Integrated Resource Planning

Roundtable 18-4

September 26, 2018

Meeting Logistics

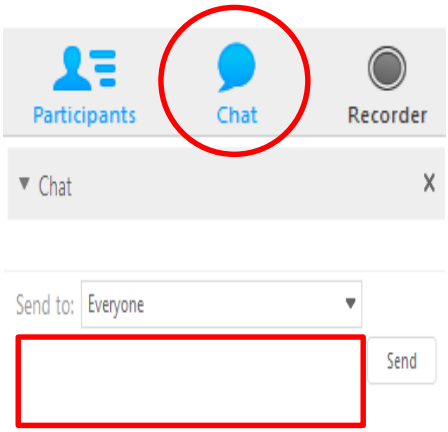
Local Participants:

- World Trade Center facility
- Wireless internet access
  - Network: 2WTC_Event
  - Password: 2WTC_Event$
- Sign-in sheets

Virtual Participants:

- Ask questions via ‘chat’ feature
- Meeting will stay open during breaks, but will be muted
- Electronic version of presentation: *portlandgeneral.com/irp*

>> Integrated Resource Planning



AGENDA

- ❑ Final Navigant Results
- ❑ Draft Portfolios
- ❑ Draft Scoring Metrics
- ❑ Draft Renewable Supply Side Study

Safety Moment

Distributed Resource and Flexible Load Study: Updated Results

Navigant

DISTRIBUTED RESOURCE AND FLEXIBLE LOAD STUDY

ROUNDTABLE

SEPTEMBER 26, 2018

Portland General Electric

TROVE PREDICTIVE DATA SCIENCE

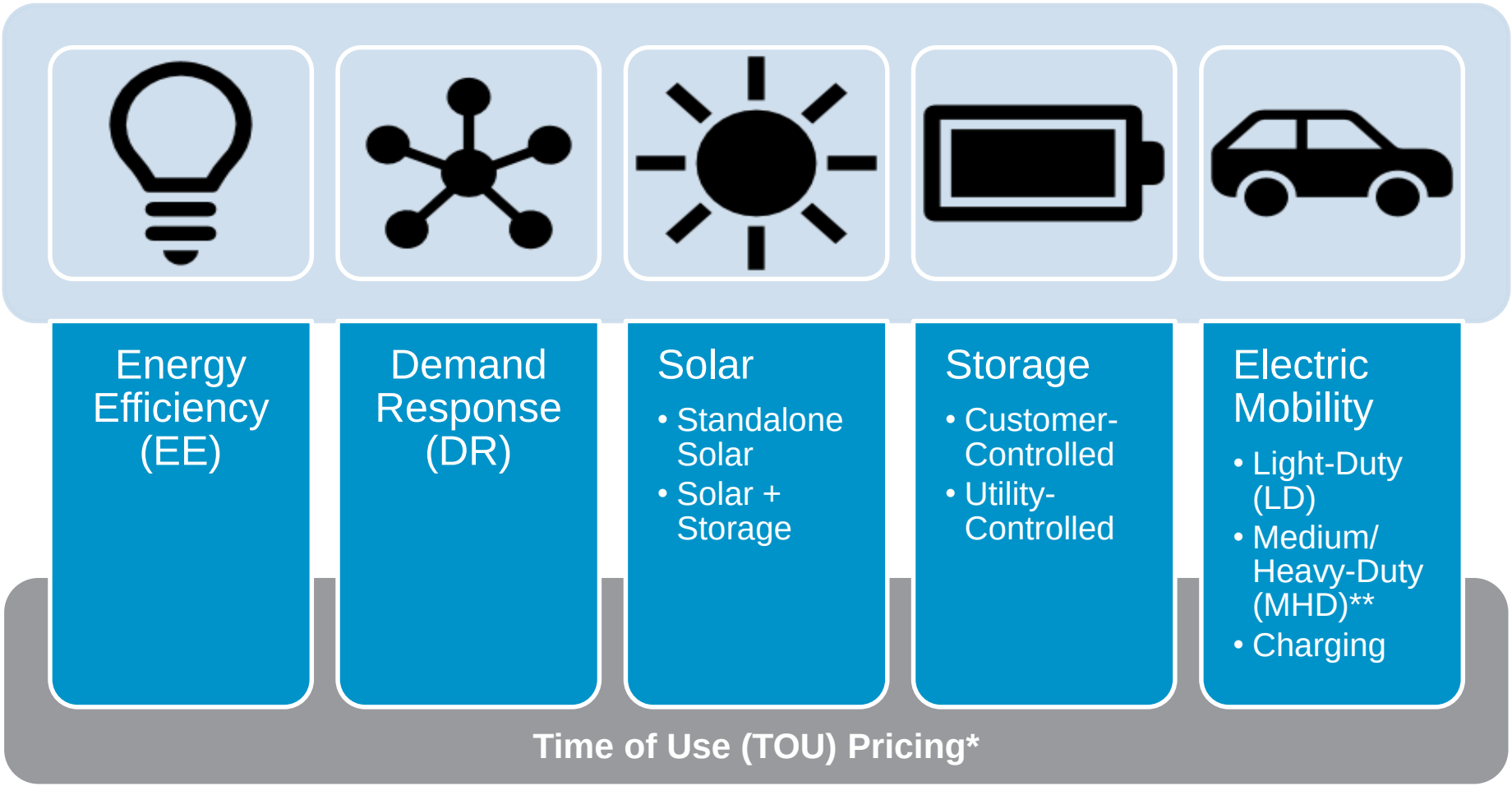
NAVIGANT

AGENDA

1. Study Overview
2. Base Case Final Results
3. Interactive Effects Approach
4. Load Profiles Approach
5. Scenario Drivers
6. Next Steps

DISTRIBUTED RESOURCES ADDRESSED

STUDY OVERVIEW



** TOU for residential customers; not applied to EE or medium/heavy-duty. ** MHD assessed separately from results presented today.*

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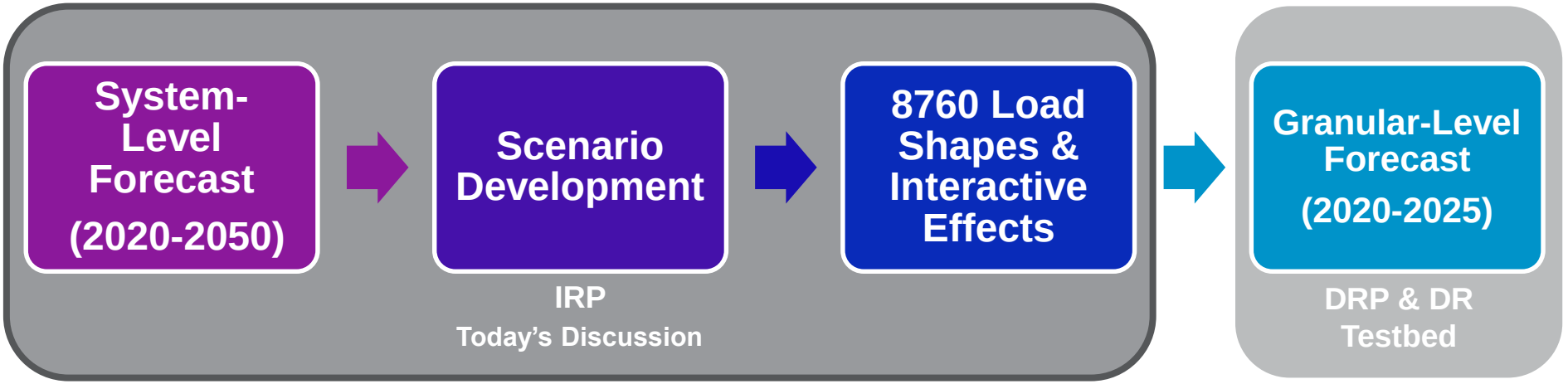
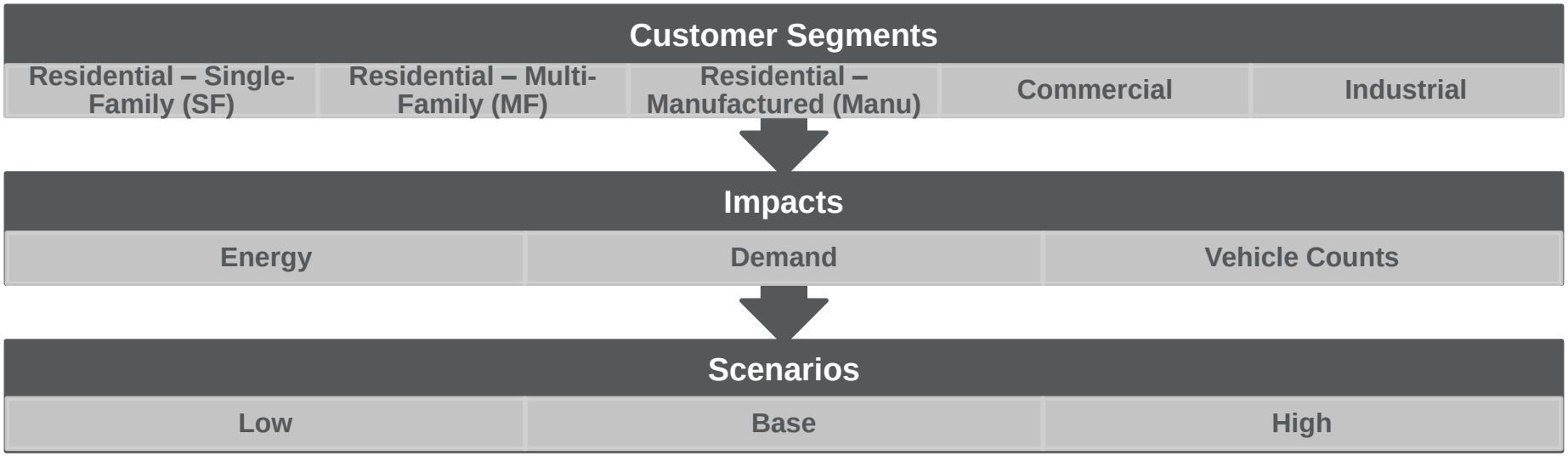
DISTRIBUTED RESOURCES SCOPE AND APPROACH

STUDY OVERVIEW





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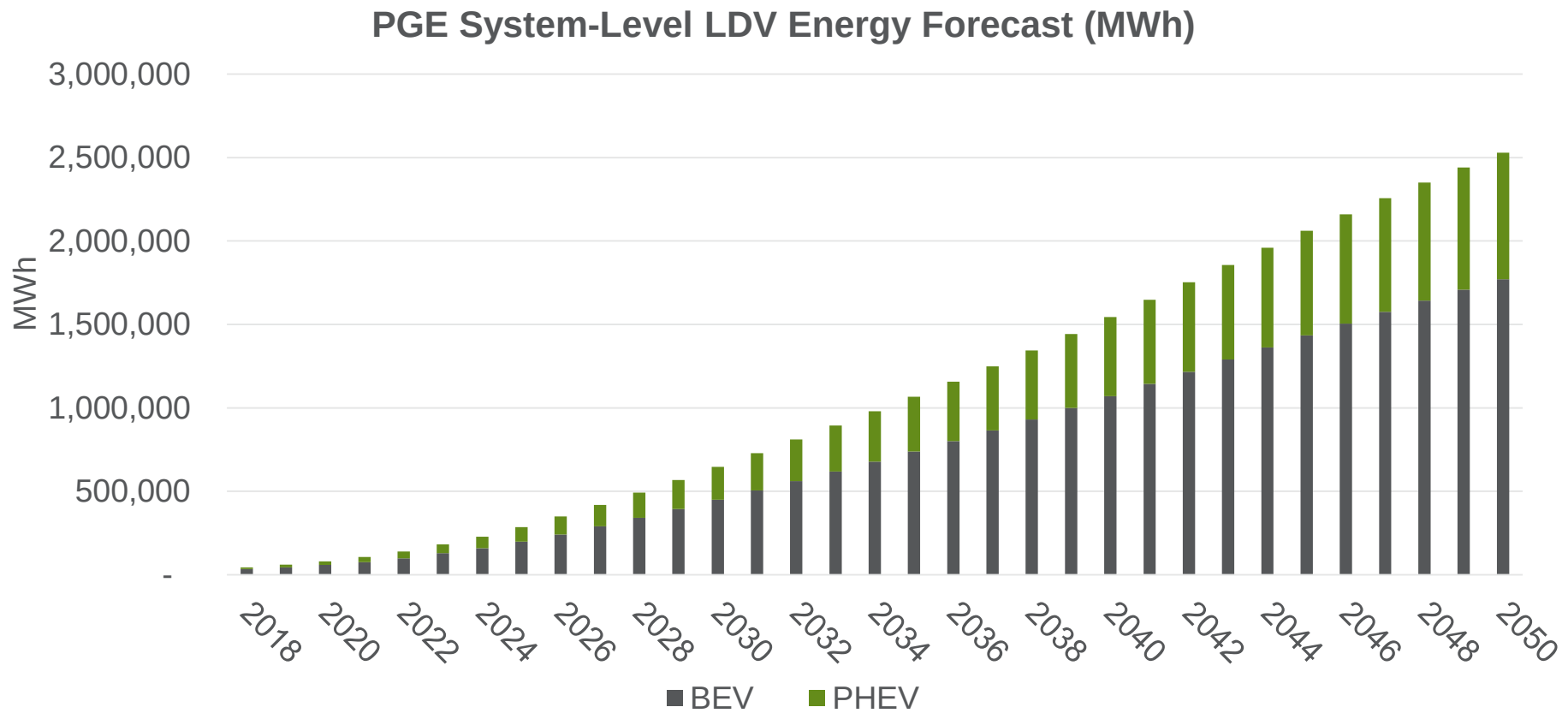
LD VEHICLES

BASE CASE FINAL RESULTS

Light-duty vehicle adoption in PGE's system is forecast to grow by about 60x between 2018 and 2050, with BEV adoption expected to be slightly ahead of PHEV adoption.



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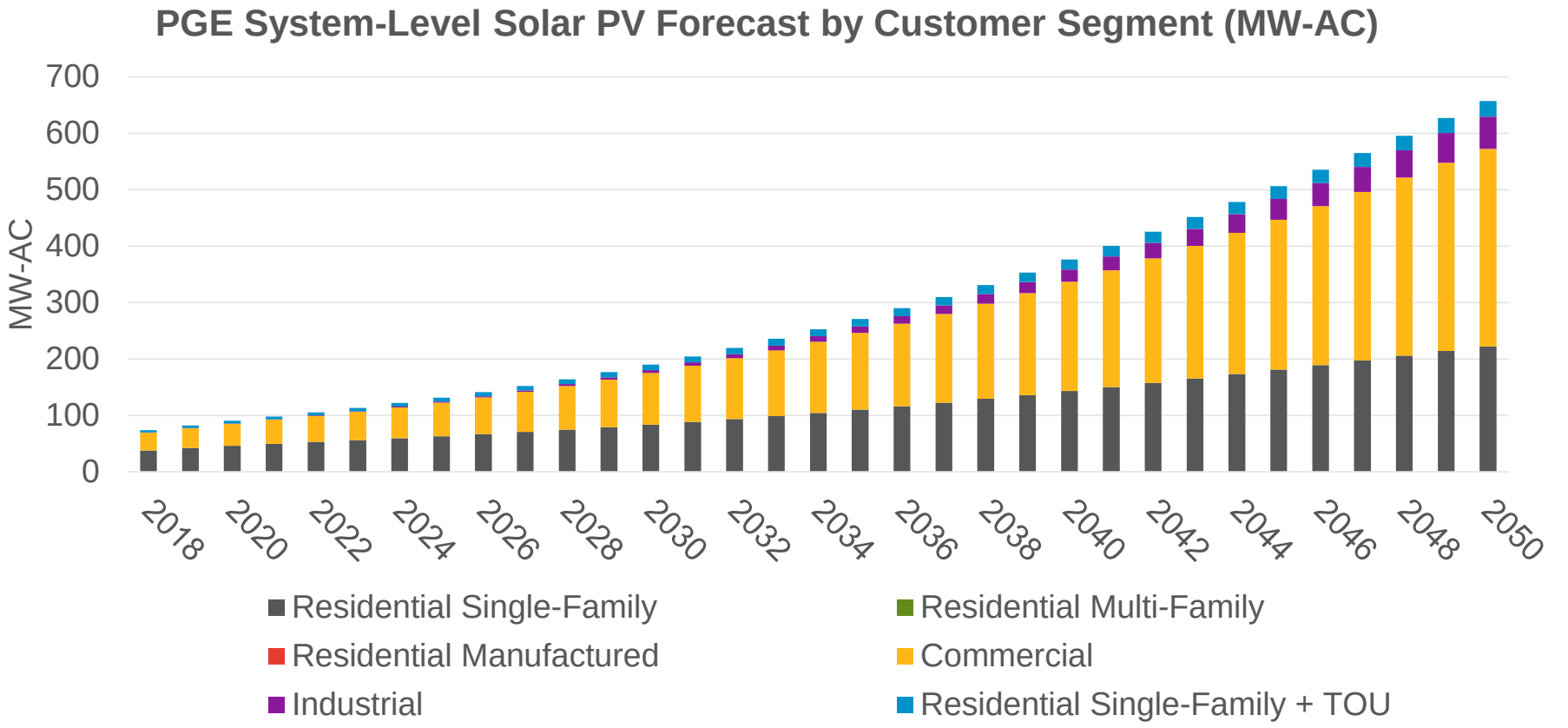
SOLAR BY CUSTOMER SEGMENT

BASE CASE FINAL RESULTS

Solar PV growth is forecast to be driven primarily by Residential Single-Family and Commercial customers, given logistical limitations for other customer segments, with about 2.5x growth forecast before 2030.



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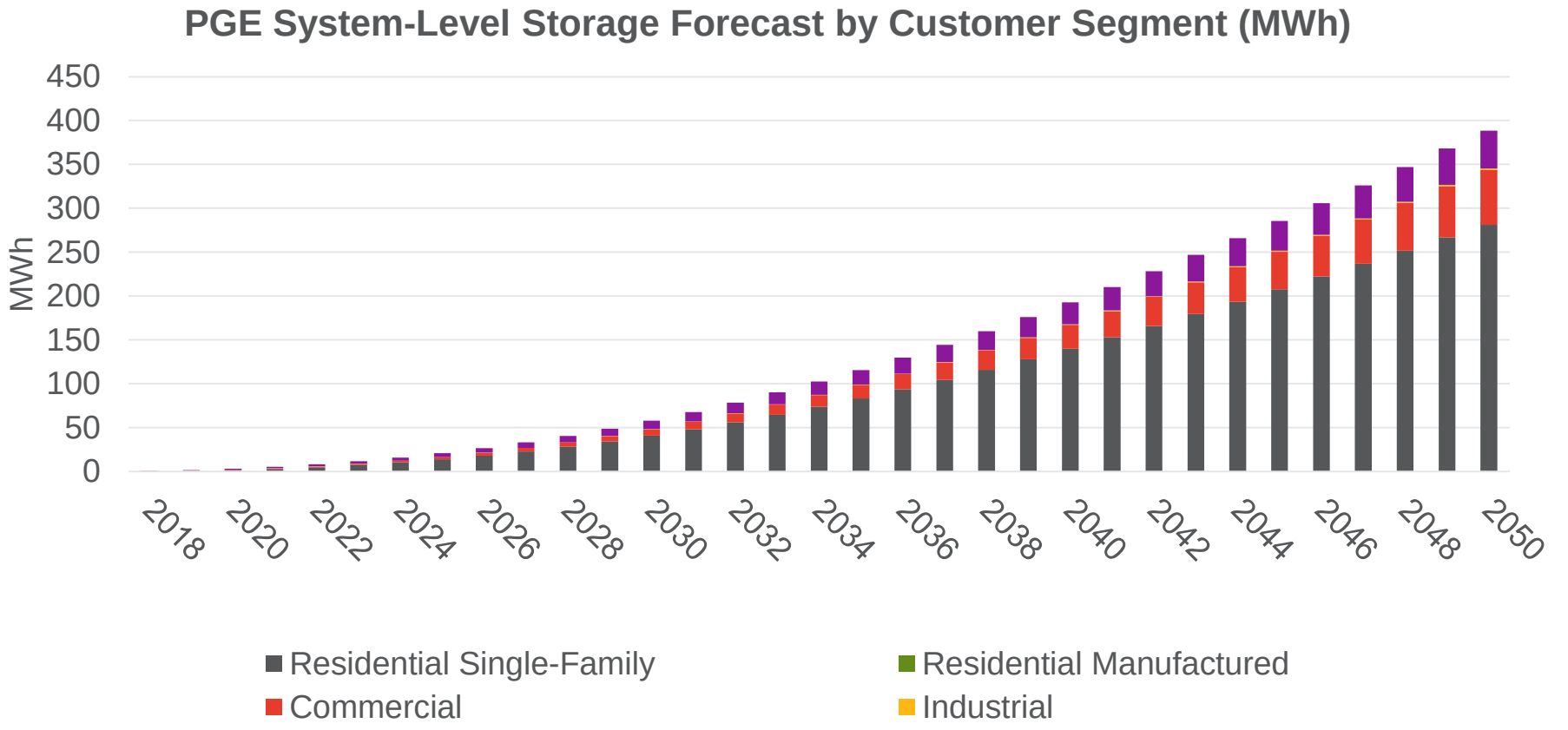
STORAGE BY CUSTOMER SEGMENT

BASE CASE FINAL RESULTS

Storage growth is forecast to be driven primarily by Residential Single-Family customers with TOU and Commercial customers, with significant growth forecast before 2030.



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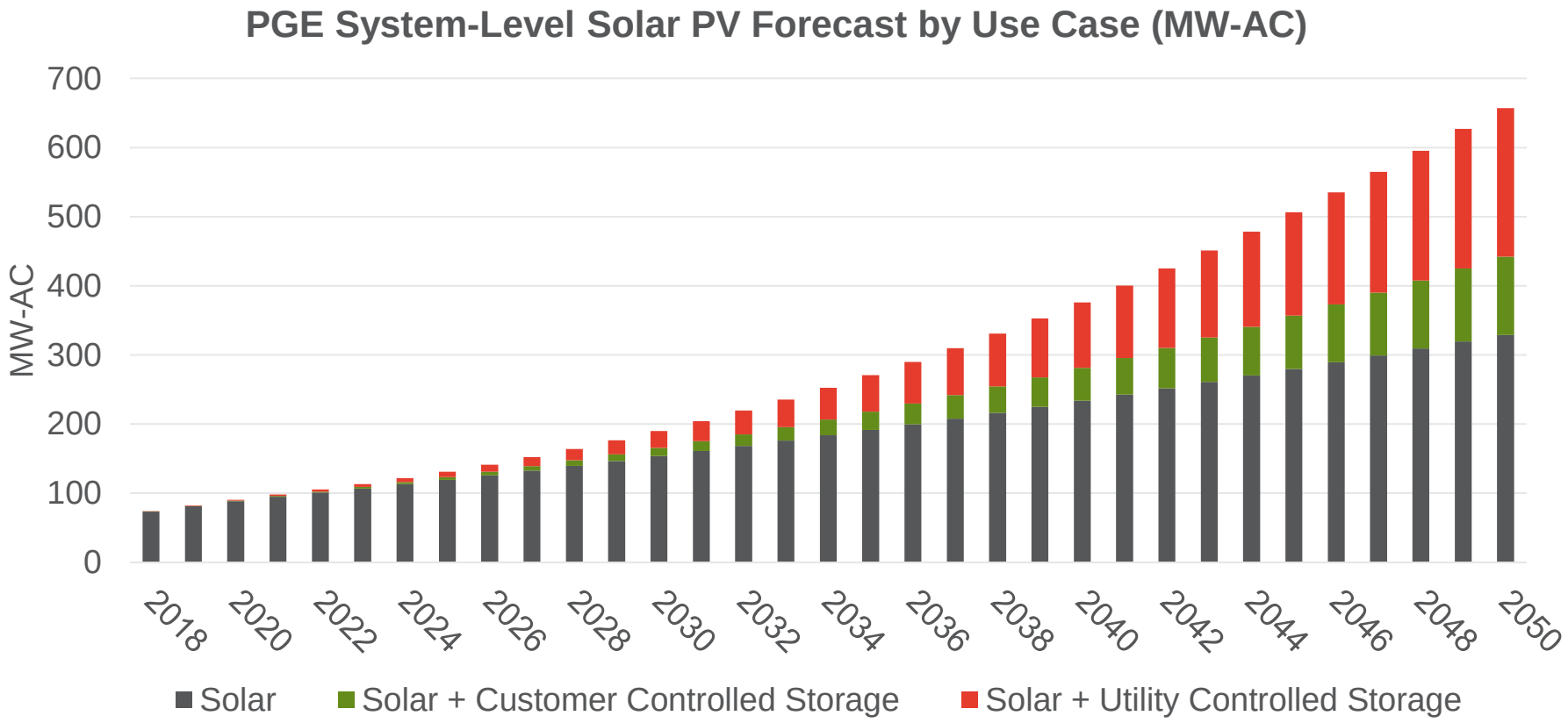
SOLAR BY USE CASE

BASE CASE FINAL RESULTS

Solar PV growth is expected to continue around historical levels into the future. Solar + Storage comprises a much smaller market share, relative to standalone Solar PV alone. Customer operated Solar + Storage is expected to split the market, though this varies by sector.



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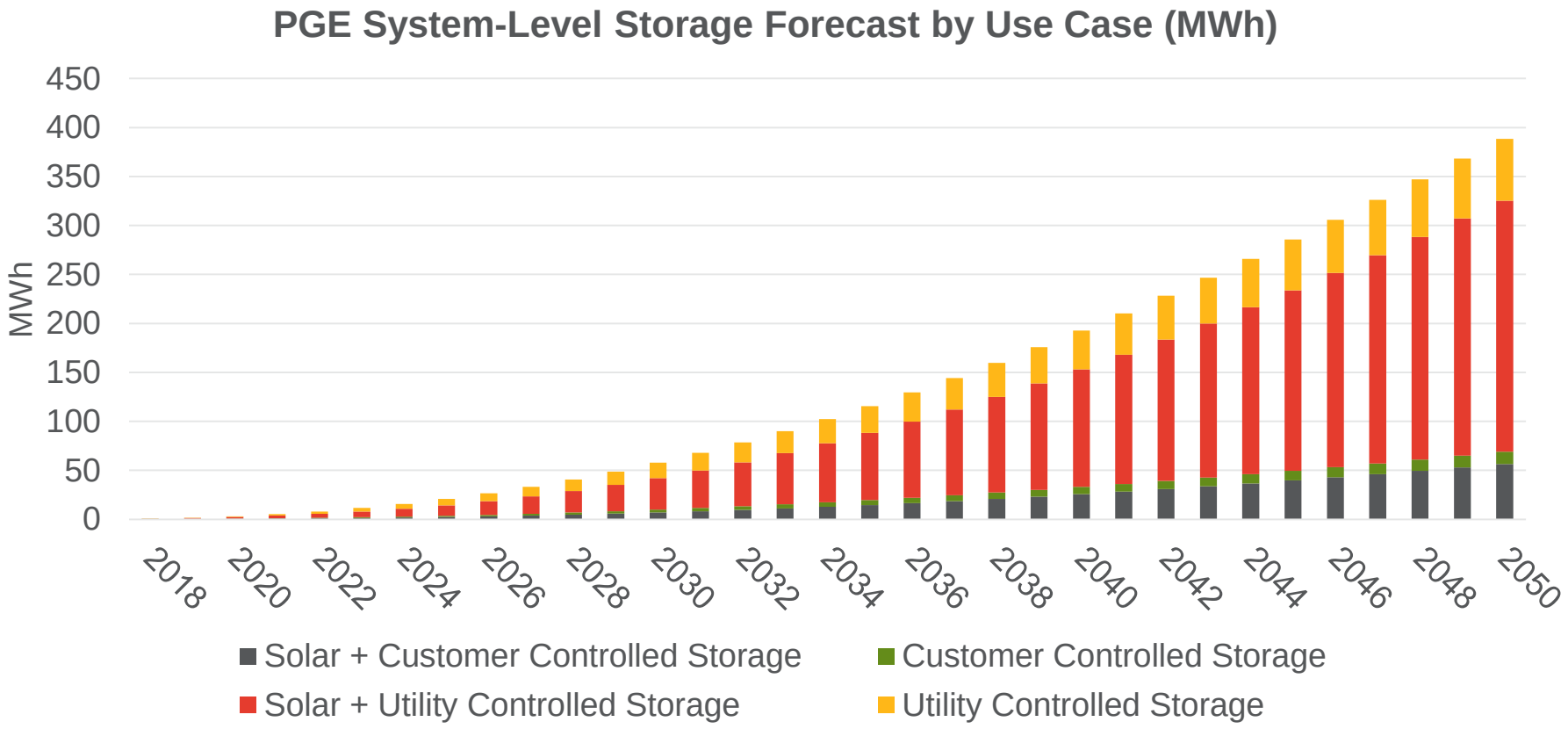
STORAGE BY USE CASE

BASE CASE FINAL RESULTS

Customer-sited storage is expected to grow rapidly, but total installed capacity is limited by customer familiarity, economics, and competition with solar PV. Overall, utility controlled storage is expected to gain more market share than customer operated storage due to assumed incentive levels, though this varies by sector.



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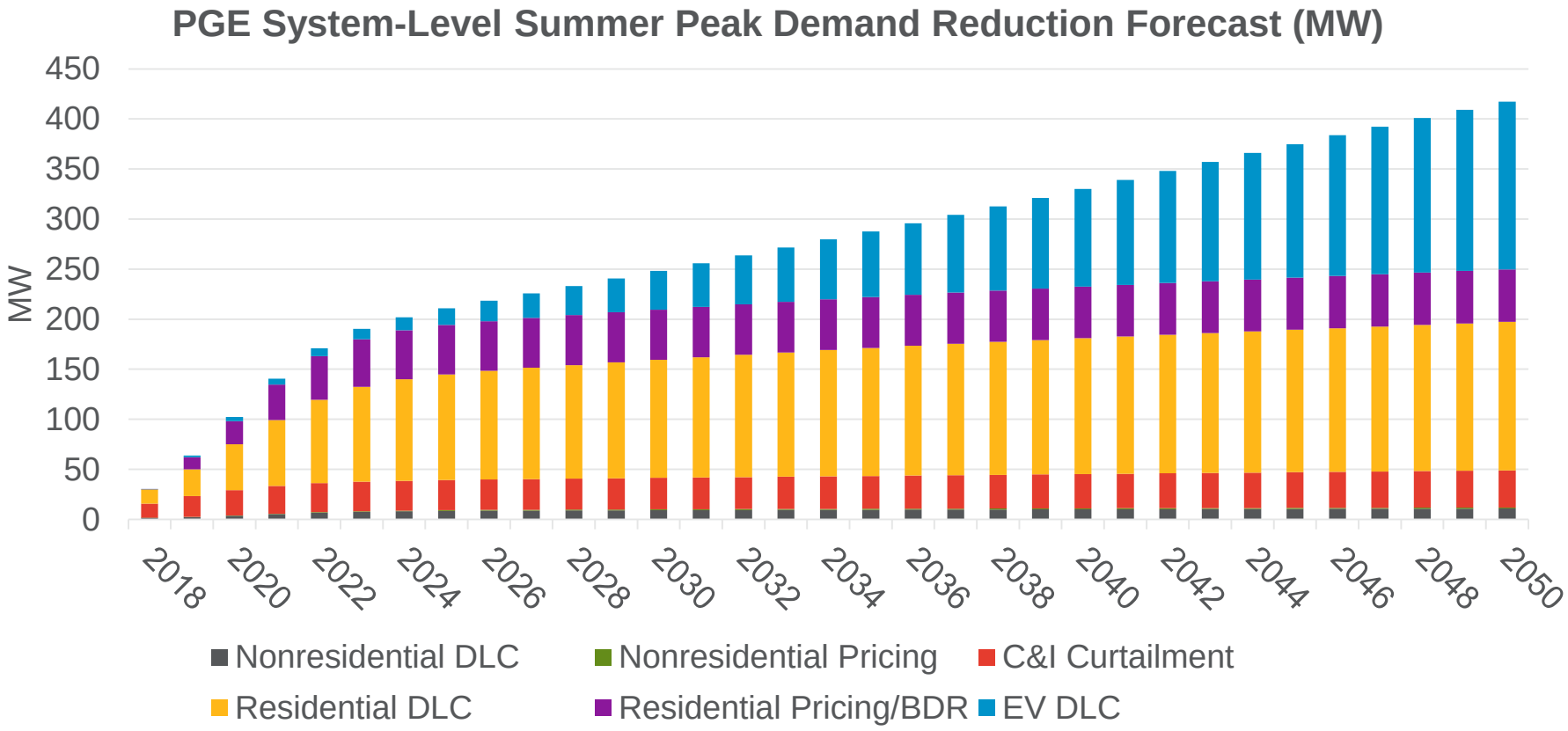
DR BY PROGRAM TYPE – SUMMER

BASE CASE FINAL RESULTS

Summer DR is forecast to be largely from Residential DLC initially, with LDV DLC growing to be almost equal to Residential DLC by 2050.



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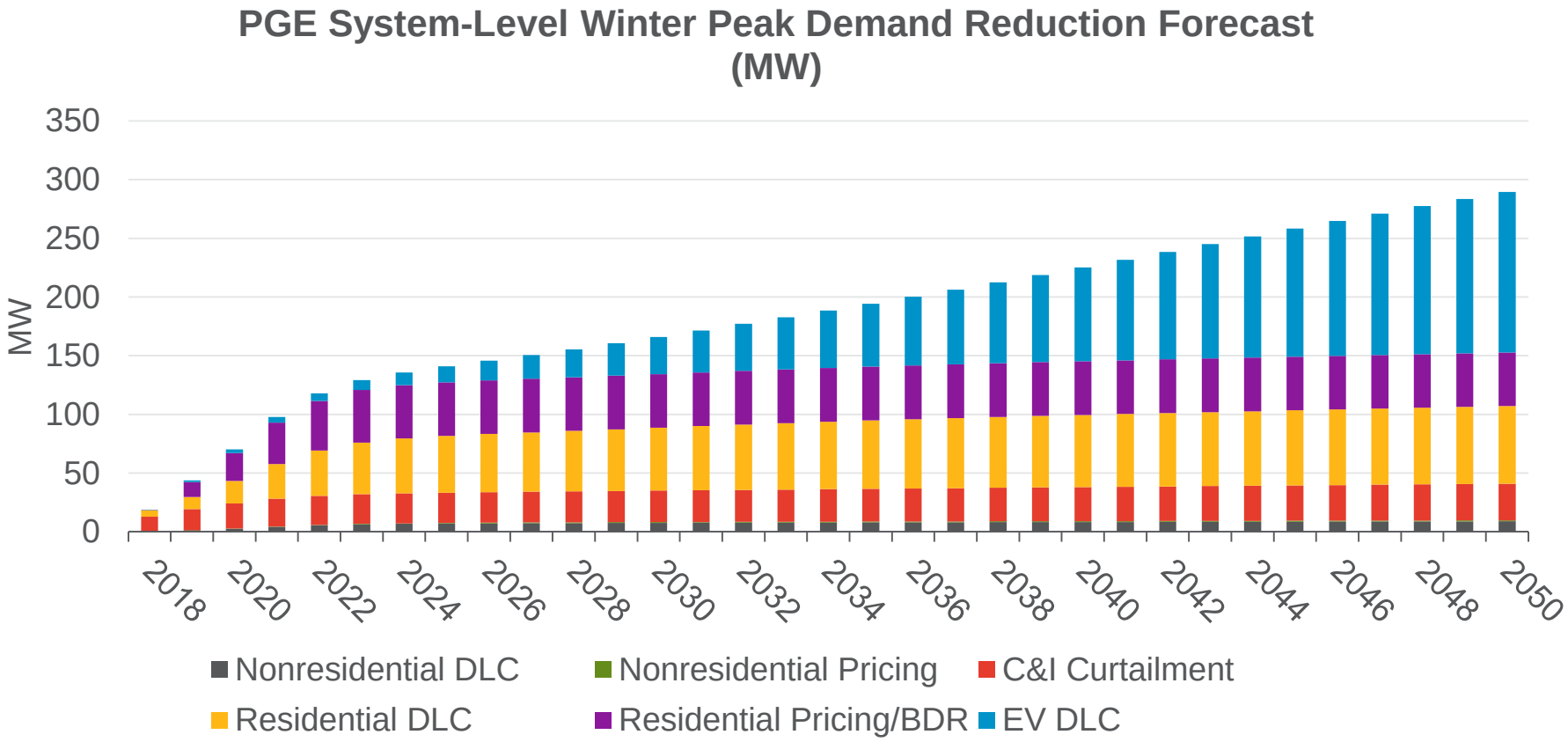
DR BY PROGRAM TYPE – WINTER

BASE CASE FINAL RESULTS

Winter DR is forecast to be lower than Summer DR, given less potential from Residential DLC. However, LDV DLC is not expected to vary as significantly between seasons and is forecast to be greater than Residential DLC by 2050.



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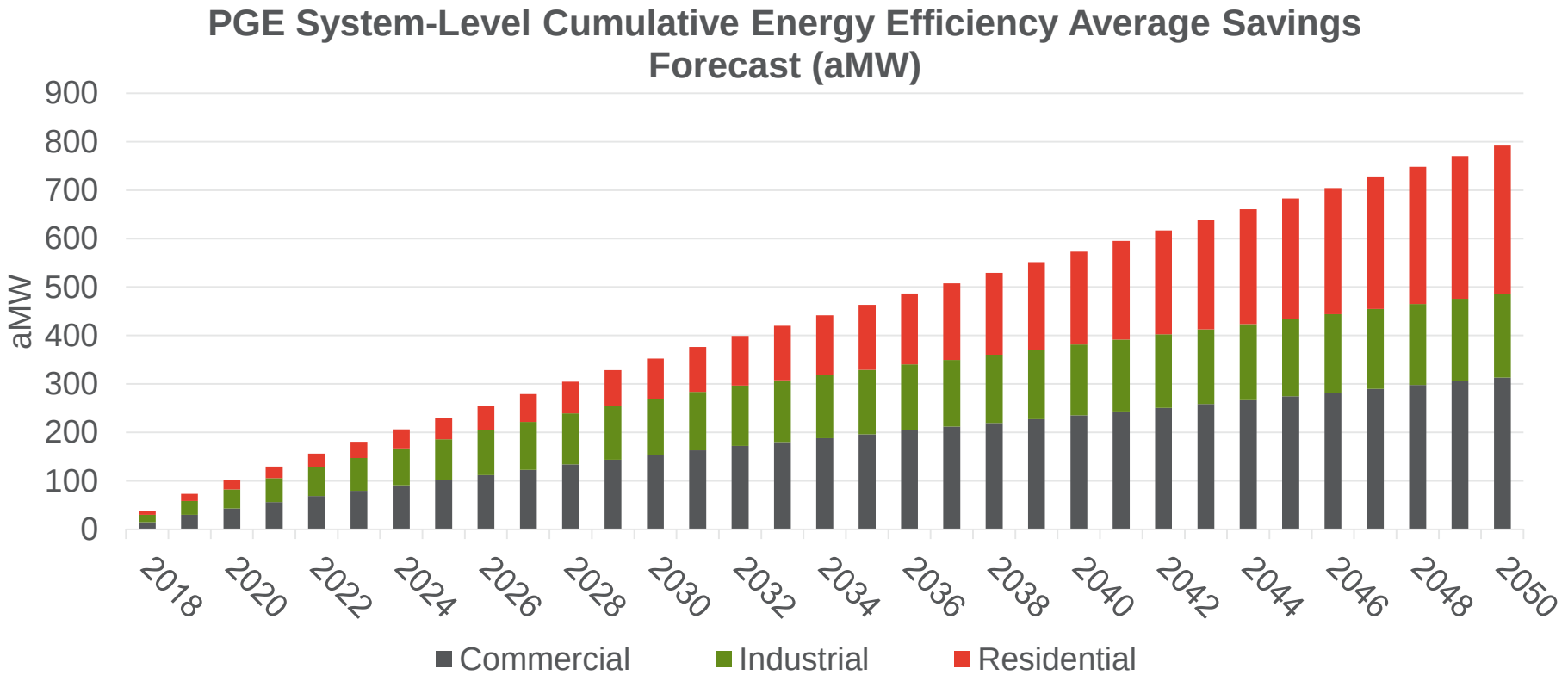
EE BY CUSTOMER SECTOR

BASE CASE FINAL RESULTS

The contribution from Residential EE grows relative to C&I EE, as C&I potential slows over time. The total cumulative EE is forecast to be nearly 800 aMW by 2050.



Source: Energy Trust of Oregon

** Residential MF new construction included as Commercial in Energy Trust forecast*

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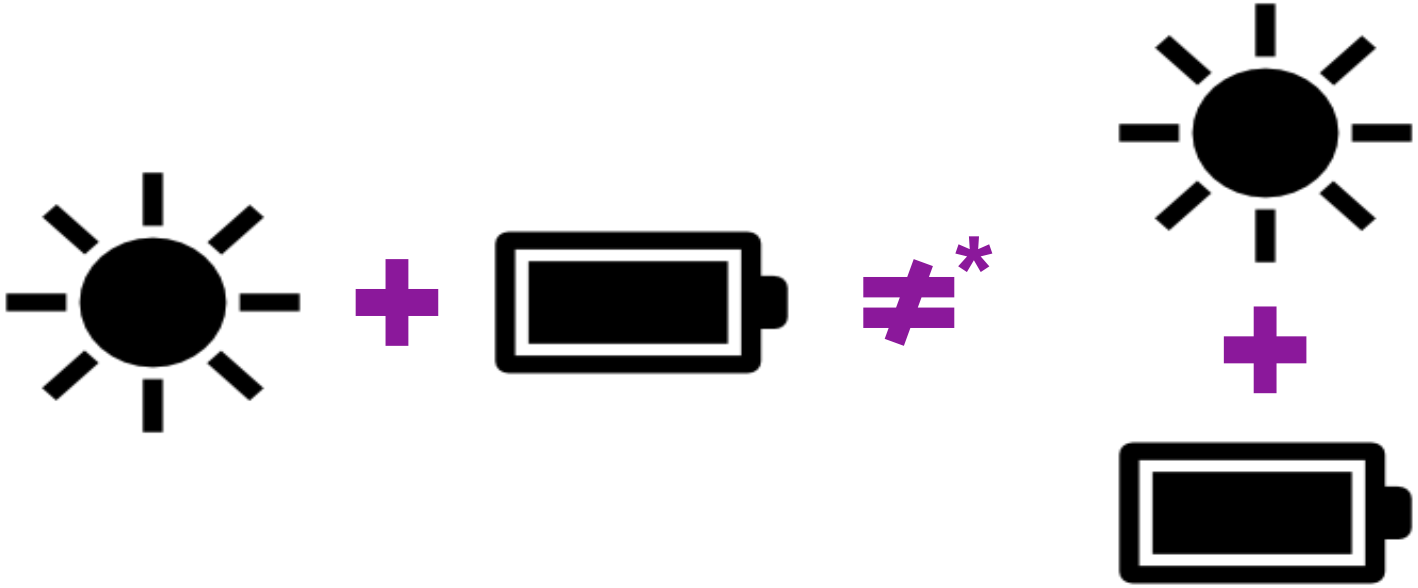
DEFINITION OF INTERACTIVE EFFECTS

INTERACTIVE EFFECTS APPROACH

How the **presence of one DER might change another DER's load shape**, beyond the simple addition of the two load shapes.



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TYPES OF INTERACTIVE EFFECTS

INTERACTIVE EFFECTS APPROACH

Interactive effects can influence participation and/or the net impact on system load, and be either direct or indirect influences.

Participation

- Customers that participate in one DER may have higher propensity to participate in another DER

Net Impact on System Load

- Interaction could increase or decrease net system load from what it would have been otherwise

Direct

- E.g., presence of Solar influences load shape of Storage

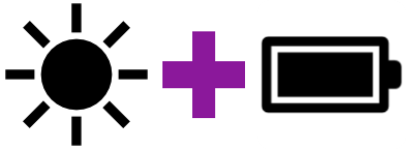
Indirect

- E.g., presence of EE influences customer's choice in size of Solar system

INTERACTIVE EFFECTS ADDRESSED IN THIS STUDY

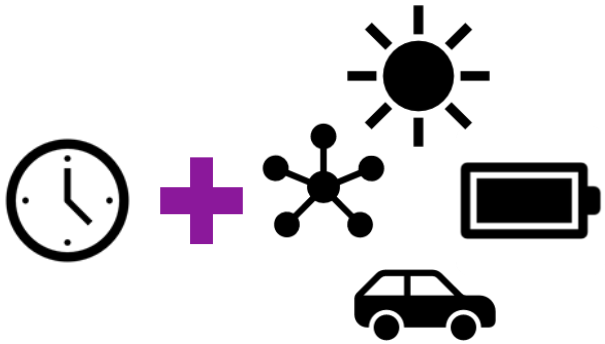
INTERACTIVE EFFECTS APPROACH

This analysis focuses on the interactions that are likely to impact the forecasts the most, with the acknowledgement that some interactions are still too uncertain to quantify.



Solar + Storage
Captures interactions in impacts and participation for solar + storage at a customer site

LDV + DR
Explicitly accounts for LDV participation in Direct Load Control

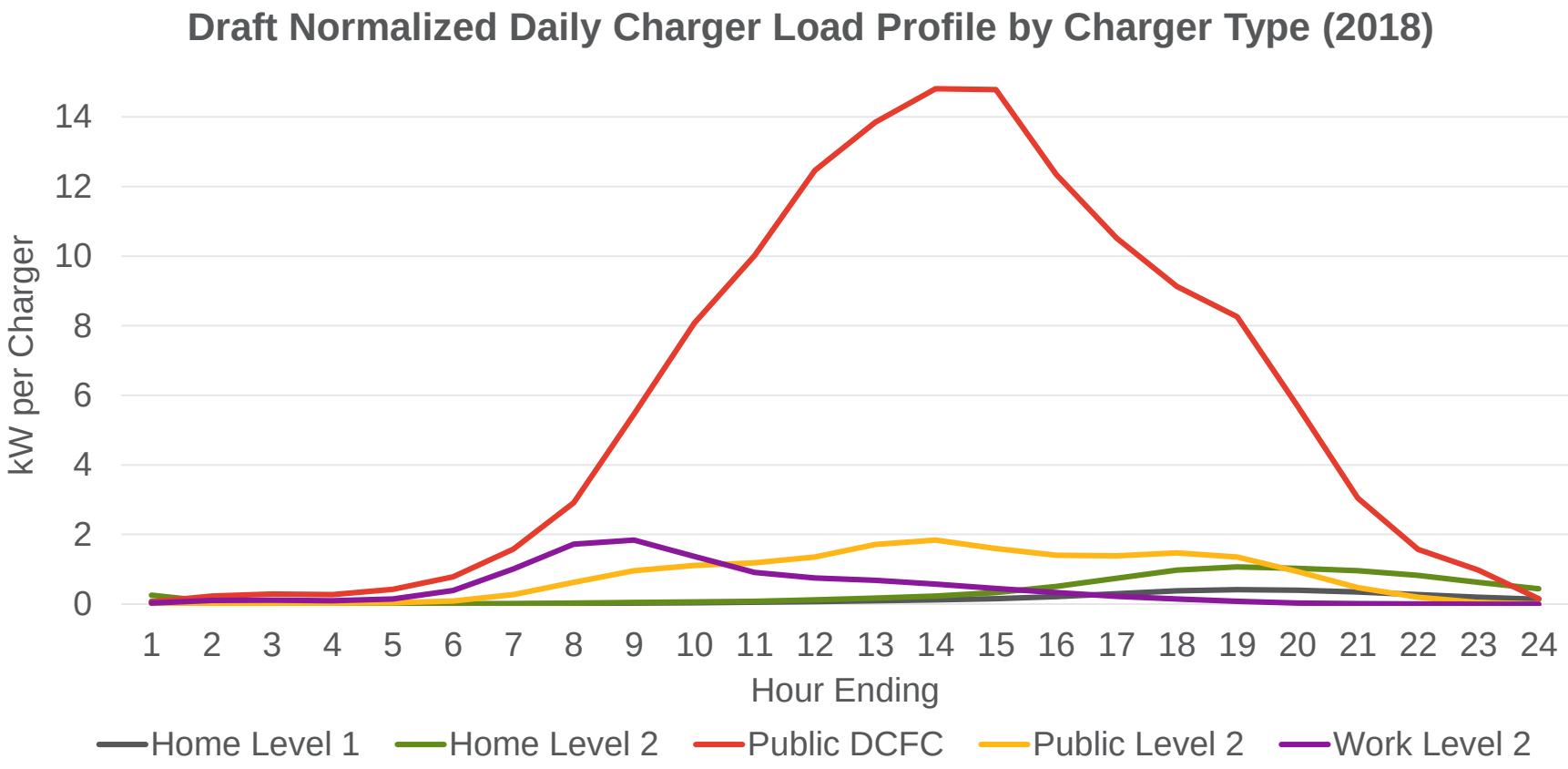


Pricing (TOU) + Other DER
Scenario analysis examines influence of pricing on the other DERs, including other DR types

LD VEHICLES LOAD PROFILE – PER CHARGER

LOAD PROFILES APPROACH

Home Levels 1 and 2 charging peak in the evening, while Workplace Level 2 charging peaks in the morning and Public DCFC and Level 2 peak mid-day.



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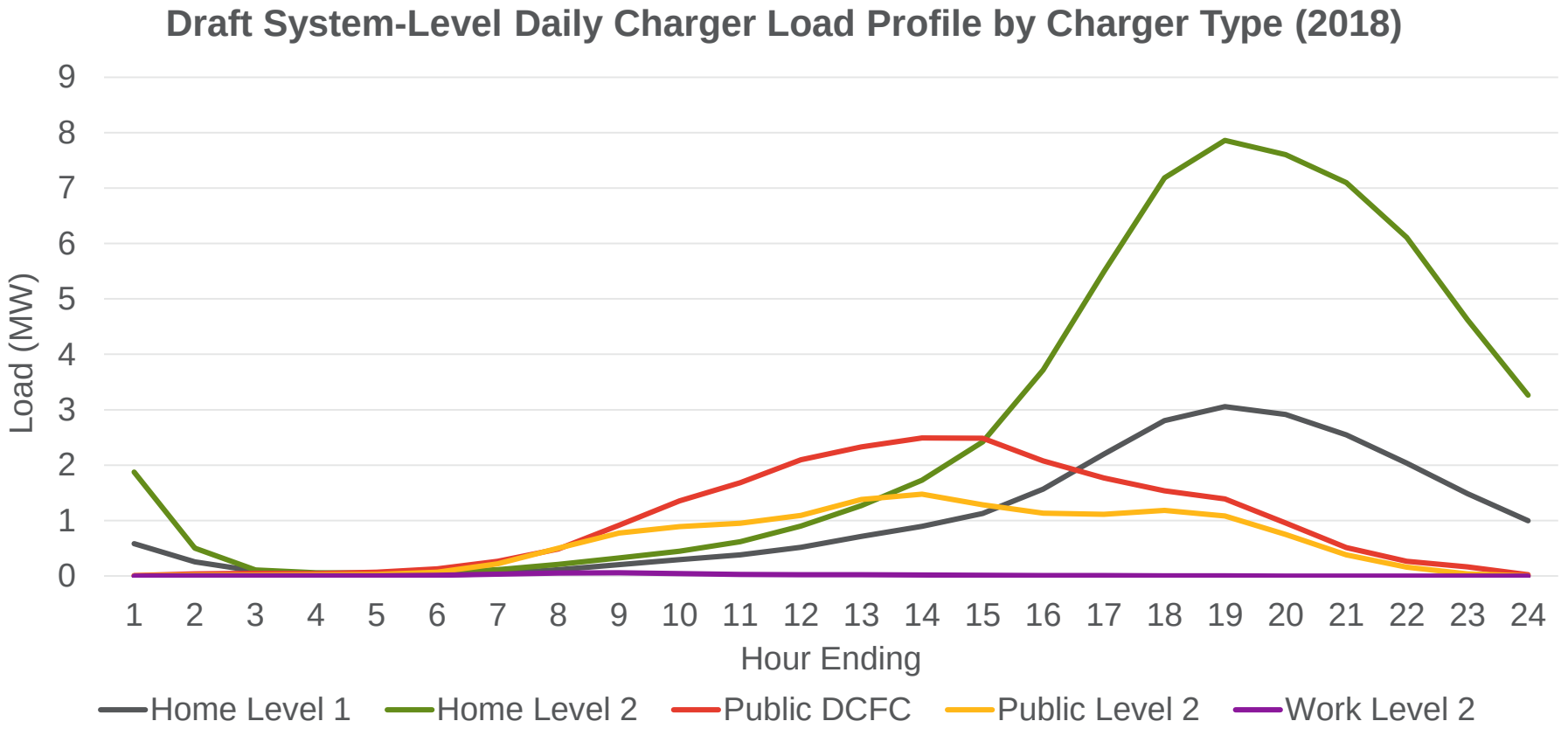
LD VEHICLES LOAD PROFILE – SYSTEM-LEVEL

LOAD PROFILES APPROACH

At an aggregate level, Home Levels 1 and 2 charging peaks are significantly greater than the system-level Public DCFC charging peak.



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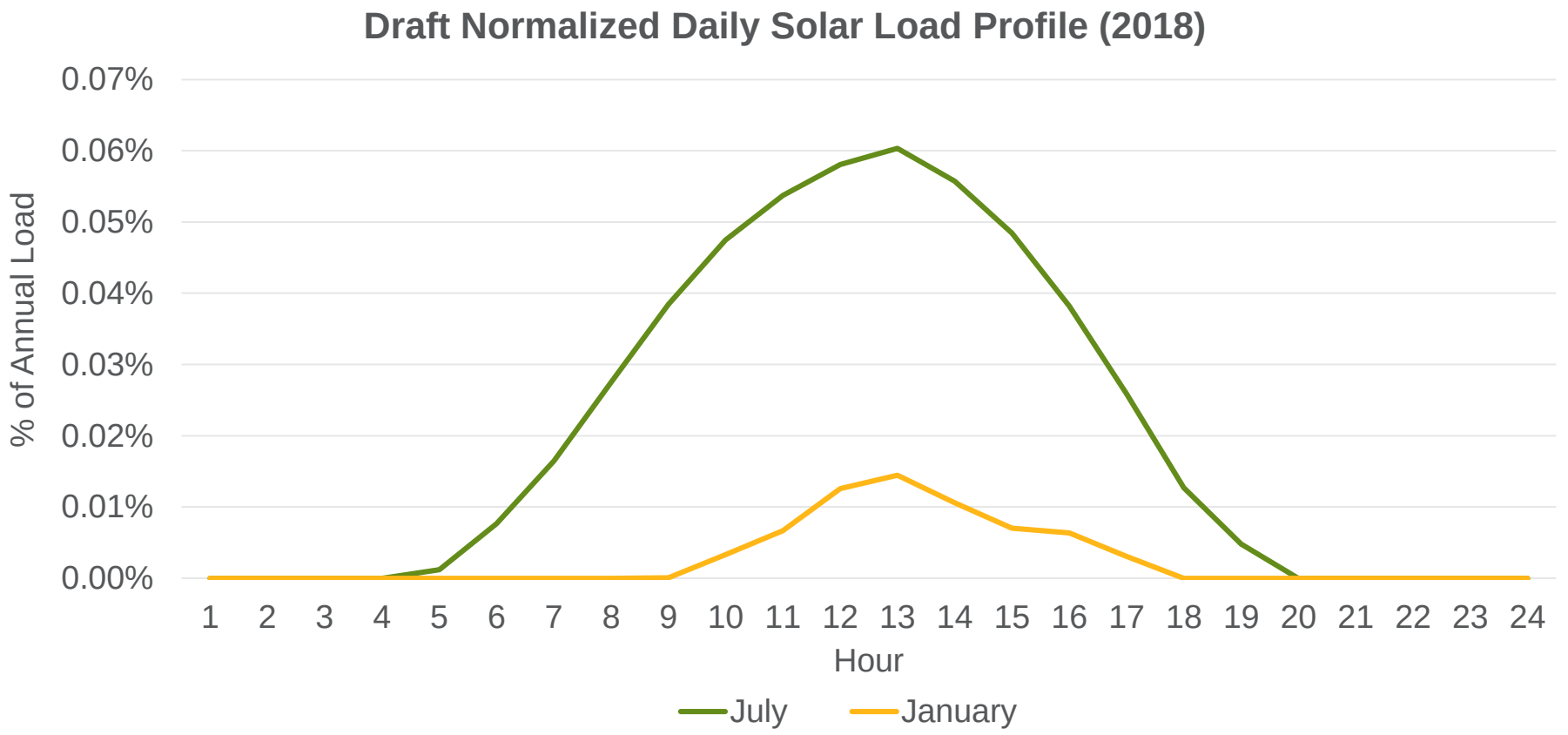
SOLAR LOAD PROFILE

LOAD PROFILES APPROACH

The load profile for Solar peaks midday and is roughly 4x higher during summer months than in winter months.



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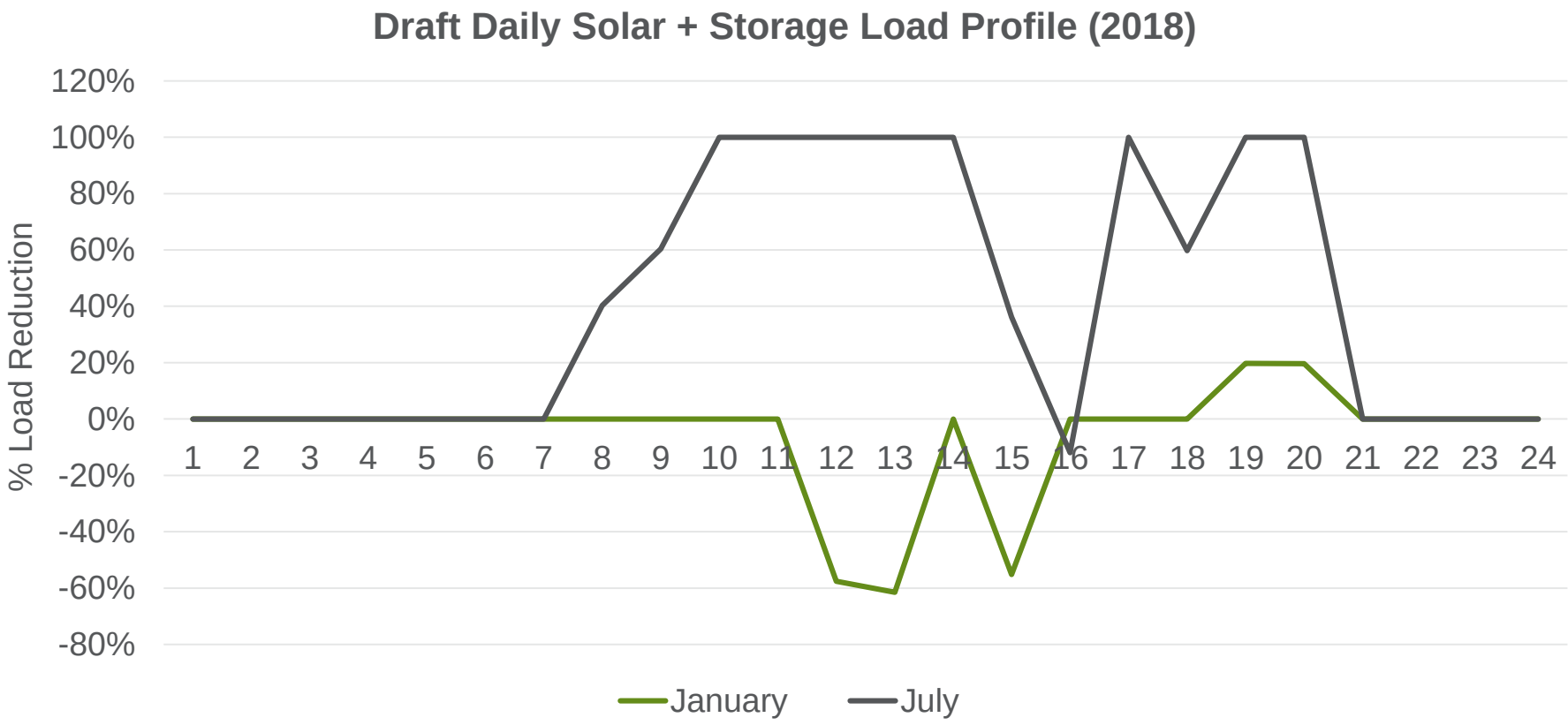
SOLAR + STORAGE LOAD PROFILE

LOAD PROFILES APPROACH

The net effect on system load for Solar + Storage varies by season. During the summer months, the solar PV system provides energy in the daytime and the storage system discharges during the TOU period from hours 16 to 20 resulting in a net decrease to system load, . During the winter months, the system has a net increase to system load while charging midday.



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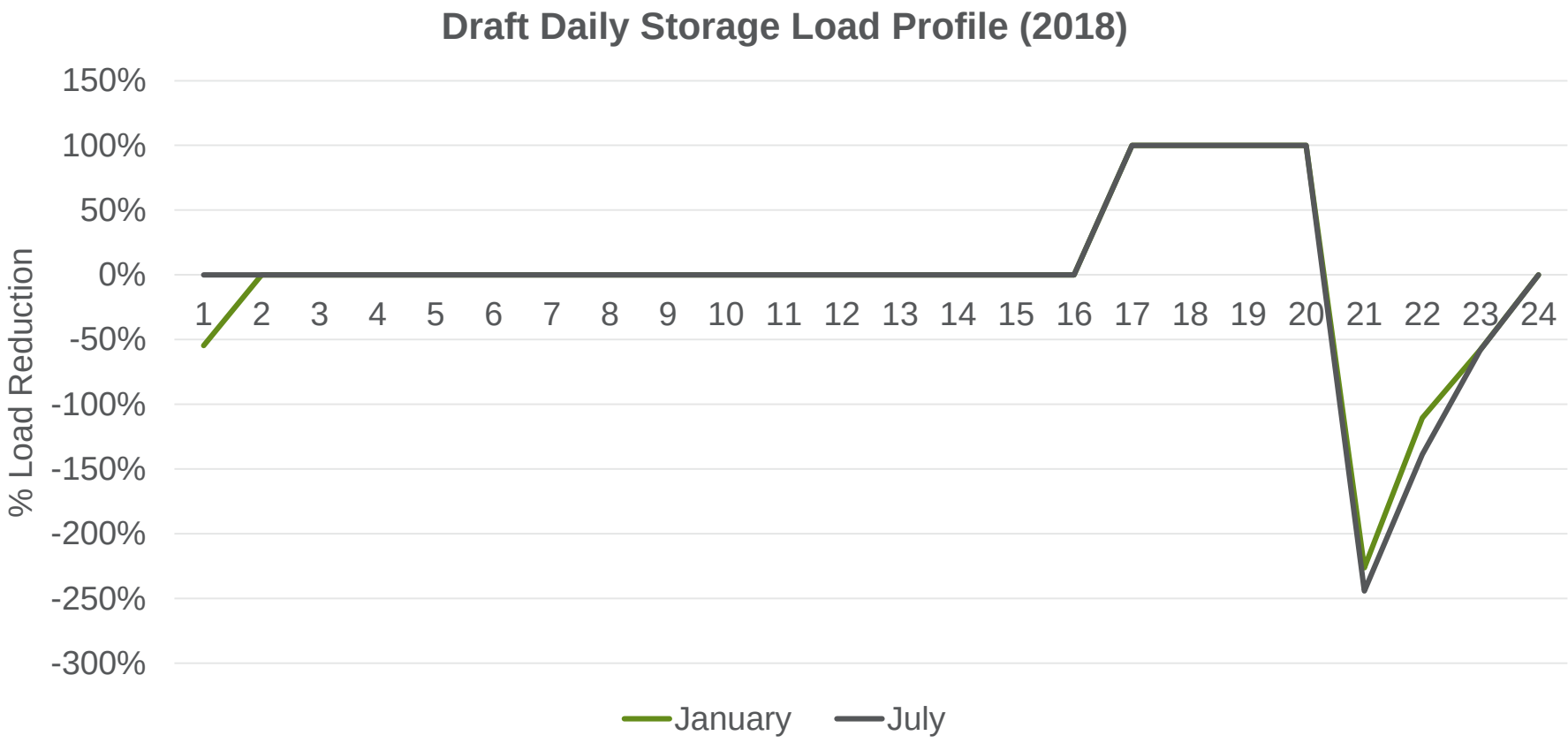
STORAGE LOAD PROFILE

LOAD PROFILES APPROACH

The load profile for Storage shows similar behavior during the summer and winter months, with Storage discharging during the TOU hours and charging immediately following.



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HIGH SCENARIO

SCENARIO DRIVERS

<table>
<tr><th>Technology / Driver</th><th>Technology Costs</th><th>Policies</th><th>Carbon Prices</th><th>Pricing</th></tr>
<tr><td>Overall Effect</td><td>Lower technology costs</td><td>More favorable policies for DER</td><td>Higher carbon prices in electricity and gasoline</td><td>Opt-out TOU participation</td></tr>
<tr><td>EE</td><td colspan="4">Energy Trust All-Achievable Scenario</td></tr>
<tr><td>DR</td><td colspan="2">+50% by 2030</td><td>No change*</td><td rowspan="4">Opt-out residential TOU***</td></tr>
<tr><td>Solar</td><td>Low PV $</td><td rowspan="2">Increased marketing and ITC continues through 2050</td><td rowspan="3">High carbon $</td></tr>
<tr><td>Storage</td><td rowspan="2">Low Li-Ion $</td></tr>
<tr><td>EV</td><td>Increased vehicle availability + vehicle production** + marketing</td></tr>
</table>

* Given no energy impacts estimated
** Vehicle production to be based off CA, starting in 2020
*** Opt-out rate based on opt-out rate assumed in PGE DR potential study

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LOW SCENARIO

SCENARIO DRIVERS

Technology / Driver	Technology Costs	Policies	Carbon Prices	Pricing
Overall Effect	Higher technology costs	Less favorable policies for DER	Lower carbon prices in electricity and gasoline	No TOU participation
EE	Energy Trust Cost-Effective Scenario (same as Base Case)			
DR	-50% by 2030		No change*	0% residential TOU
Solar	High PV $	Decreased marketing	Low carbon $	
Storage	High Li-Ion $			
EV		Decreased vehicle availability + vehicle production** + marketing		

* Given no energy impacts estimated

** Vehicle production to be based off low production state, starting in 2020

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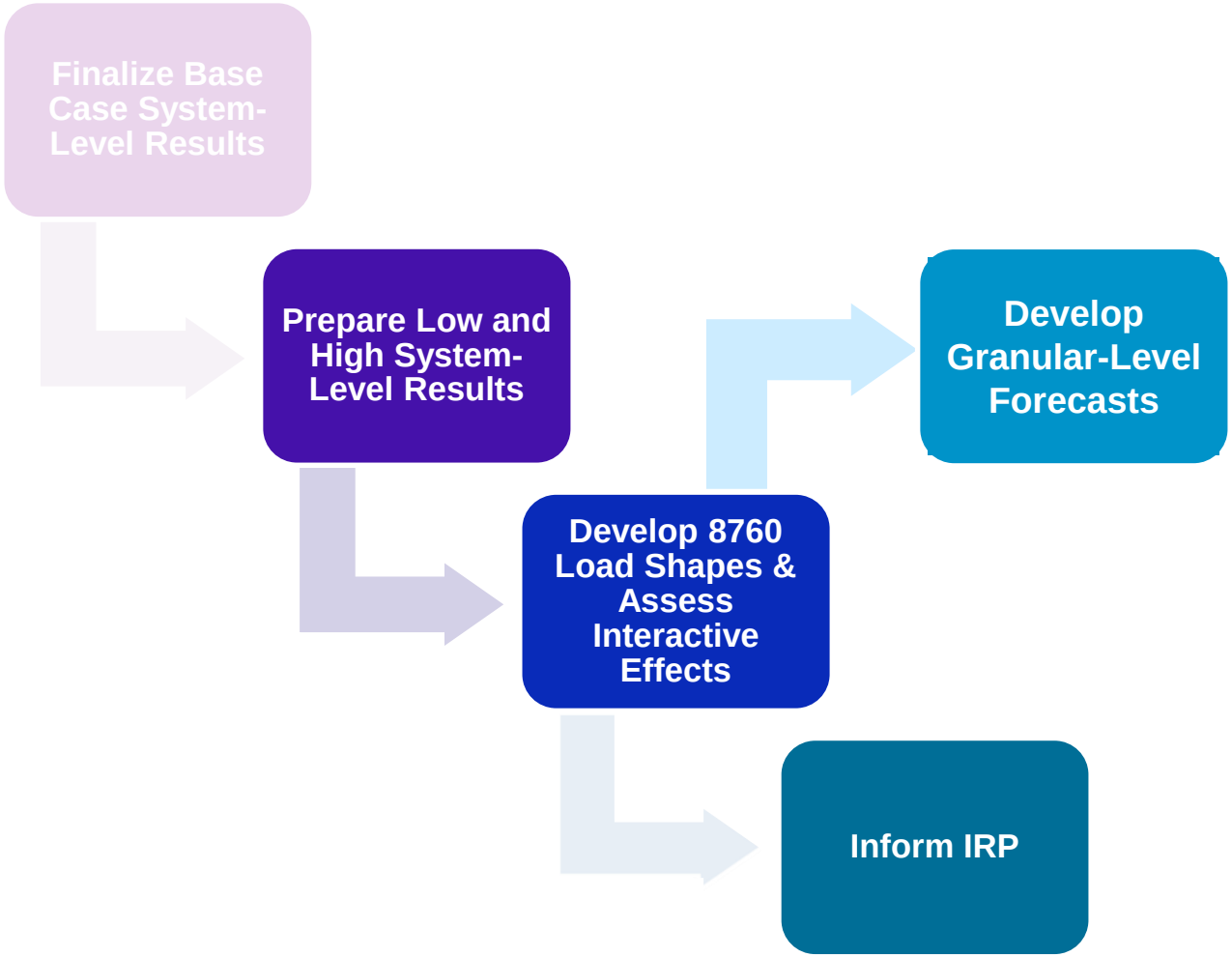
NEXT STEPS



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QUESTIONS?

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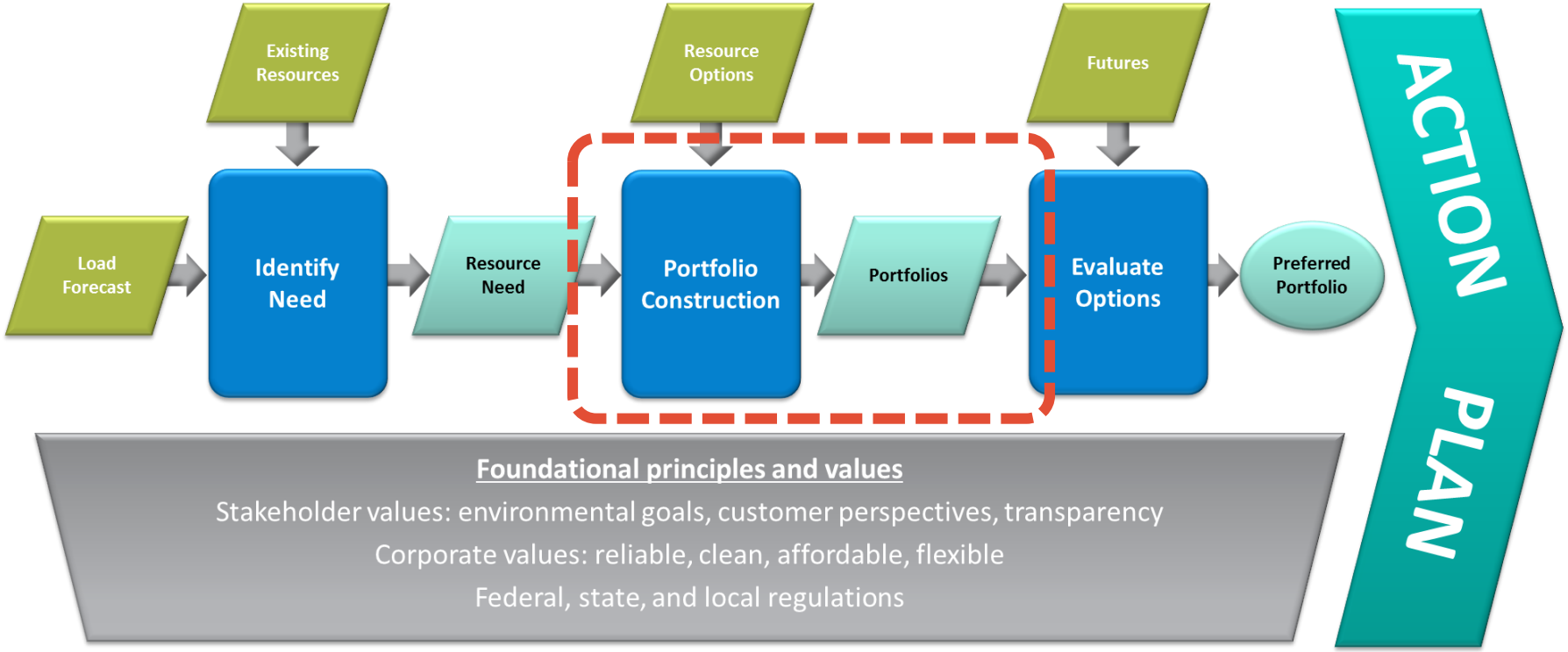
Draft Portfolios

Elaine Hart

Portfolio Construction



Draft Portfolio Design Principles

Portfolios are designed to meet a set of constraints

- **Capacity needs**
  - In the near-term, must meet Reference Case capacity need
  - In the long-term (post-2025), capacity additions are future-specific and can meet different capacity needs in different futures
- **RPS needs**
  - RPS obligations must be met in all years with REC retirements
  - Require physical compliance (generation equal to or great than RPS obligation) in 2040-2050
- **Energy position**
  - No minimum energy need constraint
  - Incremental generation limited in 2040-2050 to the greater of the forecasted net market purchases and the forecasted physical RPS shortage
- **Resource addition constraints**

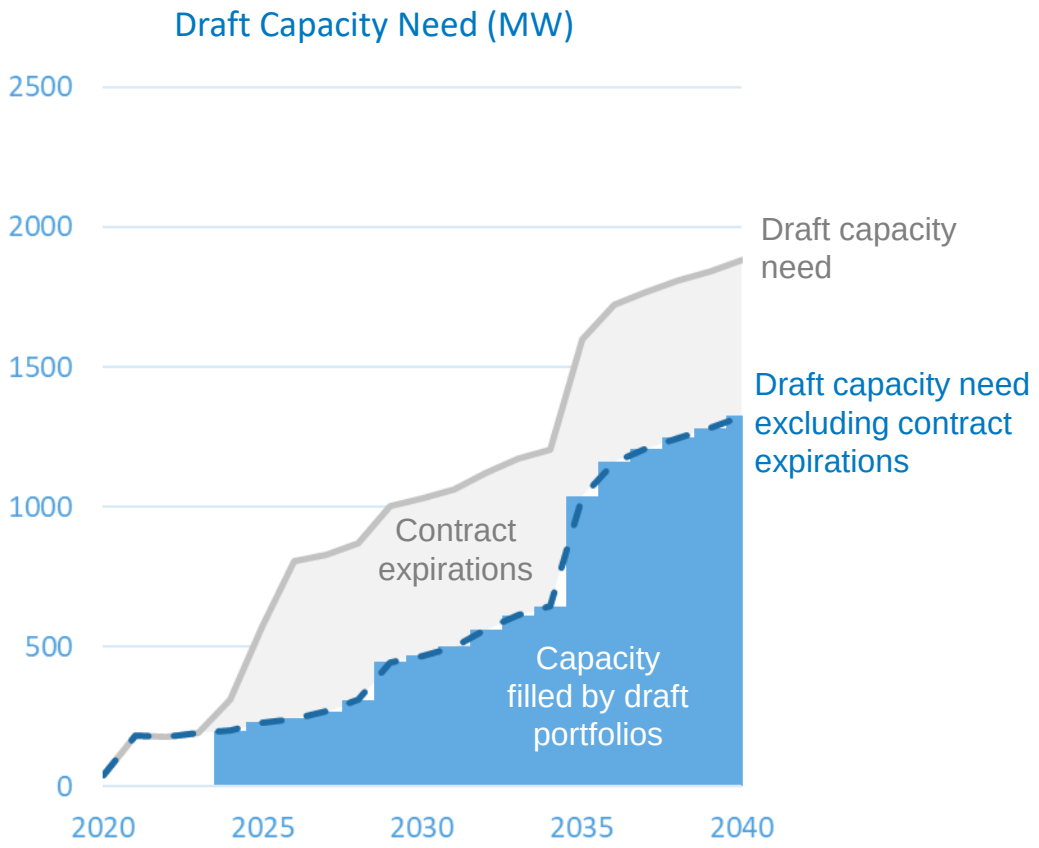
Draft Portfolio & Scoring Caveats

Draft analysis does not reflect pending updates, including:

Update Needed	Draft Approach
September Load Forecast	Draft analysis uses Reference June load forecast and plug data for low and high load futures
DER Study output	Draft analysis relies on 2016 IRP assumptions and PGE's Energy Storage Proposal
Market Capacity Study output	Draft analysis makes the same assumption as the 2016 IRP (200 MW in all but summer on-peak hours)
Finalized dispatch results	Draft analysis uses draft dispatch simulation results. PGE is continuing to refine these simulations based on updated data from Supply Side Studies and model tuning.
Finalized flexibility analysis results	Draft analysis incorporates approximations of flexibility value for dispatchable resources, excludes variable renewable integration costs
Finalized cost and performance data	Draft analysis uses prior draft of renewable cost and performance data and plug numbers for low and high technology cost futures
Outcome of Renewables RFP	Draft analysis assumes a 100 MWa Gorge Wind addition in 2021, consistent with PGE's 2016 IRP Revised Renewable Action Plan

Draft Capacity Needs

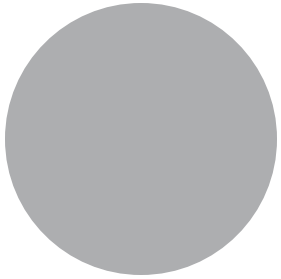
- Draft analysis indicates near-term capacity needs, which grow in the mid-2020s as contracts expire
- Draft portfolios shown today make the following assumptions:
  - Long-term resource actions are considered for capacity needs beginning in 2024. Consistent with 2016 IRP, capacity needs in the 2021-2023 time frame may be met through short- and mid-term activities
  - Capacity needs resulting from the expiration of contracts in mid-2020s are excluded from this draft analysis



Draft Portfolios

Included today:

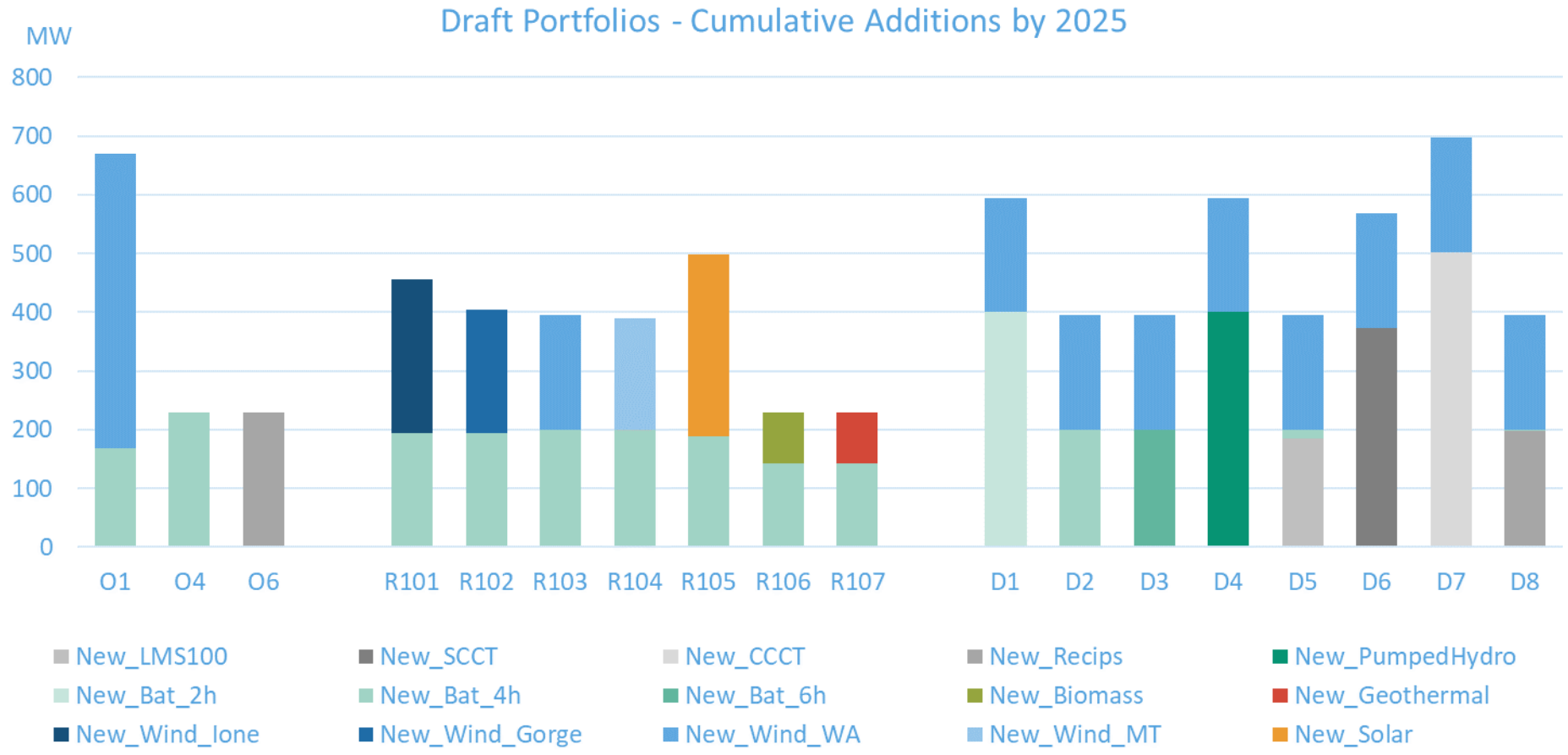
- Cost-Optimized Portfolios
- Renewable Resource Portfolios
- Dispatchable Resource Portfolios



Not included today:

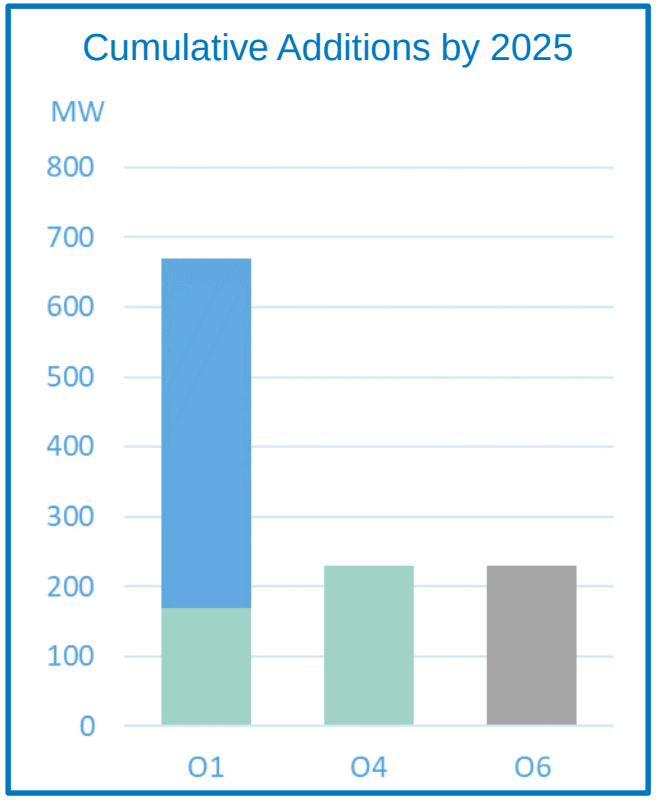
- Renewable size and timing portfolios
- Portfolios with non-cost objectives:
  - Risk-minimizing Portfolios
  - Carbon-minimizing Portfolios
- Additional hand-designed portfolios

Draft Portfolios



Draft Portfolios

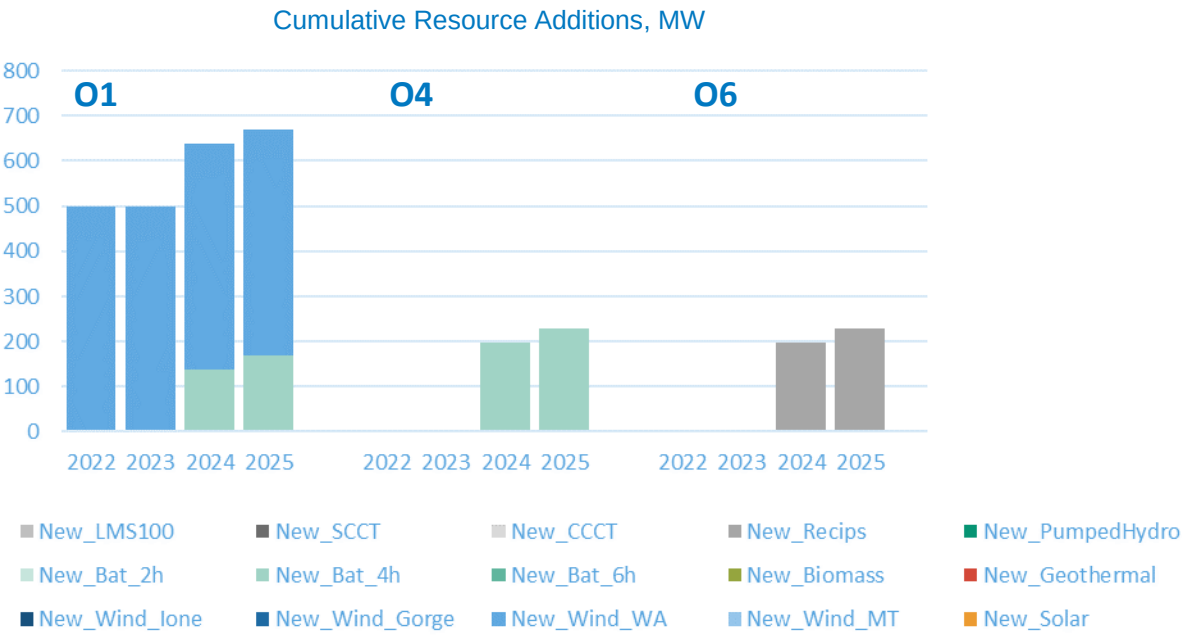
Cost-Optimized Portfolios



- **O1:** Minimize average long-term NPVRR across futures
- **O4:** Minimize average near-Term NPVRR across futures
- **O6:** Minimize Reference Case near-term NPVRR

Draft Portfolios
Cost-Optimized Portfolios

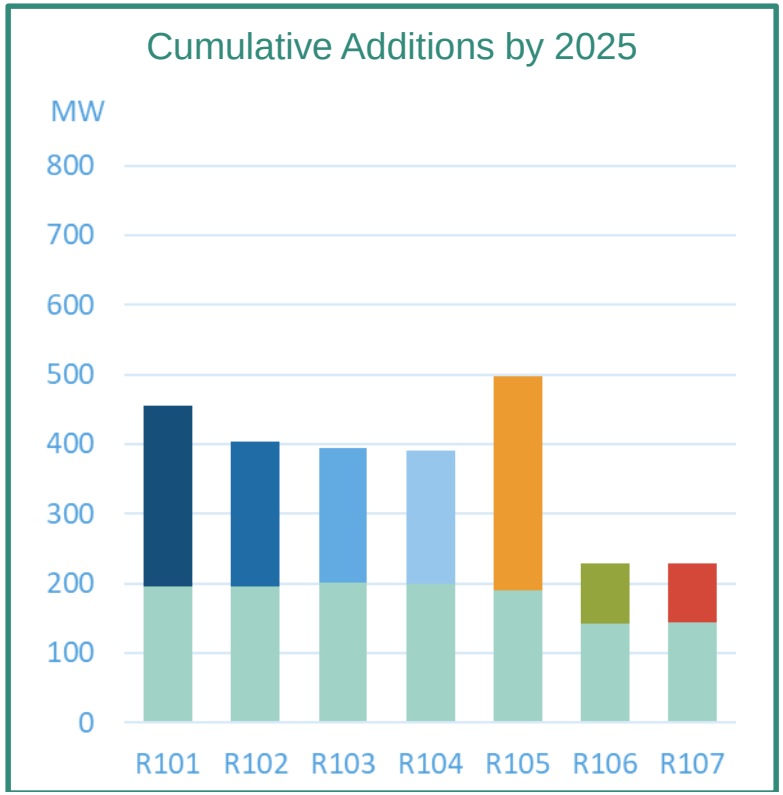
Optimized portfolios reflect various near-term renewable and capacity strategies



Draft – subject to change

Draft Portfolios

Renewable Resource Portfolios



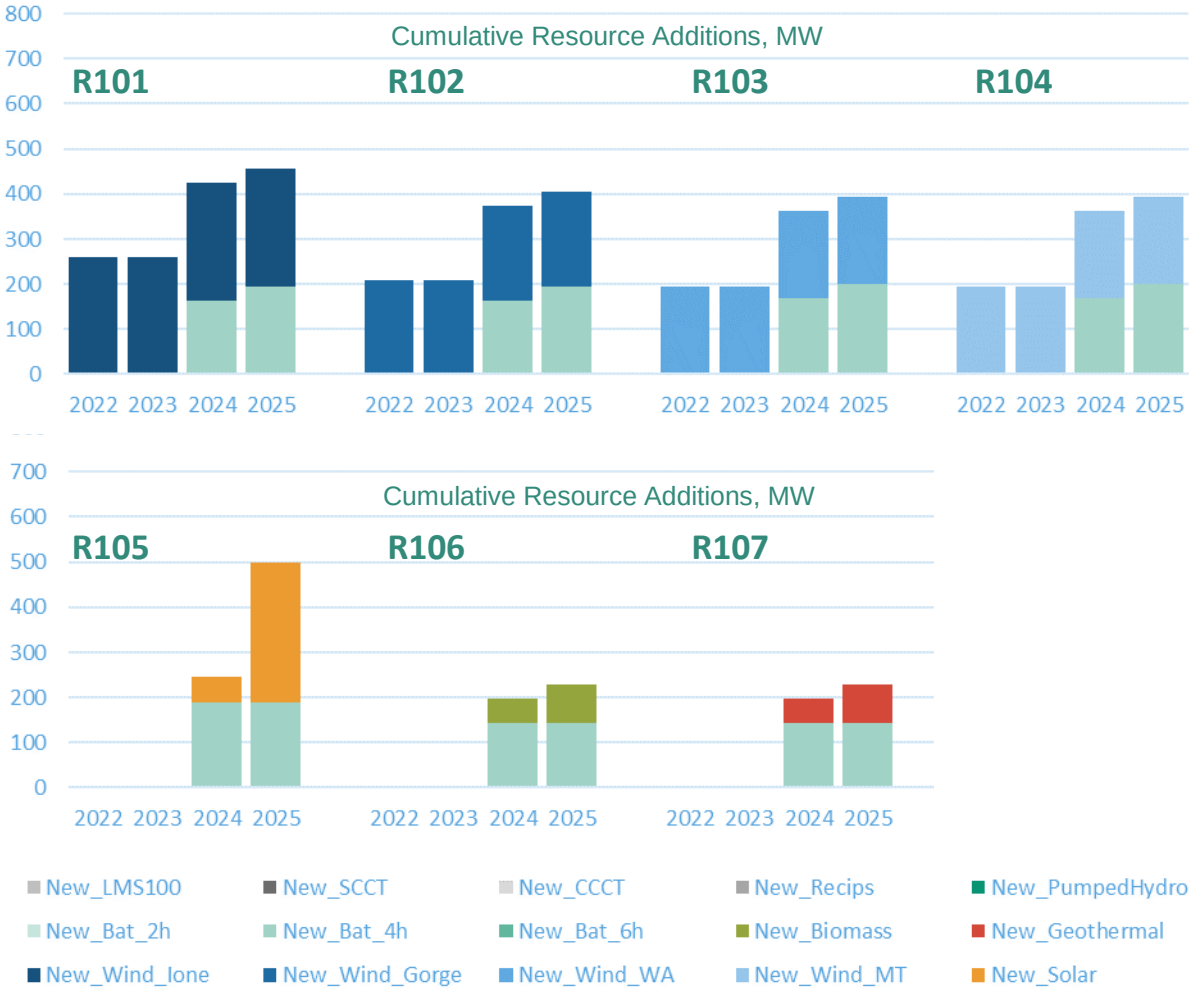
80 MWa of renewables by 2025, plus 4-hr batteries for remaining capacity needs

- **R101:** Ione Wind
- **R102:** Gorge Wind
- **R103:** Washington Wind
- **R104:** Montana Wind
- **R105:** Central Oregon Solar
- **R106:** Biomass
- **R107:** Geothermal

Draft Portfolios

Renewable Resource Portfolios

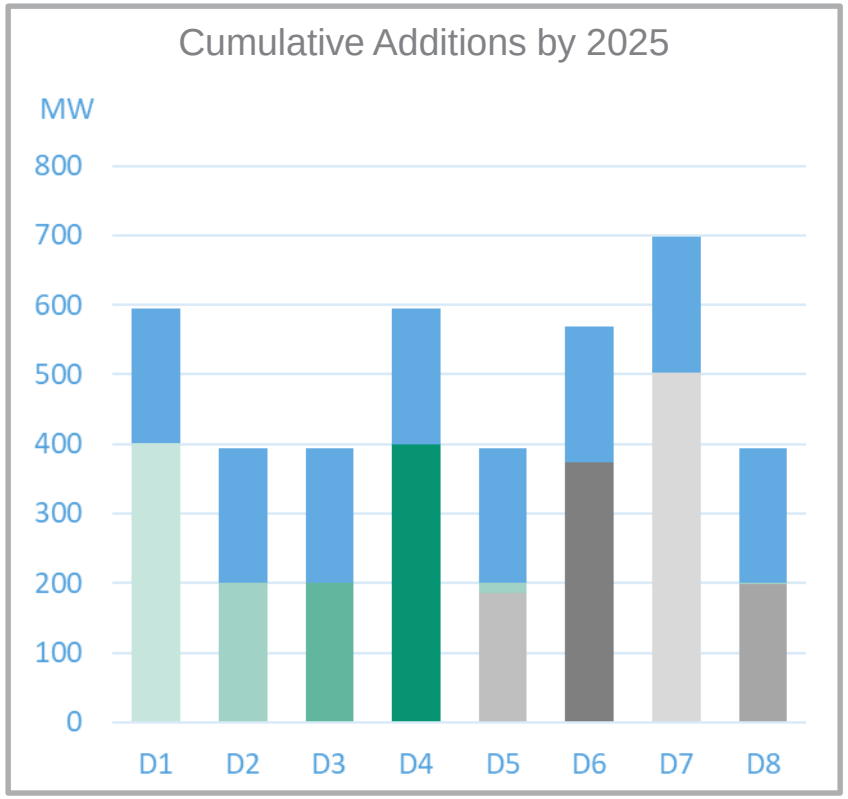
Renewable portfolios reveal differential timing impacts of PTC and ITC ramp down



Draft – subject to change

Draft Portfolios

Dispatchable Resource Portfolios



80 MWa Wind, plus 200+ MW of Dispatchable Capacity by 2025, unit sizes enforced:

- **D1:** 2hr Batteries (400 MW)
- **D2:** 4hr Batteries (200 MW)
- **D3:** 6hr Batteries (200 MW)
- **D4:** Pumped Storage (400 MW)
- **D5:** LMS100 (2 units)
- **D6:** SCCT (1 unit)
- **D7:** CCCT (1 unit)
- **D8:** Reciprocating Engine (11 units)

Draft Portfolios

Dispatchable Resource Portfolios

Unit size considerations lead to wide range of 2024 capacity addition sizes across draft portfolios

Draft – subject to change

Next Steps

Update data and refine draft portfolios:

- Cost-Optimized Portfolios
- Renewable Resource Portfolios
- Dispatchable Resource Portfolios

Produce additional draft portfolios:

- Renewable size and timing portfolios
- Portfolios with non-cost objectives:
  - Risk-minimizing Portfolios
  - Carbon-minimizing Portfolios
- Additional hand-designed portfolios
- **Stakeholder-requested portfolios**

Scoring Metrics in the 2019 IRP

Sima Beitinjaneh

Scoring Metrics List

Cost metrics

- Ref Case NPVRR through 2025/2050/20years
- Expected Value NPVRR through 2025/2050/20years

Economic risk

- Semi Variance of NPVRR
- Standard Deviation of NPVRR
- TailVar90 of NPVRR
- Carbon Constraint Future Cost

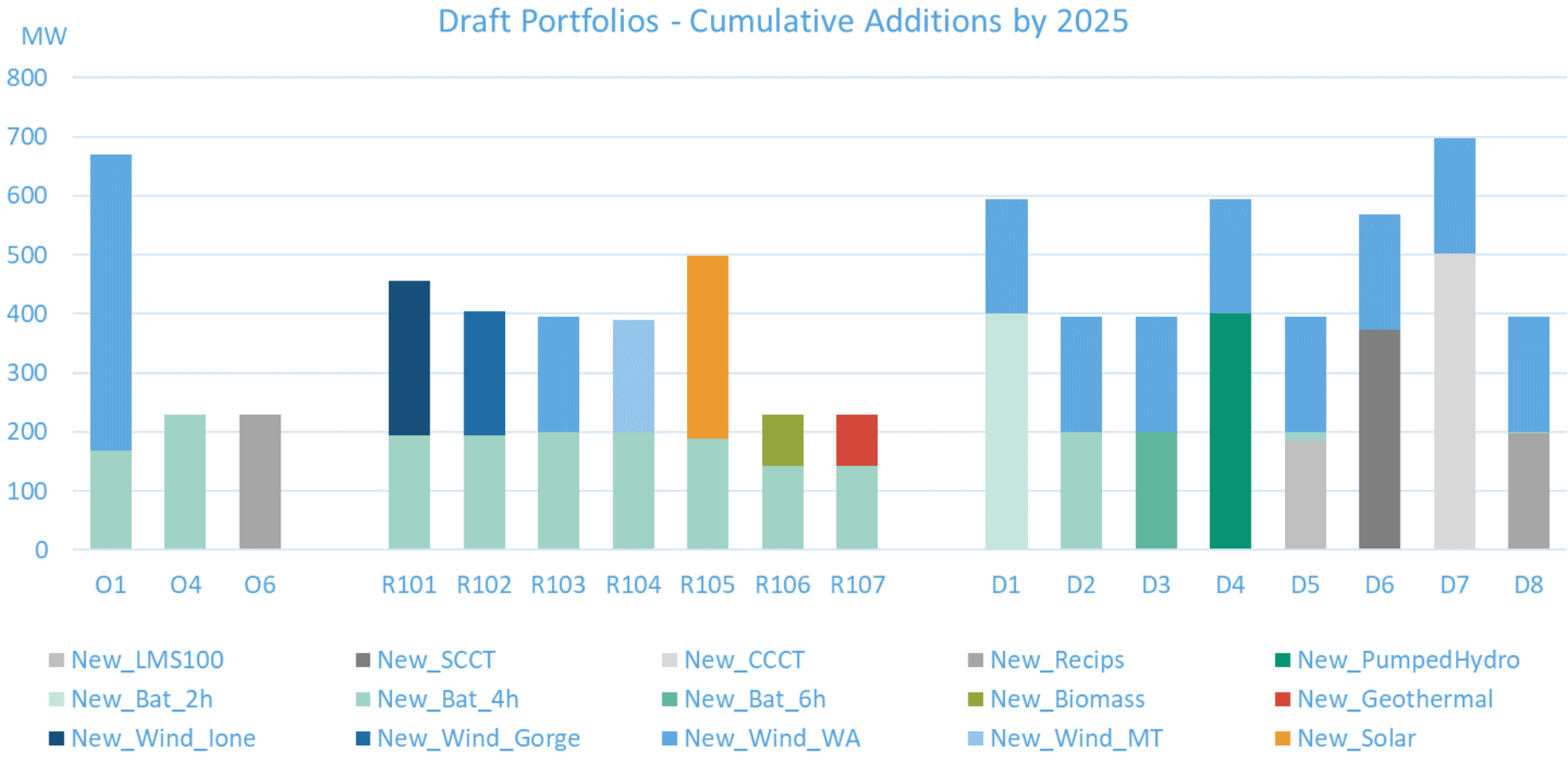
Environmental risk

- Ref Case cum. GHGs through 2050
- Expected Value cum GHGs through 2050
- NOx/SOx cum. Emissions through 2050
- Water consumption

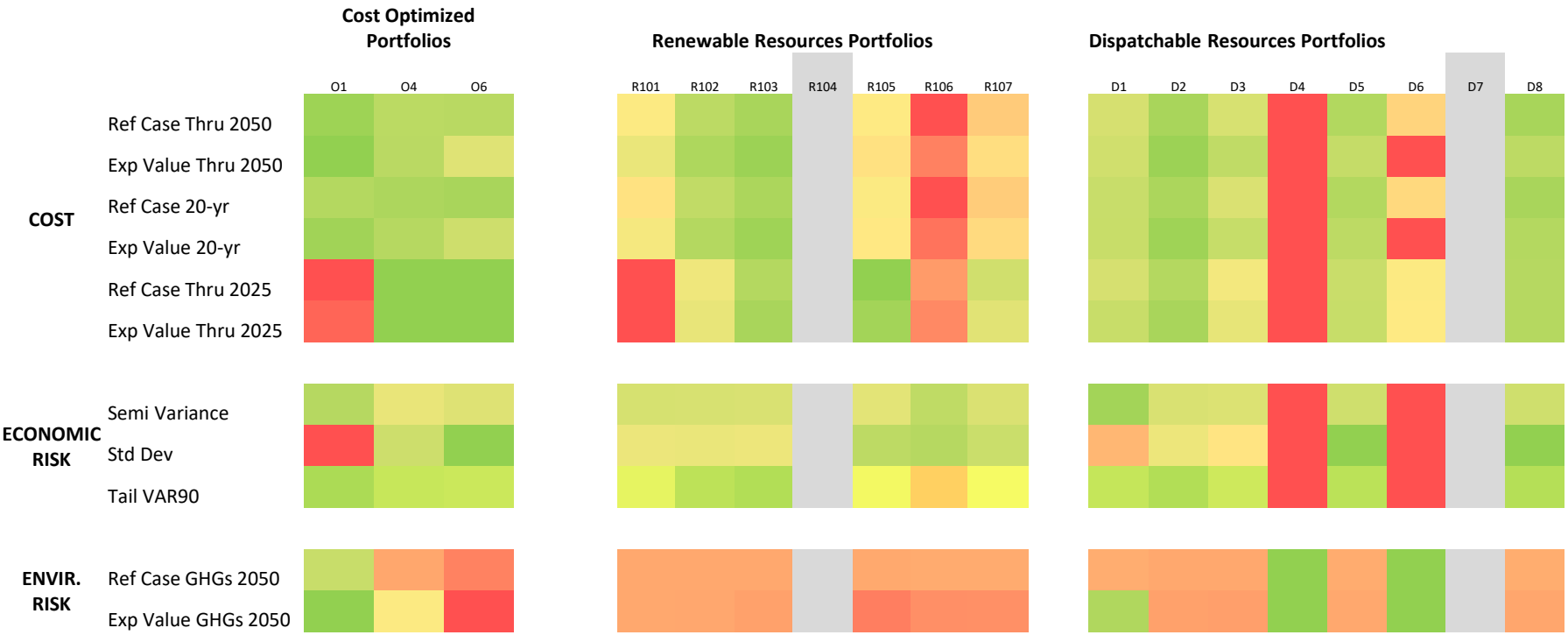
Reliability Risk

- TailVar90 of Loss of Load events
- Expected Unserved Energy

Draft Portfolios



Draft Portfolio Scoring



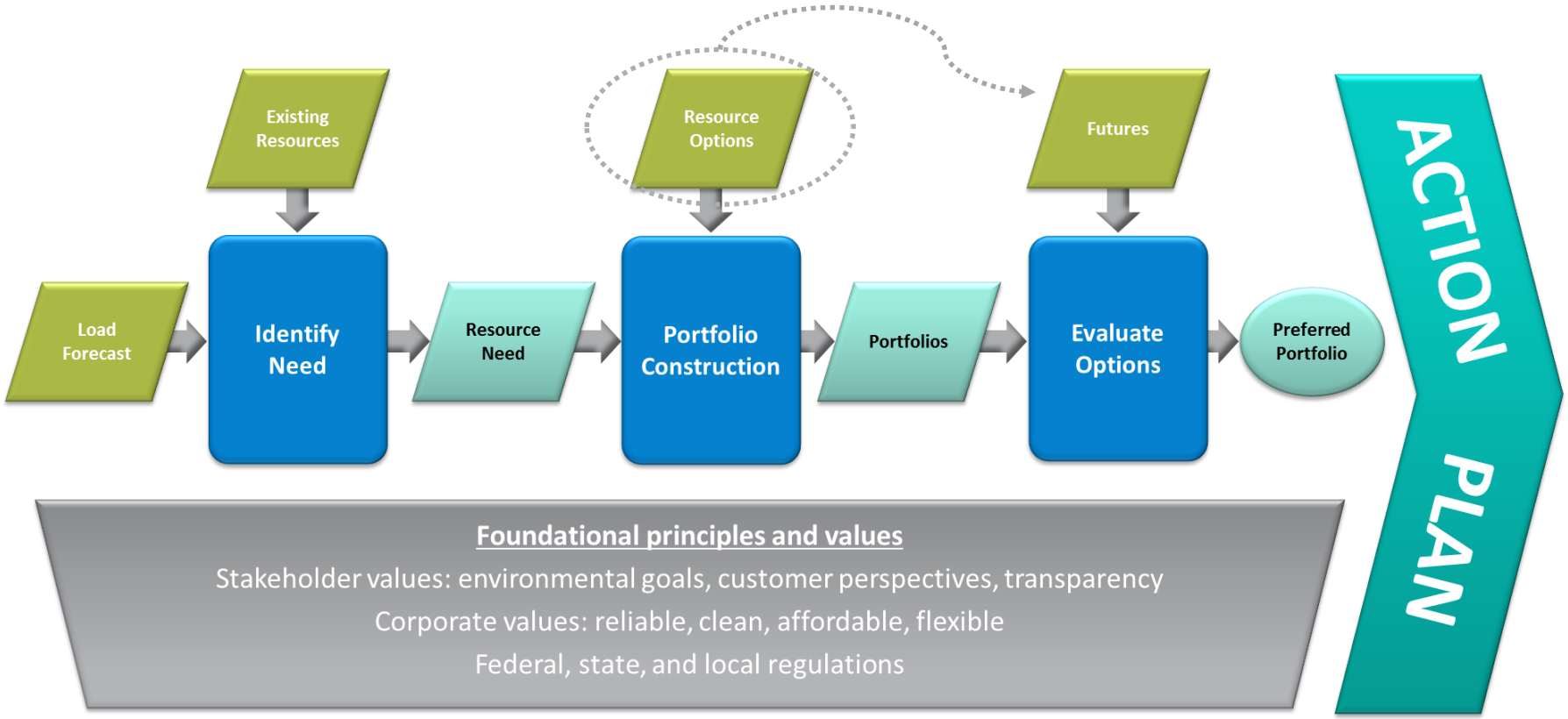
Renewables Supply Side Resources

Draft Characteristics

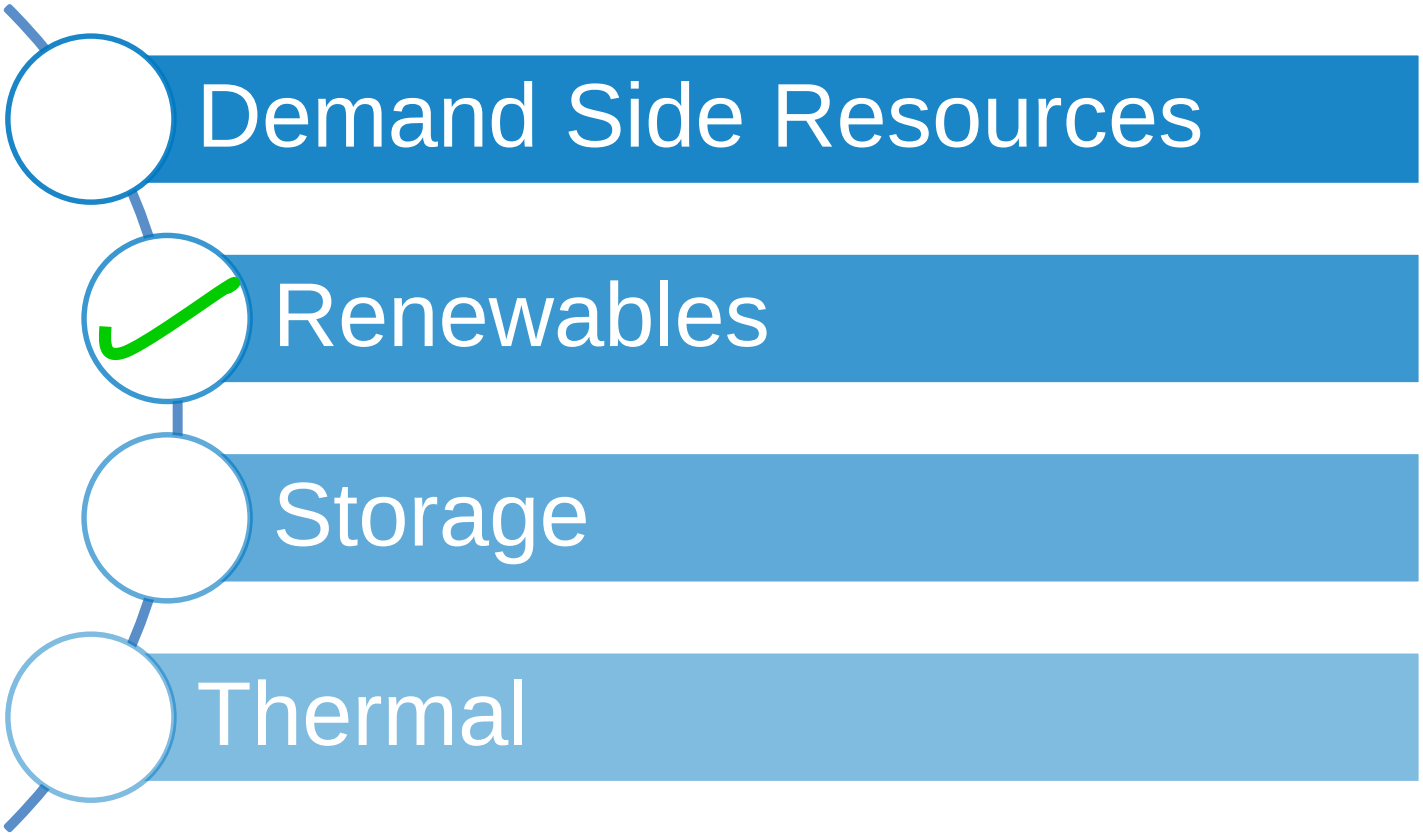
Sima Beitinjaneh

IRP Modeling Process

Resource Options impact Portfolio Construction and Futures



2019 IRP Draft
Wind and Solar Characteristics



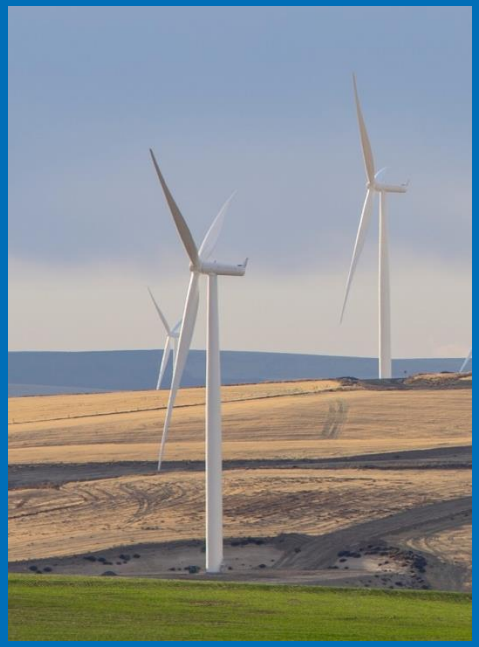
Supply Side Resources

For generic new resource options in the 2019 IRP, PGE contracted HDR Engineering Inc. to develop cost and technical assumptions for generic supply side resources located in the PNW.

- Reviewing draft characteristics for Wind and Solar today.
- Draft characteristics for Energy Storage and Thermals (including biomass and geothermal) were shared during RT-3.

Wind Resources

Draft Characteristics



Characteristics	Ione	Gorge	SE WA	MT
Overnight Capital Cost, $/kW	$1,508	$1,539	$1,531	$1,520
Fixed O&M, $/kW-yr	$37	$37	$37	$37
Land Lease, $/MWh	$1.70	$1.70	$1.70	$1.70
Annual Capacity Factor	32.7%	40.8%	42.9%	42.9%

Cost in 2018$ for a notice to proceed in 2018

Solar Resources

Draft Characteristics

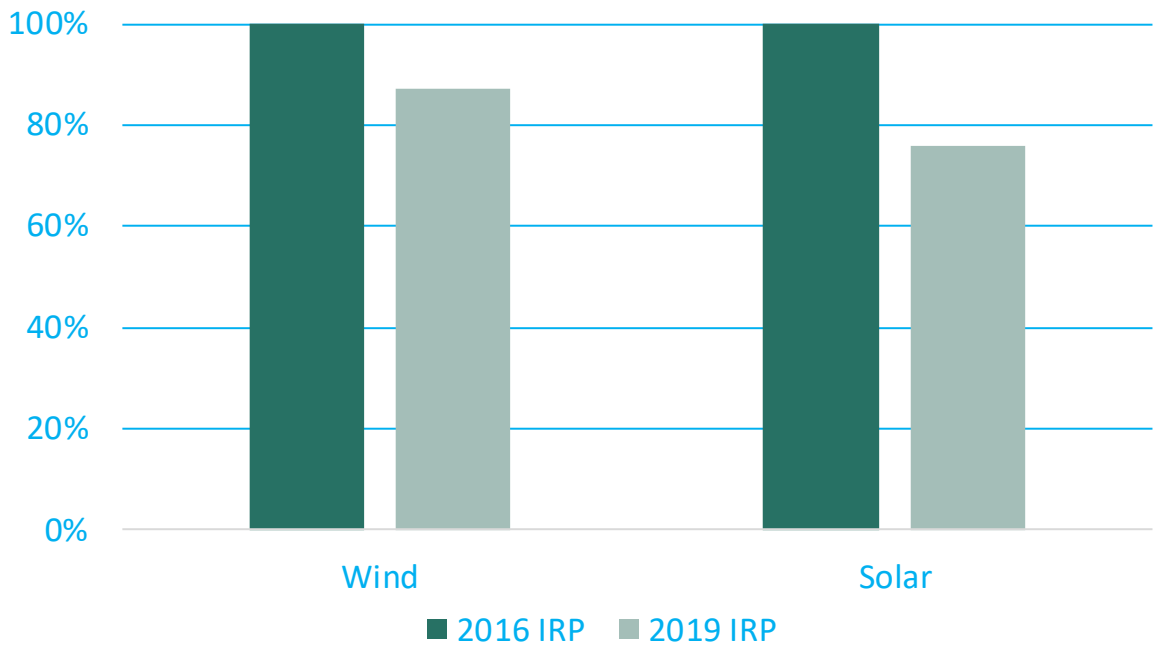
Characteristics	Central OR Tracking
Overnight Capital Cost, $/kW	$1,510
Fixed O&M, $/kW-yr	$22.20
Land Lease, $/MWh	$4.22
Annual Capacity Factor	24.8%

Cost in 2018$ for a notice to proceed in 2018

Capital Cost Comparison to 2016 IRP

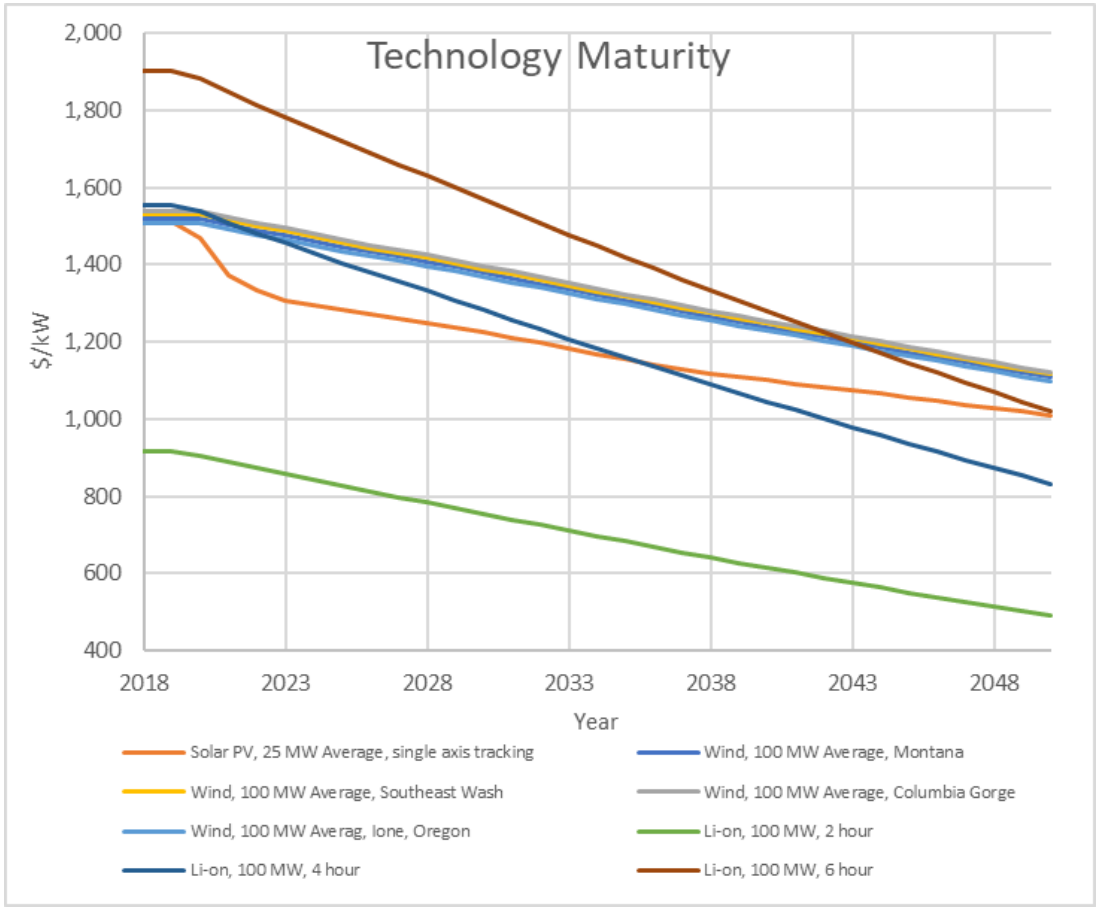
Total Overnight Capital Costs declined for both wind and solar resources

Overnight capital cost percentage changes for a 2018 Notice to Proceed



Technical Maturity Outlook

Draft Characteristics



Source: HDR forecast based on the trends of Energy Information Administration's (EIA) 2017 Annual Energy Outlook (AEO)

Wrap up

Elaine Hart

Upcoming 2018 Roundtables

Roundtable 18-5 **Wednesday, October 31, 2018** **(8:00 am - 1:00 pm PST)** **2 World Trade Center, Skybridge A&B** **121 SW Salmon St., Portland, OR 97204**	**AGENDA** ▪ **Load Forecast Update** ▪ **Market Capacity Study** ▪ **Resource Need Update** ▪ **Variable Resource Integration Costs** ▪ **Portfolio & Scoring Update**
Roundtable 18-6 Wednesday, November 28, 2018 (8:00 am - 1:00 pm PST) 2 World Trade Center, Plaza Conference 121 SW Salmon St., Portland, OR 97204	AGENDA ▪ Flexibility Adequacy & Flexibility Value ▪ Portfolio & Scoring Update ▪ Distribution Resource Planning ▪ Transmission

https://www.portlandgeneral.com/our-company/energy-strategy/resource-planning/integrated-resource-planning/irp-public-meetings

Wrap Up

- Thank you for your participation today!
- Please provide feedback regarding draft portfolios & scoring through our online feedback form or by emailing IRP@pgn.com
  - Portfolio request form can be submitted over email to IRP@pgn.com
  - Stakeholder requested portfolios to be considered prior to the October Roundtable must be submitted by Wednesday, October 10th