Massachusetts Clean Peak Standard: Market Model

Final Report

August 27, 2019

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Acronyms

- ACP = Annual Compliance Payment
- AD = Anaerobic Digestion
- AMI = Advanced Metering Infrastructure
- BTM = Behind the Meter
- CAPEX = Capital Expenditures
- CES = Clean Energy Standard, Customized Energy Solutions
- CP = Clean Peak
- CPS = Clean Peak Standard
- CPEC = Clean Peak Energy Credit
- DOER = Department of Energy Resources
- DPU = Department of Public Utilities
- DRR = Demand Response Resource
- EDC = Electric Distribution Company
- EE = Energy Efficiency
- EV = Electric Vehicle
- FTC = Federal Tax Credit
- GWSA = Global Warming Solutions Act
- IC = Interconnection
- IFOM = In Front of the Meter
- ISO = Independent System Operator
- ITC = Investment Tax Credit
- LBW = Land Based Wind
- LCOE = Levelized Cost of Energy
- LT = Long-Term
- M&V = Measurement & Verification
- NM = Net Metering
- OPEX = Operating Expense
- OSW = Offshore Wind
- PPA = Power Purchase Agreement
- PURPA = Public Utilities Regulatory Policies Act
- QESS = Qualified Energy Storage System
- QRPS = Qualified RPS Resource
- REC = Renewable Energy Credit
- ROR = Run-of-River
- RPS = Renewable Portfolio Standard
- SEA = Sustainable Energy Advantage
- SMART = Solar Massachusetts Renewable Target Program
- SREC = Solar Renewable Energy Credit
- TX = Transmission
- VNM = Virtual Net Metering
- WACC = Weighted Average Cost of Capital

1. Introduction

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Introduction

- Context
- Clean Peak Energy Standard
  - Concept, Overview of Statute, DOER Straw Proposal
  - Challenges
- CPS Objectives, Constraints
- Purpose of this Report
- Scope
  - Initial
  - Reasons for refinement
  - Refined scope
- Organization of Report

Context

- Massachusetts and regional market and policy dynamics are leading to material transitions in the ISO New England power system
  - Increasing renewable energy targets (Renewable Portfolio Standards) and procurement policies driving distributed solar, utility-scale renewables, and offshore wind
    - Driving increasingly large volumes of resource-dependent clean energy resources dominated by variable production (wind, solar)
    - While generators that produce at peak times have smaller ‘premiums’ and can therefore compete more effectively than others, RPS drives supply without explicit regard for production at times of system peaks
  - Retirement/replacement of historic generation fleet dominated by baseload and load-following generators
  - The Commonwealth’s Global Warming Solutions Act (GWSA) demands rapid decarbonization of the generation fleet as well as electrification of the transportation and heating sectors
  - Integration of increasing quantities of variable, non-baseload and non-dispatchable renewables require investments (in flexible supply capable and a more flexible grid) to maintain reliability
  - Peak loads met by fossil generation increase emissions of criteria pollutants and greenhouse gases
  - A disproportionate share of costs to provide electric service are driven by a small amount of peak hours. As shown in the State of Charge, from 2013-2015, the top 10% of hours accounted for 40% of annual electric spending
- These factors drive needs to encourage clean energy options that can produce at times of peak demand, and flexible resources to enable the integration of large quantities of renewable energy generation

An Act to Advance Clean Energy

- On August 9, 2018, Governor Baker signed H.4857 into law as Chapter 227 of the Acts of 2018
- Among other things the Act required that DOER establish a first-in-the-nation Clean Peak Energy Standard (CPS), an idea initially promoted in Massachusetts by Governor Baker in **H.4318 - An Act Promoting Climate Change Adaptation, Environmental and Natural Resource Protection, and Investment in Recreational Assets and Opportunity** (summarized in Digest 67), but with substantial revisions to the Governor's original proposal.
- The CPS would require every retail electric supplier providing service under contracts executed or extended after December 31, 2018 to provide a minimum percentage of kilowatt-hour sales to end-use customers in the commonwealth from clean peak resources.
  - DOER to establish a minimum baseline that must be met with "Clean Peak Energy Certificates" (CPECs) beginning January 1, 2019. Each year thereafter, retail electricity suppliers would increase the amount of sales served by clean peak resources by at least 0.25% each year

CPS Statutory Language

- **Clean Peak Resource**: Clean Peak Resource is defined as a qualified RPS resource, a qualified energy storage system or a demand response resource that generates, dispatches or discharges electricity to the electric distribution system during seasonal peak periods, or alternatively, reduces load on said system.
- **Demand response resource (DRR):** Changes in electric usage by end-use customers in the commonwealth from their normal consumption patterns in response to:
  - (i) changes in the price of electricity over time, including, but not limited to, time-of-use rates for residential and small commercial and industrial customers; or
  - (ii) incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized
- **Qualified energy storage system (QESS)**: An energy storage system, as defined in section 1 of chapter 164, that commenced commercial operation or provided incremental new capacity at an existing energy storage system on or after January 1, 2019; provided, however, that such system *operates primarily to store and discharge renewable energy* as defined in said section 1 of said chapter 164.
- **Qualified RPS resource (QRPS)**: A renewable energy generating source, as defined in subsection (c) or in subsection (d) of section 11F that has:
  - (i) installed a qualified energy storage system at its facility; or
  - (ii) commenced commercial operation on or after January 1, 2019.

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Clean Peak Standard

- Any eligible resource that generates, dispatches or discharges energy to the electric grid during a Seasonal Peak Period will generate CPECs
- CPECs can be sold to retail electricity suppliers, which are required to purchase a certain amount each year
- DOER is responsible for:
  - Establishing the eligibility criteria to qualify;
  - Setting an Alternative Compliance Payment (ACP) rate and procurement processes to establish CPEC values;
  - Establishing annual compliance requirements;
  - Establishing the four Seasonal Peak Periods in which facilities must operate

Background: DOER Objectives and Key Design Features from DOER Straw Proposal

This report describes development for DOER by its Consulting Team of a market model to reflect objectives and design features contained in the April 2, 2019 Straw Proposal, and to enable DOER to investigate the setting of CPS obligation targets and the ACP level, and explore the impacts of eligibility, multiplier and other design features.

DOER Objectives were articulated in the April 2, 2019 Straw Proposal:

- Align clean energy generation with periods of peak demand on the electric power system to mitigate the emissions and costs associated with these periods
- Encourage co-location and/or co-operation of energy storage and clean generation
- Incentivize and enable continued deployment of renewable generation by flattening the net electric load curve

Key Design Features articulated in DOER Straw Proposal included:

- Categories of Eligible Clean Peak Resources: includes RPS Class I resources online on/after 1/1/19 (Category 1), existing Class I/II RPS resources paired with QESS (Category 2), New or Existing QESS systems that operate primarily to store and discharge renewable energy, and demand response resources
- Proposed CPS dates defining the four seasons, and proposed CPS seasonal peak periods, each totaling 4 hours, which are the hours of each day the CPEC are generated dependent on the current season
- *Initially proposed* CPEC Multipliers which include a multiplier based on the current season (3x for summer and winter, 1x for fall and spring), and a 15x multiplier for the actual peak day of each season
- Proposal for a required CPEC Procurement from EDCs

- CPS Straw Proposal Presentation Boston, MA April 2, 2019: https://www.mass.gov/files/documents/2019/04/02/Clean%20Peak%20Straw%20Proposal%203.29.19%20.pdf

CPS Market Modeling Constraints & Challenges

- The CPS is a complex and first of its kind policy that required addressing broad range of issues to craft a coherent policy
- A model of the behavior of a market for CPECs must account for a variety of interacting policy design features, many of which are at DOER's discretion to interpret or determine, including:
  - Geographic & interconnection eligibility (transmission vs. distribution connected resources, if and how resources outside of MA qualify)
  - The ACP
  - The annual compliance obligation as a function of the minimum standard requirement, which DOER has set at 0% for 2019, but which must be established for 2020 and must escalate thereafter at or above 0.25% of load annually
  - The eligibility treatment of contracted or hedged supply, i.e., those resources already benefiting and financed under other programs
  - Establishment of Peak and Resilience multipliers, and potentially, other multipliers
- The enabling statute imposed design challenges, including:
  - A single policy accommodating broad range of disparate resource types with different cost, revenues, drivers, needs
  - The DR category spans a broad and heterogeneous potential pool of Clean Peak Resources, which presents practical challenges, including (i) understanding and modeling a wide range of potential use cases, many of which have site-specific costs or need little or no investment, cost curve challenging, (ii) resource-specific modeling methodologies ,and (iii) issues with respect to establishing performance baselines, measurement, verification, and free riding
  - The mechanics of 'virtual pairing' of renewable energy generators and energy storage devices
  - The interpretation of Category 3: QESS "operate primarily to store and discharge renewable energy"
  - A short implementation timeframe, which practically may necessitate phased implementation
- The enabling statute left many features to be interpreted and determined by DOER
- Design of the CPS is also subject to several constraints, including:
  - Acceptable ratepayer impact, which DOER defined in the Straw Proposal as not exceeding 0.5¢/kWh of retail sales
  - Design to maintain Supply-Demand tension to make CPEC revenue somewhat predictable/reliable than in a market likely to be well oversupplied
  - Effectiveness at achieving objectives cost-effectively
  - A policy preference to incent the deployment of new Clean Peak Resources over support of existing Clean Peak Resources, and the potential to differentiate the level of support to accomplish that preference
  - The potential establishment of a long-term CPEC contract or tariff (revenue hedging) program
- Assessing program costs and benefits

2. Scope

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Consulting Team

- DOER engaged the team of Sustainable Energy Advantage, LLC (SEA, prime contractor) and Customized Energy Solutions (CES) to provide analysis to support DOER's policy development efforts, with a focus on quantification of key design features, cost and benefits
- Team members had collaborated on 2017 *State of Charge* Report for DOER
- Each firm brings industry-leading expertise
  - SEA: renewable energy and portfolio standard design and analysis
  - CES: energy storage, DR, wholesale market
- The two firms operated in an integrated manner and provided a comparable level of input to the overall work-product
- SEA's Bob Grace served as overall project manager, while CES's Vinayak Walimbe served as manager of their efforts

Scope - Initial

- DOER initially sought Consulting Team's support to help analyze how Clean Peak Resources may be appropriately valued and compensated in the Commonwealth's CPS
- Contractor tasked with analyzing the total market size and expected costs and benefits to ratepayers of different potential incentive policy frameworks
- The initial scope, as envisioned by DOER, included the following tasks
  - Task 1. Identify and evaluate range of technologies and uses that should be included in the definition of Clean Peak Resources
  - Task 2. Identify and evaluate methodology of providing support to technologies and uses
  - Task 3. Identify and evaluate the amount of incentive needed under proposed methodologies
  - Task 4. Identify and evaluate the level of demand increase needed to support
  - Examine the level the CPS's Minimum Standard needs to be set at in order to sufficiently support the technologies identified in Task 1 at the incentive levels identified in Task 3
  - Task 5. Cost/benefit analysis of the proposed program design(s), to include production cost modeling of reference case and desired policy cases
  - Task 6. Support stakeholder engagement sessions
- The initially-envisioned deliverables included:
  - **Report of Clean Peak Resource price trends and projections in the Massachusetts market** for different projects sizes and types, assumptions and results demonstrating economic value needed to sustain project development for the identified project sizes and types
  - **Policy analysis report** describing policy design options and evaluating the comparative direct cost and risks to ratepayers of each scenario modeled

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DOER's evolving needs ➔ Drove Scope Refinement

- Rapidly evolving circumstances, DOER's internal policy analysis, and accelerated and compressed timeline (relative to that proposed by Consulting Team) drove a refinement of the scope towards modified emphasis and a shift in core deliverables from reports to analysis and a modeling tool
- Initially, Consulting Team was to identify range of issues and options, analyze and present metrics, costs, benefits and recommendations
- By the time the consulting engagement commenced, DOER had developed a Straw Proposal, selecting many design features to meet its objectives, and its needs had evolved and narrowed
- Rather than having Consulting Team model an approach, DOER:
  - Desired to keep many design variables open and sought insight on how choices would impact obligation scale, ACP and ratepayer cost impact
  - Sought from Consulting Team:
    - An analysis of technology/use case costs, revenue gaps, CPEC production under DOER's Straw Proposal structure and multipliers, and resource potential
    - A model that would allow DOER to consider a wide range of interacting design decisions relating to eligibility decisions (including use cases and possible exclusions for categories of resources not needing further policy support), long-term contracting co-policy, initial targets and rate of escalation, multipliers, etc.
  - Shifted focus to emphasize:
    - Technology/use cases, CPEC production, economics and resource potential of each
    - Impacts of policy design decisions on effectiveness at stimulating supply mix changes to impact system peak, and associated ratepayer impact
  - Altered desired core deliverable ~~from comprehensive policy study~~ to development of a modeling tool that DOER can use to explore and consider various design features
- ~~Furthermore, the compressed timeline and DOER's desire to keep certain design options open, pending analysis requiring the Consulting Team's model to evaluate, presented a sequencing challenge, effectively precluded the initially-intended production cost modeling exercise of selected policies at this stage of DOER's policy development to be concluded in time to impact DOER's proposed regulations~~

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Scope - Refined

- Shifted from analysis and detailed documentation thereof to a narrower focus on developing and populating a Task 4 model that DOER could use to explore key design decisions
  - Emphasis on (initial) Tasks 1, 3 and 4
- Expanded efforts to consider a wide range of use cases and design options (DOER preference to keep many options open pending analysis at this stage)
- To accomplish the above subject to a fixed budget, modified/scaled-back other tasks for initial phase as follows:
  - Modified and scaled back Task 2 research and analysis
    - DOER had determined in their Straw Proposal against using multipliers or other mechanisms to favor or differentiate support across different technologies
    - Model incorporated option of providing long-term (LT) contract or revenue hedge, to be used by DOER to explore policy options; DOER deprioritized exploration of other mechanisms for differential support
  - Simplified Task 5 cost-benefit analysis approach and shifted primary responsibility of analysis to DOER, utilizing benchmark measures and relying on recent studies (such as *State of Charge*, and *Avoided Energy Supply Components in New England: 2018 Report*) rather than modeled results to estimate benefits
  - Deprioritized Task 6, as Consulting Team deliverables sufficiently armed DOER to proceed without consulting support in stakeholder engagement at this juncture
- Revised deliverables:
  - Task 3 model (documenting assumptions for technology/use cases and their cost trends, and calculation of revenue gaps)
  - Task 4 model (documenting resource potential estimates, and enabling DOER to explore impact of key design features on output metrics of market scale and cost at selected ACP values under selected eligibility and contracting (hedge) assumptions

Purpose and Organization of this Report

- Purpose:
  - To document **Phase I** of the Consulting Team's efforts:
    - Identifying technology/use cases modeled
    - Describing modeling approach
    - Outlining key assumptions
- Organization
  - Section 1 serves as an Introduction, laying out policy drivers, DOER's statutory mandate, DOER's CPS Policy Straw Proposal
  - This Section 2 outlines the scope of the Consulting Team effort
  - Section 3 introduces an overview of modeling methodology developed for DOER, consisting of two major components, the economic analysis of revenue gaps, and the CPS market analysis
  - Sections 4 through 14 provide a detailed description of each of the modeling analysis steps, including key assumptions and results. These pertain to eligible technologies, production profiles, projections of CPEC production, the revenue gap analysis, projections of resource potential, profitability and market size analysis at various ACP levels, and calculation of ratepayer impact and other key metrics

3. Methodology Approach: Overview

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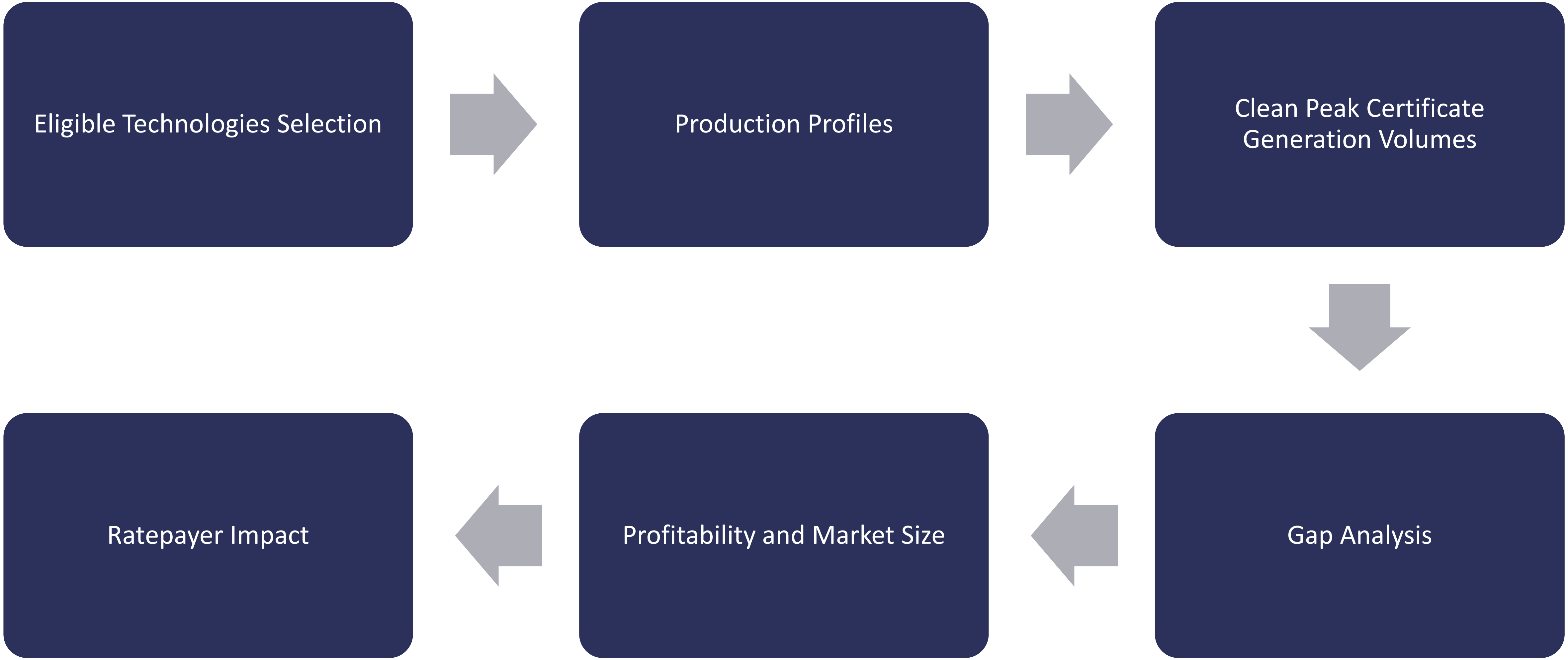
Modeling Overview



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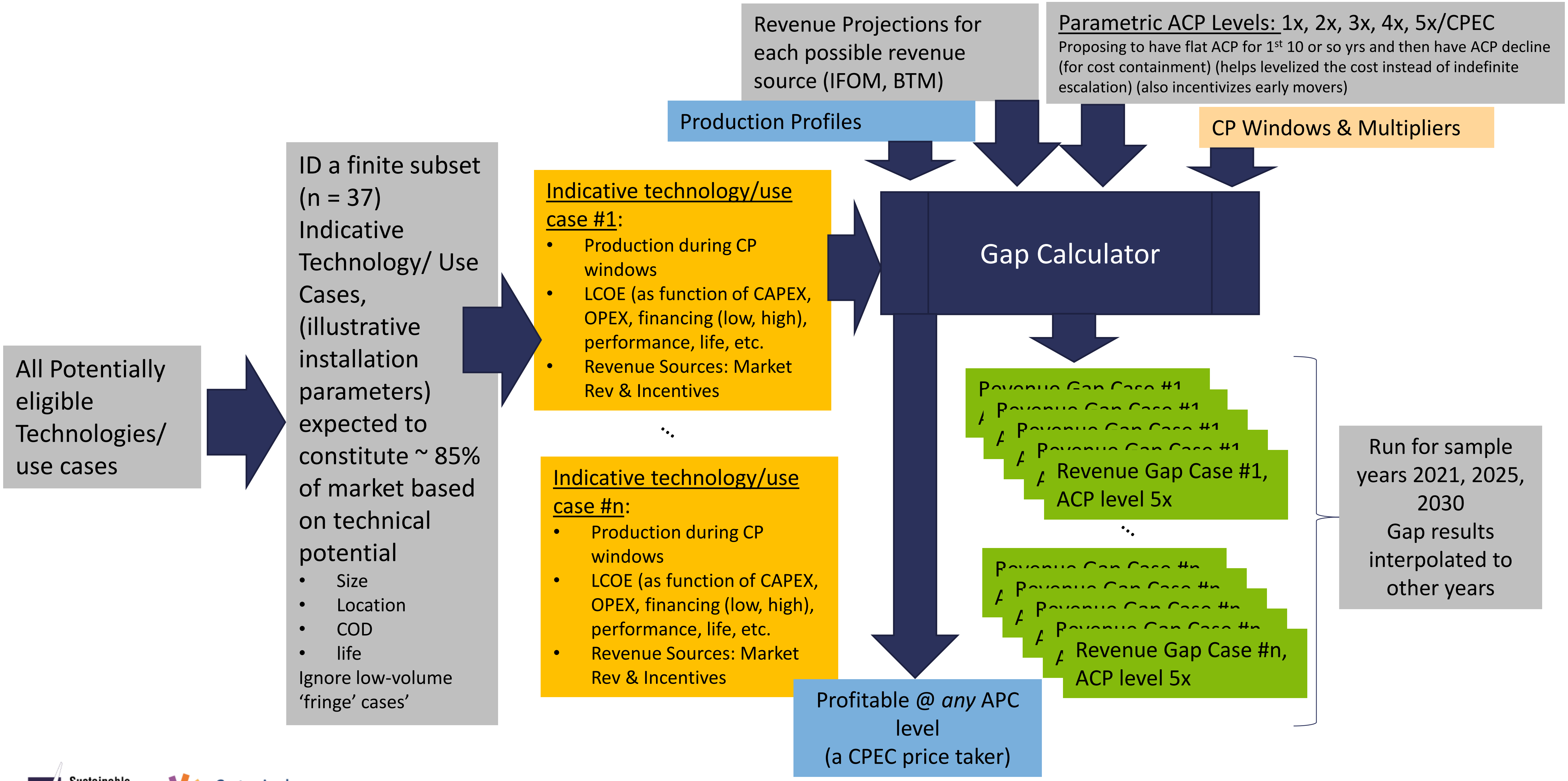
Analysis Methodology Detail: Economic Analysis of Revenue Gaps



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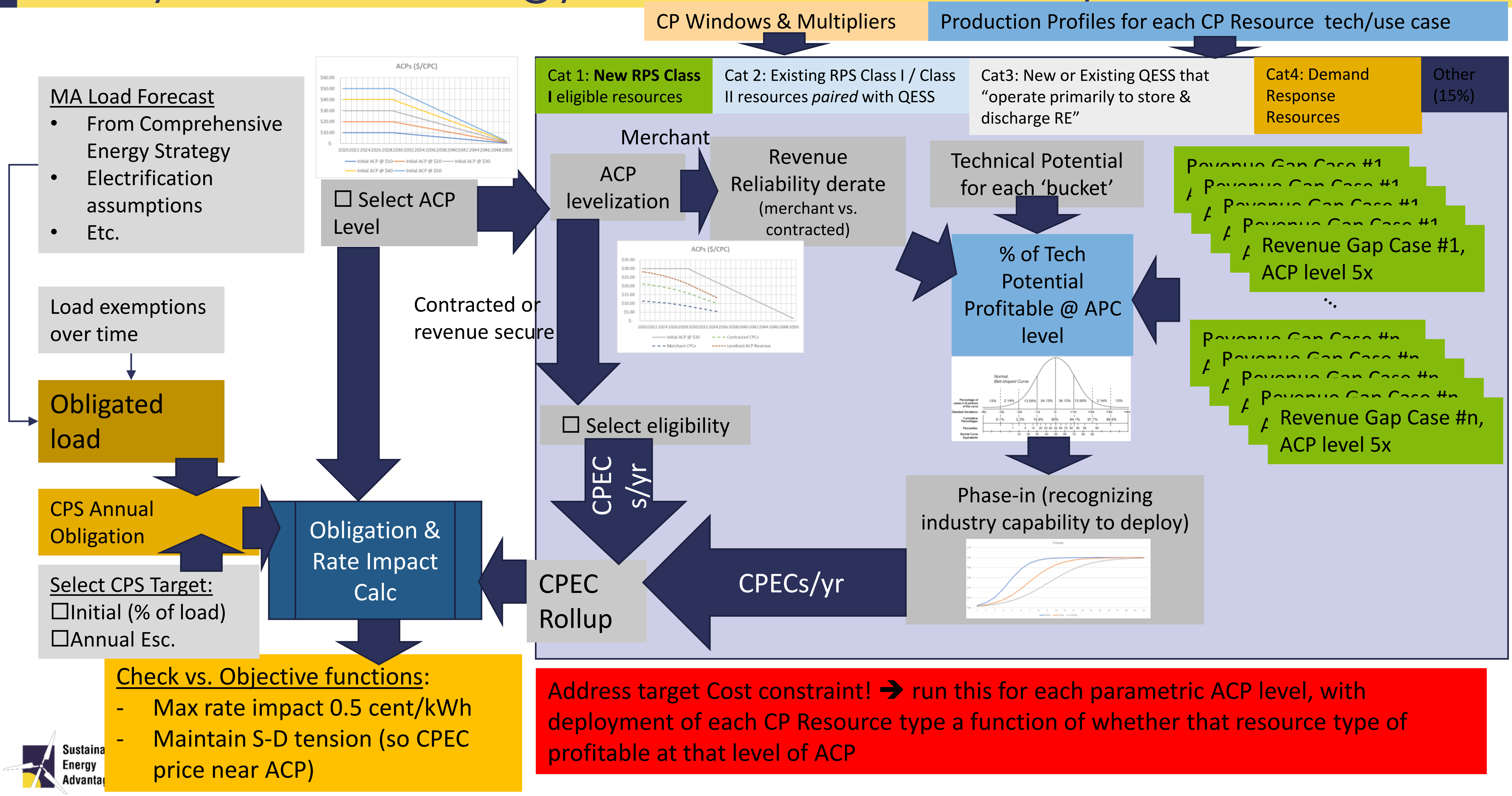
Analysis Methodology Detail: Market Analysis



4 Identify Technology/Use cases

- *This section includes modeling assumptions aligned with DOER's April 2, 2019 Straw Proposal. It is not a representation of specific details (eligibility, multipliers, CPS Seasonal peak periods, etc.) subsequently developed by DOER, influenced by use of the model, and reflected in the Draft Regulation*

Economic Analysis of Revenue Gaps:
Step 1: Identify Technology / Use cases

- One of the primary tasks of this study is to investigate, identify and inspect the range of technologies and uses that are compliant with the statutory of definition of Clean Peak Resources. Steps included:
  - Clearly identifying the statutory language on Clean Peak Resources
  - Exploring the range of available technologies, their configurations, use cases, potential issues (where there exists latitude for interpretation), options and implications and a set of recommendations on the selection of eligible technologies and applications that not only meet the statutory definition of Clean Peak Resources as further elaborated in the DOER Straw Proposal**,** but stay true to the spirit of the law
  - Identifying recommendations for those technology, application and use cases feasible to implement in the initial regulations, versus those that may be considered at a later date subject to addressing implementation challenges
  - Identifying illustrative technologies, applications and use cases likely to represent the majority of CPECs production for analysis in the remainder of this report
- In order to create a model of the CPS, Consulting Team needed to bound the number of potential installations
- Of the broad range of potentially eligible technology and use cases, the Consulting Team identified a total of 37 - in their judgement – most likely to be material
  - Assumed to contribute to 85% of the market potential
  - Other 'fringe cases' not analyzed
  - Analysis results can be scaled up to reflect 100% of market

Categories of Eligible Clean Peak Resources

Category 1: New RPS Class I eligible resources in operation on or after 1/1/19

Category 2: Existing RPS Class I / Class II resources that are paired with a Qualified Energy Storage System

Category 3: New or Existing Qualified Energy Storage Systems that operate primarily to store and discharge renewable energy

Category 4: Demand Response Resources

Category 3: Updates

Virtually Paired: A QESS implies an energy storage asset that is **virtually paired** with a qualified renewable generator provided that the asset is charged from the grid during the required charge hours as determined by DOER, e.g.:

- **Wind - Charge hours** 11 PM to 6 AM
- **Solar - Charge hours**
    - Winter: 11 AM to 2 PM
    - Spring: 9 am to 3 pm
    - Summer: 9 am to 1 pm
    - Fall: 10 am to 2 pm

Team discussed the concept of **Net Energy Agreement** between QESS and RE generator but deemed it unnecessary at this stage. Team also decided to mention penalties for potential non-compliance due to violation in charging hours without specifying them.

Physically Paired: (Category 1/3) New RPS Class I eligible resources paired with New Qualified Energy Storage Systems, in operation on or after 1/1/19

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Dimensions of CPS Eligibility: Vintage and Location

- **Vintage**:
  - **Category 1:** In operation after 1/1/2019
  - **Category 2: Class I or Class II RPS resources that:**
  - a) Reached commercial operation prior to 1/1/2019, AND
  - b) Have installed a QESS that commenced operation after December 31, 2018;
  - **Category 3:** Commenced commercial operation after 1/1/2019
  - **Category 4:** For eligible existing DR programs, no specific vintage; Passive DR and EE installed after 1/1/19
- **Location and Interconnection**
  - Connected to the transmission grid across ISO-New England control area
  - Connected to the distribution grid in the Commonwealth of Massachusetts

Dimensions of CPS Eligibility: Metering and Verification

- **Metering/Verification**
  - **Category 1**: Direct metering at the project site for renewable energy generated and dispatched to the grid during Clean Peak windows will provide verification of Clean Peak energy production. (includes sub- and direct metering, and applies to BTM as applicable)
  - **Category 2**: Charging energy supplied from Clean Peak qualifying resource requires physical pairing and delivered to grid through common collector; direct metering of paired resource production during Clean Peak windows will provide verification of Clean Peak production.
  - **Category 3**: Direct metering of QESS to validate virtual pairing and charging during defined periods. With respect to the Renewable Energy facility, DOER may or may not require metering.
  - **Category 4**: Assumed metered usage comparison to a baseline and potentially additional data from EV/Charging Stations (Specific metering requirements, e.g., identifying charging during non-CPS hours, to be determined by DOER).

Eligibility Input Assumptions: Should supply with policy-based fully-compensatory revenue streams be eligible?

LT Contract & Tariff Eligibility	Cat1: New (COD 1/1/19 or later)	Cat 2: Existing (COD pre-1/1/19)	Cat 3: QESS	Cat 4: DR
Pre-CPES LT Contracts or Tariffs				
MA SREC-1		Yes		
MA SREC-2	No	Yes		
MA SMART	No		Yes	
MA OSW	Yes		Yes	
All Other Fully Compensatory Contracts or Tariffs from MA or other states	No	No	Inel	Inel
All Merchant	Yes	Yes	Yes	Yes
Future LT Contracts or Tariffs				
MA SMART	No		Yes	
MA OSW	Yes		Yes	
All Other Fully Compensatory Contracts or Tariffs from MA and other states	No	No	Inel	Inel
All Merchant	Yes	Yes	Yes	Yes

Dilemma:

- Want to send operational signals and encourage ESS installation…
- But quantities so vast, that liberal eligibilities can squeeze out new installations

Model initially set up with these assumptions, but each can be toggled by user to explore impact

Note: The table shown is a snapshot of the model's input table showing illustrative input assumptions, the implications of which can be explored by varying the inputs, and do not represent the specific conditions considered by DOER or subsequently adopted by DOER for the Draft Regulations

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Category 1:
New MA RPS Class I-Eligible Renewables

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Category 1: New RPS Class I Eligible Resources

RPS Class I Renewables

New renewable energy facilities that began commercial operation after 1997, generate electricity using any of the following technologies, and meet all other program eligibility criteria: Solar photovoltaic; Solar thermal electric; Wind energy; Small hydropower; Landfill methane and anaerobic digester gas; Marine or hydrokinetic energy; Geothermal energy; Eligible biomass fuel

Eligibility Consideration

- New RPS Class I in operation after 1/1/2019 are eligible to qualify and participate
- Upon qualifying a new RPS Class I, all electricity delivered by the resource during Seasonal Peak Periods will be eligible to generate CPECs

Eligibility Issue

- Should project with access to long-term contracts or tariff sufficient to make projects financeable be eligible?
- Examples: OSW with Section 83C contracts; SMART solar projects, projects with existing long-term contracts from other states

Category 1: New Class I RPS Eligible Resources
Potential long-term contracting eligibility options

Option	Implication
A. Include (past) (future) contracted or tariffed supply	▪ Past projects get windfalls ▪ Increases scale of policy targets (by a lot), reduces incentive diverts CPS incentive from projects that may need it ▪ Class I REC premium is lower (due to supplemental revenue source) ▪ Future project may face increased risks, leading to increased cost of finance, increased expected value of ratepayer impacts ▪ Operator has incentive to maximize production during peak windows ▪ Past contracts get windfalls

B. Exclude only past contracted supply	▪ No windfalls for past contracts
	▪ Policy targets are smaller than 'include' case, so CP incentive can support more incremental supply
	▪ For future projects:
	    ▪ Class I REC premium is lower (due to supplemental rev source)
	    ▪ Future project may face increased risks, leading to increased cost of finance, , increased expected value of ratepayer impacts
	    ▪ Operator has incentive to maximize production during peak windows

C. Exclude all contracted supply	▪ Mitigate windfalls ▪ No increased risk to developers, so maintain contracting at least cost ▪ Operator does not have incentive to maximize production during peak windows ▪ Reducing sale of eligible supply, allowing CPS incentive to focus in incentivizing more incremental peak supply
D. Include, but provide CPECs to buyers (EDCs)	▪ Operator has incentive to maximize production during peak windows ▪ Don't increase cost of finance ▪ Otherwise, same as 'include' case
E. Exclude, but (for OSW at least) incorporate CP performance criteria or availability in future EDC contracts (small penalty/bonus sufficient to stimulate)	▪ No increased financing risk to developers, so maintain contracting at least cost ▪ No windfalls ▪ Policy targets are smaller than 'include' case, so CP incentive can support more incremental supply ▪ Operator has incentive to maximize production during peak windows

Category 1: Discussion

- Eligible technologies: Solar, Wind (land and offshore), biomass, biogas, hydroelectric
- Examples of most likely use cases:
  - Transmission-interconnected
  - Distribution-interconnected
  - BTM (undersized, oversized)
- Expected high volume application:
  - OSW (unless excluded)
  - Large-scale LBW – scale is largely dependent on future LT contracting polices by MA and other states (unless excluded)
    - Not under policy-driven LT contracts
  - Utility-scale solar IC to TX system under LT contracts (unless excluded)
  - Utility-scale solar IC to TX system not under LT contracts (e.g., NM, VNM, Community solar, PURPA)
  - Solar Distribution Connected IFOM, in MA
    - Under tariff (unless excluded)
    - Not under tariff (VNM, PURPA, Class I)
  - Solar BTM, in MA
    - Under tariff (unless excluded)
    - Oversized NM, VNM
    - Sized to load NM

Category 2:
Existing RPS Class I / Class II resources paired with Qualified Energy Storage System (QESS)

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Storage Technologies

Mechanical

- **Pumped Storage** - Stores electrical energy as the potential energy of water. Typically, this involves pumping water into a large reservoir at a high elevation and when required, the water in the reservoir is guided through a hydroelectric turbine, which converts the energy of flowing water to electricity.
- **Compressed Air Energy Storage** - converts electrical energy into compressed air, which is stored either in an underground cave or above ground in high-pressure containers and is typically used for long durations for use in a future period.
- **Flywheel** -Store electrical energy as the rotational energy in a heavy mass. Flywheel energy storage systems typically consist of a large rotating cylinder supported on a stator.

Electrochemical

- **Lithium Ion, Lead Acid, Sodium Sulphur, Sodium Nickel Chloride** – Versatile batteries that can be adopted for a variety of use cases and applications ranging from high power to long duration operation.
- **Flow Batteries** – energy is stored in the electrolyte (the fluid) instead of the electrodes. The electrolyte solutions are stored in tanks and pumped through a common chamber separated by a membrane that allow for transfer of electrons.

Thermal

- **Molten Salt, Chilled Water, Latent – Ice Storage, Phase Change Materials** – In these systems excess thermal energy is collected for later use. For example, storage of solar energy for night heating; summer heat for winter use; winter ice for space cooling in the summer.

Chemical (Hydrogen)

- **Power-to-Power/Gas (Fuel Cells)** - Typically utilizes electrolysis of water to produce hydrogen as a storage medium that can subsequently be converted to energy in various modes, including electricity (via fuel cells or engines), as well as heat and transportation fuel (power-to-gas).

Category 2: Existing Class I/II Renewables Paired with Storage

RPS Class I Renewables

New renewable energy facilities that began commercial operation after 1997, generate electricity using any of the following technologies, and meet all other program eligibility criteria: Solar photovoltaic; Solar thermal electric; Wind energy; Small hydropower; Landfill methane and anaerobic digester gas; Marine or hydrokinetic energy; Geothermal energy; Eligible biomass fuel

RPS Class II Renewables

Similar to RPS Class I, this class pertains to generation units that use eligible renewable resources but have an operation date prior to January 1,1998

Eligibility Consideration

- **QESS**: The Qualified Energy Storage System (QESS) paired with the Class I/Class II resource must be at least:
  - 25% of the nameplate power of the facility; and
  - Have a minimum 4-hour duration of storage
- Upon qualifying an existing RPS Class I/II resource, all electricity delivered by the resource during Seasonal Peak Periods will be eligible to generate CPECs

Category 3:
Stand-Alone Qualified Energy Storage System (QESS)

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Qualified Energy Storage System (QESS)

Eligibility Consideration

A QESS implies an energy storage asset that is **primarily charged from renewable energy** provided that the asset is:

Charged from the grid during the required charge hours as determined by DOER

- **Solar - Charge hours 11 AM to 2 PM**
- **Wind - Charge hours 11 PM to 6 AM**

Considerations to implications, measurement, verification and need of potential contractual agreements with specific renewable generators for charging the storage asset outside of DOER defined hours was agreed to be considered in future phases of this study.

Category 4:
Demand Response Resources

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Category 4: Demand Response Resources

Category	Includes	Use Cases	Other
Active Demand Response	Consumption offset/replaced by Behind The Meter generating resource such as Energy Storage or other dispatchable qualifying generating resource	▪ Discharging qualifying energy storage system / dispatching qualifying generation resource to provide kWh rather than consuming from grid	Avoided grid consumption must be provided by RPS eligible resources
Active Demand Response	Electric vehicle charging	▪ Unidirectional - Reducing / interrupting / avoiding electric vehicle charging ▪ Bidirectional – Similar participation and qualification as stationary, Behind the Meter QESS	Must be able to demonstrate that the EV would have been charging otherwise; simply having it plugged in and not charging does not qualify for CPEC if it would not have been charging. M&V issues are complicated.
Active Demand Response	Load reduction / curtailment – consumption simply reduced by turning off / back equipment that would otherwise be running/consuming electricity during the CP periods	▪ Adjusting thermostat ▪ Stopping industrial process ▪ Reducing speed of variable speed equipment ▪ Delaying / interrupting refrigeration or other periodic process supporting habitability or industrial processes	M&V issues are complicated with establishment of appropriate baselines.
Passive Demand Response (not considered eligible in Phase I)	Reduction of demand / consumption resulting from installation of more energy efficiency equipment such as lighting, HVAC, etc.	▪ Energy efficient lighting retrofit ▪ Replacement of HVAC system with higher efficiency equipment ▪ Insulation / high efficiency window replacement	▪ M&V issues are more complicated for Passive DR / EE ▪ Passive DR / EE should be 'new' in order to qualify (existing EE is embedded in the baseline load)

For all categories demand response resources may be an aggregate of multiple technologies and multiple locations

- Applies to selected use cases

Category 4: Considerations & Implications

Consideration	Implication
A. Frequency of participation	▪ Available and operating during all hours of the defined CP periods or operating as available during CP periods; former could severely limit participation and likely to only passive resources and active resources enabled by other technologies. ▪ More frequent participation results in greater award of CPEC, however, could impact performance measurement under conventional methods (baseline) ▪ Seasonal resource availability ▪ Performance measurement will require new methods (likely direct metering) to support higher level of participation during CP period
B. Technologies	▪ Enabling storage technologies source of charging/stored energy needs to need to meet the same [similar] qualifying criteria as IFOM qualifying resources, e.g., BTM storage used to enable DR should have same qualifying criteria as an IFOM QESS.
C. Vintage	▪ No vintage requirement for Active Demand Response resources. ▪ Passive Demand Response resources, e.g., Energy Efficiency measures, initially will not be eligible for qualification as Clean Peak Resources, pending further investigation to ensure proper incentive structure exists. ▪ Subject to such further investigation and should such Passive DR resources become eligible, there should be a vintage threshold such as 1/1/19 such that it should "new" along the similar lines as other Qualified Clean Peak Resource. ▪ Existing Passive resources / EE measures will already have been reflected in the baseline and, therefore, not contributing to new offsets of the peak loads.
D. Dual Use/M&V	▪ Dual use – should a demand reduction for other purposes, e.g., demand charge avoidance, can also qualify for CPS. ▪ Consideration should be given to alternative performance measurement methods such as direct (sub)metering of enabling technologies or other measures. M&V requirements could prove cost prohibitive; lack of widespread AMI deployment might be a limiting factor.

Summary of Technology/Use Cases

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Technology / Use Cases #1-10

Case #	1	2	3	4	5	6	7	8	9	10
Rev Hedge	PPA	Merchant	PPA	Merchant	PPA	Merchant	PPA	Merchant	PPA	Merchant
CPS Category	1	1	1	1	1	1	1	1	1	1
Standard Technology/"Slice"	Offshore Wind (OSW)	Offshore Wind (OSW)	Land Based Wind (LBW)	Land Based Wind (LBW)	Utility-Scale Solar	Utility-Scale Solar	Utility-Scale Solar	Utility-Scale Solar	Utility-Scale Solar	Utility-Scale Solar
Standard Technology #	1	1	2	2	3	3	4	4	5	5
Tech Detail	N/A	N/A	N/A	N/A	Fixed-Axis	Fixed-Axis	Single-Axis Tracking	Single-Axis Tracking	Single-Axis Tracking, Bifacial	Single-Axis Tracking, Bifacial
Application (Resource)	Offshore	Offshore	Maine mountain	Maine mountain	Ground-Mount	Ground-Mount	Ground-Mount	Ground-Mount	Ground-Mount	Ground-Mount
Levelization Term (yrs)	20	20	20	20	20	20	20	20	20	20
Discount Rate	7.46%	8.69%	7.46%	7.45%	7.46%	7.46%	7.46%	7.46%	8.59%	8.59%
Merchant or Contracted	N/A	Merchant	N/A	Merchant	N/A	Merchant	N/A	Merchant	N/A	Merchant

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Technology / Use Cases #11-20

Case #	11	12	13	14	15	16	17	18	19	20
Rev Hedge	SMART, SREC	Merchant	SMART, SREC	Merchant	SMART, SREC	Merchant	SMART, SREC	Merchant	PPA	Merchant
CPS Category	1	1	1	1	1	1	1	1	2	2
Standard Technology/"Slice"	DG Solar	DG Solar	DG Solar	DG Solar	DG Solar	DG Solar	DG Solar	DG Solar	LBW+QESS	LBW+QESS
Standard Technology #	6	6	7	7	8	8	9	9	10	10
Tech Detail	Fixed-Axis	Fixed-Axis	Single-Axis Tracking	Single-Axis Tracking	Fixed-Axis	Fixed-Axis	Fixed-Axis	Fixed-Axis	N/A	N/A
Application (Resource)	Ground-Mount	Ground-Mount	Ground-Mount	Ground-Mount	C&I Rooftop, sized to load	C&I Rooftop, sized to load	Resi rooftop	Resi rooftop	Maine mountain	Maine mountain
Levelization Term (yrs)	20	20	20	20	20	20	20	20	20	20
Discount Rate	8.57%	7.57%	8.57%	7.57%	8.57%	7.57%	9.09%	7.99%	9.60%	9.46%
Merchant or Contracted	N/A	Merchant	N/A	Merchant	N/A	Merchant	N/A	Merchant	Contracted	Contracted

Technology / Use Cases #21-30

Case #	21	22	23	24	25	26	27	28	29	30
Rev Hedge	SREC I or II	SREC I or II	Merchant	Merchant	Merchant	Merchant	SREC I or II	SREC I or II		
CPS Category	2	2	2	2	2	2	2	2/4	3	1/3
Standard Technology/"Slice"	SREC 1/2 + QESS	SREC-1/2 + QESS	Biomass + QESS	Waste-to-Energy + QESS	Hydro - ROR + QESS	Hydro - Storage + QESS	SREC-1/2 + QESS	SREC-1/2 + QESS	Virtually Paired QESS	QESS physically paired with OSW
Standard Technology #	11	12	15	16	17	18	13	14	19	20
Tech Detail	Fixed-Axis	Fixed-Axis	N/A	N/A	N/A	N/A	Fixed-Axis	Fixed-Axis	N/A	N/A
Application (Resource)	Ground-Mounted, VNM	IFOM, VNM, Landfill	IFOM	IFOM	IFOM	IFOM	BTM, C&I Rooftop	BTM, Resi rooftop	IFOM	
Levelization Term (yrs)	20	20	20	20	20	20	20	20	20	20
Discount Rate	9.60%	9.60%	9.60%	9.60%	9.60%	9.60%	8.57%	12.00%	9.80%	9.03%
Merchant or Contracted	Contracted	Contracted	Contracted	Contracted	Contracted	Contracted	Contracted	Contracted	Contracted	Contracted

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Technology / Use Cases #31-37

Case #	31	32	33	34	35	36	37
Rev Hedge							
CPS Category	1/3	1/3	1/3	4		4	4
Standard Technology/"Slice"	QESS physically paired with LBW->(case 4)	QESS physically paired with Cat-1 Utility-Scale Solar	QESS physically paired with Cat-1 DG Solar	Demand Resource - Load curtailment	Utility Demand Resource - Resource enabled load reduction	ISO Demand Resource - Resource Enabled Load Reduction	Demand Resource - EV Charging
Standard Technology #	21	22	23	24	25	25	26
Tech Detail				Load Curtailment	Load Curtailment (enabled by Storage)	Load Curtailment (enabled by Storage)	
Application (Resource)	IFOM	BTM	BTM	BTM	BTM	BTM	BTM
Levelization Term (yrs)	20	20	20	20	20	20	20
Discount Rate	8.01%	8.26%	7.69%	8.59%	8.57%	8.57%	12.00%
Merchant or Contracted	Contracted	Contracted	Contracted	Contracted	Contracted	Contracted	Merchant

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5 Develop ‘standard’ installation characteristics

- Step 2: indicative installation characteristics for Indicative Technology & Use Cases

Step 2: Develop 'standard' installation characteristics

- For each technology and use case, developed 'standard' indicative installation characteristics deemed representative of the broad range possible characteristics
- Assumed to represent 'mean' cost or revenue gap installation for the category
- This standard installation was subjected to economic analysis
- For each technology and use case, selected 'standard' indicative installation characteristics consisted of
  - Technology characteristics and configuration
  - Location (ISONE Zone, Utility)
  - Scale (MW)
  - Capacity Factor
  - Interconnection level
  - IFOM or BTM
  - Rate (if BTM)
- Installations that do not have a revenue hedge or contracted PPA's are considered for analysis of revenue gaps

Case Summary – CPS Category 1*

Case	2	4	6	8	10	12	14	16	18
CPS Category	1	1	1	1	1	1	1	1	1
Standard Technology	Offshore Wind (OSW)	Land Based Wind (LBW)	Utility-Scale Solar	Utility-Scale Solar	Utility-Scale Solar	DG Solar	DG Solar	DG Solar	DG Solar
Tech Detail	N/A	N/A	Fixed-Axis	Single-Axis Tracking	Single-Axis Tracking, Bifacial	Fixed-Axis	Single-Axis Tracking	Fixed-Axis	Fixed-Axis
Application (Resource)	Offshore	Maine mountain	Grount-Mount	Grount-Mount	Grount-Mount	Grount-Mount	Grount-Mount	C&I Rooftop, sized to load	Resi rooftop
Rev Hedge	Merchant	Merchant	Merchant	Merchant	Merchant	Merchant	Merchant	Merchant	Merchant
Scale (MW)	800 MW	150 MW	50 MW	50 MW	50 MW	2 MW	2 MW	0.5 MW	0.007 MW
Capacity Factor	55%	35%	18%	18%	26%	18%	22%	18%	18%
Standard Location (zone, applicable utility rate)	SEMA	Maine (Northern, nodal)	Maine (Southern, Nodal)	Maine (Southern, Nodal)	Maine (Southern, Nodal)	NGRID	NGRID	Eversource East	Eversource East
Associated Production Profile	OSW Standard	LBW Standard	Perfect Ground Mount	Perfect Ground-Mount with SIngle Axis Tracking	N.A.	Perfect Ground Mount	Perfect Ground Mount, 1-Axis	Slightly Imperfect flatter roof mount	Materially imperfect azimuth, and tilt
Interconnection Level	Transmission	Transmission	Transmission or Distribution	Transmission or Distribution	N.A.	Distribution	Distribution	Distribution	Distribution
Topology	IFOM	IFOM	IFOM	IFOM	IFOM	IFOM	IFOM	BTM	BTM
Asset Configuration	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I
Incentives	Renewable Energy Certificates (RECs)	Renewable Energy Certificates (RECs)	Renewable Energy Certificates (RECs)	Renewable Energy Certificates (RECs)	Renewable Energy Certificates (RECs)	Renewable Energy Certificates (RECs)	N/A	Renewable Energy Certificates (RECs)	Renewable Energy Certificates (RECs)
Potential Revenue Components	Wholesale Energy Market	Wholesale Energy Market	Wholesale Energy Market	Wholesale Energy Market	Wholesale Energy Market	PURPA avoided cost	PURPA avoided cost	Retail Bill Savings - Energy & Demand	Net Metering
	Forward Capacity Market	Forward Capacity Market	Forward Capacity Market	Forward Capacity Market	Forward Capacity Market				

Most Likely | **Likely** | **Unlikely**

*** Use Cases Requiring a Revenue Gap Model**

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Case Summary – CPS Category 2*

Case	19	20	21	22	23	24	25	26	27	28
CPS Category	2	2	2	2	2	2	2	2	2	2
Standard Technology	**LBW + QESS**	**LBW + QESS**	**DG Solar + QESS**	**DG Solar + QESS**	**Biomass + QESS**	**Waste-to-Energy + QESS**	**Hydro - ROR + QESS**	**Hydro - Storage + QESS (Baseload)**	**BTM Solar + QESS**	**BTM Solar + QESS**
Tech Detail	**N/A**	**N/A**	**Fixed-Axis**	**Fixed-Axis**	**N/A**	**N/A**	**N/A**	**N/A**	**Fixed-Axis**	**Fixed-Axis**
Application (Resource)	**Maine mountain**	**Maine mountain**	**Ground-Mounted, VNM**	**IFOM, VNM, Landfill**	**IFOM**	**IFOM**	**IFOM**	**IFOM**	**BTM, C&I Rooftop**	**BTM, Resi rooftop**
Rev Hedge	PPA	Merchant	SREC I or II	SREC I or II	Merchant	Merchant	Merchant	Merchant	SREC I or II	SREC I or II
Scale (MW)	60 MW	60 MW	2 MW	2 MW	100 MW	100 MW	50 MW	50 MW	0.25 MW	0.005 MW
Capacity Factor	35%	35%	18%	17%	100%	100%	48%	100%	17%	17%
Standard Location (zone, applicable utility rate)	Maine (Northern, nodal)	Maine (Northern, nodal)	NGRID	NGRID	N/A	N/A	West Central MA	Maine	NGRID	NGRID
Associated Production Profile	LBW Standard + QESS Optimal (accounts for RT losses)	LBW Standard + QESS Optimal (accounts for RT losses)	Perfect Ground-Mount Solar + QESS Optimal (accounts for RT losses)	Imperfect Ground-Mount Solar + QESS Optimal (accounts for RT losses)	Baseload	Baseload	Hydro - ROR + QESS	Hydro - Storage + QESS	Slightly Imperfect flatter roof mount	Materially imperfect azimuth, and tilt
Interconnection Level	Transmission	Transmission	Distribution	Distribution	Transmission	Transmission	Transmission	Transmission	Distribution	Distribution
Topology	IFOM	IFOM	IFOM	IFOM	IFOM	IFOM	IFOM	IFOM	BTM	BTM
Asset Configuration	Existing Class I/II paired with QESS	Existing Class I/II paired with QESS	Existing Class I/II paired with QESS	Existing Class I/II paired with QESS	Existing Biomass power plant paired with QESS	Existing Waste-to-Energy power plant paired with QESS	Existing Hydro ROR paired with QESS	Existing Hydro Storage paired with QESS	Existing Class I/II paired with QESS	Existing Class I/II paired with QESS
Incentives	N/A	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)
Potential Revenue Components	Forward Capacity Market	Forward Capacity Market	Forward Capacity Market/ICAP	Forward Capacity Market/ICAP	Forward Capacity Market	Forward Capacity Market	Forward Capacity Market	Forward Capacity Market	Retail Bill Savings - Energy & Demand	Retail Bill Savings - Energy & Demand
	Wholesale Energy Market	Wholesale Energy Market	Spinning Reserves	Spinning Reserves	Spinning Reserves	Spinning Reserves	Wholesale Energy Market	Spinning Reserves	Forward Capacity Market	ICAP
	Spinning Reserves	Spinning Reserves	Frequency Regulation	Frequency Regulation	Frequency Regulation	Frequency Regulation	Spinning Reserves	Frequency Regulation	ICAP	Utility Demand Response
	Frequency Regulation	Frequency Regulation	SREC+NMC (as operating plant, no gap)	SREC+NMC (as operating plant, no gap)			Frequency Regulation		Non-Spin Reserve	
									Frequency Regulation	

Most Likely **Likely** **Unlikely**

*** Use Cases Requiring a Revenue Gap Model**

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Case Summary – CPS Category 3 & 4*

Demand Response – Resource enabled and EV Discharging are functionally similar and will have access to the same potential revenue streams.

Case	29	30	31	32	33	35	36	37
CPS Category	3	1/3	1/3	1/3	1/3	4	4	4
Standard Technology	QESS virtually paired renewable generator	QESS physically paired with Cat-1 OSW	QESS physically paired with Cat-1 LBW	QESS physically paired with Cat-1 Utility-Scale Solar	QESS physically paired with Cat-1 DG Solar	Utility Demand Resource - Resource enabled load reduction	ISO Demand Resource - Resource enabled load reduction	Demand Resource - EV Charging #
Tech Detail	N/A	N/A	N/A	Single-Axis Tracking	Single-Axis Tracking	Load Curtailment (enabled by Storage)	Load Curtailment (enabled by Storage)	Load Curtailment (enabled by curtailing / modulating Electric Vehicle charging)
Application (Resource)	IFOM	Offshore	Maine mountain	Grount-Mount	Grount-Mount	BTM	BTM	BTM
Rev Hedge	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Scale (MW)	0	800 MW	150 MW	50 MW	2 MW	0.1 MW	0.1 MW	0.1 MW
Capacity Factor	20%	55%	35%	18%	22%	20%	20%	20%
Standard Location (zone, applicable utility rate)	SEMA	SEMA	Maine (Northern, nodal)	Maine (Southern, Nodal)	NGRID	NEMA	NEMA	NEMA
Associated Production Profile	N/A	OSW Standard	LBW Standard	Perfect Ground-Mount with Single Axis Tracking	Perfect Ground Mount, 1-Axis	Load Specific	Load Specific	Load Specific
Interconnection Level	Transmission	Transmission	Transmission	Transmission or Distribution	Distribution	Utility BTM / DG interconnection	Utility BTM / DG Interconnection	Utility BTM / DG interconnection
Topology	IFOM	IFOM	IFOM	IFOM	IFOM	BTM		BTM
Asset Configuration	QESS	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	Demand Resource paired with QESS	Demand Resource enabled by QESS	Demand Resource enabled by EV charging
Incentives	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Utility Demand Response/ ISO-NE PRD Payments	N/A	N/A
Potential Revenue Components	Forward Capacity Market	Forward Capacity Market	Forward Capacity Market	Forward Capacity Market	Forward Capacity Market/ICAP	Retail Bill Savings - Energy & Demand	Retail Bill Savings - Energy & Demand	Retail Bill Savings - Energy (TOU arbitrage)
	Energy Arbitrage	Wholesale Energy / Arbitrage	Wholesale Energy / Arbitrage	Wholesale Energy / Arbitrage	Spinning Reserves	ICAP Tag reduction savings	ICAP Tag reduction savings	ICAP Tag reduction savings
	Spinning Reserves	Spinning Reserves	Spinning Reserves	Spinning Reserves	Frequency Regulation		ISO-NE FCM Payments	
	Frequency Regulation	Frequency Regulation	Frequency Regulation	Frequency Regulation				

Demand Response - Avoided EV charging - is a combination of a variation of Passive DR (the unidirectional, 'not charging' case) and resource enabled (the bidirectional, discharging the vehicle's battery) case. M&V requirements will be determined, basis availability of suitable data.

Most Likely — Likely — Unlikely

*** Use Cases Requiring a Revenue Gap Model**

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Case Summary – CPS Category 1 & 4: Use Cases NOT Requiring a Revenue Gap Model

Case	1	3	5	7	9##	11	13	15	17	34
CPS Category	1	1	1	1	1	1	1	1	1	4
Standard Technology	Offshore Wind (OSW)	Land Based Wind (LBW)	Utility-Scale Solar	Utility-Scale Solar	Utility-Scale Solar	DG Solar	DG Solar	DG Solar	DG Solar	Demand Resource - Load curtailment #
Tech Detail	N/A	N/A	Fixed-Axis	Single-Axis Tracking	Single-Axis Tracking, Bifacial	Fixed-Axis	Single-Axis Tracking	Fixed-Axis	Fixed-Axis	Load Curtailment
Application (Resource)	Offshore	Maine mountain	Grount-Mount	Grount-Mount	Grount-Mount	Grount-Mount	Grount-Mount	C&I Rooftop, sized to load	Resi rooftop	BTM
Rev Hedge	PPA	PPA	PPA	PPA	PPA	SMART, SREC	SMART, SREC	SMART, SREC	SMART, SREC	
Scale (MW)	800 MW	150 MW	50 MW	50 MW	50 MW	2 MW	2 MW	0.5 MW	0.007 MW	0.1 MW
Capacity Factor	55%	35%	18%	22%	26%	18%	22%	18%	18%	20%
Standard Location (zone, applicable utility rate)	SEMA	Maine (Northern, nodal)	Maine (Southern, Nodal)	Maine (Southern, Nodal)	Maine (Southern, Nodal)	NGRID	NGRID	Eversource East	Eversource East	NEMA
Associated Production Profile	OSW Standard	LBW Standard	Perfect Ground Mount	Perfect Ground-Mount with SIngle Axis Tracking	*Technology/use case not used at this time*	Perfect Ground Mount	Perfect Grount Mount, 1-Axis	Slightly Imperfect flatter roof mount	Materially imperfect azimuth, and tilt	Load Specific
Interconnection Level	Transmission	Transmission	Transmission or Distribution	Transmission or Distribution	Transmission or Distribution	Distribution	Distribution	Distribution	Distribution	N/A
Topology	IFOM	IFOM	IFOM	IFOM	IFOM	IFOM	IFOM	BTM	BTM	BTM
Asset Configuration	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	New RPS Class I	Demand Resource
Incentives	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	Investment Tax Credit (ITC)	SMART/ SREC	SMART/ SREC	SMART/ SREC	SMART/ SREC	N/A
Potential Revenue Components	PPA	PPA	PPA	P**PA	PPA	NMC, AOBC	NMC, AOBC	Retail Bill Savings - Energy & Demand	Net Metering	Retail Bill Savings - Energy & Demand

Not considered due to M&V issues to be considered in future phases
placeholder developed for advanced technology not used at this time

Most Likely | Likely | Unlikely

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6 Estimate CPEC Production

- Step 3

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Step 3: Estimate CPEC Production

- To estimate CPEC production, the Consulting Team:
  - Developed CPEC annual 8760 hourly production profiles for each standard technology
    - Renewable energy technologies based on indicative actual, projected or modeled production data for a single year
    - For energy storage applications alone, or physically or virtually paired with renewables, using simulation program to optimize performance
    - For DR technologies
      - Used representative C&I load profile (NatGrid G-3) [2018 as reference year]
      - Identified daily peak demands
      - On days of highest demand each week, simulated a dispatch of the load curtailment at 15% of actual load
      - Calculated 10 in 10 baseline for each dispatch day and determined measured performance (in kWh) against baseline
      - Converted the measured performance to % of max reduction capability in every CP interval across the 8760 data set
      - Average the CP interval % across similar day types and months
      - Extrapolated out over each hour of 2017 based on the day type – month averages
  - Estimated CPEC production based on:
    - Production profiles
    - DOER's Straw Proposal Clean Peak windows
    - Actual monthly peak based on a single recent year of hourly ISO-NE load data
    - DOER's proposed Clean Peak multipliers

Production Profile, Dispatch and CPEC Calculations

Dispatch

- **Renewables:** For “standard” location RE generation profile is generated.
- **ESS**
  - ESS dispatch is based on CES CoMETS models.
    - QESS prioritizes discharge during Clean Peak Periods which impacts other potential revenue streams
    - QESS participates in other market value streams during non-Clean Peak Period windows and weekends, wherever feasible
    - Physically paired QESS - charges through RE 100% of the time, and during least cost hours
    - Virtually paired QESS charges from the Grid only during designated charging hours

CPEC Calculation

$CPECs=(AverageMWxSeasonalMultiplierxNumberofHoursofWindow)+(kWinActualMonthlypeakhourxSeasonalMultiplierxActualPeakMultiplierx1hour)$

Seasonal Multiplier: Summer, Winter = 3x, Spring and Fall = 1x
System Peak Multiplier = 15x
Minimum Load Multiplier is NOT considered
Resiliency Multiplier is considered in Task 4 model separately

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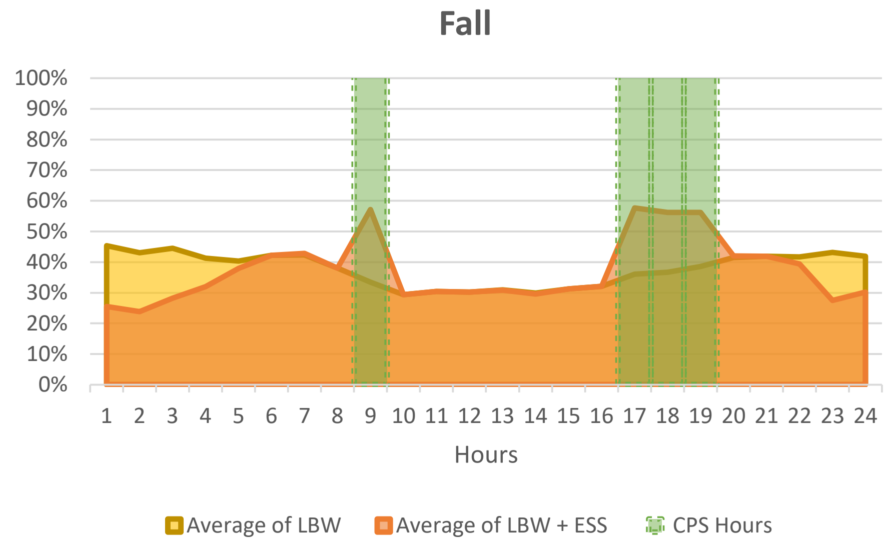
Production Profile Input Assumptions: Renewable Energy

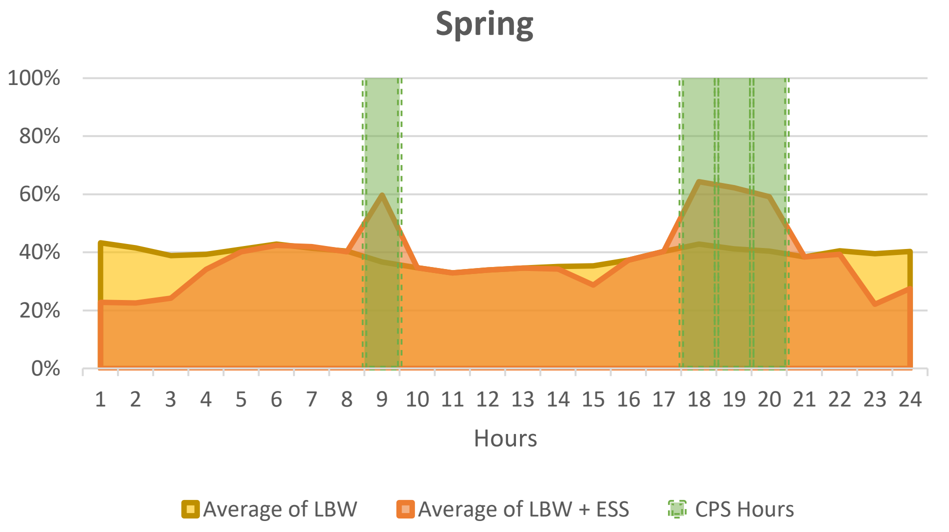
Resource Type	Profile Data Source	Notes
Offshore Wind	DOER	Anonymized data
Land-Based Wind	SEA database	Anonymized actual production data from a Maine Wind Plant (used with permission for NE-REMO)
Hydro, Run-of-River	Idaho National Engineering and Environmental Laboratory (INL), MA ROR monthly profile	MA data as proxy
Hydro, Storage	Idaho National Engineering and Environmental Laboratory (INL), ME ROR monthly profile	
Baseload: applied to Biomass, landfill gas, biogas, or waste-to-energy	Equal in all hours	
Solar Profile #1: Perfect Ground Mount, Fixed (Open Rack)	NREL PV Watts, unitized per peak kW(AC)	Indicative, idealized configuration. Applied to Utility-Scale Solar, SMART, SREC, IFOM
Solar Profile #2: Imperfect Ground Mount, Fixed-Axis	NREL PV Watts, unitized per peak kW(AC)	Indicative configuration. Applied to IFOM, VNM, Landfill
Solar Profile #3 Slightly Imperfect flatter roof mount, Fixed (Roof Mount)	NREL PV Watts, unitized per peak kW(AC)	Indicative configuration. Applied to: BTM, C&I Rooftop
Solar Profile #4 Materially imperfect azimuth, and tilt, Fixed (Roof Mount)	NREL PV Watts, unitized per peak kW(AC)	Indicative configuration. Applied to: BTM, Resi rooftop
Solar Profile #5 Perfect Ground Mount, 1-Axis Tracking	NREL PV Watts, unitized per peak kW(AC)	Indicative, idealized configuration. Applied to: IFOM, Ground-Mount

Production Profile Input Assumptions: DR

Resource Type	Profile Data Source	Notes
Utility and ISO Demand Resource – Resource enabled load reduction	BECO G2 Profile, scaled for analysis by 200	Rate Plan – Eversource G-2 BE
Demand Resource – EV Charging	BECO R Profile, scaled for analysis by 300	Rate Plan – Eversource Greater Boston Service Area R1

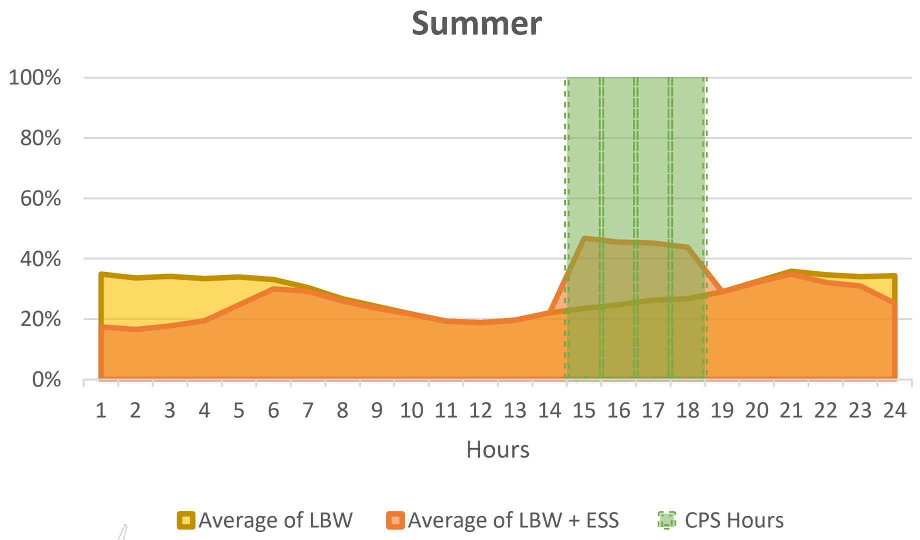
Illustration: Optimized simulation of Land-based Wind + QESS
Production Profiles & CPEC Volumes – LBW, LBW + QESS

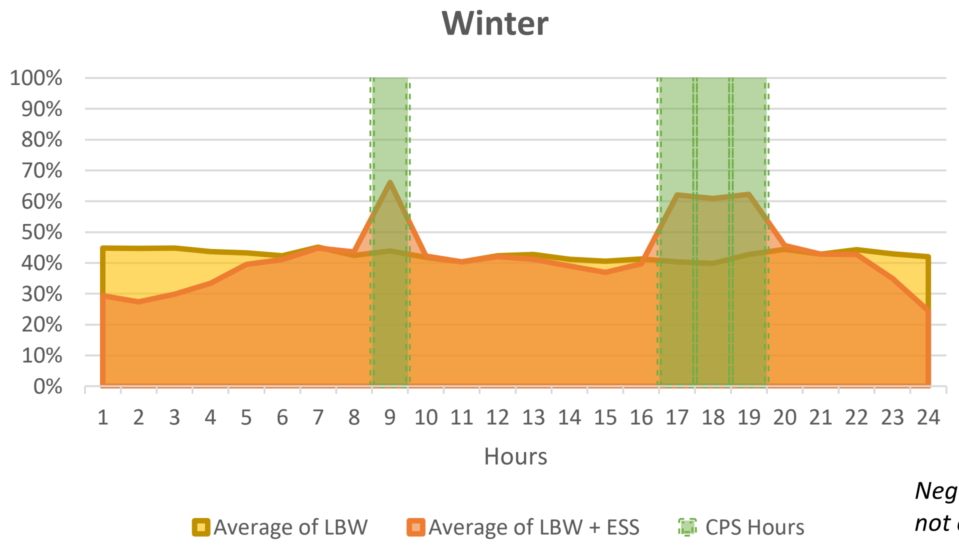




* CPEC Volumes are on a per MW basis

Season	CPEC (Seasonal) LBW	CPEC (Seasonal) LBW+QESS
Spring	79	117
Summer	285	491
Fall	73	112
Winter	283	423
Total	**720**	**1144**





Season	CPEC (System Peak) LBW	CPEC (System Peak) LBW+QESS
Spring	11	19
Summer	52	85
Fall	14	22
Winter	48	71
Total	**125**	**197**

Negative Multipliers for Production during Minimum Loads is not considered

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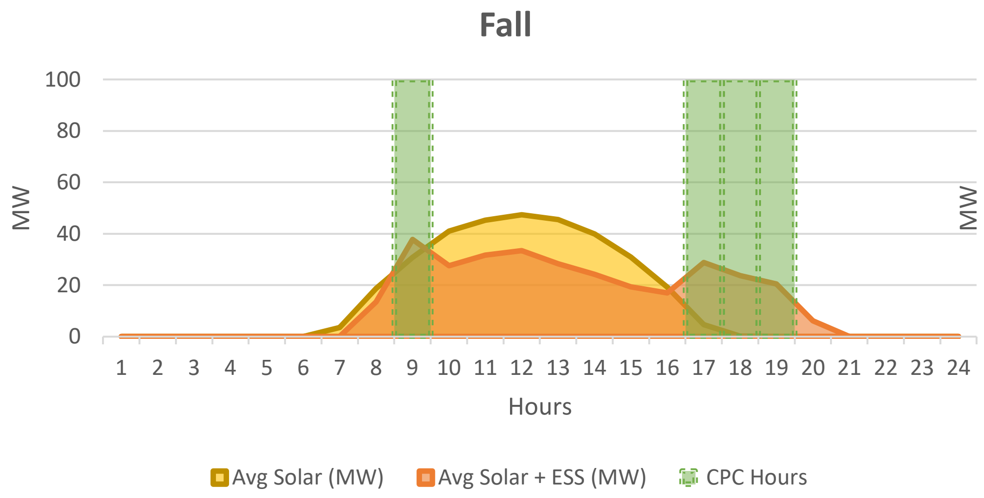
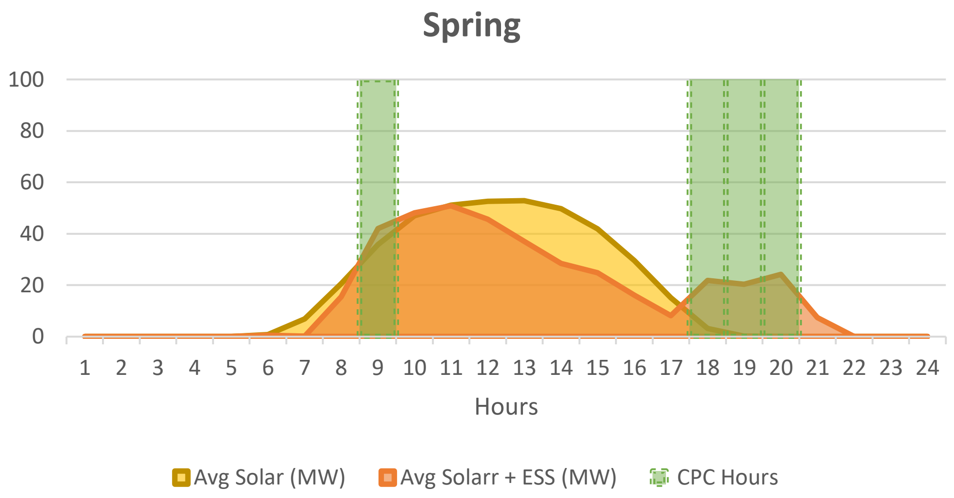
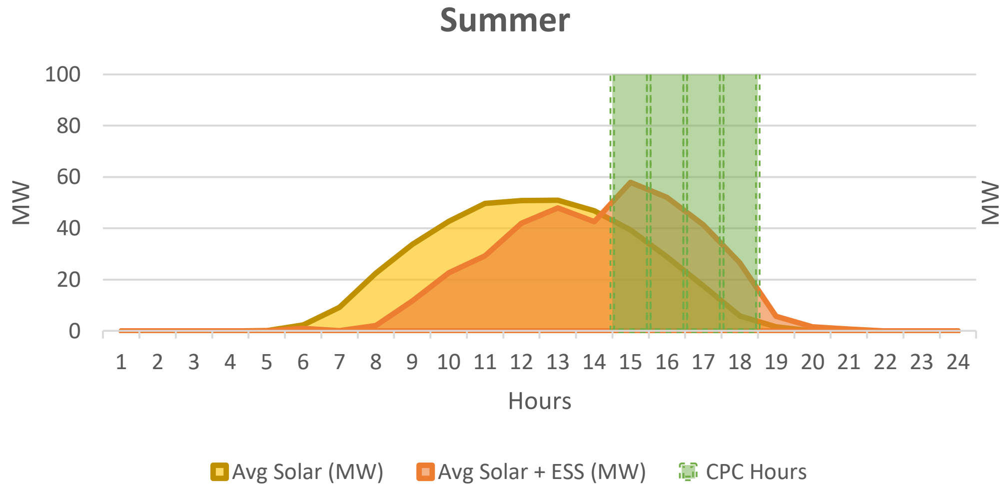
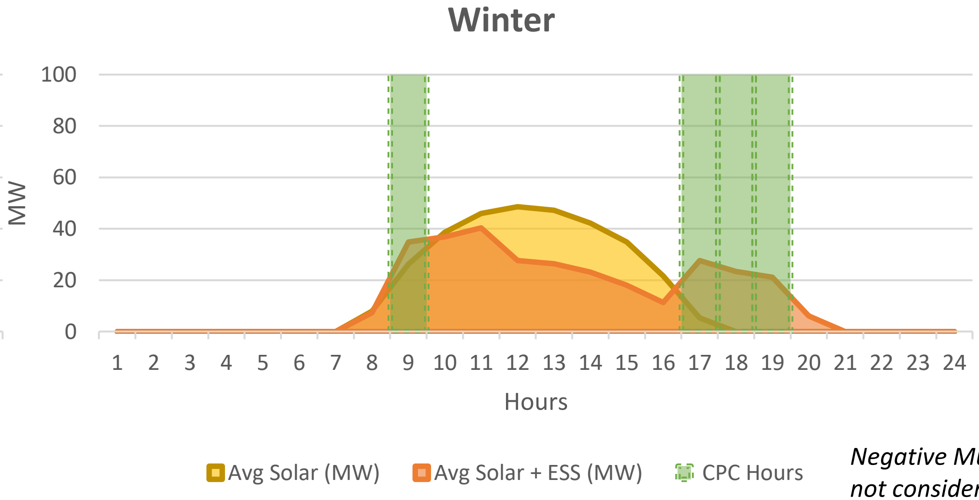
Illustration: Optimized simulation of Solar+ QESS

Production Profiles & CPEC Volumes – Solar, Solar + QESS









*** CPEC Volumes are on a per MW basis**

	CPEC (Seasonal)	
Season	**Utility-Scale Solar**	**SREC-1/2 + QESS**
Spring	24	68
Summer	280	519
Fall	23	66
Winter	69	211
Total	**397**	**865**

	CPEC (Peak)	
Season	**Utility-Scale Solar**	**Solar + QESS**
Spring	-	8
Summer	29	67
Fall	1	9
Winter	-	34
Total	**31**	**118**

Negative Multipliers for Production during Minimum Loads is not considered

*** CPEC Volumes are on a per MW basis**

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For a ‘perfect ‘ CPEC resource, estimated maximum CPEC production per MW based on a single year’s historical peak load data

Periods, Multipliers, Max CPECs/MW							
	1	2	3	4			
Period	Spring	Summer	Fall	Winter	Actual Monthly System Peak	MaxCPECs/yr /MW including monthly actual peak	
# of Hours/mo of weekday peaks	4	4	4	4	1		
Period Start	3/1	5/15	9/15	12/1			
Period End	5/14	9/14	11/30	2/28			
Daycount	75	123	77	90	12		
Weekdays	71.4%	71.4%	71.4%	71.4%	100%		
Holidays	1	3	3	4	0		
Avg. CP Day/yrs	52.6	84.9	52.0	60.3	12.0		
Seasonal Multiplier	1	3	1	3	15		
Season Max CPECs/yr /MW	210.3	1,018.3	208.0	723.4		2,160.0	
Monthly Peaks Assumed in Season	2	4	3	3	12		
Actual Monthly System Peak MaxCPECs/yr /MW	30.0	180.0	45.0	135.0		390.0	
MaxCPECs/yr /MW including monthly actual peak	240.3	1198.3	253.0	858.4		2550.0	<== Annual Total

Expected CPEC Production as % of Maximum in each period for Each Standard Technology

Srd. Tech #	Elig. Cat.	Standard Technology	Tech Detail	Use Case	Spring (% of Max)	Summer (% of Max)	Fall (% of Max)	Winter (% of Max)	Spring Actual Sys.Peak	Summer Actual Sys.Peak	Fall Actual Sys.Peak	Winter Actual Sys.Peak
1	1	OSW			63%	44%	58%	59%	84%	70%	63%	74%
2	1	LBW			38%	28%	35%	40%	38%	29%	31%	36%
3	1	Utility-Scale Solar	Fixed-Axis		12%	27%	11%	10%	1%	16%	3%	0%
4	1	Utility-Scale Solar	Single-Axis Tracking		17%	40%	16%	15%	1%	32%	6%	0%
5	1	Utility-Scale Solar	Single-Axis Tracking, Bifacial		19%	46%	18%	18%	1%	37%	7%	0%
6	1	DG Solar (SMART, SREC-2 etc.)	Fixed-Axis	IFOM, Grount-Mount	12%	27%	11%	10%	1%	16%	3%	0%
7	1	DG Solar (SMART, SREC-2 etc.)	Single-Axis Tracking	IFOM, Grount-Mount	17%	40%	16%	15%	1%	32%	6%	0%
8	1	DG Solar (SMART, SREC-2 etc.)	Fixed-Axis	BTM, C&I Rooftop	10%	35%	9%	8%	1%	25%	5%	0%
9	1	DG Solar (SMART, SREC-2 etc.)	Fixed-Axis	BTM, Resi rooftop	13%	18%	12%	11%	1%	6%	2%	0%
10	2	LBW+QESS		IFOM	56%	48%	54%	60%	63%	47%	48%	52%
11	2	SREC-1/2 + QESS	Fixed-Axis	IFOM, VNM Ground-Mounted	33%	50%	32%	30%	26%	37%	20%	25%
12	2	SREC-1/2 + QESS	Fixed-Axis	IFOM, VNM, Landfill	35%	43%	33%	30%	26%	30%	18%	25%
13	2	SREC-1/2 + QESS	Fixed-Axis	BTM, C&I Rooftop	27%	52%	27%	22%	26%	35%	21%	25%
14	2	SREC-1/2 + QESS	Fixed-Axis	BTM, Resi rooftop	32%	36%	30%	27%	26%	17%	18%	25%
15	2	Biomass/LFG + QESS		IFOM	123%	124%	124%	123%	125%	125%	125%	125%
16	2	Waste-to-Energy + QESS		IFOM	123%	124%	124%	123%	125%	125%	125%	125%
17	2	Hydro - ROR + QESS		IFOM	85%	63%	66%	78%	88%	67%	65%	81%
18	2	Hydro - Storage + QESS		IFOM	123%	124%	124%	123%	125%	125%	125%	125%
19	3	QESS	Virtually Paired w/Any Renewable		70%	98%	89%	88%	100%	100%	100%	100%
20	3	QESS	Physically paired with OSW		86%	67%	81%	81%	109%	95%	88%	99%
21	3	QESS	Physically paired with LBW->(case 4)		57%	48%	54%	60%	63%	47%	48%	52%
22	3	QESS	Physically paired with Solar(solar profile #5, case 8)		38%	63%	37%	35%	26%	54%	23%	25%
23	3	QESS	Physically paired with Solar (solar profile #5, case 14)		38%	63%	37%	35%	26%	54%	23%	25%
24	4	Demand Resource	Load Curtailment		9%	9%	13%	14%	13%	10%	14%	14%
25	4	Demand Resource	Resource Enabled Load Reduction		81%	74%	80%	76%	100%	67%	100%	98%
26	4	Demand Resource	EV Charging		81%	74%	81%	78%	100%	67%	100%	100%

7 Revenue Gap Analysis

- Step 4

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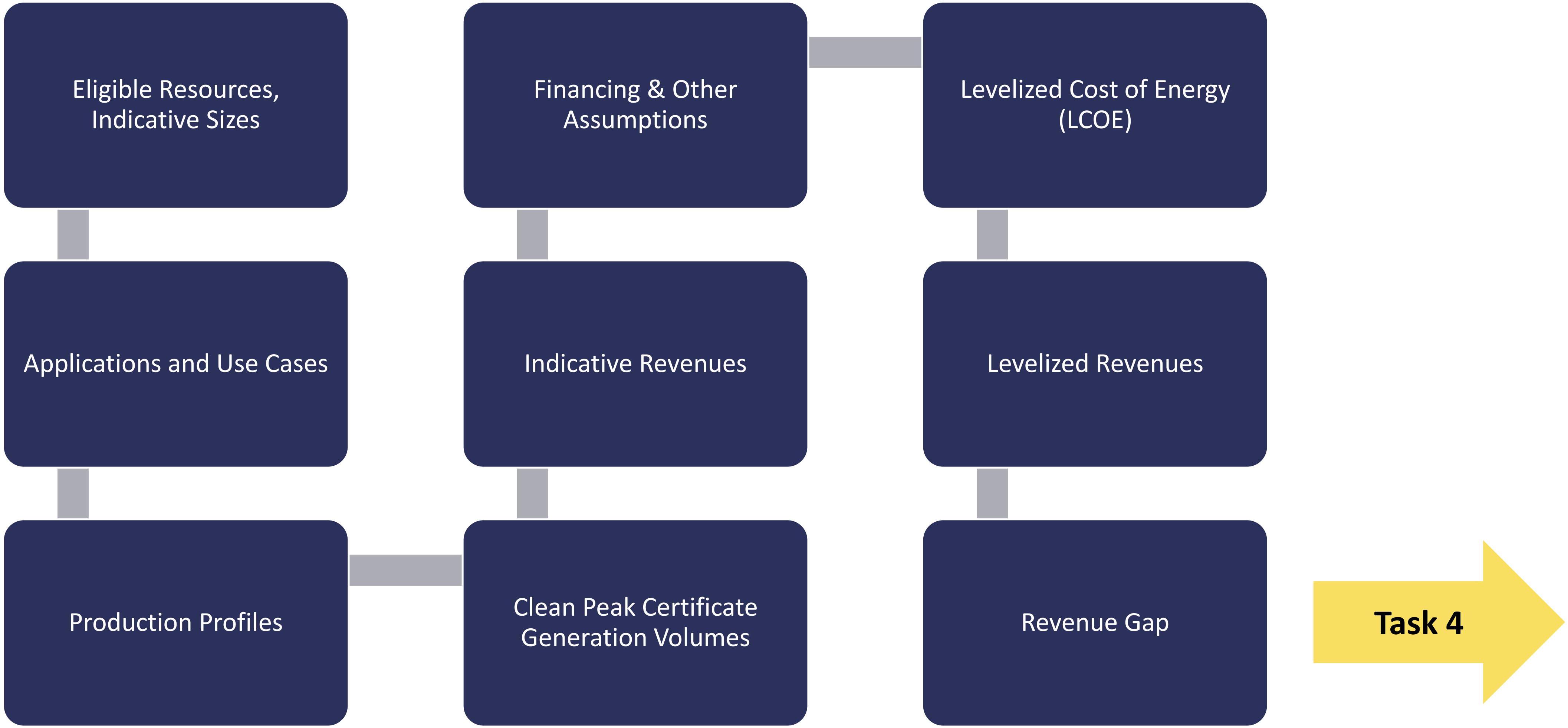
Step 4: Gap Analysis - Modeling Overview



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Step 4: Gap Analysis

- Identified technology/use cases that are financially viable with all the revenues streams available to them currently i.e. those that are insensitive to the level of Clean Peak incentives, such as:
  - Renewable energy projects with revenue hedges or full compensation through other means, such as those with an existing fully-compensatory long-term PPA or tariff, projects in the Massachusetts SMART program or other similar tariff programs; Massachusetts SREC projects
- For the remaining use cases where costs are greater than revenues, total annual costs and nominal levelized per-unit costs were estimated based on assumptions for renewables, energy storage, and DR such as CAPEX, OPEX, financing costs and structure, tax treatment, other incentives, and operating life
  - Financing costs varied depending on degree of hedging of CPEC revenue assumed: Low (CPEC revenues hedged) and High (Merchant CPECs)
  - Financing costs varied depending on Debt-Equity ratio (which in turn depends on current Revenue Hedge) and Loan Tenure: Low (Higher amount of debt as revenues are certain) and High (Equity component is higher as revenues are not certain)
  - Levelized costs calculated as Levelized Cost of Energy (LCOE, $/MWh) and Levelized Cost of CPECs ($/CPEC)
- Projected revenues from sources other than CPECs were estimated, considering as applicable, projected:
  - Most likely revenue streams included: FCM, Energy, Spinning / Non-spinning reserves, Frequency Regulation, Bill savings, ICAP, Demand Response, RECs, ITCs (see additional notes next page)
- Levelized cost and levelized revenue were compared and when costs > revenue, this constituted a nominal levelized revenue 'gap' ($/CPEC) coming online in the indicated year
  - Based on the assumptions used and for purposes of this analysis, the calculated gap for each indicative installation was assumed to represent the 'mean' gap for the technology/use case category, subject to a variance for projects with differences in factors such as scale and scale economies, site-specific cost or revenue factors, locations, etc.
- Revenue gaps were calculated for sample years of 2021, 2025, 2030 (final year), and interpolated for the years in between
- Result: Levelized revenue gap per CPEC, with and without LT revenue hedge

Gap Analysis:
Additional Notes on Revenue Sources

- ICAP is an assumed revenue source for cases 27,28, 35,36,37
- Revenue streams considered:
  - Capacity
  - Energy
  - Spin
  - Non-Spin
  - Regulation
  - Bill Management
  - Demand Response - Wholesale
  - Demand Response - Utility
  - ICAP
  - SMART Incentive Payments
  - Distribution Deferral
  - AOBC
  - PURPA Avoided Cost
  - RECs/SRECs
- Of these: Non-spin, regulation, distribution deferral, AOBC and PURPA avoided cost wasn't used for any of the cases, as they were assumed to be either very small, uncertain, or only applied in the hedged cases whose gap was not modeled

Illustration: Financing Assumptions
Merchant projects

Case		4	20	31
CPS Category		1	2	1/3
Standard Technology		Land Based Wind (LBW)	LBW + QESS	QESS physically paired with Cat-1 LBW
Parameters				
Capital Structure				
Debt	%	40%	30%	40%
Equity	%	60%	70%	60%
Debt Amount	$	$	$	$
Equity Amount	$	$	$	$
Debt Method	*1: Mortgage, 2: Amortization Schedule*	1	1	1
Interest Rate	%	6%	6%	7%
Loan Tenure	Years	10	10	10
Cost of Equity	%	10%	12%	10%
Income Tax Rate	%	21%	21%	21%
WACC	%	8.0%	9.8%	8.5%
Others				
Depreciation (Book)	Years	20	20	20
Depreciation (MACR)	Years	7	7	7
Working Capital	Months of O&M	0	0	0
Interest on Working Capital	%	12%	12%	12%
RE ITC	%	18%	0%	18%
ESS ITC	% of ESS Cost	0%	18%	18%
Total ITC Benefit	$	$	$	$
ITC Years	Years	5	5	5

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Levelized Costs, Revenues and Gap
LBW in Cat 1, 2 and 3

Category 1 Land Based Wind

	$/CPEC	$/MWh
Levelized Cost	$361	$99
Levelized Revenue	$252	$77
GAP	**$109.22**	**$22.19**

Category 2 LBW + QESS

	$/CPEC	$/MWh
Levelized Cost	$41	$184
Levelized Revenue	$23	$123
GAP	**$17.77**	**$60.47**

Category 1/3 QESS physically paired with Cat-1 LBW

	$/CPEC	$/MWh
Levelized Cost	$62	$183
Levelized Revenue	$22	$90
GAP	**$39.97**	**$93.47**

Assumptions for Capital Expenditures, Interconnection Costs and Discount Rate impact LCOE calculations

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Assumptions - Gap Analysis

Case	2	4	6	8	10	12	14	16	18
CPS Category	1	1	1	1	1	1	1	1	1
Standard Technology	Offshore Wind (OSW)	Land Based Wind (LBW)	Utility-Scale Solar	Utility-Scale Solar	Utility-Scale Solar	DG Solar	DG Solar	DG Solar	DG Solar
Tech Details	N/A	N/A	Fixed-Axis	Single-Axis Tracking	Single-Axis Tracking, Bifacial	Fixed-Axis	Single-Axis Tracking	Fixed-Axis	Fixed-Axis
Application (Resource)	Offshore	Maine mountain	Ground-Mount	Ground-Mount	Ground-Mount	Ground-Mount	Ground-Mount	C&I Rooftop, sized to load	Resi rooftop
Revenue Hedge	Merchant	Merchant	Merchant	Merchant	Merchant	Merchant	Merchant	Merchant	Merchant
Investment Term	20	20	20	20	20	20	20	20	20
RE Capacity	800	150	50	50	2	2	2	0.5	0.007
Capex									
RE equipment price	$3,760	$1,497	$946	$1,045	$1,250	$1,754	$1,894	$1,952	$3,158
ESS (DC system) Price	$300	$300	$300	$300	$300	$300	$300	$300	$300
PCS/Inverter Price	$200	$200	$200	$200	$200	$200	$200	$200	$200
OPEX									
RE O&M	$128.0	$149.0	$43.0	$55.0	$12.0	$16.0	$42.0	$16.0	$37.0
ESS O&M (including warranties)	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0	$8.0
O&M Escalation	0.00%	0.00%	0.00%	0.00%	2.25%	2.25%	2.25%	2.25%	2.25%
Storage Charging Cost (RE)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Storage Charging Cost (Grid)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Capital Structure									
Debt	37%	40%	25%	25%	60%	45%	45%	45%	40%
Interest Rate	6%	6%	6%	6%	8%	7%	7%	7%	7%
Loan Tenure	10	10	10	10	10	10	10	10	7
Cost of Equity	11%	10%	9%	9%	12%	10%	10%	10%	10%
WACC	8.7%	8.0%	7.7%	7.7%	8.6%	7.9%	7.9%	7.9%	8.3%
Others									
Interest on Working Capital	12%	12%	12%	12%	12%	12%	12%	12%	12%
RE ITC	18%	18%	30%	30%	30%	24%	24%	24%	24%
ESS ITC	0%	0%	0%	0%	0%	0%	0%	0%	0%

All values for Year 2021. RE Equipment Price, ESS Price, PCS Price and RE and ESS O&M assumptions change with years

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Assumptions - Gap Analysis

Case	19	20	21	22	23	24	25	26	27	28
CPS Category	2	2	2	2	2	2	2	2	2	2
Standard Technology	LBW + QESS	LBW + QESS	DG Solar + QESS	DG Solar + QESS	Biomass + QESS	Waste-to-Energy + QESS	Hydro - ROR + QESS	Hydro - Storage + QESS (Baseload)	BTM Solar + QESS	BTM Solar + QESS
Tech Details	N/A	N/A	Fixed-Axis	Fixed-Axis	N/A	N/A	N/A	N/A	Fixed-Axis	Fixed-Axis
Application (Resource)	Maine mountain	Maine mountain	Ground-Mounted, VNM	IFOM, VNM, Landfill	IFOM	IFOM	IFOM	IFOM	BTM, C&I Rooftop	BTM, Resi rooftop
Revenue Hedge	PPA	Merchant	SREC I or II	SREC I or II	Merchant?	Merchant?	Merchant?	PPA?	SREC I or II	SREC I or II
Investment Term	20	20	20	20	20	20	20	20	20	20
RE Capacity	60	60	2	2	100	100	50	50	0.25	0.005
Capex										
RE equipment price	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
ESS (DC system) Price	$280	$280	$300	$300	$260	$260	$280	$280	$400	$700
PCS/Inverter Price	$200	$200	$250	$250	$200	$200	$200	$200	$250	$350
OPEX										
RE O&M	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
ESS O&M (including warranties)	$9.0	$9.0	$10.0	$10.0	$8.0	$8.0	$9.0	$9.0	$10.0	$12.0
O&M Escalation	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%
Storage Charging Cost (RE)	$30.0	$27.7	$40.2	$39.6	$32.8	$32.8	$32.8	$32.8	$203.3	$222.2
Storage Charging Cost (Grid)	$8.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Capital Structure										
Debt	30%	30%	30%	30%	30%	30%	30%	30%	50%	0%
Interest Rate	7%	6%	7%	7%	7%	7%	7%	7%	8%	7%
Loan Tenure	10	10	10	10	10	10	10	10	20	0
Cost of Equity	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
WACC	9.9%	9.8%	9.9%	9.9%	9.9%	9.9%	9.9%	9.9%	9.0%	12.0%
Others										
Interest on Working Capital	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%
RE ITC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
ESS ITC	30%	18%	24%	24%	30%	30%	30%	30%	30%	30%

All values for Year 2021. RE Equipment Price, ESS Price, PCS Price and RE and ESS O&M assumptions change with years

Assumptions - Gap Analysis

Case	29	30	31	32	33	35	36	37
CPS Category	3	1/3	1/3	1/3	1/3	4	4	4
Standard Technology	QESS virtually paired renewable generator	QESS physically paired with Cat-1 OSW	QESS physically paired with Cat-1 LBW	QESS physically paired with Cat-1 Utility-Scale Solar	QESS physically paired with Cat-1 DG Solar	Utility Demand Resource - Resource enabled load reduction	ISO Demand Resource - Resource enabled load reduction	Demand Resource - EV Charging
Tech Details	N/A	N/A	N/A	Single-Axis Tracking	Single-Axis Tracking	Load Curtailment (enabled by Storage)	Load Curtailment (enabled by Storage)	Load Curtailment (enabled by curtailing / modulating Electric Vehicle charging)
Application (Resource)	IFOM	Offshore	Maine mountain	Ground-Mount	Ground-Mount	BTM	BTM	BTM
Revenue Hedge	Merchant	Merchant	Merchant	Merchant	Merchant	0	0	0
Investment Term	20	20	20	20	20	20	20	20
RE Capacity	-	800	150	50	2	-	-	-
Capex								
RE equipment price	$0	$3,760	$1,497	$1,045	$1,894	$1,250	$1,250	$0
ESS (DC system) Price	$240	$240	$260	$280	$300	$400	$400	$0
PCS/Inverter Price	$180	$180	$200	$200	$200	$250	$250	$0
OPEX								
RE O&M	$0	$128	$149	$55	$42	$12.0	$12.0	$12.0
ESS O&M (including warranties)	$7.0	$7.0	$8.0	$9.0	$8.0	$55.0	$55.0	$55.0
O&M Escalation	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%	2.25%
Storage Charging Cost (RE)	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0
Storage Charging Cost (Grid)	$33.6	$0.0	$0.0	$0.0	$0.0	$150.0	$150.0	$150.0
Capital Structure								
Debt	30%	37%	40%	25%	45%	50%	50%	0%
Interest Rate	7%	7%	7%	7%	7%	8%	8%	8.00%
Loan Tenure	10	10	10	10	10	20	20	20
Cost of Equity	12%	11%	10%	10%	10%	12%	12%	12.00%
WACC	10.1%	9.0%	8.5%	8.5%	8.1%	9.0%	9.0%	12.0%
Others								
Interest on Working Capital	12%	12%	12%	12%	12%	12%	12%	12%
RE ITC	0%	18%	18%	30%	30%	0%	0%	0%
ESS ITC	0%	18%	18%	30%	30%	0%	0%	0%

All values for Year 2021. RE Equipment Price, ESS Price, PCS Price and RE and ESS O&M assumptions change with years

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8 Estimating Obligated Load

- Step 5

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Analysis Methodology Detail: Market Analysis

Step 5: Estimating Obligated Load

- Load was estimated based on:
  - Application of CPS to load in Massachusetts' investor-owned utility territories
  - Assumed deployment of energy storage, renewables, electrification strategies consistent with MA Comprehensive Energy Strategy
  - Estimated exemptions of retail load under contract
  - Table to the right shows inputs and assumptions for Annual CPS Obligated Load (MWh/year)

Compliance Year	MA Applicable Load (MWh/yr)	Retail Exemptions (MWh/yr)	Annual CPES Obligated Load (MWh/yr)
2019	46,000,000	30,820,000	15,180,000
2020	45,233,845	15,379,507	29,854,338
2021	44,795,180	-	44,795,180
2022	44,589,071	-	44,589,071
2023	44,603,368	-	44,603,368
2024	44,825,015	-	44,825,015
2025	45,295,955	-	45,295,955
2026	46,173,889	-	46,173,889
2027	47,374,446	-	47,374,446
2028	48,594,182	-	48,594,182
2029	49,991,531	-	49,991,531
2030	51,913,300	-	51,913,300
2031	52,384,241	-	52,384,241
2032	53,262,175	-	53,262,175
2033	54,462,732	-	54,462,732
2034	55,682,468	-	55,682,468
2035	57,079,817	-	57,079,817

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9 Revenue estimate for indicative use case under selected ACP

- Step 6

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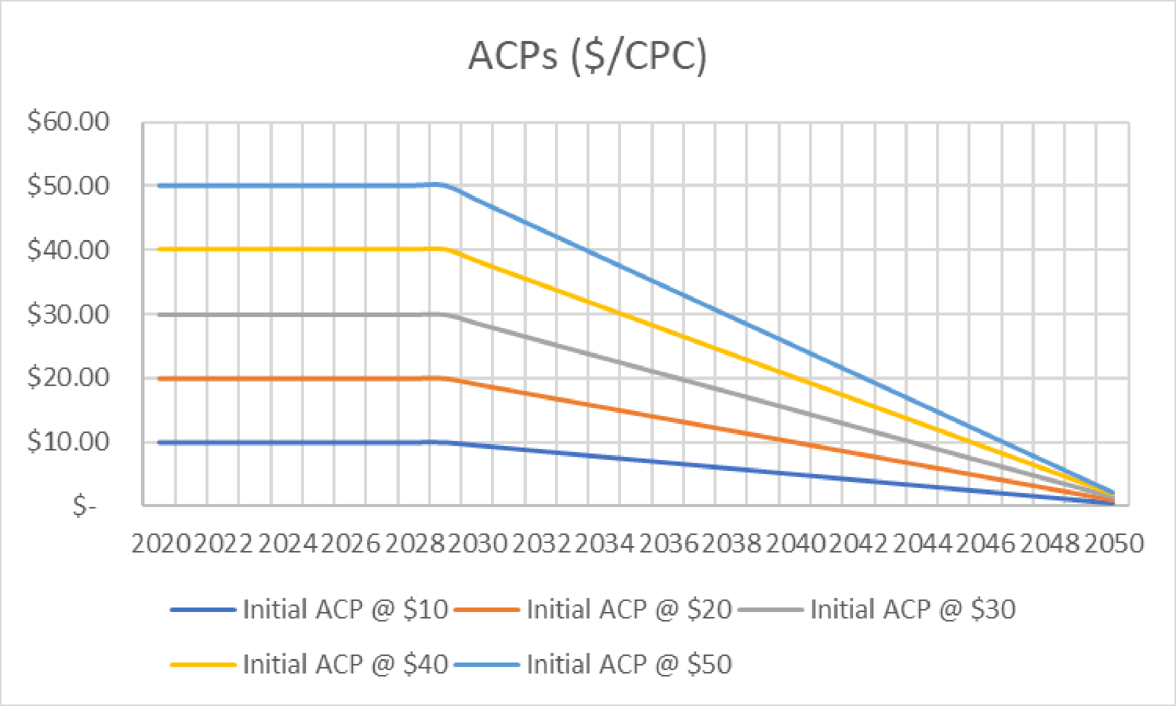
Step 6: Revenue estimate under selected ACP

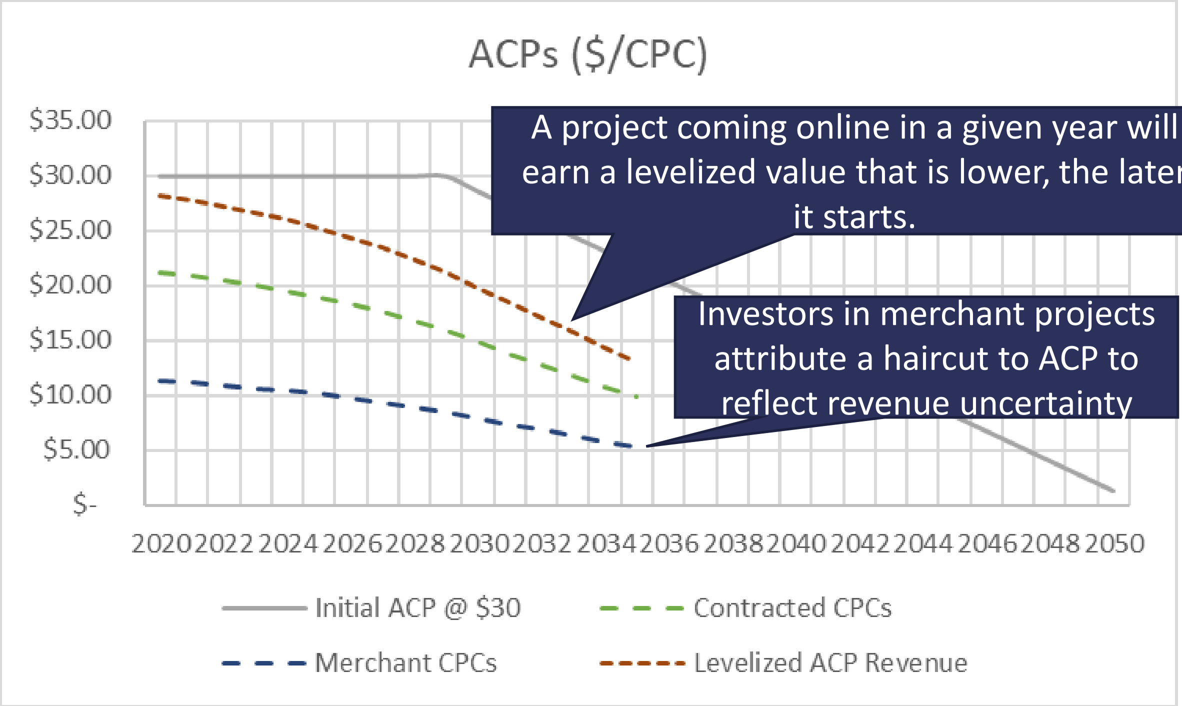
- ACP assumed to be set initially for 10 years, then decline linearly thereafter to zero by the end of the policy after 2050
- ACP levelized: The model calculates a levelized ACP for each year with an assumed levelization term of 20-years (a placeholder that can be adjusted) and using technology-specific discount rates that take into account the Weighted Average Cost of Capital (WACC) of the investor in the technology of interest. The discount rates are calculated within the CES Gap Model
- Because of ACP decline, the nominal levelized ACP revenue for any selected initial ACP will be lower for each successive year of commercial operation
- Contracted CPEC revenue (as a result of an assumed CPS hedge co-program) were assumed to be hedged at a user-defined percentage (initially, 75%) of the levelized ACP level
    - Consistent with trading off some upside for revenue certainty, which in turn can lower financing costs and make more CP Resources viable
- Revenue Reliability derate (merchant vs. contracted)
    - In contrast, merchant CPEC revenues are assumed to be discounted in investor financial pro formas to a user-defined percentage (40%) of the ACP level to account for market and regulatory risk

ACPs, Levelized ACP, and Assumed Realized ACP for Merchant and Contracted Projects



User can select an initial ACP from $10 - $50/CPEC in $10 increments; declines after 10 yrs to zero at end of policy

Illustration for Initial ACP @ $30/CPEC



A project coming online in a given year will earn a levelized value that is lower, the later it starts.

Investors in merchant projects attribute a haircut to ACP to reflect revenue uncertainty

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Discount rate input assumptions and revenue reliability derate input assumptions

Discount rates

- Based on the WACC for each supply block, based on CES Gap Analysis
- Range from 7.45% to 9% for Cat I resources, with Residential Rooftop Solar having the highest discount rate
- All Cat 2 resources have an assumed 9.6% discount rate, except for:
  - SREC C&I Rooftop + QESS which has an assumed 8.57% discount rate; and
  - SREC Residential Rooftop + QESS which has a 12% discount rate
- Cat 3 resources range between 7.69% (QESS physically paired with DG solar) and 9.8% (Virtually paired QESS)
- Most Cat 4 resources have a discount rate of 8.57% except for Demand Resource-EV Charging which has an assumed discount rate of 12%

CPEC Procurement

- Initial assumptions regarding available to use cases: Procurement should focus on facility types that may not have other sources of long-term financing available to them
- Initial model setup assumes: All QESS (Cat 2, Cat 3-virtual, Cat 1/3, Cat 4 resource-enabled load curtailment) are contracted

Discount rate and revenue reliability derate input assumptions

Case	CPS Category	Standard Technology	Tech Details	Application (Resource)	CPEC Revenue Hedge	WACC % 2021	WACC % 2025	WACC % 2030
2	1	Offshore Wind (OSW)	N/A	Offshore	Merchant	8.7%	8.7%	8.7%
4	1	Land Based Wind (LBW)	N/A	Maine mountain	Merchant	8.0%	7.4%	7.4%
6	1	Utility-Scale Solar	Fixed-Axis	Ground-Mount	Merchant	7.7%	7.5%	7.5%
8	1	Utility-Scale Solar	Single-Axis Tracking	Ground-Mount	Merchant	7.7%	7.5%	7.5%
10	1	Utility-Scale Solar	Single-Axis Tracking, Bifacial	Ground-Mount	Merchant	8.6%	8.6%	8.6%
12	1	DG Solar	Fixed-Axis	Ground-Mount	Merchant	7.9%	7.6%	7.6%
14	1	DG Solar	Single-Axis Tracking	Ground-Mount	Merchant	7.9%	7.6%	7.6%
16	1	DG Solar	Fixed-Axis	C&I Rooftop, sized to load	Merchant	7.9%	7.6%	7.6%
18	1	DG Solar	Fixed-Axis	Resi rooftop	Merchant	8.3%	8.0%	8.0%
19	2	LBW + QESS	N/A	Maine mountain	PPA	9.9%	9.6%	9.3%
20	2	LBW + QESS	N/A	Maine mountain	Merchant	9.8%	9.5%	9.1%
21	2	DG Solar + QESS	Fixed-Axis	Ground-Mounted, VNM	SREC I or II	9.9%	9.6%	9.3%
22	2	DG Solar + QESS	Fixed-Axis	IFOM, VNM, Landfill	SREC I or II	9.9%	9.6%	9.3%
23	2	Biomass + QESS	N/A	IFOM	Merchant?	9.9%	9.6%	9.3%
24	2	Waste-to-Energy + QESS	N/A	IFOM	Merchant?	9.9%	9.6%	9.3%
25	2	Hydro - ROR + QESS	N/A	IFOM	Merchant?	9.9%	9.6%	9.3%
26	2	Hydro - Storage + QESS (Baseload)	N/A	IFOM	PPA?	9.9%	9.6%	9.3%
27	2	BTM Solar + QESS	Fixed-Axis	BTM, C&I Rooftop	SREC I or II	9.0%	8.6%	8.6%
28	2	BTM Solar + QESS	Fixed-Axis	BTM, Resi rooftop	SREC I or II	12.0%	12.0%	12.0%
29	3	QESS virtually paired renewable generator	N/A	IFOM	Merchant	10.1%	9.8%	9.5%
30	1/3	QESS physically paired with Cat-1 OSW	N/A	Offshore	Merchant	9.0%	9.0%	9.0%
31	1/3	QESS physically paired with Cat-1 LBW	N/A	Maine mountain	Merchant	8.5%	8.0%	8.0%
32	1/3	QESS physically paired with Cat-1 Utility-Scale Solar	Single-Axis Tracking	Ground-Mount	Merchant	8.5%	8.3%	8.2%
33	1/3	QESS physically paired with Cat-1 DG Solar	Single-Axis Tracking	Ground-Mount	Merchant	8.1%	7.7%	7.7%
35	4	Utility Demand Resource - Resource enabled load reduction	Load Curtailment (enabled by Storage)	BTM		9.0%	8.6%	8.6%
36	4	ISO Demand Resource - Resource enabled load reduction	Load Curtailment (enabled by Storage)	BTM		9.0%	8.6%	8.6%
37	4	Demand Resource - EV Charging	Load Curtailment (enabled by curtailing / modulating Electric Vehicle charging)	BTM		12.0%	12.0%	12.0%

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10 Estimate technical potential of each use case

- Step 7

Step 7: Estimate technical potential of use case

- For each Technology/Use Case category, a technical potential by season and year was developed. These were developed for nearly all resources in the model. However some supply 'buckets' include placeholders which are described in more detail on subsequent slides.
- Assumptions for each 'bucket' of supply differed, depending on the nature of the resource (see illustrations, next slide)
  - For example, merchant land-based wind is one bucket, and contracted land-based wind is another, each having different assumptions and placed in separate tables in the model
  - Renewable Energy technical potential was determined based on existing known resources, existing statutory language for future procurements, and future expectations based on the interconnection queue, and expected/possible future procurements
  - Demand Response:
    - Utility Compliance Filings for 3-year EE Plans, reconciliation with estimated 2019-2021 measures for Active DR participation and classification into direct load control, storage enabled and EV charge management; decreasing escalation rate applied form the three years of data provided
    - For ISO-NE PRD participation, ISO reference data reflects 95 MW of Active Demand Response in MA; utilized same proportions of summer/winter and storage / non-storage as the utility estimates and then escalated at a decreasing rate out through 2035
    - For EV Charging: EIA 2018 estimates of EV Sales in New England; applied a percentage of the total New England sales to MA based on 2017 registration data (MA to all of NE); applied a charging capacity of 7.6kW (typical capacity of a Level 2 charging station) to convert vehicles to available capacity and applied annual growth rate
  - QESS: QESS technical potential is based on a screening-level analysis of potential wholesale market size of the corresponding market products that QESS is expected to participate – capacity, energy and spin. QESS technical potential was assumed to be constrained by considering the market size of all market revenue streams needed to make a project economically viable at the highest CPEC value considered, where the size of each potential market (in MW) is the product of the overall market size and the assumed maximum energy storage penetration in that market. The analysis concluded that capacity market penetration represented the largest driver of technical potential. Participation in frequency regulation is NOT assumed due to small market size and large uncertainty of the revenue. Year over year market sized is informed based on cost curve of energy storage, forecasts of stacked revenues and assumed high value of CPEC.
- MW quantities were combined with CPEC production profiles and CP multipliers to estimate potentially available CPECs

Technical Potential Input Assumptions

Land Based Wind (Max Annual Capacity MW)

	CAT 1					CAT 2			CAT 1/3
Compliance Year	Pre CPES LBW Under Contract to MA	Pre CPES LBW Under Contract to Other States	Merchant LBW	Future LBW Under Contract to MA	Future LBW Under Contract to Other States	Pre CPES LBW Under Contract to MA QESS	Pre CPES LBW Under Contract to Other States, Paired with QESS	Pre CPES Merchant LBW Paired with QESS	QESS Physically Paired w/LBW (Cat 1/3)
2022	0	8.83	-	0	95.24	487.2	50	773.0	-
2026	0	8.83	1,800	0	251.40	487.2	50	773.0	1,800
2034	0	8.83	6,600	0	251.40	487.2	50	773.0	6,600

Supply Bucket	Basis
Pre CPES LBW Under Contract to MA	Only wind project is an import
Pre CPES LBW Under Contract to Other States	Only two wind projects existing
Merchant LBW	Based on existing projects and development pipeline
Future LBW Under Contract to MA	No projects expected
Future LBW Under Contract to Other States	Based on assumptions about known/expected procurements
Pre CPES LBW Under Contract to MA QESS	
Pre CPES LBW Under Contract to Other States, Paired with QESS	
Pre CPES Merchant LBW Paired with QESS	Based on tracking of development pipeline and interconnection queue
QESS Physically Paired w/LBW (Cat 1/3)	Based on Cat 1 Merchant Wind

Technical Potential Input Assumptions

Offshore Wind (Max Annual Capacity MW)

Compliance Year	CAT 1					CAT 1/3
	Pre-CPES MA Sec. 83 Contracted OSW	Pre CPES Other States' Contracted OSW	Merchant OSW	Future MA Sec. 83 Contracted OSW	Future Other State Contracted OSW	QESS Physically Paired w/OSW (Cat 1/3)
2022	800	0	0	0	0	0
2026	800	700	0	800	200	0
2034	800	700	4800	2400	1803	4800

Supply Bucket	Basis
Pre-CPES MA Sec. 83 Contracted OSW	Based on existing known projects
Pre CPES Other States' Contracted OSW	
Merchant OSW	Placeholder, based on tracking development pipeline
Future MA Sec. 83 Contracted OSW	Based on expect future procurements
Future Other State Contracted OSW	Based on CT procurement of 2000 MW
QESS Physically Paired w/OSW (Cat 1/3)	Placeholder, based on Cat 1 Merchant OSW

Utility-Scale Solar (Max Annual Capacity MW)

Compliance Year	CAT 1						Cat 1/3
	Pre CPES Utility Scale Solar, Fixed Axis, MA Contracted	Pre CPES Utility Scale Solar, Fixed Axis, Other State Contracts	Merchant Fixed-Axis Solar	Merchant Single-Axis Solar	Future Utility Scale Solar, Fixed Axis, Other State Contracts	Future Utility Scale Solar, Single Axis Tracking, Other State Contracts	QESS Physically Paired w/Single Axis Utility-Scale Solar (Cat 1/3)
2022	129	409	0	0	122	122	0
2026	129	663	600	600	719	719	600
2034	129	663	2200	2200	719	719	2200

Supply Bucket	Basis
Pre CPES Utility Scale Solar, Fixed Axis, MA Contracted	Based on existing known projects
Pre CPES Utility Scale Solar, Fixed Axis, Other State Contracts	
Merchant Fixed-Axis Solar	Placeholder estimates based on our tracking of the development pipeline and interconnection queue
Merchant Single-Axis Solar	
Future Utility Scale Solar, Fixed Axis, Other State Contracts	Based on expected future procurements
Future Utility Scale Solar, Single Axis Tracking, Other State Contracts	
QESS Physically Paired w/Single Axis Utility-Scale Solar (Cat 1/3)	Placeholders based on our tracking of the development pipeline and interconnection queue

Note: all other supply blocks for Utility-Scale Solar were assumed to have 0 MW potential due to either no project currently existing, or none expected to be built in the future.

Technical Potential Input Assumptions

Distributed Solar (Max Annual Capacity MW)

Compliance Year	CAT 1														CAT 2				CAT 1/3
	Pre CPES SMART Fixed-Axis Ground Mount	Pre CPES SREC Fixed-Axis Ground Mount	Pre CPES SMART Fixed-Axis C&I Rooftop	Pre CPES SREC Fixed-Axis C&I Rooftop	Pre CPES SMART Fixed-Axis Res Rooftop	Pre CPES SREC Fixed-Axis Res Rooftop	Merchant Fixed-Axis Ground-Mount	Merchant Single-Axis Ground-Mount	Merchant Fixed-Axis C&I Rooftop	Merchant Fixed-Axis Res Rooftop	Future SMART Fixed-Axis Ground Mount	Future SMART Single-Axis Ground Mount	Future SMART Fixed-Axis C&I Rooftop	Future SMART Fixed-Axis Res Rooftop	SREC 1/2 Ground Mounted Paired with QESS	SREC 1/2 Landfill Paired with QESS	SREC 1/2 C&I BTM Paired with QESS	SREC 1/2 Residential BTM Paired with QESS	QESS Physically Paired w/ DG Solar
2022	459	24.7	83	14.1	58	0	0	0	0	0	422	15	187	65	648	151	456	766	15
2026	459	24.7	83	14.1	58	0	0	0	0	0	890	71	696	174	648	151	456	766	71
2034	459	24.7	83	14.1	58	960	960	960	1080	240	890	71	696	174	648	151	456	766	71

Note: Pre-CPS SMART Single-Axis and SREC Single-Axis Ground mount systems were assumed to have 0 MW potential due to no existing projects.

Supply Bucket	Basis
Pre CPES SMART Fixed-Axis Ground Mount	**Based on existing known projects**
Pre CPES SREC Fixed-Axis Ground Mount	
Pre CPES SMART Fixed-Axis C&I Rooftop	
Pre CPES SREC Fixed-Axis C&I Rooftop	
Pre CPES SMART Fixed-Axis Res Rooftop	
Pre CPES SREC Fixed-Axis Res Rooftop	
Merchant Fixed-Axis Ground-Mount	**Extrapolate pace from SEA SMART program projections**
Merchant Single-Axis Ground-Mount	**Same total technical potential as Fixed Axis**
Merchant Fixed-Axis C&I Rooftop	**Extrapolate pace from SEA SMART program projections**
Merchant Fixed-Axis Res Rooftop	
Future SMART Fixed-Axis Ground Mount	**Based on expected future SMART procurements**
Future SMART Single-Axis Ground Mount	
Future SMART Fixed-Axis C&I Rooftop	
Future SMART Fixed-Axis Res Rooftop	
SREC 1/2 Ground Mounted Paired with QESS	Historical actual project population
SREC 1/2 Landfill Paired with QESS	Historical actual project population
SREC 1/2 C&I BTM Paired with QESS	Historical actual project population
SREC 1/2 Residential BTM Paired with QESS	Historical actual project population
QESS Physically Paired w/ DG Solar	

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Technical Potential Input Assumptions

All other resources (Max Annual Capacity MW)

Compliance Year	CAT 2				CAT 3	Cat 4			
	Biomass & LFG Paired with QESS	Waste-to-Energy Paired with QESS	Hydro ROR with QESS	Hydro Storage with QESS	Virtually Paired QESS	Demand Resource - Load Curtailment	Utility Demand Resource - Resource Enabled Load Reduction	ISO Demand Resource - Resource Enabled Load Reduction	Demand Resource - EV Charging
2022	136	283.5	249	49.0	25	124	27	13	23
2026	136	283.5	249	49.0	595	301	96	40	53
2034	136	283.5	249	49.0	1,795	1,085	413	128	244

Supply Bucket	Basis
Biomass & LFG Paired with QESS	Includes all MA I/2 eligible Biomass plants in MA
Waste-to-Energy Paired with QESS	Includes all MA 1/2 eligible Waste-to-Energy plants in MA
Hydro ROR with QESS	Includes all MA 1/2 eligible ROR units
Hydro Storage with QESS	Includes all MA 1/2 eligible Hydro storage
Virtually Paired QESS Utility Demand Resource - Resource Enabled Load Reduction Demand Resource - EV Charging	Please see slide 77

11 Percentage of % of technical potential profitable at selected APC

- Step 8

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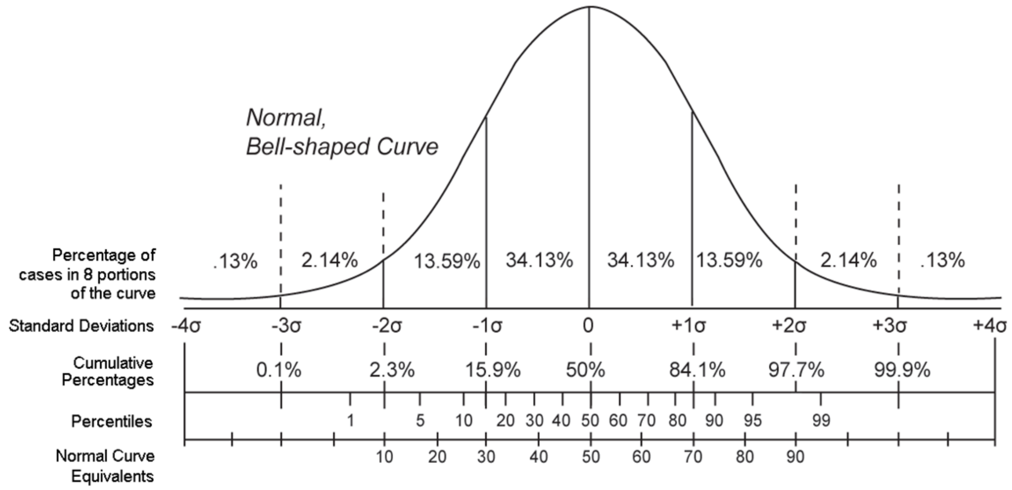
Step 8: % of technical potential profitable at selected APC

- Using the (presumed mean) nominal levelized revenue gap ($/CPEC) from the gap analysis, an inferred variance of costs around the mean was assumed, to yield a representation for real projects around indicative case
  - Assumed a normal distribution, and carved the cumulative probability distribution from -3 standard deviations to > +3 standard deviations around the mean
  - By comparing the levelized ACP revenue at each assumed level of initial ACP ($0, $10, $20, $30, $40, $50) for each year, with the percentage of the probability distribution of revenue gap exceeded by the levelized ACP, an estimate of the percentage of the technical potential that would be economically deployed if CPEC prices were as projected (as a function of that ACP) can be derived
    - See illustration on next slide

Profitability: comparing assumed revenues at selected ACP with revenue gap ➔ Drives deployment

Illustration:
Pre-CPS LBW Under Contract to MA Online Prior to 2019, Paired with QESS in a 1 to 0.25 RE to QESS ratio



Compliance Year	Profitable @ levelized ACP Revenue associated with Initial ACP = $0	Profitable @ levelized ACP Revenue associated with Initial ACP = $10	Profitable @ levelized ACP Revenue associated with Initial ACP = $20	Profitable @ levelized ACP Revenue associated with Initial ACP = $30	Profitable @ levelized ACP Revenue associated with Initial ACP = $40	Profitable @ levelized ACP Revenue associated with Initial ACP = $50
2019	0.1%	0.1%	0.1%	0.1%	0.1%	2.3%
2020	0.1%	0.1%	0.1%	0.1%	2.3%	2.3%
2021	0.1%	0.1%	0.1%	0.1%	2.3%	15.9%
2022	0.1%	0.1%	0.1%	0.1%	2.3%	15.9%
2023	0.1%	0.1%	0.1%	0.1%	2.3%	15.9%
2024	0.1%	0.1%	0.1%	0.1%	15.9%	50.0%
2025	0.1%	0.1%	0.1%	2.3%	15.9%	50.0%
2026	0.1%	0.1%	0.1%	2.3%	15.9%	84.1%
2027	0.1%	0.1%	0.1%	2.3%	50.0%	84.1%
2028	0.1%	0.1%	0.1%	15.9%	50.0%	97.7%
2029	0.1%	0.1%	2.3%	15.9%	84.1%	99.9%
2030	0.1%	0.1%	2.3%	50.0%	99.9%	100.0%
2031	0.1%	0.1%	15.9%	97.7%	100.0%	100.0%
2032	0.1%	2.3%	84.1%	100.0%	100.0%	100.0%
2033	0.1%	84.1%	100.0%	100.0%	100.0%	100.0%
2034	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
2035	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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12 Phase-in of Potential Supply

- Step 9

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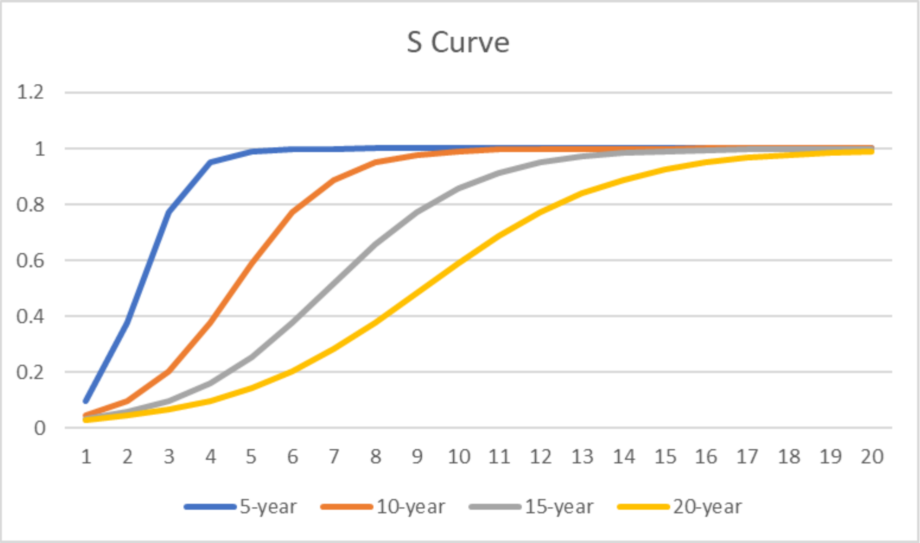
Analysis Methodology Detail: Market Analysis
Step 9: Apply Phase-in of technical potential profitable at ACP

- Step 9: Apply Phase-in (recognizing industry capability to deploy) to yield projected CPECs for each use case and bucket.
- Phase-in constraints (once profitable, can't all be built overnight)
- S-Curves used to project phase-in of technical potential ➔ reflect observed patterns of technology diffusion
- Generic curves applied, with specific shape selected reflecting expert judgement on factors impacting speed to penetrate once profitable
- This approach throttles technical potential to reflect the reality that it takes time to fully engage supply chain to install profitable technical potential
- User inputs include two factors when choosing S-Curve:
  - the number of years lag from a project respond to an opportunity to project reaching commercial operation, and
  - the number of years over which it takes the technology to reach full potential (ex: 5-year time frame, with a 1-year lag)



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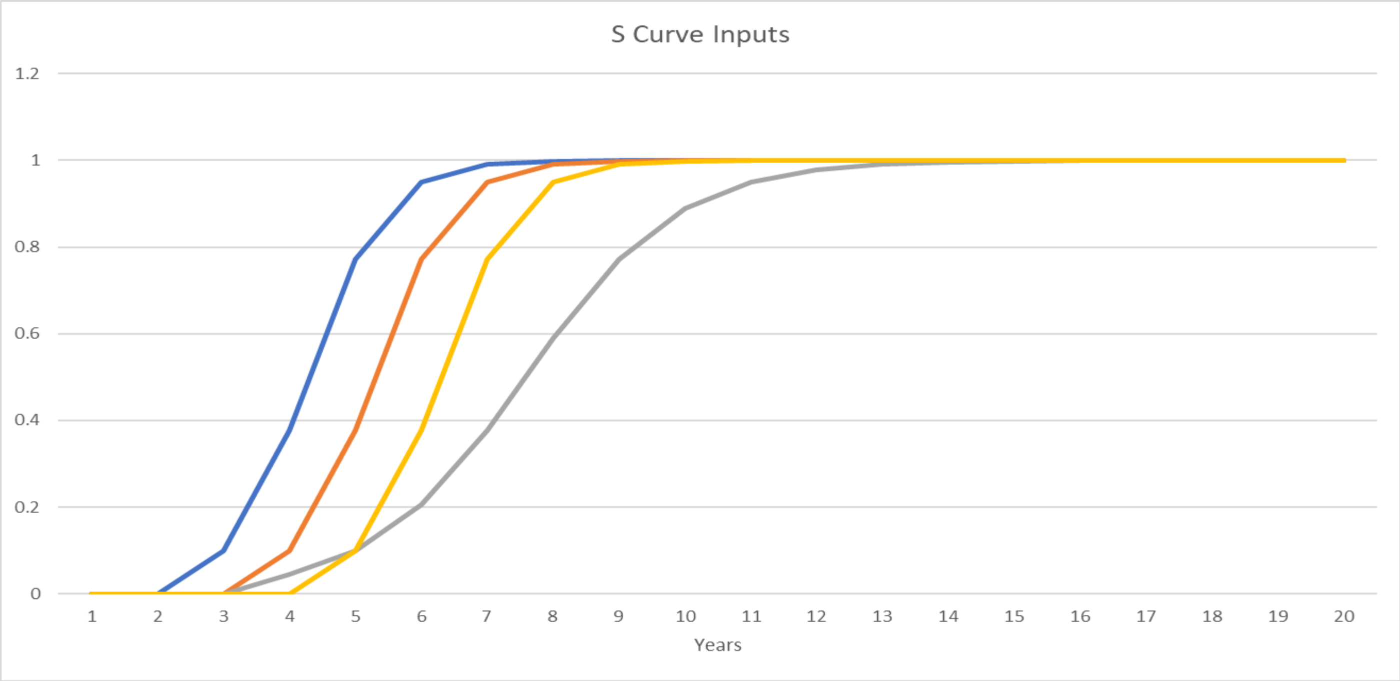
S-Curve Input Assumptions



Technology Type	Utility-Scale Solar Fixed-Axis	Utility-Scale Solar Single-Axis Tracking	Utility-Scale Solar Single-Axis Tracking Bifacial	LBW+QESS	Biomass + QESS	Waste-to-Energy + QESS	Virtually Paired QESS	QESS physically paired with LBW->(case 4)	QESS physically paired with Cat-1 Utility-Scale Solar	QESS physically paired with OSW	Offshore Wind (OSW)	DG Solar Fixed-Axis Ground Mount	DG Solar Single-Axis Tracking Ground Mount	QESS physically paired with Cat-1 DG Solar
S Curve # of Years	5 yr (3 yr lag)									5 yr (4 yr lag)		10 yr (3 yr lag)		

Technology Type	DG Solar C&I Rooftop Fixed-Axis	DG Solar Residential Rooftop Fixed Axis	SREC 1/2 Ground Mounted + QESS	SREC-1/2 Landfill + QESS	Land Based Wind (LBW)	Hydro - ROR + QESS	Hydro - Storage + QESS	SREC-1/2 C&I Rooftop + QESS	SREC-1/2 Residential Rooftop + QESS	Demand Resource - Load curtailment	Utility Demand Resource - Resource enabled load reduction	ISO Demand Resource - Resource Enabled Load Reduction	Demand Resource - EV Charging
S Curve # of Years	5 yr (2 yr lag)												

- Each resource type in each category includes different time frame and lag assumptions which are the Consulting Teams’ assumptions (judgement) based on understanding of technology characteristics (listed below, with matching colors to the relevant S-Curve on the graph to the left)
- These assumptions could be refined through further analysis

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13 User Inputs

- Step 10

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Step 10: User Inputs

- Initial ACP level, $/CPEC (in discreet steps from $10 to $50)
- Eligibility decisions on various categories of supply to be included or excluded based on availability of sufficiently hedged revenue
- Assumed long-term CPEC hedge opportunities (contracted CPECs vs. merchant)
    - User can select which categories are assumed to be supported through a CPEC-hedging (long-term contract or tariff) program
- Initial CPS target and annual target escalation (%/yr)
- Resilience multiplier

Contracted vs. Merchant

- Every ‘merchant’ use case module has choice of:
  - Merchant CPECs (gap calculated assuming investor attributes a material haircut to ACP revenues, initially set at 40% of levelized ACP)
  - Contracted CPECs
    - e.g., DOER/DPU establishes EDC tariff or contracting program to stabilize CPEC revenues
    - gap calculated assuming incentive locks in revenues at 75% of levelized ACP
- Straw Proposal: CPEC Procurement
  - *Procurement should focus on facility types that may not have other sources of long-term financing available to them*
  - *New AD & biomass not modeled (fringe cases)*
- Initial model setup assumes:
  - All QESS (Cat 2, Cat 3-virtual, Cat 1/3, Cat 4 resource-enabled load curtailment are contracted)
- This can be varied, but the choice is all or none for each use type

Resilience Multiplier

- Every use case module has choice of:
  - Resilience multiplier applies (Y/N)
  - % of installations within use case that qualify for multiplier
- Current modeling simplification: whatever % of installations is selected is used to ‘derate’ of calculation of CPECs produced, relative to all such installations receiving the multiplier (e.g., if the resilience multiplier would grant 100 CPECs to an installation, a 50% value for ‘% of installations within use case that qualify for multiplier’ would reduce CPECs to 50 for all installations
  - This works well for non-merchant use cases
  - A more accurate approach for merchant use cases would split the use case, and calculate a different ‘gap’ for those installations with and without an incentive, and then model CPEC quantities separately
- Initial model setup assumes:
  - See table, per DOER initial direction
- This can be varied
- Simplifying assumption (so far) ➔ *impact on Gap not (yet) addressed in Gap model*

Use Case	% of installations
Resi Rooftop Solar (Cat1, 2 & 4)	90%
C&I Rooftop Solar (Cats 1, 2 & 3)	25%
Ground Mount DG solar (IFOM) (Cats 1, 2 & 3)	5%

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14 Calculate and Assess results

- Step 11

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Step 11: Calculate and Assess results

- Calculate CPEC production from each type of applications projected as profitable in each year and roll up totals
- Calculate summary result metrics
- Compare to Objective Functions:
  - Is ratepayer impact under maximum ratepayer direct impact? (0.5¢/kWh)
  - Does it maintain Supply-Demand tension (so CPEC price near ACP)?
- Estimate impact (savings) from long-term contracting
  - Compare estimated maximum ratepayer exposure with no CPEC contracts ($/year) vs. the estimated maximum ratepayer exposure net after CPEC contract savings ($/year)
  - Based on user-defined assumptions of technology/use cases assumed eligible for long-term contracts, and user-defined assumption of long-term contract price as a percent of ACP
  - This feature was only partially implemented in version delivered to DOER

Obligation and Rate Impact Calculation: Results

Illustrative inputs selected to show optimization features

Turns red if violates rate impact constraint

Minimum Standard Inputs

Obligation Calculator

How to set?

0.50% annual rate of standard escalation

Compliance Year	Annual CPES Obligated Load (MWh/yr)	ACP ($/CPC)	Total Projected Supply (CPCs/Yr)	Estimated Compliance Obligation (CPCs/yr)	Estimated Minimum Standard (%)	Estimated Maximum Ratepayer Exposure ($/yr)	Estimated Total Ratepayer Costs ($/MWh)	Estimated Total Ratepayer Costs (¢/kWh)
2019	15,180,000	$ -	228,850	0		$ -	$ -	0.00
2020	29,854,338	$ 40.00	2,677,633	2,686,890	9.00%	$ 107,475,616	$ 3.60	0.36
2021	44,795,180	$ 40.00	2,895,818	4,255,542	9.50%	$ 170,221,686	$ 3.80	0.38
2022	44,589,071	$ 40.00	4,096,817	4,458,907	10.00%	$ 178,356,285	$ 4.00	0.40
2023	44,603,368	$ 40.00	4,179,054	4,683,354	10.50%	$ 187,334,147	$ 4.20	0.42
2024	44,825,015	$ 40.00	4,442,249	4,930,752	11.00%	$ 197,230,065	$ 4.40	0.44
2025	45,295,955	$ 40.00	5,694,588	5,209,035	11.50%	$ 208,361,395	$ 4.60	0.46
2026	46,173,889	$ 40.00	5,997,665	5,540,867	12.00%	$ 221,634,667	$ 4.80	0.48
2027	47,374,446	$ 40.00	6,252,172	5,921,806	12.50%	$ 236,872,230	$ 5.00	0.50
2028	48,594,182	$ 40.00	7,071,669	6,317,244	13.00%	$ 252,689,746	$ 5.20	0.52
2029	49,991,531	$ 40.00	7,419,126	6,748,857	13.50%	$ 269,954,267	$ 5.40	0.54
2030	51,913,300	$ 38.18	8,347,173	7,267,862	14.00%	$ 277,500,187	$ 5.35	0.53
2031	52,384,241	$ 36.36	8,805,770	7,595,715	14.50%	$ 276,207,816	$ 5.27	0.53
2032	53,262,175	$ 34.55	9,695,891	7,989,326	15.00%	$ 275,994,905	$ 5.18	0.52
2033	54,462,732	$ 32.73	10,126,933	8,441,723	15.50%	$ 276,274,584	$ 5.07	0.51
2034	55,682,468	$ 30.91	11,201,588	8,909,195	16.00%	$ 275,375,112	$ 4.95	0.49
2035	57,079,817	$ 29.09	11,919,588	9,418,170	16.50%	$ 273,983,120	$ 4.80	0.48

Turns red if there is no demand tension at selected minimum standard %

Conclusion

- Consulting Team presented DOER with an unlocked spreadsheet model, allowing DOER to select and modify key input parameters, explore ratepayer cost, supply-demand tension and resource deployment implications of design choices and targets and to further modify the model and its inputs as needed
- Consulting Team demonstrated use of the model to DOER and trained DOER staff on its use in live and virtual meetings, and submitted working model to DOER on June 6, 2019 (as well as a modified version with additional capabilities, on June 18, 2019)
- Thereafter, DOER used the tool (and further adapted it) to evaluate the impacts of various policy scenarios to inform design decisions leading to development of the Draft Regulations