Training on Integrated Resource Planning for South Carolina Office of Regulatory Staff

Treating Energy Efficiency and Demand Response As a Resource in Electric Utility Integrated Resource Plans

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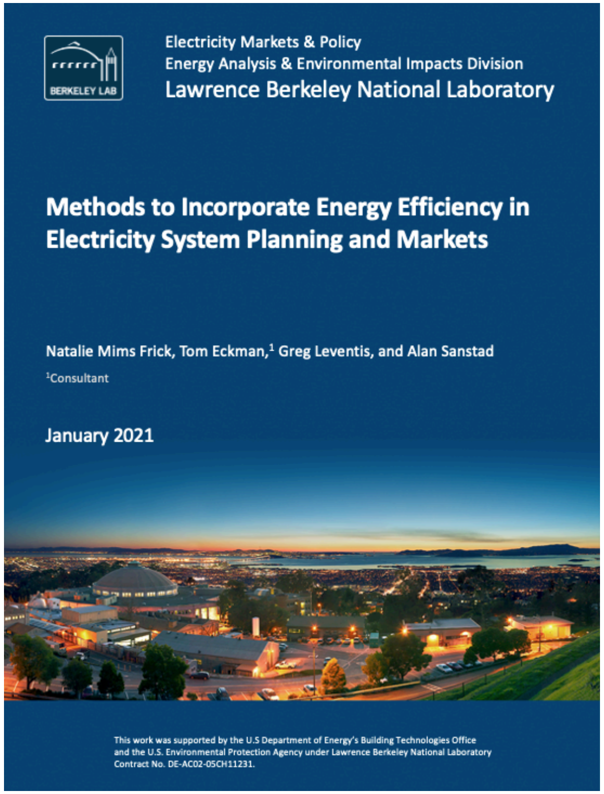
ENERGY TECHNOLOGIES AREA | ENERGY ANALYSIS AND ENVIRONMENTAL IMPACTS DIVISION | ELECTRICITY MARKETS & POLICY

Technical assistance opportunity

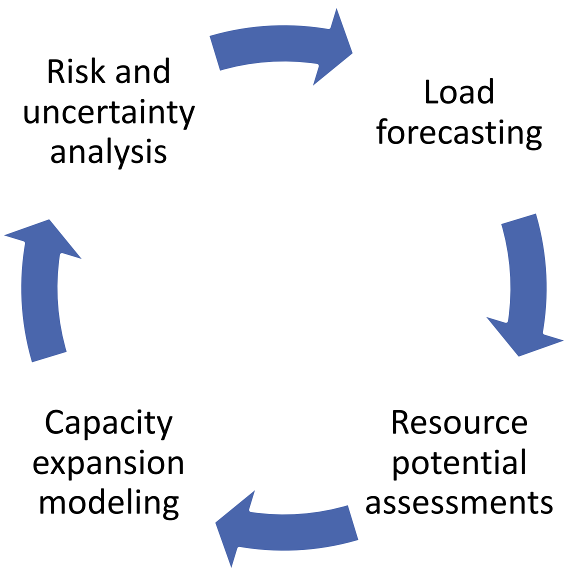
- With support from U.S. Department of Energy's Building Technologies Office, and in collaboration with NARUC and NASEO, Berkeley Lab is offering technical assistance to states interested in analyzing energy efficiency as a resource in electricity planning — specifically, development and use of energy efficiency supply curves.
- Assistance is based on a new Berkeley Lab report, *Methods to Incorporate Energy Efficiency in Electricity System Planning and Markets*
- Complete this online questionnaire if you are interested – **state responses are due March 12**
- For follow-up questions, contact:
  - Natalie Mims Frick: nfrick@lbl.gov



Technical assistance funds are limited. All responses will be considered and will inform development of technical assistance topics and delivery approaches to best address needs articulated.

Overview

- Using energy efficiency (EE) or demand response (DR) as a selectable resource requires a different process than using these resources as a decrement to the load forecast.
- Allowing a capacity expansion model to select EE or DR resources permits optimization between *all resources* (e.g., supply and demand side).
- Today, we focus on changes that may need to occur in load forecasting, resource potential assessments and capacity expansion modeling to use EE and DR as a selectable resource.



In many IRPs the amount and timing of EE and DR development are determined in a six step process.

- Step 1 – Estimate *technical potential* on a *per application* basis (i.e. savings per unit)
- Step 2 – Estimate *economic potential* on a *per application* basis (i.e., levelized cost per unit) based on "avoided cost" of "proxy" resource or capacity expansion model marginal resource analysis
- Step 3 – Estimate *number of applicable units* (account for physical limits, retirements, new construction, etc.)
- Step 4 – Estimate *economic potential* for *all applicable* units
- Step 5 – Estimate *economically achievable* potential for *all realistically achievable* units
- Step 6 – **Reduce the load forecast provided to the capacity expansion model** by the amount of *economically achievable* savings resulting from Step 5 before that model is used to "optimize" the supply side resources

When considering EE and DR as a selectable resource in IRP, the **process** and **order** are different.

- Step 1 – Estimate *technical potential* on a *per application* basis (i.e. savings per unit)

- Step 2 – Estimate *number of applicable units* (account for physical limits, retirements, new construction, etc.)

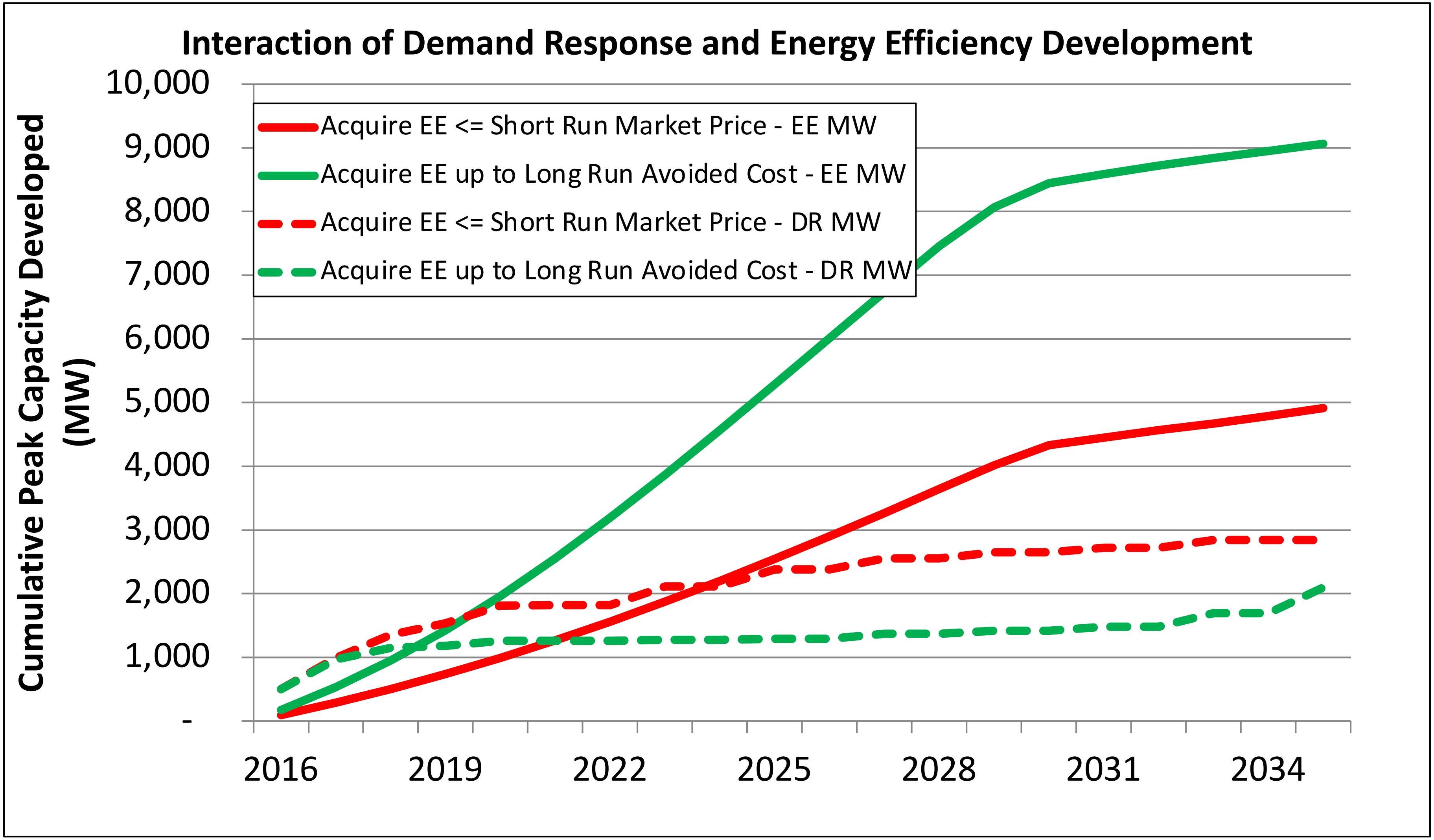
- Step 3 – Estimate *technical potential* for *all applicable* units

- Step 4 – Estimate *achievable potential* for *all realistically achievable* units

- Step 5 – Estimate *economic potential* for *all realistically achievable* units **by competing EE and DR against supply side resources in capacity expansion modeling***

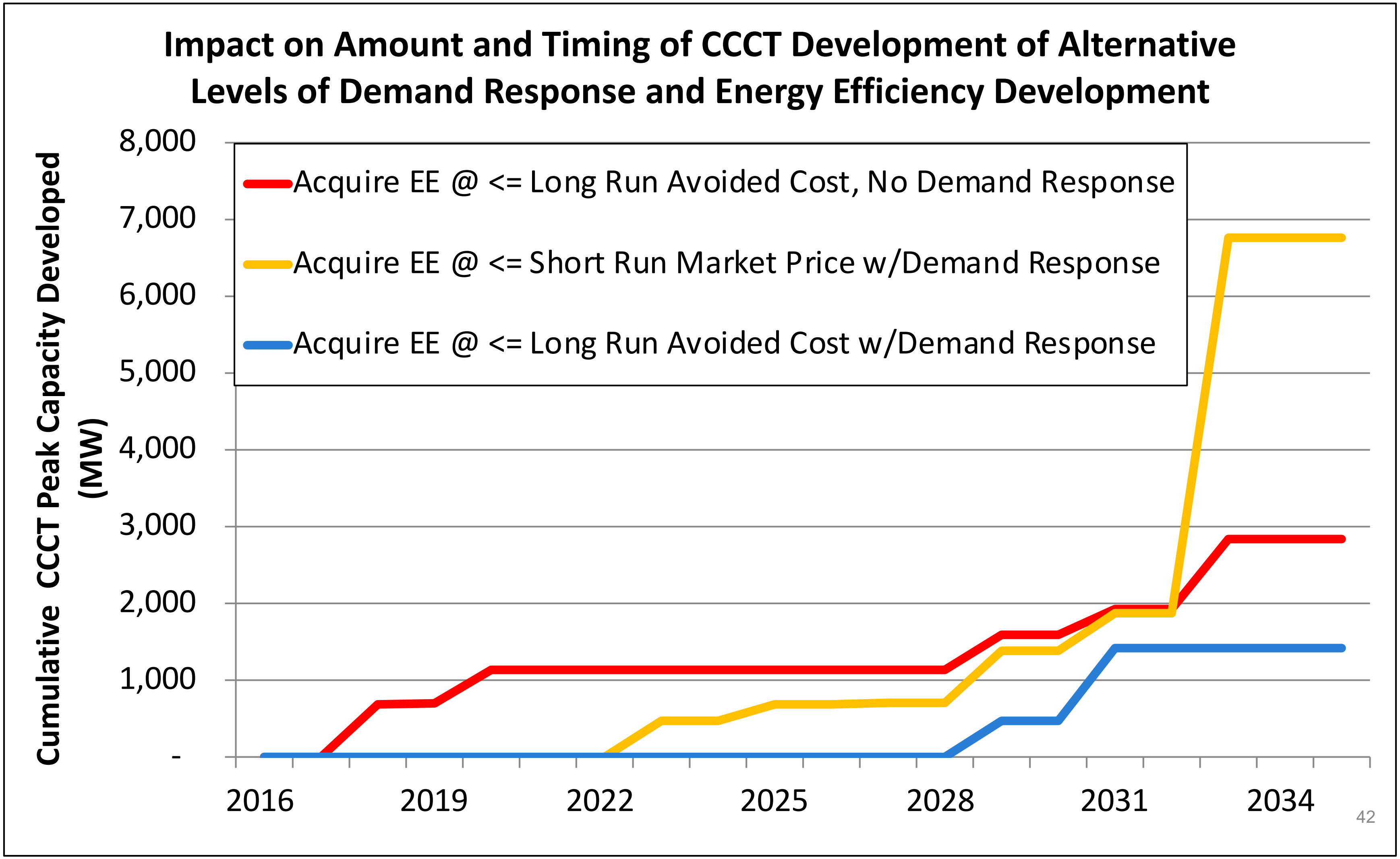
*Where EERS requirements exist they are typically modeled as "must build" resources and only additional increments above the minimum EERS compete against generating resources in capacity expansion modeling.

Treating EE and DR as selectable resources in a capacity expansion model permits optimization *between these resources*



Source: Northwest Power and Conservation Council, 7th Power Plan

Treating EE and DR as selectable resource options in a capacity expansion model permits optimization *across supply side and demand side resources*



Source: Northwest Power and Conservation Council, 7th Power Plan

Load forecasting

- Regardless of if a load decrement or direct competition approach is used, internal consistency between load forecast and EE or DR potential assessments is necessary to avoid potential for *over* or *under* estimating remaining EE and DR potential
  - Baseline use/efficiency assumptions should be equivalent
  - "Units" (e.g. houses, commercial floor space, appliance counts) should be identical
- Internal consistency is most readily achieved when end-use and statistically adjusted engineering (SAE) load forecasting models are used
  - When econometric load forecasting models are used "calibration" between load forecast and EE potential assessments is typically done at the sector (i.e., residential, commercial) level.
  - This is typically done by translating measure level EE savings in kWh derived from the potential assessment to percent improvements off a baseline and reducing the load forecast by these percentages.

Load forecasting considerations for direct competition method

- Load forecast are not decremented with an assumed level of EE*and DR
- Baseline load forecast used in capacity expansion/resource optimization model assumes “frozen efficiency” (i.e., no price responsive improvements occur) only efficiency improvements from stock turnover and known codes and standards
- EE and DR costs should reflect all utility system impacts not accounted for in capacity expansion resource optimization process
  - Example – Capacity expansion model does not estimate value of deferred transmission and distribution, therefore EE and DR levelized cost input into model should be “net” of deferred T&D.
  - Example – If non-energy benefits, such as the value of water savings, are to be included in the valuation of energy efficiency, the levelized cost input into the model should be “net” of the value of such benefits

*Note: Where EERS requirements exist, they are modeled as “must build” resources and only additional increments above EE “compete.”

Resource potential assessments

- The objective of efficiency and demand response resource potential assessments is to provide accurate and reliable information on:
  - Quantity of EE or DR available
  - Timing of availability (e.g., new construction, stock turnover)
  - EE or DR measure cost
  - Load or savings shape
- EE/DR resource potential assessment improvements include:
  - Resource quantity is not constrained by assumed levels of required consumer cost-sharing (i.e., achievable potential is only assumed to be constrained by non-financial market barriers (e.g., product availability, delivery infrastructure limits, split-incentives for renters versus owners).
  - Data is available to represent the quantity of EE or DR that can be reliably obtained at a range of costs, in the form of measures or groups of measures with similar characteristics (e.g., load shapes, levelized cost, and deployment constraints).

What is an efficiency supply curve?

- Each supply curve represents the aggregate savings of a bundle of individual energy efficiency measures with unique characteristics.
- Multiple supply curves are necessary to account for end-use load shape, development limits, and cost of resource acquisition.
- Efficiency supply curves quantify the levels of efficiency that can be obtained at various ranges of costs.

- These curves enable the direct competition of energy efficiency and generation investments. This approach treats energy efficiency as a selectable resource that can be acquired to meet future demand for both energy and capacity for bulk power systems.

Energy efficiency potential studies: Examples

Energy efficiency potential studies were used by three of the utilities to identify the amount of future efficiency that is available for the optimization model to select as part of the IRP.

Criteria	I&M 2018/2019 IRP	Xcel Energy (MN) 2019 IRP	Tennessee Valley Authority (TVA) 2019 IRP	PacifiCorp 2019 IRP
Potential identified	Technical, economic, maximum achievable and realistic achievable potential	Technical, economic, max achievable, and program	Potential study is a near term action outcome of the IRP	Technical and achievable technical potential
Potential used in IRP	Maximum achievable and realistic achievable potentials are used to create efficiency bundles.	Efficiency was modeled as bundles. Bundles were created from max achievable and program potential and Xcel created “optimal” potential.	Non-public analysis based on historical programs and potential impacts of new programs used to create efficiency bundles.	Technical achievable potential used to create efficiency bundles.

I&M 2018-2019 IRP efficiency bundles

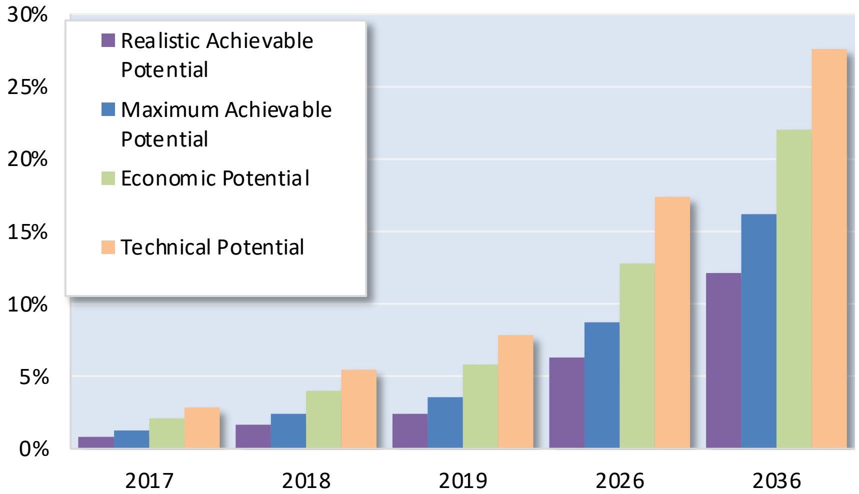


Table 6. Residential Top Measures from Market Potential Study

Rank	Residential Measure	2019 Cumulative Energy Savings (MWh)	% of Total
1	Interior Lighting - LED Screw-In Lamps	71,419	42.5%
2	Exterior Lighting - LED Screw-in Lamps	29,857	17.8%
3	Thermostat - WIFI	17,324	10.3%
4	Interior Lighting - Exempted LED Screw-In Lamp[11]	17,242	10.3%
5	Refrigerator - Decommissioning and Recycling	6,201	3.7%
6	Water Heating - Water Heater - ES 2.0 Heat Pump	4,595	2.7%
7	Freezer - Decommisioning and Recycling	3,851	2.3%
8	Windows - High Efficiency	2,065	1.2%
9	Windows - Install Reflective Film	1,509	0.9%
10	Appliances - Air Purifier – ENERGY STAR	1,462	0.9%
11	Water Heater - Temperature Setback	1,061	0.6%
12	Cooling - Central AC – SEER 14	995	0.6%
13	Central AC - Maintenance	988	0.6%
14	Whole-House Fan - Installation	887	0.5%
15	Water Heater - Low-Flow Showerheads	815	0.5%
16	Water Heater - Pipe Insulation	775	0.5%
17	Appliances – Refrigerator – CEE TIER 1	696	0.4%
18	Insulation - Ceiling	693	0.4%
19	Appliances – Dehumidifier – ENERGY STAR	611	0.4%
20	Electronics - Personal Computers	553	0.3%
	Total Top Measures	**163,598**	**97.4%**
	Total Cumulative savings in 2019	**168,038**	**100%**

Table 7. Commercial Top Measures from Market Potential Study[12]

Rank	Commercial Measure	2019 Realistic Achievable Cumulative Savings (MWh)	% of Total
1	Interior Lighting – LED Screw-in Lamps	38,341	21.7%
2	Interior Lighting - LED High-Bay Fixtures	17,291	9.8%
3	Interior Lighting - Occupancy Sensors	14,131	8.0%
4	Interior Lighting - Linear Lighting	10,192	5.8%
5	Retrocommissioning	9,326	5.3%
6	Exterior Lighting - LED Area Lighting	7,938	4.5%
7	Water Heating - Water Heater EF 2.0 - Heat Pump	6,247	3.5%
8	Cooling - Water-Cooled Chiller - COP 9.77 (0.36 kW/TR)	6,113	3.5%
9	Interior Fluorescent - Delamp and Install Reflectors	4,731	2.7%
10	Exterior Lighting - LED Screw-in Lamps	4,704	2.7%
11	Ventilation - Ventilation	4,586	2.6%
12	Office Equipment - Desktop Computer	4,568	2.6%
13	Chiller - Chilled Water Reset	4,340	2.5%
14	HVAC - Economizer	4,334	2.4%
15	Office Equipment - Server	4,019	2.3%
16	Cooling - Air-Cooled Chiller - COP 4.40 (EER 15.0)	3,907	2.2%
17	Ventilation - Demand Controlled	2,861	1.6%
18	Ventilation - Variable Speed Control	2,330	1.3%
19	RTU - Advanced Controls	2,111	1.2%
20	Refrigeration - High Efficiency Compressor	1,849	1.0%
	Total Top Measures	**153,922**	**87.0%**
	Total Cumulative savings in 2019	**176,999**	**100%**

Source: I&M

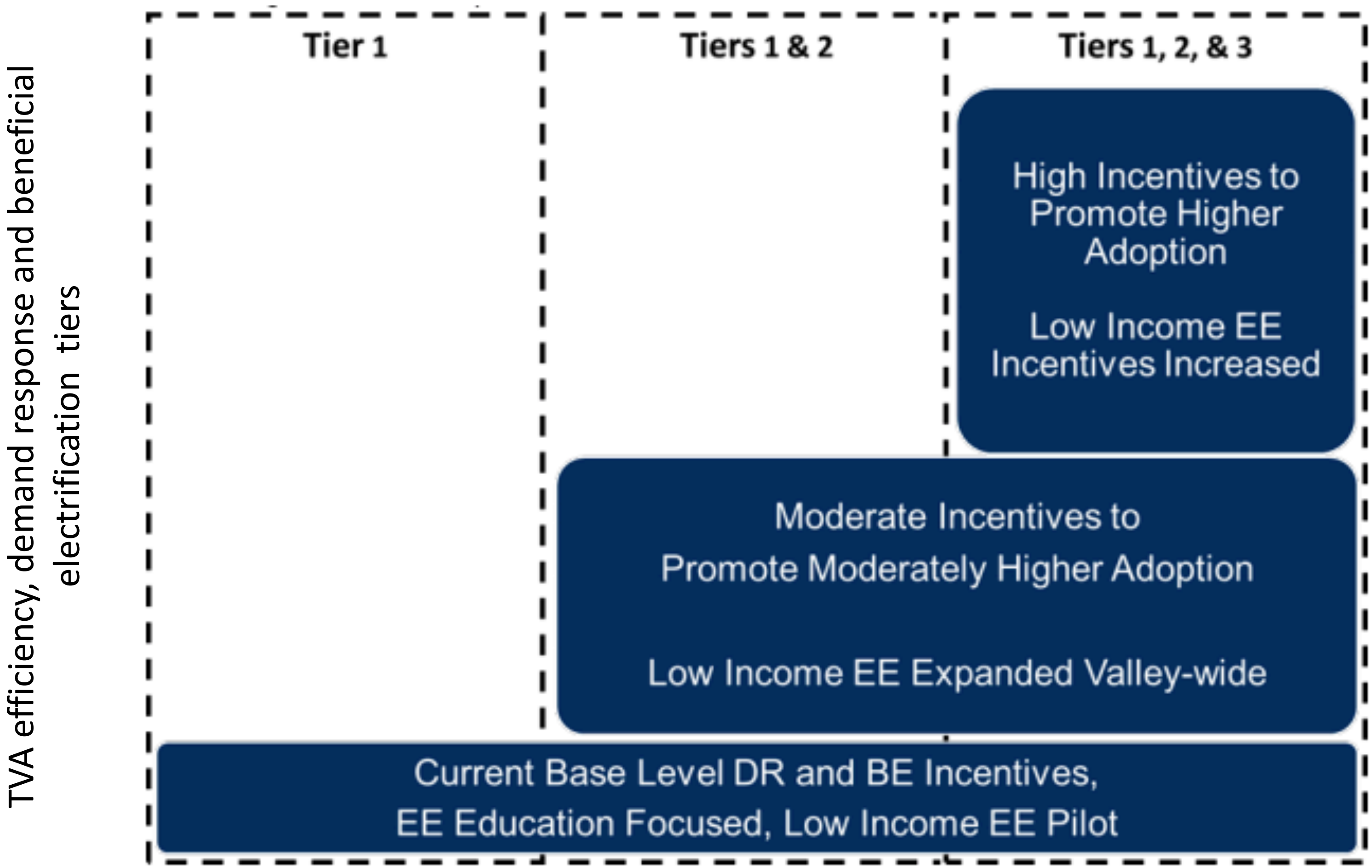
Xcel 2019-2020 IRP EE and DR bundles

- Xcel created three EE and DR bundles
- Efficiency
  - Optimal: developed by Xcel based on optimal demand reduction
  - Program and Maximum are based on the EE potential study
- Demand response
  - Existing demand response was included in the load forecast
  - DR bundles were sized based on “supply curve thresholds”
  - First bundle was forced into model because of Commission requirements to procure 400 MW of DR

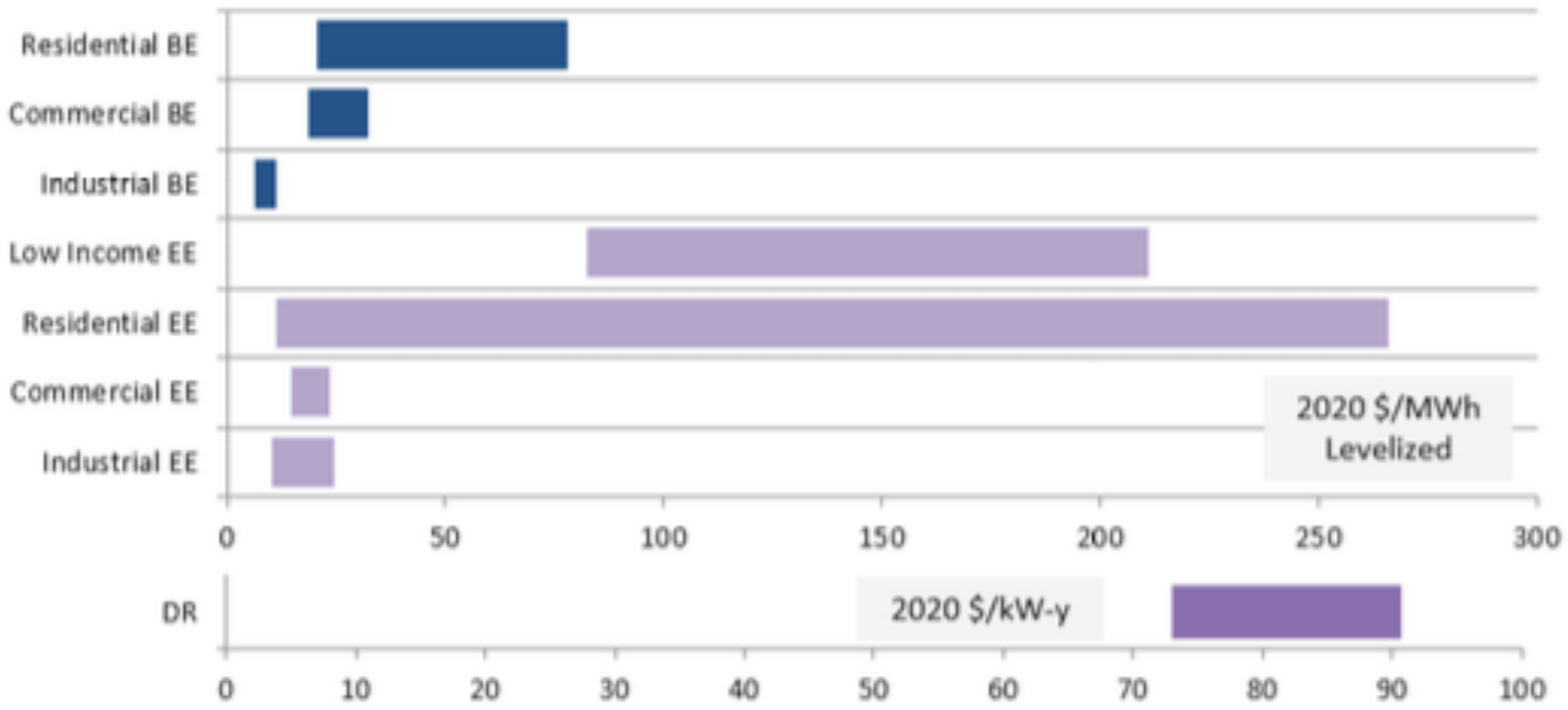
EE Bundle Name	2020 MWh	Price ($000)
Program	621	100,989
Optimal	43	12,598
Maximum	231	148,331

DR Bundle #	2020 – 2034 MW	Price ($000)
1	270-542	14,380 – 38,224
2	107-242	7,659 – 22,911
3	89 – 112	11,311 – 18,984

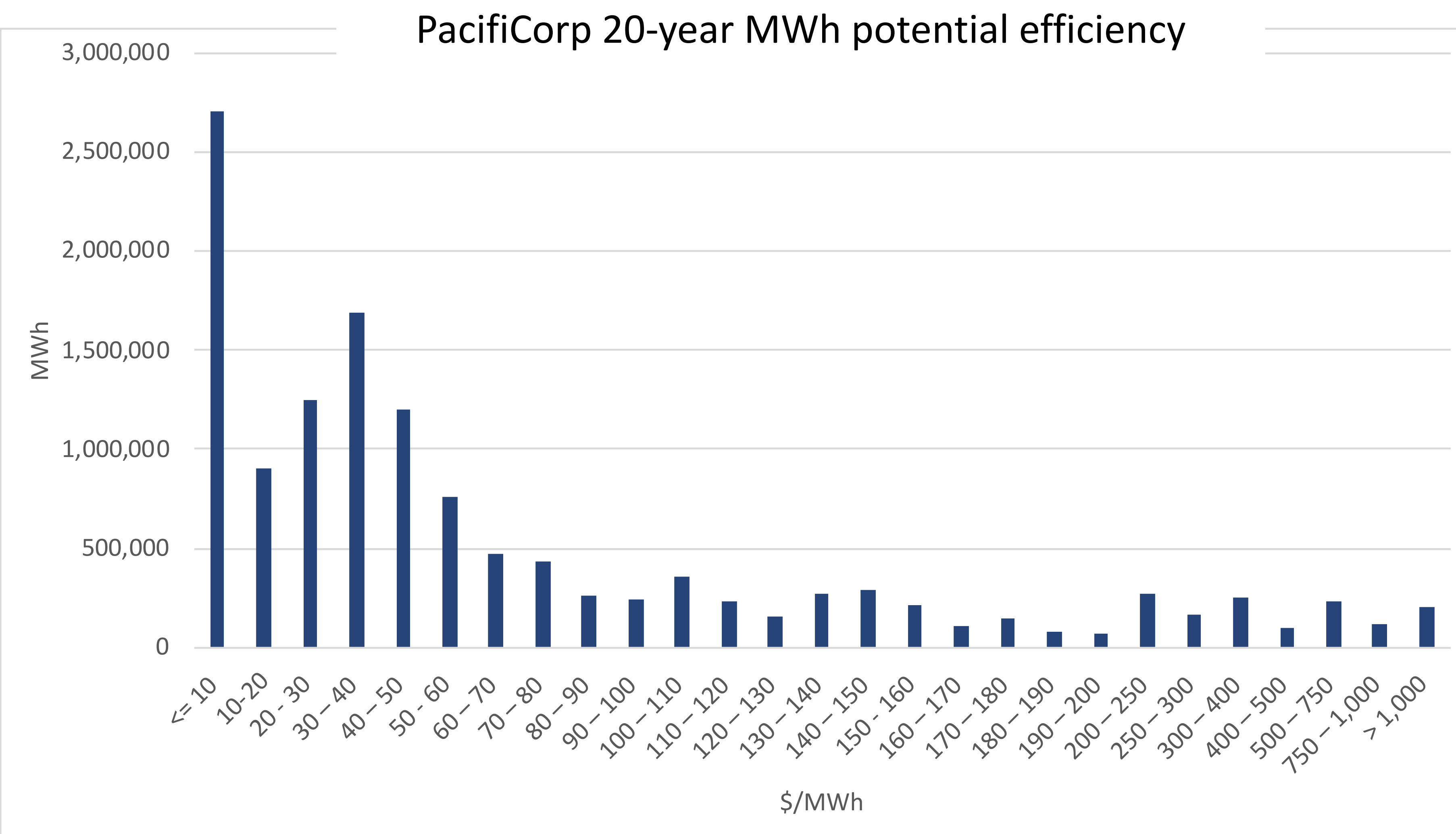
TVA EE, DR and beneficial electrification (BE) tiers



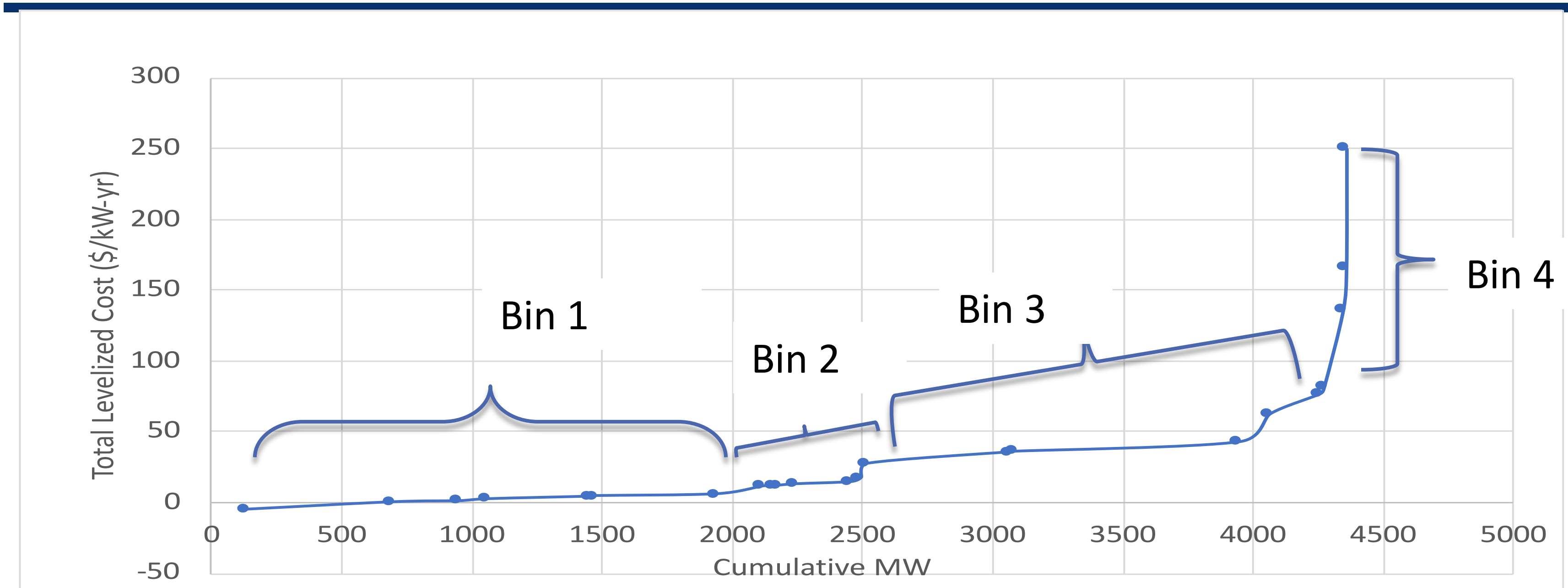
TVA EE, DR, and BE options and costs



PacifiCorp EE bundles



Northwest Power and Conservation Council DR supply curve (2021)



Bin	Construction Costs ($/kW-yr)	Fixed O&M Costs ($/kW-yr)	Variable O&M ($/kW-yr)	Total Levelized Cost ($/kW-yr)	Total Potential (MW)
Bin 1	4.08	(1.98)	150.00	2.13	1937
Bin 2	12.32	0.69	150.00	13.09	554
Bin 3	22.59	18.69	150.00	41.30	1571
Bin 4	66.80	28.90	150.00	95.87	295

Source: NWPCC

Capacity expansion models

- Capacity expansion models test alternative resource mixes and development timing (e.g., resource strategies) against a range of future conditions (e.g., load growth, natural gas prices, emissions costs or limits, or both).
- They identify the "least cost" resource strategy <u>and may or may not</u> account for "risk."
- Capacity expansion models do NOT determine:
  - Acceptable level of "cost"
  - Acceptable level of "risk"
  - Which resource strategy is "preferred"

Considerations for using direct competition of efficiency and demand response

- Capacity expansion models require decision rules that determine when a resource is acquired
  - Resources are always developed to meet reliability standards
  - Resources are considered for development if they meet specified economic conditions
  - The conditions that determine if for EE or DR are selected should be comparable to generating resources

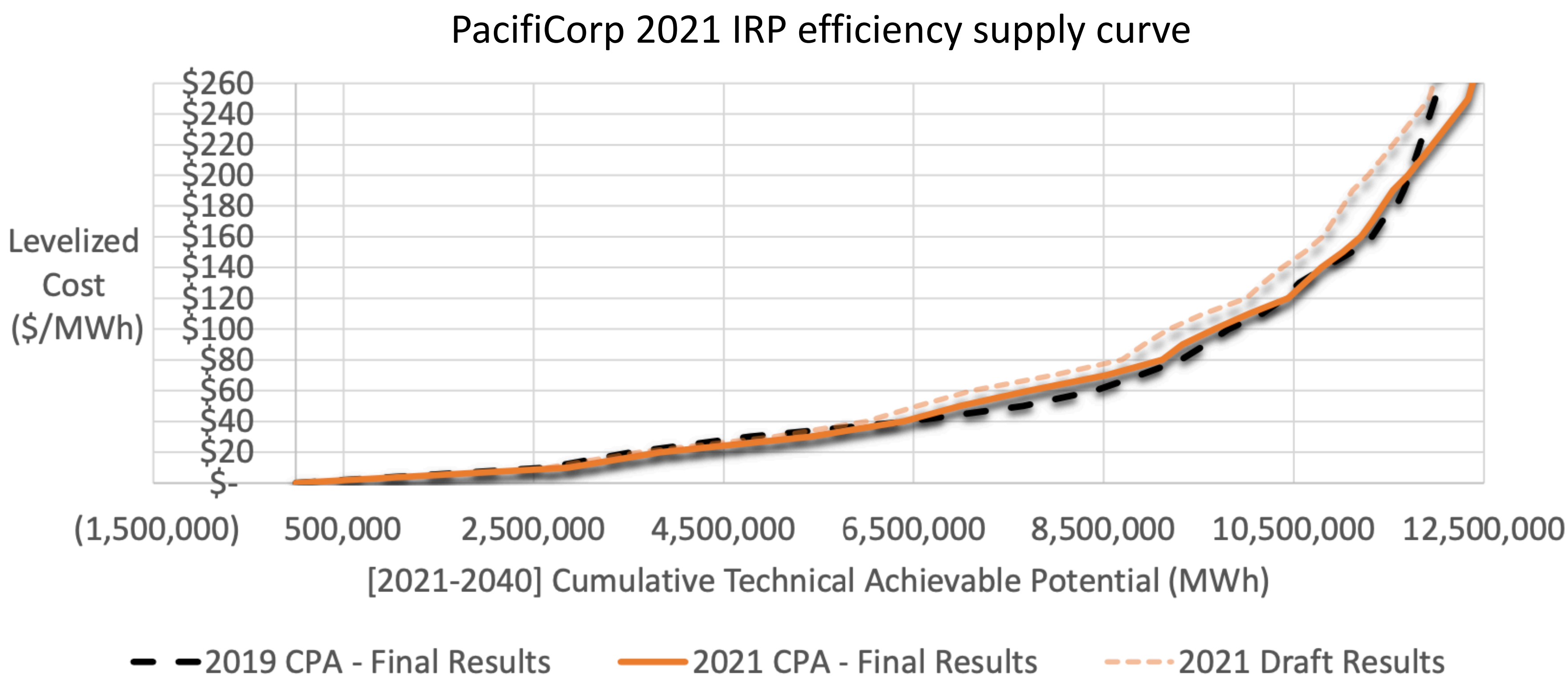
	SUPPLY SIDE COMPARISON			
	DR	EE	BE	Conventional Resource*
Year Available	2020	2020	2020	2023+
Outage Rate				✓
Heat Rate				✓
CO2 Emissions				✓
Fuel Costs				✓
Fuel Escalation				✓
O&M Costs	✓	✓	✓	✓
O&M Escalation	✓	✓	✓	✓
Capital Costs				✓
Capital Escalation				✓
Transmission Contingency Cost				✓
Project Contingency Cost				✓
Capacity Factor	✓	✓	✓	✓
Technology Shifts	✓	✓	✓	

*Conventional Resources could include nuclear, coal, gas, hydro, etc.

Source: TVA

Potential modifications to capacity expansion planning acquisition logic (1)

- Unlike supply side resources EE and DR can be acquired across a wide range of costs (i.e., EE has a nearly continuous supply curve)



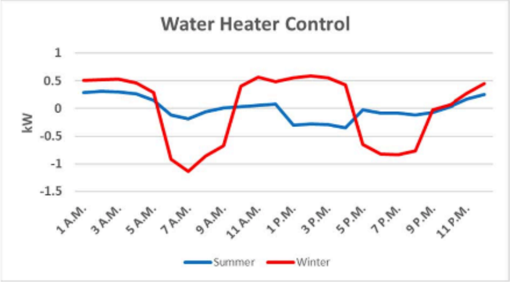
Source: PacifiCorp Conservation Potential Assessment

Potential modifications to capacity expansion planning acquisition logic (2)

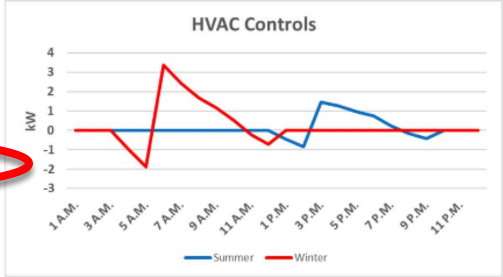
- Maximum Retrofit Pace Constraint:
  - Resource optimization models will "build") all retrofit EE and other DERs with cost below the marginal dispatch of existing generating resources at first opportunity – unless constrained
  - Real-world infrastructure limits maximum annual retrofit development constraints on the annual acquisition of retrofit EE and DERs must be set in the model. Limits may be grow through time or fixed for 20-yrs (i.e., assumes delivery infrastructure never expands)

2019 IRP Programs – Residential DR

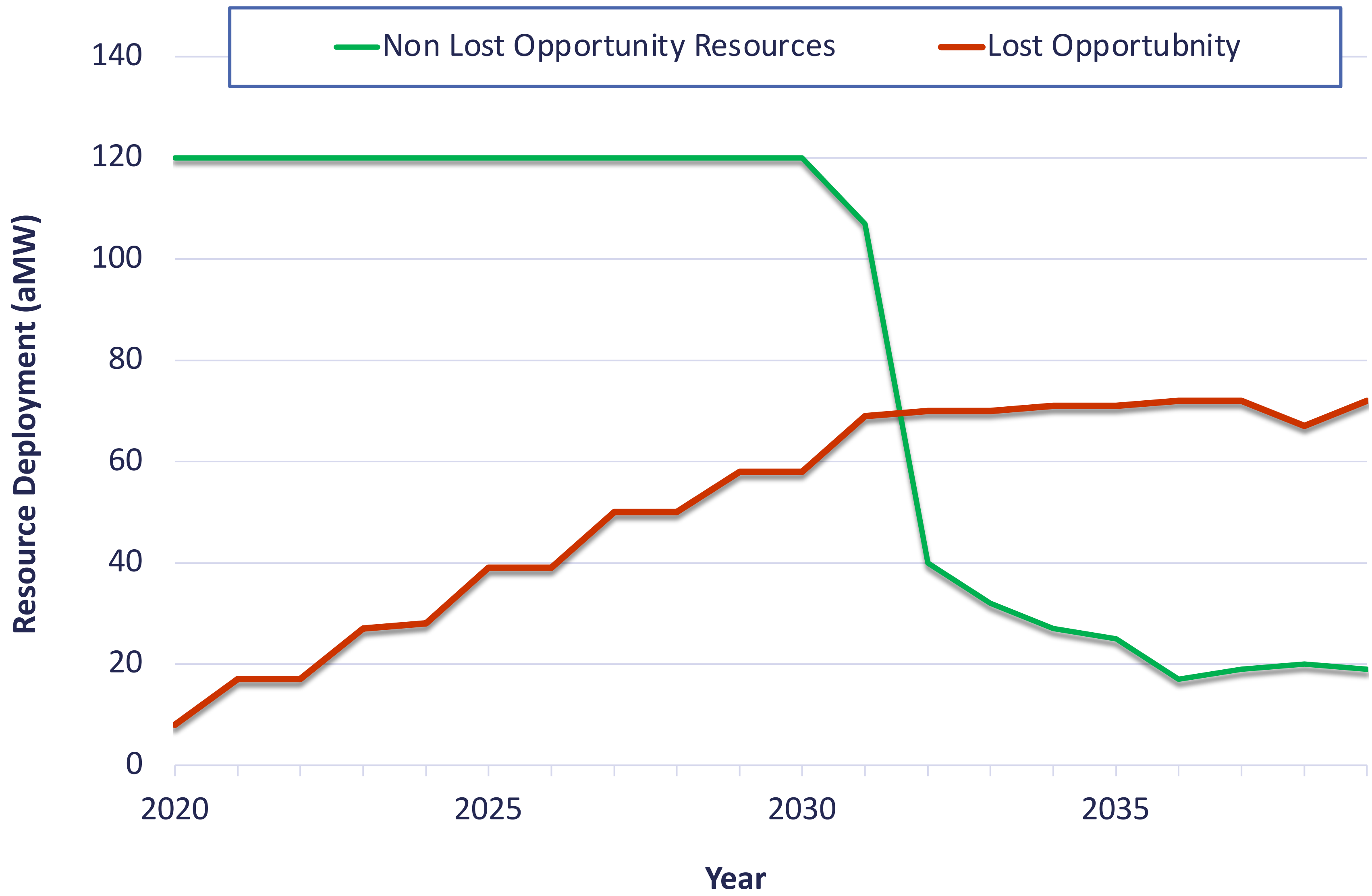
- Hypothetical water heater control program modeled (top graph)
- Hypothetical HVAC control program included as a selectable option (lower graph)



Residential DR		
	Water Heater	HVAC Controls
Max Cumulative Installations	100,000	400,000
Annual Incentive Cost/Unit	$50	$60
Upfront Equipment Cost/Unit	$120	$45
Annual Incentive Cost	$5,000,000	$24,000,000



Northwest Power and Conservation Council deployment rates



Potential modifications to capacity expansion planning acquisition logic (3)

- Lost Opportunity "Found Again" Acquisition Logic
  - Some lost-opportunity resources present more than one acquisition "opportunity" (e.g. water heaters are replaced on average every 12 years)
  - Due either to their high cost or, more likely constraints on their maximum achievable ramp rate these resource might not be selected when they first occur
  - Acquisition logic should permit savings that is not "acquired" at the first opportunity, be considered for acquisition at next opportunity, if it occurs within planning period.