-Assessment Results

- Pre-Assessment Overview
- Key Changes
- Assessed DERs

Pre-Assessment Overview

Objective: Identify DER technologies that are most relevant to the Ontario context and likely to represent opportunity areas with high value and/or uptake for consideration in the study scope

Measure List & Assessment
Develop measure long-list and capture key characteristics

Measure Screening
Screen measures against criteria that capture Ontario-specific considerations & general competitiveness

Assessed DERs
Short-list key measures and outline approach, baseline and assumptions

Scope: The pre-assessment includes the following DER categories:

- Demand Response (DR) measures
- Behind-the-meter (BTM) Battery Storage
- Front-of-the-Meter (FTM) Battery Storage
- BTM Solar Photovoltaics (PV)
- FTM Solar Photovoltaics (PV)
- Other (e.g. other FTM / BTM generation / storage)

Key Changes

Based on received comments from the IESO, feedback from stakeholders, and other considerations (e.g. data availability), the following updates to the Pre-Assessment were done:

- **Measure list adjustments**
  - Blended Vehicle-to-Building (V2B) measures with Vehicle-to-Grid (V2G) measures
  - EV Smart Charging using on-board telematics reassessed for inclusion in the study
  - Commercial pools/spa removed from measure list due to expected low opportunity size and limited data availability
  - Residential thermal storage for heating readded; previously removed from list by error of omission

- **Approach adjustments**
  - “Alignment with system needs and characteristics” criteria adjusted to “Alignment with / capability to meet system needs”
  - “Relevance to study objectives/scope” removed from screening criteria.

- Responses to Stakeholder comments and questions were drafted by the IESO and Project Team and are available online on the DER Potential Study webpage.
- Excel file with revised pre-assessment results, highlighting latest measure list as well as the proposed market/measure characterization approach for each, is available on the DER Potential Study webpage.

Assessed DERs: Context

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The next slides highlight the final list of "Assessed DERs" (i.e. ones to include in the study) based on the outcome of the assessment, stakeholder input and other considerations.

The measures are grouped into three lists*:

- Residential BTM
- Non-Residential BTM
- FTM Resources

List of Acronyms

- **ASHP:** Air-Source Heat Pump
- **BTM:** Behind-the-meter
- **CAES:** Compressed Air Energy Storage
- **CHP:** Combined Heat and Power
- **C&I:** Commercial & Industrial
- **DG:** Distributed Generation
- **DMSHP:** Ductless Mini-Split Heat Pump
- **DR:** Demand Response
- **EV:** Electric Vehicle
- **FTM:** Front-of-the-meter
- **GSHP:** Ground-Source Heat Pump
- **HDV:** Heavy-Duty Vehicle
- **LDV:** Light-Duty Vehicle
- **MDV:** Medium-Duty Vehicle
- **V2G:** Vehicle-to-Grid

*Further market segmentation will be completed for the assessment of potential – this grouping is only for ease of pre-assessment.

Assessed DERs: Residential BTM Resources

Measures that passed qualitative screening:

Measure Group	Measure
Distributed generation	BTM solar with smart inverter
HVAC	AC Thermostat Dual-Fuel Space Heating Smart Thermostat Dual-Fuel Space Heating Smart Switch ASHP/DMSHP Smart Thermostat
Other load flexibility	Behavioral-based flexibility
Passenger EV charging	Smart EV Chargers Vehicle-to-Grid (V2G) Passenger EV Telematics

Measure Group	Measure
Pools and spas	Pool pumps
Smart appliances	Smart clothes dryer
Storage	BTM battery storage
Thermal storage	Thermal storage for cooling (AC) Thermal storage with HP Thermal storage for heating (central heat)
Water heating	Electric Resistance Water Heaters Smart Switch Smart Electric Resistance Water Heaters Smart Heat Pump Water Heaters Heat Pump Water Heater Smart Switch

Assessed DERs: Non-Residential BTM Resources

Measures that passed qualitative screening:

Measure Group	Measure
Distributed generation	Back-up Generation BTM Solar with Smart Inverters
Lighting controls	Lighting controls
EV fleet charging	LDV Fleet EV Smart Chargers LDV Fleet V2G LDV Fleet EV Telematics MDV Fleet EV Smart Chargers MDV Fleet V2G HDV Fleet EV Smart Chargers HDV Fleet V2G Off Road EVs Smart Chargers Buses EV Smart Chargers Buses V2G

Measure Group	Measure
HVAC	Large C&I HVAC Control Small C&I Smart Thermostat Small C&I ASHP/DMSHP Smart Thermostat
Other load flexibility	District Cooling/Heating Flexibility Industrial Flexibility Other Commercial Flexibility Irrigation Pump Controls Refrigeration Controls Greenhouses: Grow Lights
Storage	BTM Battery Storage
Thermal storage	Commercial HVAC Thermal Storage Thermal Storage for Refrigeration Applications
Water heating	Large Commercial Dual-Fuel Water Heating Large Commercial Hot Water Small Commercial Hot Water

Assessed DERs: FTM Resources

Measures that passed qualitative screening:

Measure Group	Measure
Distributed generation	FTM Solar FTM Small-scale Hydro

Measure Group	Measure
Storage	FTM Battery Storage

Assessed DERs: Additional Considerations

- Measures not assessed in the study **should not** be interpreted as technologies that will not exist in Ontario, but rather ones likely to play a limited role over the study period given the expected market size, cost-effectiveness and/or technology maturity
- While some DER technologies may be accessible through direct control and/or scheduled variations (e.g. EV charging), the focus of the study will be on **direct controlled versions** of the measures to highlight the maximum potential impact of the modeled DERs
- Some measures will be characterized as **"blended" measures** that represent variations with similar characteristics (e.g. Smart Thermostat for ASHP/DMSHP as a single measure, grouping scheduled and direct control strategy variations of the measure where performance is expected to be similar, etc.)
- Some commercial measures may be **grouped subject to data availability** (e.g. combined C&I curtailment if commercial baseline data does not permit split by end-use)

1st Q&A Break

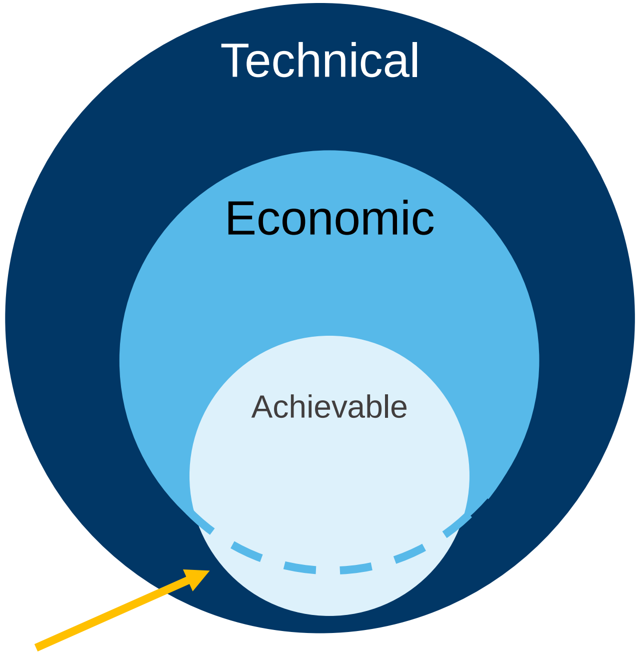
3. Proposed Approach

- Proposed Approach Overview
- Technical Potential
- Economic Potential
- Achievable Potential

Proposed Approach Overview

The DER Potential Study is intended to answer three key questions:

1. **Technical:** How much DER capacity theoretically exists in Ontario?
2. **Economic:** How much of that potential is economically viable?
3. **Achievable:** How much of that potential is likely to emerge over the next decade?



Note: Achievable potential will not exclusively be a subset of economic potential – some uptake of DERs may not be driven by system benefits, but rather by customer or other benefits.

The Study will assess DER Potential under three scenarios reflecting different market, policy and technology pathways.

Feedback Process: *Over the next three weeks, we are seeking feedback from stakeholders about the appropriateness of the proposed approach for evaluating the technical, economic and achievable potential for DERs in Ontario.*

Technical Potential: Overview

1. **Market Characterization:** Define and quantify the maximum market size for each measure and estimate growth over the study period

2. **Measure Characterization:** Capture key technical and operational characteristics for each of the Assessed DER measures

Technical Potential: Market Characterization (1/2)

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For each measure, identify the appropriate approach for technical market sizing and market growth:

- **DR Measures:** Assume full participation of the applicable equipment stock in all services that they can contribute to (e.g. number of ACs)
  - *Market growth based on segment/population growth, unless an underlying market trend impacts growth*
  - *For example, market size for EV Smart Chargers is based on EV population in Ontario (EV growth assumptions may be varied by scenario)*
- **DG and Storage:** Technology-specific theoretical limit applied based on physical, technical and/or market constraints (e.g. number of roofs suitable for solar PV deployment)
  - *Market growth based on segment / population growth (e.g. number of new builds)*

Additionally, the team will quantify the existing baseline (i.e. level of deployment) in Ontario for each measure

Technical Potential: Market Characterization (2/2)

Illustrative Example

Measure Name	Measure Type	Technical Market Sizing Approach	Market Growth Approach
AC Smart Thermostats	DR	Number of residential buildings with a central AC system	Rate of AC adoption
LDV Fleet EV Smart Charging	DR	Forecasted number of light-duty fleet vehicles in Ontario	Forecasted EV fleet adoption
Smart Clothes Dryer	DR	Number of residential customers with a clothes dryer	Forecasted adoption of smart clothes dryers
Residential BTM Solar	DG	Number of single-family homes with a rooftop suitable for solar deployment	Rate of residential new construction
Non-Residential BTM Storage	Storage	Number of commercial customers with suitable space for storage deployment	Segment population growth
FTM Solar	DG	Solar capacity needed to displace the marginal resource (i.e. natural gas) from the generation stack considering land availability and interconnection constraints	IESO Capacity Needs, Natural Gas Additions & Retirements, and Interconnection Constraints

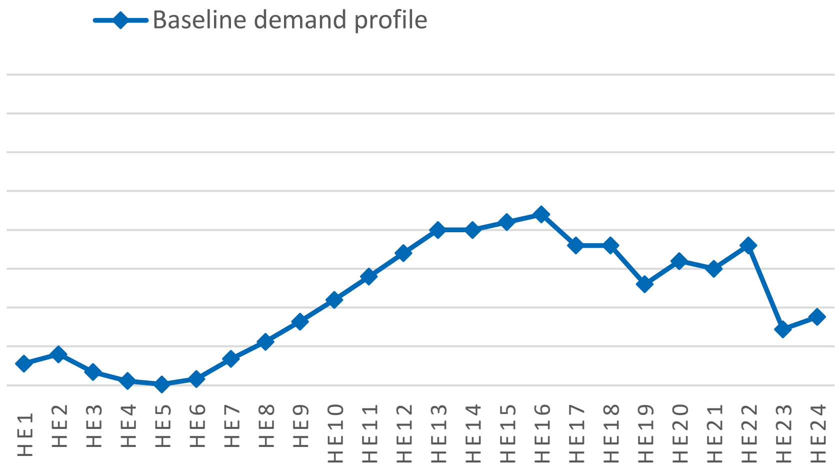
Note: The excel file provided as part of the Detailed Study Plan highlights the proposed approach for market and measure characterizations for the Assessed DER measures.

Technical Potential: Measure Characterization (1/3)

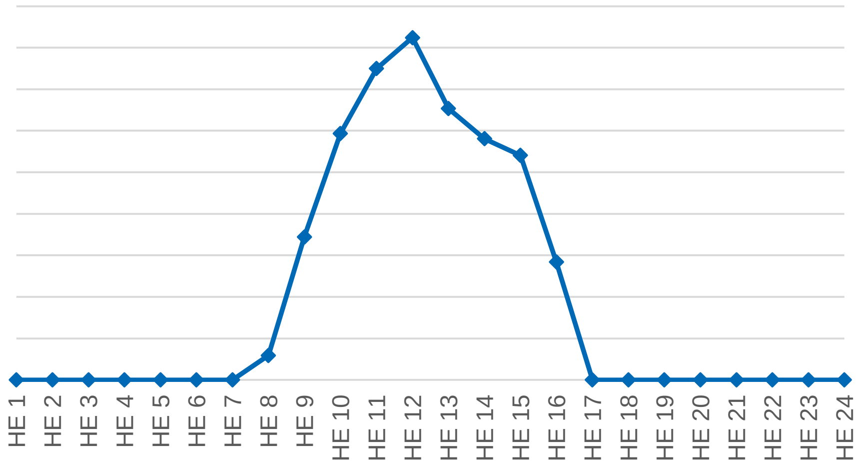
For each measure, capture key parameters that would define the measure's operational characteristics:

- **Technical Measure Sizing:** Assumed maximum theoretical size per measure
  - **DR:** Based on the load size and/or nameplate capacity of the equipment
  - **DG and Storage:** Based on maximum size constrained by technical and/or load limitations (e.g. roof size, annual consumption, customer peak demand, etc.)
- **Baseline Profile:** Assumed hourly load/generation profile prior to control
  - **DR:** Based on load characterization by segment/end-use
  - **DG:** Typical generation profile for each technology / segment based on IESO data and assumed system characteristics
  - **Storage:** N/A

Demand Response Measures



Distributed Generation Measures

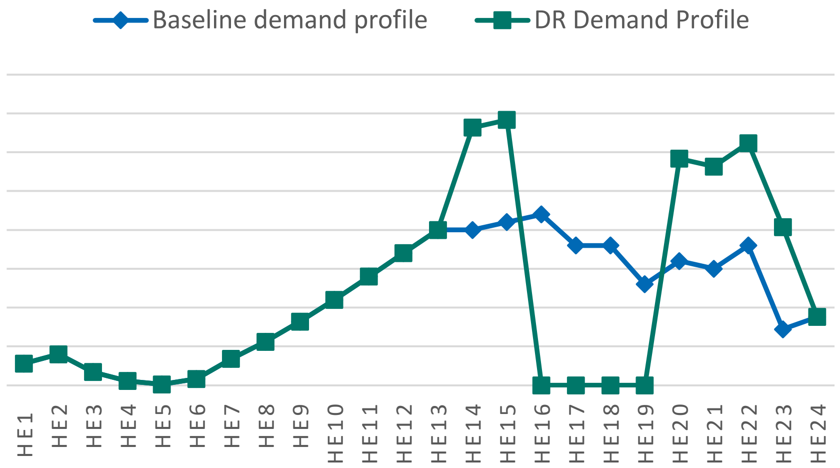


Technical Potential: Measure Characterization (2/3)

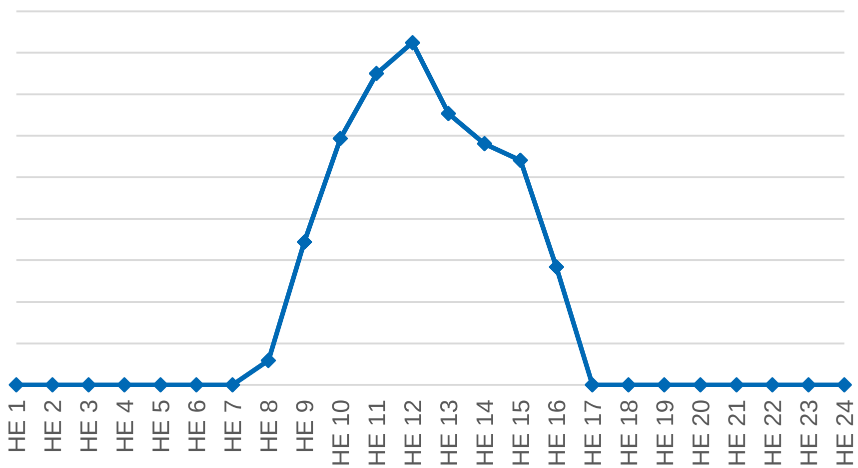
For each measure, capture key parameters that would define its operational characteristics:

- **Service Capability and Priority:** Focusing on four key grid services: energy (inject, arbitrage and/or surplus baseload generation), capacity, operating reserves (OR) and frequency regulation (FR):
    - Assess each measure's ability to contribute to the service (as defined by IESO) based on technical capability and practicality
    - Prioritize services based on the measure's abilities and the respective value/needs of each grid service
- **Modified Profile:** Assumed profile associated with the provision of each of the four services as applicable to the measure
    - **DR / Storage:** Based on an assumed control strategy
        - Top-down assumptions (e.g. % of load can be adjusted); and/or
        - Bottom-up constraints (e.g. number, duration, window of events due to operational and/or convenience constraints)
    - **DG:** N/A (service provision based on the coincidence of generation with service needs/window)
    - The characterization will identify the modified profile of a measure for nine representative days that reflect typical days (weekday, weekend, and peak day) within each season (i.e., summer, winter, shoulder season)

Demand Response Measures



Distributed Generation Measures



Technical Potential: Market & Measure Sizing (3/3)

Illustration of Measure Characterization Approach

Measure Name	Measure Type	Technical Measure Sizing	Baseline Load Profile	E*	C*	OR *	FR*	Modified Load Profile (Example: Capacity)
AC Smart Thermostats	DR	Sized to cooling and pumps and ventilation load. Varies by segment.	Direct use of the cooling and pumps & ventilation load for each segment from APO	✓	✓	✓		Called 4 hours max, with Precooling and rebound. Called not more than 12 times a year.
LDV Fleet EV Smart Charging	DR	Nameplate capacity of typical Level-2 EV Charger	Average LDV non-residential EV load profile	✓	✓	✓	✓	Curtail charging during peak hours. Provide up to 6 hours of curtailable load during the evening peak.
Smart Clothes Dryer	DR	Sized to maximum clothes dryer load	Average clothes dryer load profile from APO	✓	✓			100% of load curtailed during peak window.
Residential BTM Solar	DG	Maximum system size that can be theoretically deployed on the building's rooftop based on roof area and typical panel footprint.	Ontario-average solar generation profile (adapted to measure size)	✓	✓			Based on coincidence of generation with peak window
Non-Residential BTM Storage	Storage	Sized to customer's peak load	N/A	✓	✓	✓	✓	Sustained capacity reduction during peak hours
FTM Solar	DG	Solar capacity needed to displace the marginal resource (i.e. natural gas) from the generation stack considering land availability and interconnection constraints	Ontario-average solar generation profile (adapted to assumed system size)	✓	✓			Based on coincidence of generation with peak window.

***Service Capabilities = E:** Energy; **C:** Capacity; **OR:** Operating Reserves; **FR:** Frequency Regulation*

* Some DERs may be technically capable of providing these services, but may be unable to do so for practical reason (e.g. solar can provide OR, but practically unlikely due to economics).

Technical Potential: Key Data Sources (1/2)

The market and measure characterization will depend on a number of IESO resources:

- **Residential End-Use Survey (REUS)**
  - Equipment penetration and saturation (e.g. HVAC, water heating, smart appliance)
  - Electric share for space and water heating
- **Commercial End-Use Survey (CEUS)**
  - Equipment penetration and saturation (e.g. lighting, HVAC, water heating)
  - Electric share for space and water heating
- **Solar Achievable Potential Study (APS)**
  - BTM Solar's technical potential by segment
  - Solar generation profiles
- **Energy Efficiency (EE) Achievable Potential Study (APS)**
  - Growth of some DER equipment that are primarily driven by their EE benefits (e.g. smart thermostats, BAS systems)
- **Annual Planning Outlook (APO)**
  - Demand forecasts
  - EV and HP uptake forecasts (with adjustments for scenarios – to be discussed in Section 4)
  - End-use load characterization (8760 load shapes per segment/end-use)
  - Population breakdown by segment
  - Equipment (e.g. clothes dryer) 8760 load shapes
- **DERs Industrial Survey**
  - IESO ICI resource type, average size, participation, etc

Technical Potential: Key Data Sources (2/2)

The majority of the measure characterization inputs come from Dunsky's DER measure database

- The database is complemented with data from leading industry datasets (NREL, LBNL), recent DER potential studies, and other resources (e.g. technology providers) to capture non-jursdiction specific parameters
- Where available, Ontario-specific data is used
- In the absence of Ontario-specific data, the team will develop assumptions based on insights from regions with similar characteristics (e.g. Northeast U.S.) with the appropriate adjustments based on the professional judgement of the project team

Example of data sources used for characterizing baseline load for each measure

- **For most measures,** based on APO load characterization by segment/end-use
- **For plug-loads / equipment and emerging end-uses** (e.g. fleet charging), develop assumed load profile using Ontario-specific data where available or data from jurisdictions with similar characteristics (e.g. North East US)
- **For DG**, typical generation profile for each technology / segment based on IESO data and assumed system characteristics

Technical Potential: Output

Outcome: Technical potential results

- **Output Metrics**
  - MW nameplate capacity
  - MW capacity reductions
  - MWh energy generated
- **Break down by**
  - DER Measure / measure group
  - Study sector / segment
  - Service *capability**

Key Considerations

- The key value of technical potential is to **set the market size for each DER measure.**
- Technical potential represents the **theoretical maximum potential** for DER deployment, unconstrained by economic, market acceptance or other non-technical constraints, and should be interpreted with care.
- Technical potential results will be presented by measure / measure group, and are **not directly additive.**
- **Outcomes will highlight the capability of the measure** to provide the service based on technical characteristics, and not the actual provision of the services.

* Service capability will be determined as per the measure's technical ability to contribute to different grid services as defined in the measure pre-assessment workbook

2nd Q&A Break

Economic Potential: Overview

1. **Measure Economic Inputs:** Capture measure cost, operations and maintenance costs, lifetime, and other key parameters needed for the economic potential assessment.

2. **Benefit-cost framework:** Identify and quantify the key benefit and cost streams to be used to assess the cost-effectiveness of DERs in Ontario.

3. **Cost-Effectiveness:** Measure- and market-level cost-effectiveness testing and screening using a Total Resource Cost (TRC) test under "optimal" dispatch and unconstrained market participation.

Economic Potential: Measure Economic Inputs (1/2)

Measure Characterization (Per Unit Assumptions)

- **Measure Costs:** The incremental cost of equipment (over assumed baseline technology), control devices and telemetry over the study period considering potential cost declines where applicable.

DER Type	Assumption	Examples	Measure Cost
A	***Not primarily driven*** by financial benefits of market / program participation (i.e. DER functionality is a by-product)	***Smart thermostats, smart appliances or back-up generators*** are adopted by customers predominantly for other benefits (e.g. energy savings, comfort, resiliency)	**Cost of controls** (if applicable) (e.g. $0 for Wi-Fi-enabled smart thermostats)
B	***Somewhat driven*** by financial benefits of market / program participation (i.e. DER functionality is a co-benefit)	Choice to install a ***smart EV charger or a smart Water Heater*** is partly influenced by the incremental benefits	**Incremental cost** of the measure over the assumed baseline technology (e.g. incremental cost of smart charger over “dumb” charger)
C	***Predominantly driven*** by financial benefits of market / program participation (i.e. DER functionality is the key benefit)	Decision to adopt ***BTM solar or BTM storage*** is primarily based on the financial returns a customer expects from net-metering, market revenue or DR programs	**Full cost** of the measure (e.g. cost of new solar installation)

Economic Potential: Measure Economic Inputs (2/2)

Measure Characterization (Per Unit Assumptions)

- **Operations and Maintenance (O&M) Costs:** Appropriate O&M costs considered based on earlier dichotomy
  - For most measures (Type A & B), little to no incremental O&M cost expected (e.g. no incremental O&M for a smart water heater over a conventional water heater)
  - Limited exceptions, such as the cost of natural gas from back-up generation and dual-fuel space heating measures
  - For Type C measures, the full O&M costs of a system is considered (e.g. O&M for solar, storage, etc.)
  - ***Note:*** *This excludes M&V, telemetry and other costs, which are considered as program administrative costs (to be discussed in a later section)*
- **Cost Projections:** Capture expected cost declines over the study period
  - Some measures are expected to experience no/low cost declines (e.g. lighting controls ➔ Costs will be held constant throughout the study period
  - Most measures are expected to experience modest cost declines (e.g. bidirectional EV chargers) ➔ Costs will be assumed to decline at a fixed rate
  - A handful of measures are expected to experience significant cost declines (e.g. solar, storage) ➔ Costs will be modeled based on latest industry projections as well as potentially assessed as a lever in the scenario analysis (to be discussed in section 4)
- **Effective Useful Life (EUL):** Lifetime of the equipment and/or controls based on industry standards (defined in years)
- **Dispatchability:** The measure's operational flexibility to respond to 5-minute dispatch signals
  - Develop a derating factor for each measure (defined as the maximum percentage of all 5-minute events in a year that the DER can respond to) based on technical capability, operational constraints and practicality

Economic Potential: Benefit-Cost Framework (1/6)

Benefit-Cost Framework

- **A modified Total Resource Cost (TRC) test to be used to assess cost-effectiveness**
  - Assess cost-effectiveness of DERs from the perspective of the system and market participants
  - Consistent with the framework the IESO uses for its Energy Efficiency APS
  - Primer on TRC included in the appendix
- **Determine the appropriate benefit and cost streams**
  - **Benefits:** The value DERs contribute to the system defined as the corresponding avoided grid services (quantified using market proxies where relevant)
  - **Costs:** The incremental costs of securing the DER capacity for the identified service provision
- **Quantify the benefits (i.e. avoided costs) and cost streams; as described in the upcoming slides.**
  - Avoided costs to be update for each scenario as needed to reflect modeled market and system outlooks

Benefits

A. Avoided energy costs (carbon costs embedded)
B. Avoided surplus baseload generation (SBG)
C. Avoided generation capacity costs
D. Avoided operating reserves (OR) [10-minute spinning, 10-minute non-spinning, 30-minute spinning]
E. Avoided regulation capacity (RC)
F. Avoided / deferred transmission capacity costs
G. Avoided / deferred distribution capacity costs
H. Avoided transmission and distribution line losses
I. Demand Reduction Induced Price Effects (DRIPE)

Costs

A. Measure costs
B. Measure O&M costs
C. Program, aggregation and/or transaction costs

Economic Potential: Benefit-Cost Framework (2/6)

Approach to Quantifying Benefits and Costs

	Benefit / Cost	Methodology	Key Inputs
A	**Energy**	• Derived from Power Advisory proprietary hourly dispatch model for Ontario; • Demand is based on historical load shapes, forecasted peak demand from IESO APO and load shape manipulators for future impacts (e.g., EVs, heat pumps, industry load) • Offer data is based on Power Advisory market intelligence, rate filings, and publicly available data; planned and unplanned outages for all resource types • Commodity costs have carbon pricing and emissions performance standard rules incorporated	• Weather dependent hourly profile data for supply and demand • Future system needs as per IESO planning outlooks • Forward commodity markets
B	**Surplus Baseload Generation**	• SBG identified by zero or negative pricing hours forecasted by PA's real-time energy model • SBG cost based on information published by IESO for SBG payments; future value determined by escalation of foregone energy & SBG deferral account costs	• Forgone energy payments and SBG deferral payments by asset type
C	**Capacity**	• Based on resource requirement expectations forecasted by IESO through APO • Future resource developments that impacts resource requirements over planning horizon • Development of supply costs under multiple timelines (i.e., short-term, mid-term, and long-term)	• Resource requirement • Historic supply costs • Projected technology costs
D	**Operating Reserves**	• Statistical relationship to hourly real-time energy price forecast with adjustments for supply constraints and technology advancements	• Historic OR & HOEP prices • Future supply/demand balance • Projected technology costs
E	**Regulation Capacity**	• Based on potential future Regulation Capacity identified by the IESO • Value based on grid-scale resource costs	• Historic RC prices in Ontario and neighbouring jurisdictions

Economic Potential: Benefit-Cost Framework (3/6)

Approach to Quantifying Benefits and Costs

	Benefit / Cost	Methodology	Key Inputs
F	**Transmission Costs**	• Identification of transmission system investments to meet bulk & regional power system needs, considering forecasted electrification load growth • Deferment potential based on typical transmission capacity investments	• Regional Planning documents • Typical transmission expansion costs
G	**T&D Line losses**	• Line losses are captured as Line Losses Adjustment Factor on distribution bills; with seasonal adjustments factors as available	• Line Losses Adjustment Factor
H	**Distribution Costs**	• Forecast of system service spending by Local Distribution Companies and estimate of portion of system service used for distribution capacity expansion • Consideration of the impacts of forecasted electrification load growth	• Historic and forecasted system service spending
I	**DRIPE**	Discussed in the next slide.	
A	**Measure Costs**	As defined earlier in Measure Characterization	As defined earlier in Measure Characterization
B	**Measure O&M Costs**	As defined earlier in Measure Characterization	As defined earlier in Measure Characterization
C	**Program, aggregation and/or transaction costs**	Typical administration, marketing, resource acquisition and other costs needed to enable DER participation in markets	Based on Dunsky's Program Archetype Library and complemented with research and insights from Ontario and other jurisdictions with similar market structures

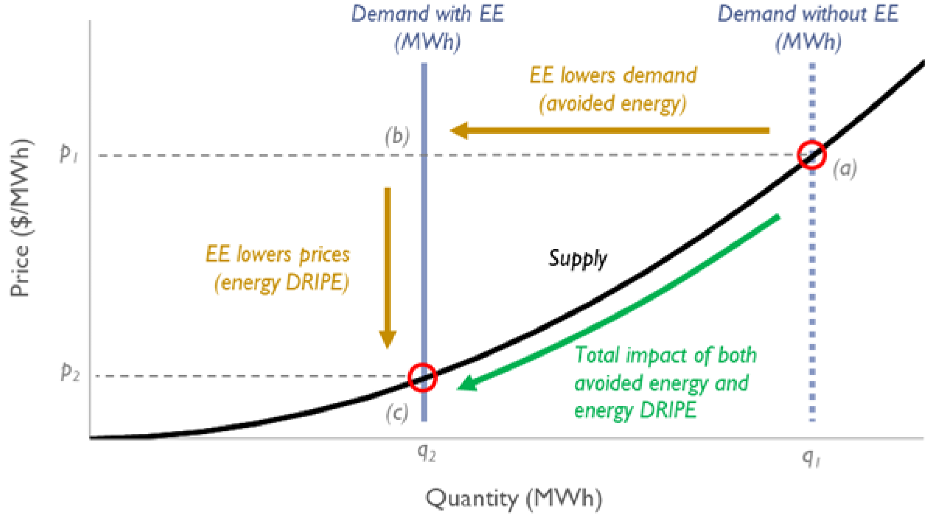
Economic Potential: Benefit-Cost Framework (4/6)

Demand Reduction Induced Price Effect (DRIPE)

- **Refers to the reduced market clearing price resulting from the reduction in capacity/energy needs induced by DERs**
  - Avoided costs represent the benefits associated with the reduced quantity of supply, DRIPE captures the benefits associated with the corresponding price reduction
  - Specifically, DRIPE refers to the reduction in clearing prices in the wholesale energy and capacity markets (relative to the "base" prices forecasted) that benefits all customers/loads
- **The DRIPE analysis will be applied to avoided energy and capacity**
  - With Ontario's expected capacity deficits over the next decade, capacity DRIPE could represent a significant benefit
  - Ancillary service market sizes are too small to reasonably apply DRIPE benefits.
- **For each scenario (reflecting different system outlooks):**
  - Estimate change in prices at different levels of DER uptake
    - ***Example:*** *Capacity DRIPE will assess the impact of DERs to decrease capacity auction prices over the time horizon along with the price reduction from avoiding the need to recontract existing resources and/or procure new resources*
  - Apply a decay factor to capture lag in realizing the benefit
    - ***Note****: The analysis does not directly capture the potential reduction in DER uptake from lower avoided cost value (i.e., lower prices reduce the economics of DERs)*

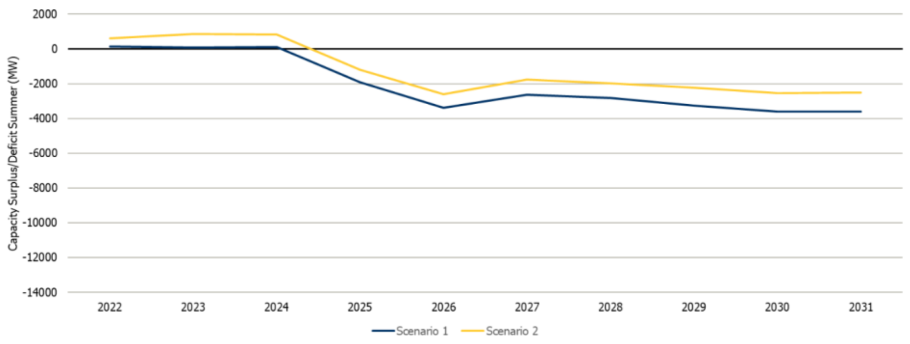
Illustration of DRIPE

(Avoided Energy Supply Components in New England, 2021)



Ontario Summer Capacity Surplus/Deficit

(IESO Annual Acquisition Report 2021)



Economic Potential: Benefit-Cost Framework (5/6)

Other Considerations

- **The study is intended to capture the value of 5-minute dispatchability of DERs where applicable.**
    - A statistical analysis of representative days will be conducted to determine standard deviation of MCPs from HOEP
    - The analysis will also cover MCP variation during SBG events to determine the value of DER dispatchability to reduce or eliminate SBG events
    - Based on the analysis, a 5-minute dispatchability adder to avoided hourly energy costs will be developed to capture the value of responding to all 5-minute dispatch signals
    - Applied to measures where relevant on a measure-by-measure basis
        - The measure derating factors (described earlier in measure characterization) determine what portion of that value can a measure reasonably attain based on technical and operational considerations
- **In developing avoided costs, we will consider the impact on Global Adjustment (GA) and potential divergence of HOEP & GA relationship in the future**
    - Future procurement initiatives announced by the IESO may contract resources under a capacity payment model versus a net-revenue requirement
    - In this case, lowering HOEP will not result in a 1:1 increase in GA; therefore, lowering potential cost savings for overall market
    - In addition, DERs could reduce future resource requirements and lower future GA cost recovery obligations

Economic Potential: Benefit-Cost Framework (6/6)

Other Considerations

- **In addition to the benefit streams captured in the study, the IESO and the project team acknowledge that DERs can contribute to additional benefits to the system and host customers (e.g. *other non-energy benefits*)**
    - These benefits are typically difficult to quantify and have therefore been left out of the benefit-cost framework
    - While their inclusion might improve the cost-effectiveness of DERs in certain niche circumstances, we do not believe the inclusion would materially increase the overall DER potential that will be revealed through this study
    - Benefits not captured in the study will be acknowledged and highlighted for further consideration in the qualitative portion of the study

Economic Potential: Cost-Effectiveness (1/2)

Measure-Level Cost-Effectiveness: Cost-effectiveness of each measure in isolation under “optimal” conditions

- **TRC results will be used to screen-out measures:**
  - $TRC_{\ Measure} = \frac{NPV\ (Lifetime\ Benefits)}{NPV\ (Total\ Costs)}$
  - Measures with TRC > 1 are considered cost-effective and included in the market-wide potential assessment
- **Measure-level cost-effectiveness will be conducted assuming:**
  - Measures participate in all services they can reasonably contribute to (as defined in Measure Characterization) with no constraints (to be referred to a use-case)
  - They are dispatched in a way that maximizes wholesale market benefits, while respecting system and measure specific constraints (e.g. mutually exclusive grid services)
  - Measures are dispatched for system-based applications
  - Measures are assigned the benefit of any service they contribute to; regardless of existing market participation or compensation rules
    - ***Note:*** *To be adjusted in achievable potential to reflect both retail and wholesale services, and consider market barriers.*

Economic Potential: Cost-Effectiveness (2/2)

Market-wide Economic Potential: Assess the cost-effective potential for DERs considering only the pool of measures that pass measure-level screening

- **System Needs Assessment**: Determine the maximum system need for each grid service
- **DER Economic Stacking**: Determine the optimized market-wide DER potential for each grid service based on the identified system needs
    - Starting with the most valuable service, stack measures by their relative cost-effectiveness up to max system needs or until no incremental cost-effective DER potential exists.
    - Repeat process for additional grid services; keeping in measures that have already been assigned to a previously assessed service and bringing in further measures as needed.
    - (If needed) Measure cost-effectiveness may be recalculated if a significant change in impacts is likely to occur due to interactive effects and/or changes in service provision.

System Needs

To ensure that the total stream of benefits required to support the measures does not exceed the system needs:

- **For capacity:** A load curve analysis is conducted with each incremental measure addition to assess its impact on load patterns and peak demand; up to the maximum of "flattening" the demand curve.
    - The load curve analysis is also used to capture interactive effects between measures and potential "bounce-back" (*e.g. measures being stacked may include pre-charge or bounce back that impact load patterns and therefore the potential for future measures)*
- **For T&D, OR, RC and energy:** Exogenous inputs will be used to set the maximum market need for a given period.
    - T&D values will be annual based on defined system needs from bulk & regional system plans for thermal capacity expansions, adjustable for different demand growth expectations
    - OR and RC market sizes are derived from reliability criteria and IESO system need definitions
    - Energy system need is derived from different demand outlooks by scenario

Economic Potential: Output

Outcome: Economic potential results

- **Output Metrics**
  - MW nameplate capacity
  - MW capacity reductions
  - MWh energy generated
  - Tonnes CO2 emission reductions
  - TRC Test Results
  - Total Benefits and Costs
- **Break down by**
  - DER Measure / measure group
  - Study sector / segment
  - Service *provision**

Key Considerations

- Economic potential represents the cost-effective portion of the technical potential of DERs **without consideration of market constraints and realities** (e.g. pace of customer adoption, etc.)
- Given the iterative nature of the approach, the **economic potential will be evaluated in parallel with achievable potential.**
- The economic potential will reflect an **aggregated province-wide potential for DERs**, however certain regions within the province could have higher economic potential (to be discussed in regional disaggregation of Achievable Potential)

* As opposed to "service capability" used under Technical Potential, "service provision" refers to the measure's estimated contribution to different services

3rd Q&A Break

Achievable Potential: Overview

1. **Measure Adjustments:** Where applicable/relevant, adjust measure sizing and/or use-case of the measure to reflect market trends and operational considerations.

2. **Market Size:** Assess the forecast adoption of each measure in Ontario as well as the expected level of participation in grid services under different scenarios.

3. **Market-Wide Potential:** Calculate optimized market-wide potential for DERs in Ontario under different scenarios under various program buckets.

Achievable Potential: Measure Adjustments

Adjustments to reflect market realities and/or scenario input that would impact achievable potential

- **Sizing adjustment**: Where applicable, adjust measure sizing to reflect market trends and/or operational constraints.
    - **Example:** BTM Solar systems are typically not sized to full technical potential (i.e. rooftop area), therefore measure sizing will be adjusted to reflect typical installation sizes (based on insights from net-metering interconnections and expected market trends)
- **Use-cases adjustment:** Where applicable, adjust a measure's assumed service provision to reflect the combination of retail and wholesale applications that some DERs will be contributing as well as market participation rules and market trends.
    - **Example:** While in the economic potential, a BTM storage system is assumed to only contribute to grid services (e.g. capacity), in reality BTM Storage systems may be primarily dispatched by a customer for bill management purposes (e.g. GA avoidance, peak demand management) which would impact the service provision

Achievable Potential: Market Size

Achievable Potential of a DER is a product of two factors:

- **DER Adoption:** The uptake of a given technology by a customer (e.g. customer installs a BTM battery); as determined by the economic attractiveness of the DER measure to a customer, and considering key barriers

- **DER Participation:** The likelihood of customers with a given technology (e.g. a smart EV charger) to participate in the market or a DR program, based on incentives and/or market revenue available to the customer, and program marketing efforts

Achievable Potential: Market Size – Adoption (1/2)

Approach for Market Adoption (i.e. the uptake of a given technology) will vary based on the type of DER

DER Type	Assumption	Example	Market Adoption Approach
A	***Not primarily driven*** by financial benefits of market / program participation (i.e. DR functionality is a by-product)	***Smart thermostats or smart appliances*** are adopted by customers predominantly for energy savings and/or comfort	Expected penetration of the technology in the market will be **based on market data and trends** (e.g. number of smart thermostats from EE APS)
B	***Somewhat driven*** by financial benefits of market / program participation (i.e. DR functionality is a co-benefit)	Choice to install a ***smart EV charger*** is partly influenced by the incremental benefits	Expected penetration of the technology in the market will be based on **high-level market adoption** to determine market growth under different scenarios (with adjustments for scenarios as relevant)
C	***Predominantly driven*** by financial benefits of market / program participation	Decision to adopt ***BTM solar PV / storage*** is based on the financial returns a customer expects from net-metering, market revenue or DR programs	**Detailed market adoption modeling** for each scenario based on market participation benefits

Achievable Potential: Market Size – Adoption (2/2)

For Type C measures, we will leverage Dunsky's suite of models; primarily the Solar and Storage Adoption Model (SAM), to forecast the uptake of the respective technologies

- **General Approach:**
  - **Market Size:** As defined in the Technical Potential
  - **Customer Economics:** Customers' willingness to adopt based on financial returns
    - Assess key benefits & costs; considering the measure's use-case, electricity rates, and key policy/market factors (e.g. incentives, net-metering)
    - Willingness-to-adopt curves highlight the portion of the market willing to adopt the technology at different levels of returns considering customers who may pursue the technology at lower cost-effectives for non-financial motivations (e.g. resiliency)
  - **Technology Diffusion:** Rate of adoption considering the technology and market maturity
    - Captured through Bass diffusion curve
    - Calibrated to historical uptake to capture local market characteristics and barriers.

To the extent possible, our team will rely on recent studies conducted in Ontario to assess the potential of the modeled technologies to avoid duplication of efforts and inconsistencies between resources, while simultaneously tailoring the analysis to the unique nature, scope and needs of the DER Potential Study.

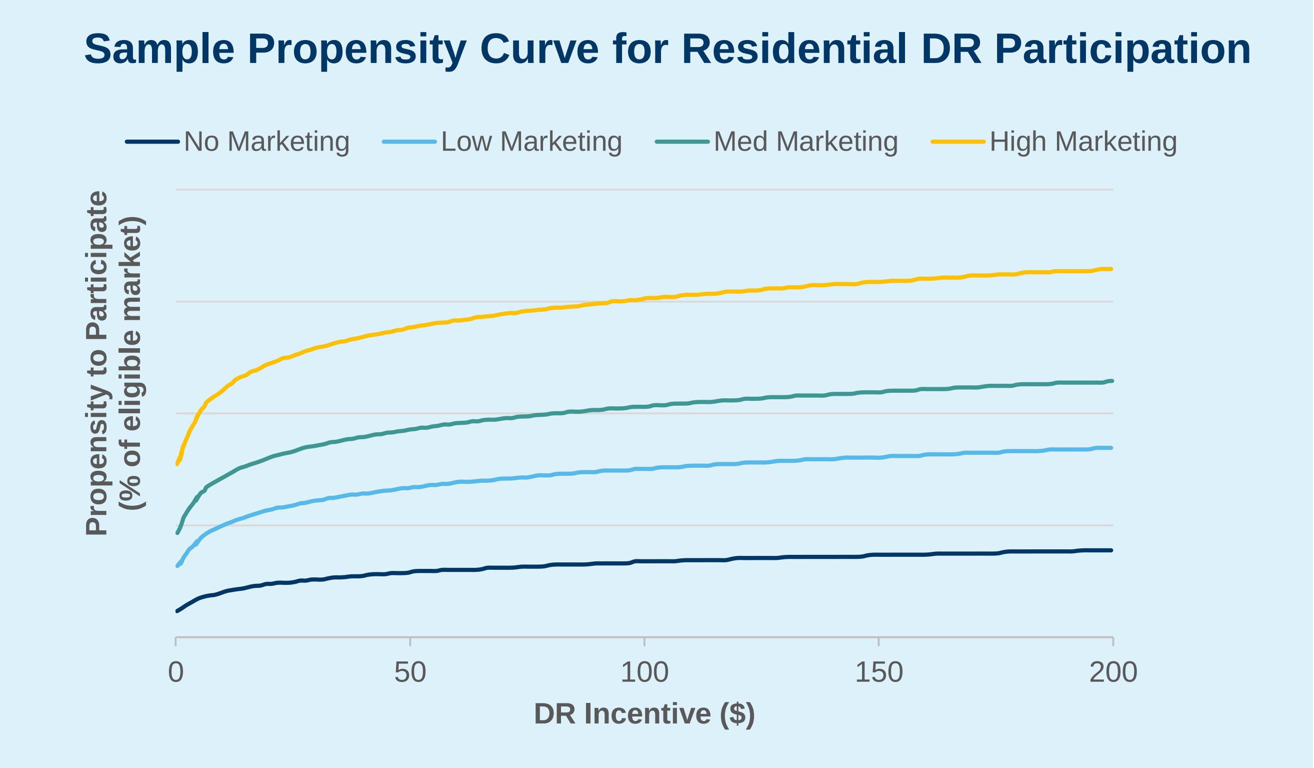
Achievable Potential: Market Size – Participation (1/2)

DER Type	Assumption	Example	Market Participation Approach
A	***Not primarily driven*** by financial benefits of market / program participation (i.e. DR functionality is a by-product)	***Smart thermostats or smart appliances*** are adopted by customers predominantly for energy savings and/or comfort	Assess **propensity to participate** in markets based on incremental revenue/incentives and marketing efforts.
B	***Somewhat driven*** by financial benefits of market / program participation (i.e. DR functionality is a co-benefit)	Choice to install a ***smart EV charger*** is partly influenced by the incremental benefits	
C	***Predominantly driven*** by financial benefits of market / program participation	Decision to adopt ***BTM solar PV / storage*** is based on the financial returns a customer expects from net-metering, market revenue or DR programs	Assume 100% of the DERs participate in the market *(given that adoption is attributed to the market revenue)*

Achievable Potential: Market Size – Participation (2/2)

To assess the portion of DERs likely to participate in the market / DR programs:

- Apply propensity curves that capture the portion of DERs in the market likely to participate in DR based on incremental revenue/incentives and marketing efforts applied
- Other barriers to participation may also be reflected in propensity curves



Feedback Process: *Over the next three weeks, we are seeking input from stakeholders on the following:*
- What participation barriers should be considered in assessing the achievable potential? (i.e. barriers to residential DR aggregation)

Achievable Potential: Market-Wide Potential (1/2)

Assessing the market-wide DER Potential

- Similar to the approach used in the Economic Potential, measures will be stacked (in order of cost-effectiveness and with consideration of market needs for different grid services) to assess the optimal market-wide achievable potential for DERs in Ontario under each scenario.

Achievable Potential: Market-Wide Potential (2/2)

Regional Segmentation

- The study is intended to assess the Ontario-wide DER potential, and detailed bottom-up modeling of DER potential by geographic region is beyond the scope of this study.
- However, to simulate conditions where DER Potential may be higher or lower, the project team will:
  - Identify or define up to five regions or *archetype* regions
  - Divide the provincial load into the above regions to conduct targeted analysis
  - Adjust key market metrics based on the size and composition of the region's population and loads
  - Develop and apply adjustments factors to reflect expected lower/higher potential due to economic factors (e.g. higher T&D deferral opportunities) or other factors (e.g. differences in barriers, greater reliability value) based on the sensitivity of the province-wide model's outputs to these factors.

Feedback Process: *Over the next three weeks, we are seeking input from stakeholders on the following:*

- *Should the regional segmentation align with the IESO planning zones, or should they reflect different regional characteristics/conditions (e.g. ubran vs. rural)?*

Achievable Potential: Output

Outcome: Achievable potential results

- **Output Metrics**
  - MW nameplate capacity
  - MW capacity reductions
  - MWh energy generated
  - Tonnes CO_2 emission reductions
  - Total Benefits and Costs
- **Break down by**
  - DER Measure / measure group
  - Study sector / segment
  - Service *provision**
  - Sub-Region

Key Considerations

- To avoid double-counting, **existing DERs (specifically existing DG and storage) are excluded from the achievable potential**. Specifically, we will use the APO's reacquisition scenario as a basis; making the assumption that existing DERs will continue to operate after the end of their contractual lifetime.
- The study will estimate the **achievable potential for all DER resources in Ontario,** including ones that do not participate in wholesale markets and/or DR programs.

* As opposed to "service capability" used under Technical Potential, "service provision" refers to the measure's estimated contribution to different services

Study Outputs and Outcomes

Outputs

Technical, economic and achievable potential for DERs in Ontario over the next 10 years

- Key Metrics
  - MW nameplate capacity
  - MW capacity reductions
  - MWh energy generated
  - Tonnes CO_2 emission reductions
  - Total Benefits and Costs
- Breakdown by:
  - DER Measure / measure group
  - Study sector / segment
  - Service capability and/or provision
  - Sub-Region

→ Outcomes

Insights and recommendations to support IESO and other stakeholders (e.g. OEB, LDCs, service providers) in unlocking the identified potential by highlighting:

- The potential, competitiveness and use-cases of DERs
- Barriers and challenges facing DER Integration
- Recommended market enhancements and analysis of the corresponding implications
- Recommended strategies for capturing value from DERs through non-market pathways, where more effective
- Recommended areas for further study

4th Q&A Break

4. Key Study Parameters

- General Parameters
- Scenarios
- Other

General Parameters

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- **The study period is 10 years; covering 2023 – 2032**
- **Proposed study segment (analysis to be done based on the sector segmentation* from the APO, however results may be collapsed for reporting purposes)**

Residential	Commercial	Industrial
• Single Family Home • Row House • Low-Rise Multi-Residential Building • High-Rise Multi-Residential Building • Other Residential Building	• Non-Food Retail • Food Retail • Restaurant • Hotel • Office • Hospital • Nursing Home • School • University & College • Warehouse/Wholesale • Other Commercial	• Mining • Primary Metals • Chemical Manufacturing • Paper Manufacturing • Transportation & Machinery

* Bulk system-connected customers are not included as they do not fit IESO's definition of DERs.
Industrial segmentation may vary based on data availability.

Scenarios (1/2)

The study will assess the potential for DERs in Ontario under three scenarios

- The scenarios are intended to reflect varying policy, regulatory and market conditions, and the impact of these conditions on DER potential in Ontario to inform planning and market enhancement efforts
- Proposed scenarios levers are:
  - Carbon pricing (i.e. varying levels of carbon price forecasts and allowance benchmarks)
  - Electrification growth rates (i.e. pace of EV and HP uptake)
  - Market participation and/or compensation (e.g. small resource participation, hybrid resources participation, changes to net-metering)
  - Technology capital cost declines (i.e. technology cost reductions and/or incentives to offset incremental costs)
  - Electricity resource mix (i.e. the resources projected to exist to meet system needs)

Scenarios (2/2)

Proposed scenario settings (preliminary)

	Scenario 1 (Low)	Scenario 2 (Mid)	Scenario 3*
Carbon Pricing	$170/ton 2030 onwards with 370 tCO2e/GWh benchmark	$170/ton 2030 onwards with 0 tCO2e/GWh benchmark	TBD
Electrification Potential	APO Forecasts	APO Forecasts +	TBD
Market Participation / Compensations	Current market participation and compensation rules	Alignment with FERC 2222 + changes to retail structures (e.g. net-metering)	TBD
Technology Capital Costs	Base cost assumptions / No Incentives	Moderate cost decline / Modest incentives	TBD
Resource Mix	APO Forecasts	APO Forecasts + Additional non-emitting resources / storage	TBD

*Scenario 3 settings will be determined following review of the outcomes of the first two scenarios.

Feedback Process: *Over the next three weeks, we are seeking input from stakeholders:*

- *Are the proposed scenarios levers the appropriate ones to consider in this study?*
- *What would appropriate assumptions be for the scenarios?*

5. Wrap-Up and Next Steps

- Requested Input/Feedback from Stakeholders
- Next Steps

Requested Input/Feedback from Stakeholders

Feedback requested over the next three weeks:

- **Approach for technical, economic and achievable potential analysis:**
  - General input on the proposed approach for evaluating DER Potential
  - General input on the proposed market and measure characterization approaches
  - Ontario-specific considerations or data sources that the team should employ in the study
- **Regional segmentation:**
  - Should the regional segmentation align with the IESO planning zones, or should they reflect different regional characteristics/conditions (e.g. urban vs. rural)?
- **Market Barriers:**
  - What specific participation barriers should be considered in assessing the achievable potential for DERs? Please speak to specific market participation barriers (e.g. participation thresholds) and non-market participation barriers (e.g. requirements for residential DR aggregation)?
- **Input on scenarios:**
  - Are the proposed scenarios levers the appropriate ones to consider in this study?
  - How might the project team incorporate and vary non-market participation barriers in the three scenarios?
  - What would appropriate assumptions be for the scenarios?

Next Steps

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- **Stakeholders:**
  - Please use the feedback form found under the November 23 entry on the DER Potential Study webpage to provide feedback and send to engagement@ieso.ca by December 14, 2021

- **Dunsky & IESO:**
  - Review and respond to stakeholder comments
  - Finalize detailed study plan
  - Commence potential assessment
  - Present results and recommendations to stakeholders June 2022

5th Q&A Break

Thank You

Questions or feedback can be directed to: engagement@ieso.ca

Materials relating to this project, including this presentation and feedback questionnaire, are available at the IESO DER Potential Study engagement page at the link below: https://www.ieso.ca/en/Sector-Participants/Engagement-Initiatives/Engagements/DER-Potential-Study

Appendix

- Total Resource Cost Test

Appendix

Total Resource Cost (TRC) Test

The TRC test includes costs and benefits at the system level as well as at participant level. The study will use a modified version of the TRC test, which will include the costs and benefits outlined in the study Benefit-Cost Framework slides. For context, the standard TRC test used by IESO to assess conservation and demand management activity cost-effectiveness is provided below:

$$Benefits = ASC + ORB + TC + NEB$$

$$Costs = PTC + PRC$$

Where:

ASC = Avoided supply-side resource costs

ORB = Other supply-side resource benefits

TC = Tax credits

NEB = Non-energy benefits

PTC = Net participant costs

PRC = Program costs

Source: IESO. (2019). Conservation & Demand Management Energy Efficiency Cost-Effectiveness Guide.