PACIFICORP: PRIVATE GENERATION RESOURCE ASSESSMENT FOR LONG TERM PLANNING

AUGUST 30, 2018

PacifiCorp

NAVIGANT

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INTRODUCTION

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INTRODUCTION

- Navigant prepared this Long-term Private Generation Resource Assessment on behalf of PacifiCorp.
- The purpose of this study is to support PacifiCorp's 2019 Integrated Resource Plan (IRP) by projecting the level of private generation resources PacifiCorp's customers might install over the next twenty years under base, low, and high penetration scenarios.
- This study builds on Navigant's previous assessment which supported PacifiCorp's 2015 and 2017 IRP, incorporating updated load forecasts, market data, technology cost and performance projections.
- The study includes projections for PacifiCorp's six state territories: UT, OR, ID, WY, CA, WA.
- Navigant evaluated five private generation resources in detail in this report:
    1. Photovoltaic Solar
    2. Small Scale Wind
    3. Small Scale Hydro
    4. Combined Heat and Power Reciprocating Engines
    5. Combined Heat and Power Micro-turbines

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PRIVATE GENERATION TECHNOLOGIES

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PRIVATE GENERATION TECHNOLOGIES

Resource Cost and Performance	Solar PV	Small-scale Wind	Small-scale Hydro	CHP- Micro-Turbines	CHP- Reciprocating Engines
Installed Cost – Res ($/kW)*	UT: $2,750/W-DC Other: $2,500/W-DC	$7,200	NA	NA	NA
Installed Cost – Non-Res ($/kW)*	All Markets: $1,900/W-DC	$6,000	$4,000	$2,685	$2,970
Average Change in Annual Installed Cost (2019-2038) (%)	-2.8% (Res) -2.5% (Non-Res)	0.0%	0.0%	-0.3%	0.4%
Fixed O&M – Res ($/kW-yr.)	$25	$40	NA	NA	NA
Fixed O&M – Non-Res ($/kW-yr.)	$23	$40	$52	NA	NA
Variable O&M	NA	NA	NA	$23	$20
Change in Annual O&M Cost (%)	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
Capacity Factor (%)	12.4%-16.8%	20% (2013) to 25% (2038)	50% ±5%	NA	NA
Fuel Cost	NA	NA	NA	PacifiCorp Gas Forecast	PacifiCorp Gas Forecast
Electric Heat Rate (HHV) (Btu/kWh)	NA	NA	NA	15,535	12,637
DC to AC Derate Factor	0.85	NA	NA	NA	NA

* Installed costs for solar PV are in $/W-DC; all other technologies are in $/W-AC

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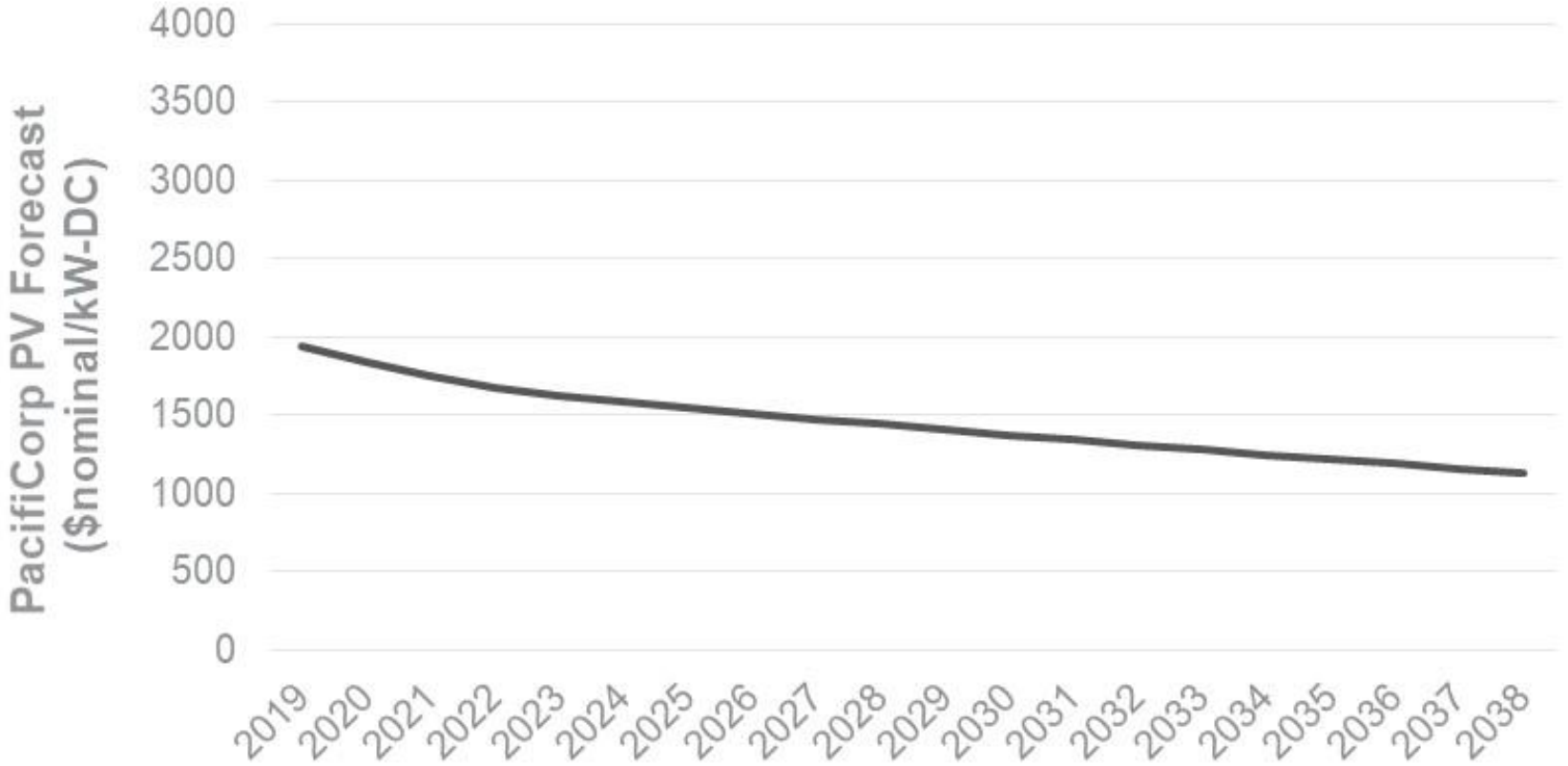
NON-RESIDENTIAL SOLAR SYSTEM COSTS, 2015-2036



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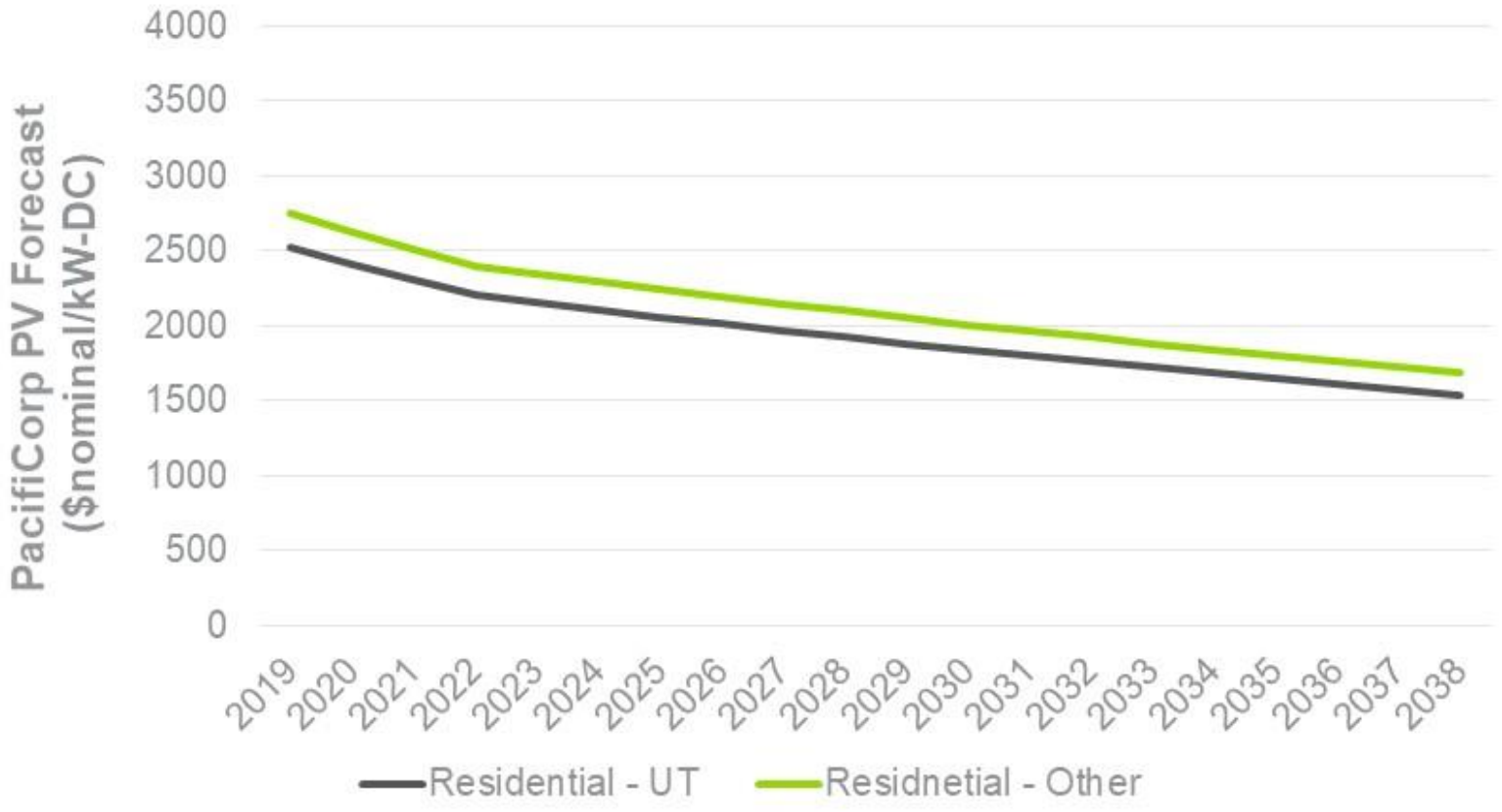
RESIDENTIAL SOLAR SYSTEM COSTS, 2015-2036



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METHODOLOGY

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METHODOLOGY

1. **Assess a Technology's Technical Potential:** Technical potential is the amount of a technology that can physically be installed without taking economics into account.
2. **Calculate First Year Simple Payback Period for Each Year of Analysis:** From past work projecting the penetration of new technologies, Navigant found that Simple Payback Period is the best indicator of uptake. Another possible metric is Return on Investment (ROI). Navigant found that most customers, especially in the residential sector, do not do sophisticated enough calculations to warrant an ROI analysis.
3. **Project Ultimate Adoption Using Payback Acceptance Curves:** Payback Acceptance Curves estimate what percentage of a market will ultimately adopt a technology. Payback Acceptance Curves do not factor in how long adoption will take.
4. **Project Actual Market Penetration Using Market Penetration Curves:** Market penetration curves factor in market and technology characteristics to project how long adoption will take.
5. **Project Market Penetration Under Different Scenarios:** Penetration can vary depending on different market scenarios.

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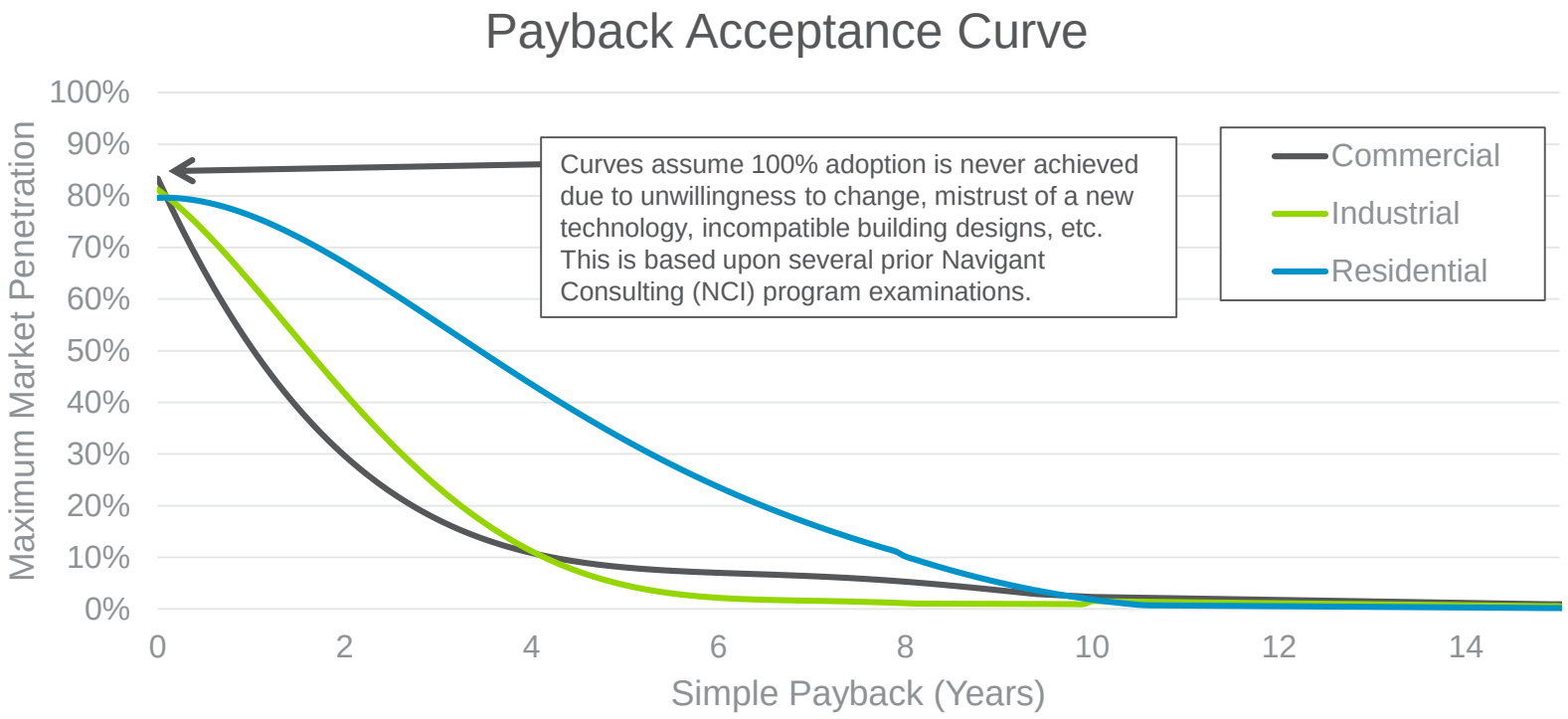
PAYBACK ACCEPTANCE

For private generation sources, Navigant used the following payback acceptance curves to model market penetration from the retail customer perspective.



Source: NCI based upon work for various utilities, federal government organizations, and state/local organizations. The curves were developed from customer surveys, mining of historical program data, and industry interviews.

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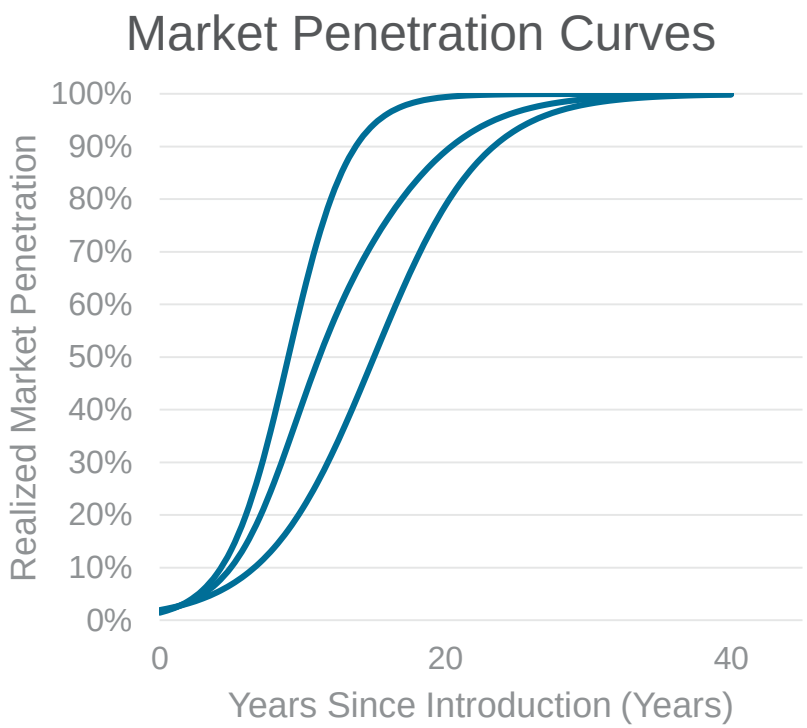
MARKET PENETRATION

Navigant uses market penetration curves to assess how a technology is adopted over time.

- Market penetration curves (sometimes called S-curves) are well established tools for estimating diffusion or penetration of technologies into the market.
- A market penetration curve provides the rate of adoption of technologies, as a function of the technology's characteristics and market conditions.
- Navigant Consulting has gathered market data on the adoption of technologies over the past 120 years and fit the data using Fisher-Pry curves.*
- The Fisher-Pry technology substitution model predicts market adoption rate for an existing market of known size.
- A key parameter when using market penetration curves is the assumed year of introduction.
  - For this study, NCI assumed the first year introduction occurred when the simple payback period was less than 25 years (per the payback acceptance curves used, this is the highest payback period that has any adoption).



*Source: Navigant Consulting, Inc., November 2008 as taken from Fisher, J.C. and R.H. Pry, A Simple Substitution Model of Technological Change, *Technological Forecasting and Social Change*, Vol 3, Pages 75 – 99, 1971

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RESULTS

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SCENARIO ASSUMPTIONS

Scenarios				
Cases	Technology Costs	Performance	Electricity Rates	Other
Base Case	• See technology and cost section	• As modeled	• Increase at inflation rate, assumed at 2.0%	• Assumes the net metering cap is achieved. Solar PV adoption forecast was adjusted in 2019 and 2020 to reflect this. • Adoption in all other years is based on customer economics.
Low Penetration	• PV: Years 1-10: Same as Base Case • Years 11+: Rate of decline is 25% lower than base case • Other: Mature technologies. Same as base case	• PV: Same as Base Case • Other: 5% worse	• Increases at 1.6%, 0.4%/year lower than the Base Case	• Assumes adoptions in based on customer economics for all years.
High Penetration	• PV: Years 1-10: Same as Base Case • Years 11+: rate of decline is 50% higher than base case • Other: Mature technologies. Same as base case	• Reciprocating Engines: 0.5% better (mature) • Micro-turbines: 2% better • Hydro: 5% better (reflecting wide performance distribution uncertainty) • PV/Wind: 1% better (relatively mature)	• Increases at 2.4%, 0.4%/year higher than the Base Case	• Assumes the net metering cap is achieved. Solar PV adoption forecast was adjusted in 2019 and 2020 to reflect this. • Adoption in all other years is based on customer economics.

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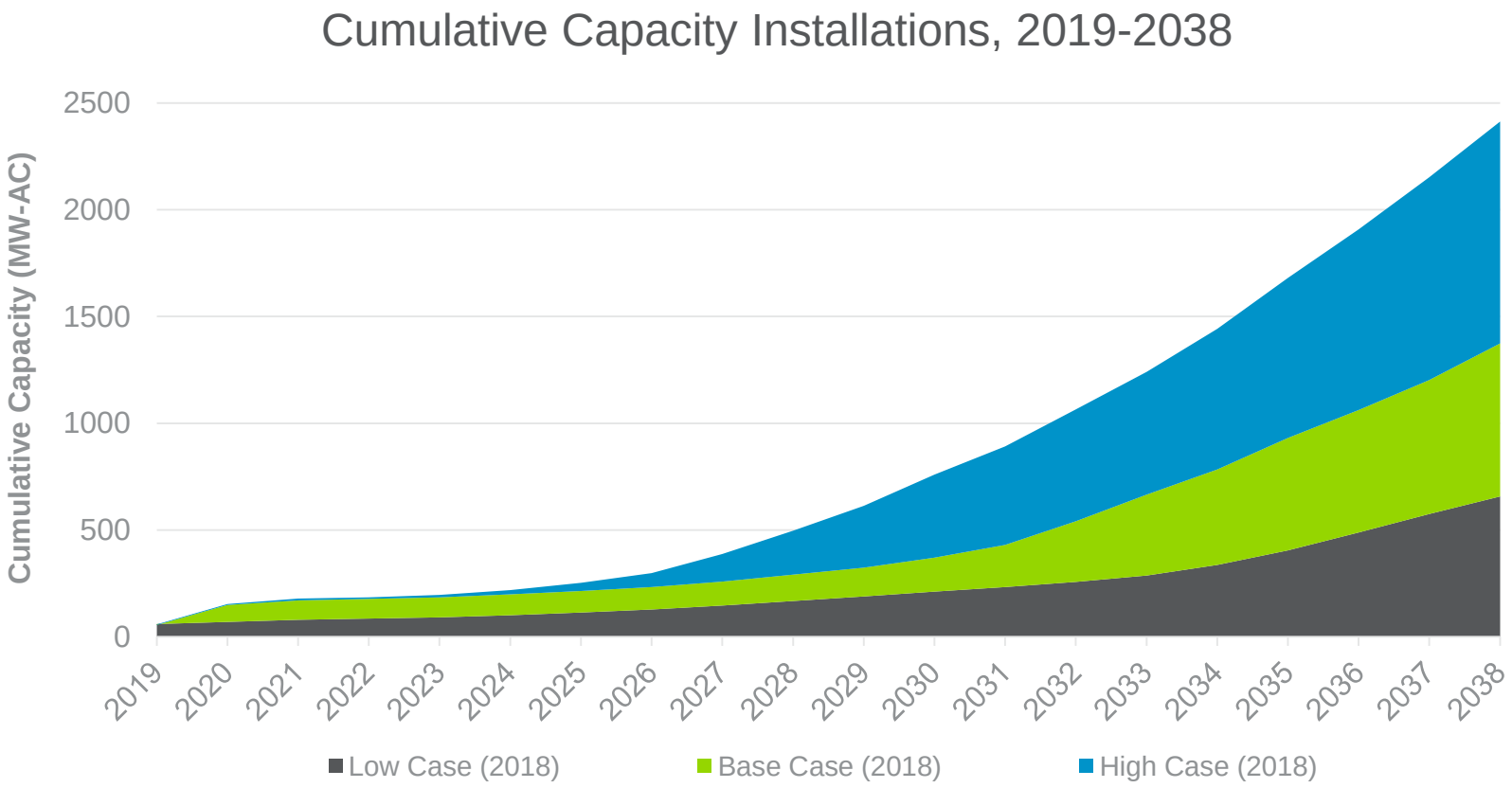
PRIVATE GENERATION – ALL CASES AND STATES



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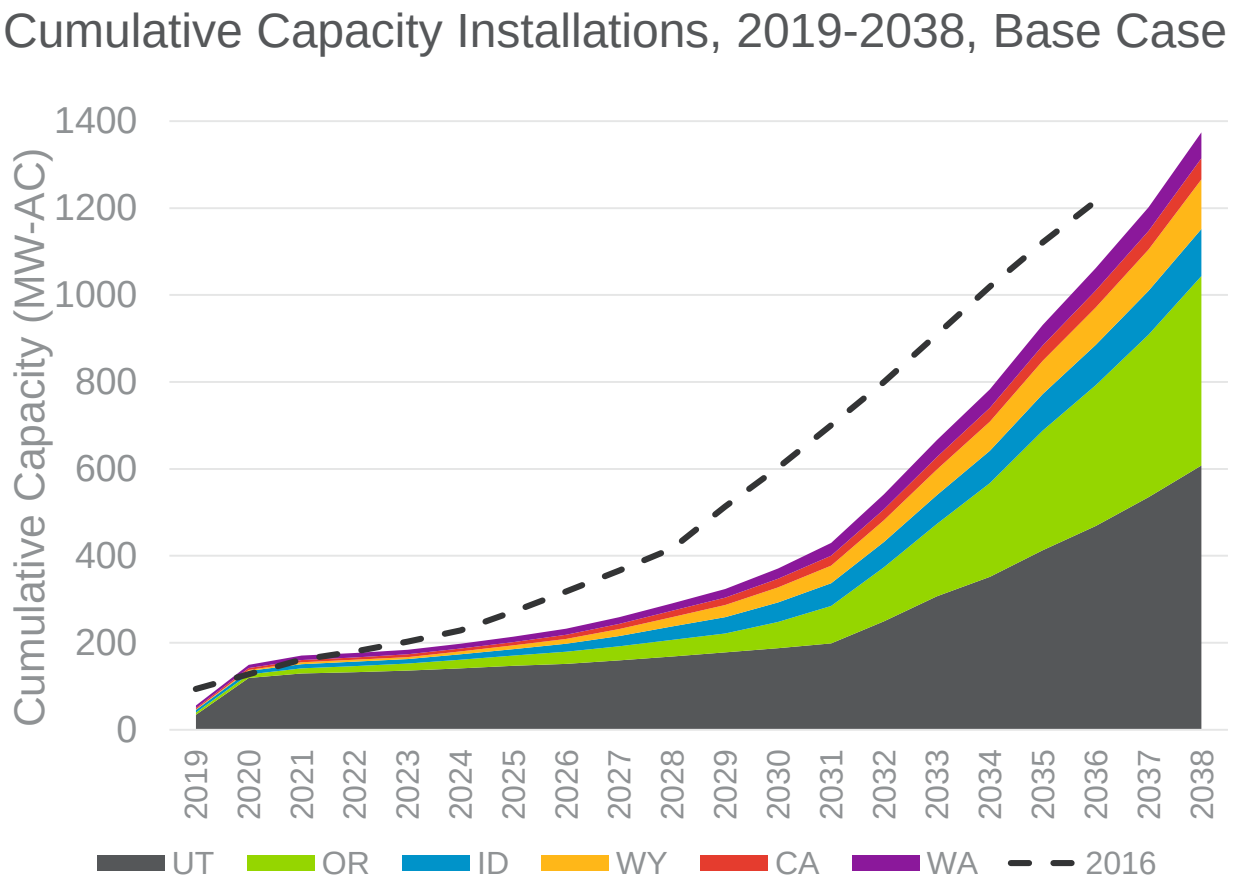
PRIVATE GENERATION – BASE CASE



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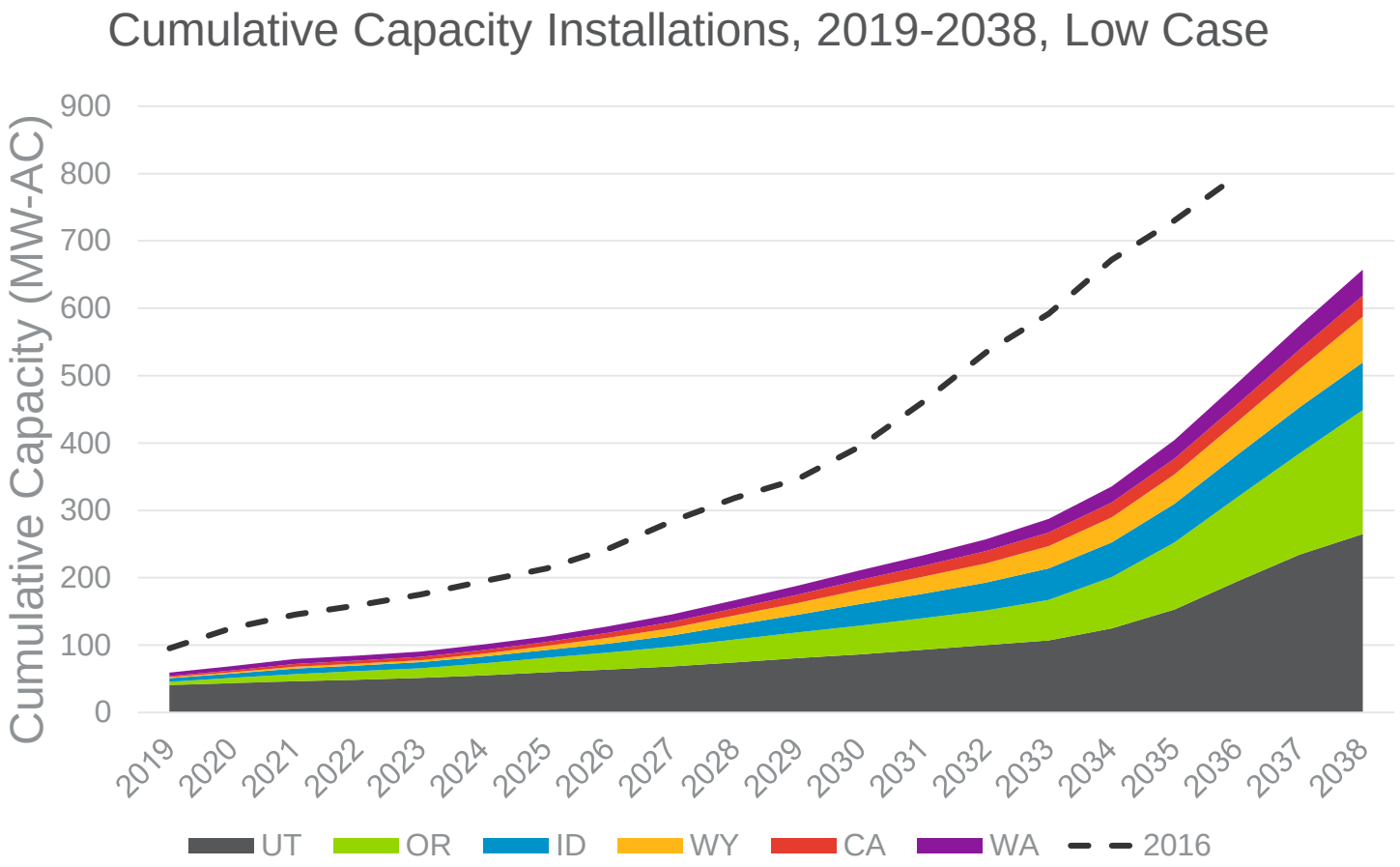
PRIVATE GENERATION – LOW CASE



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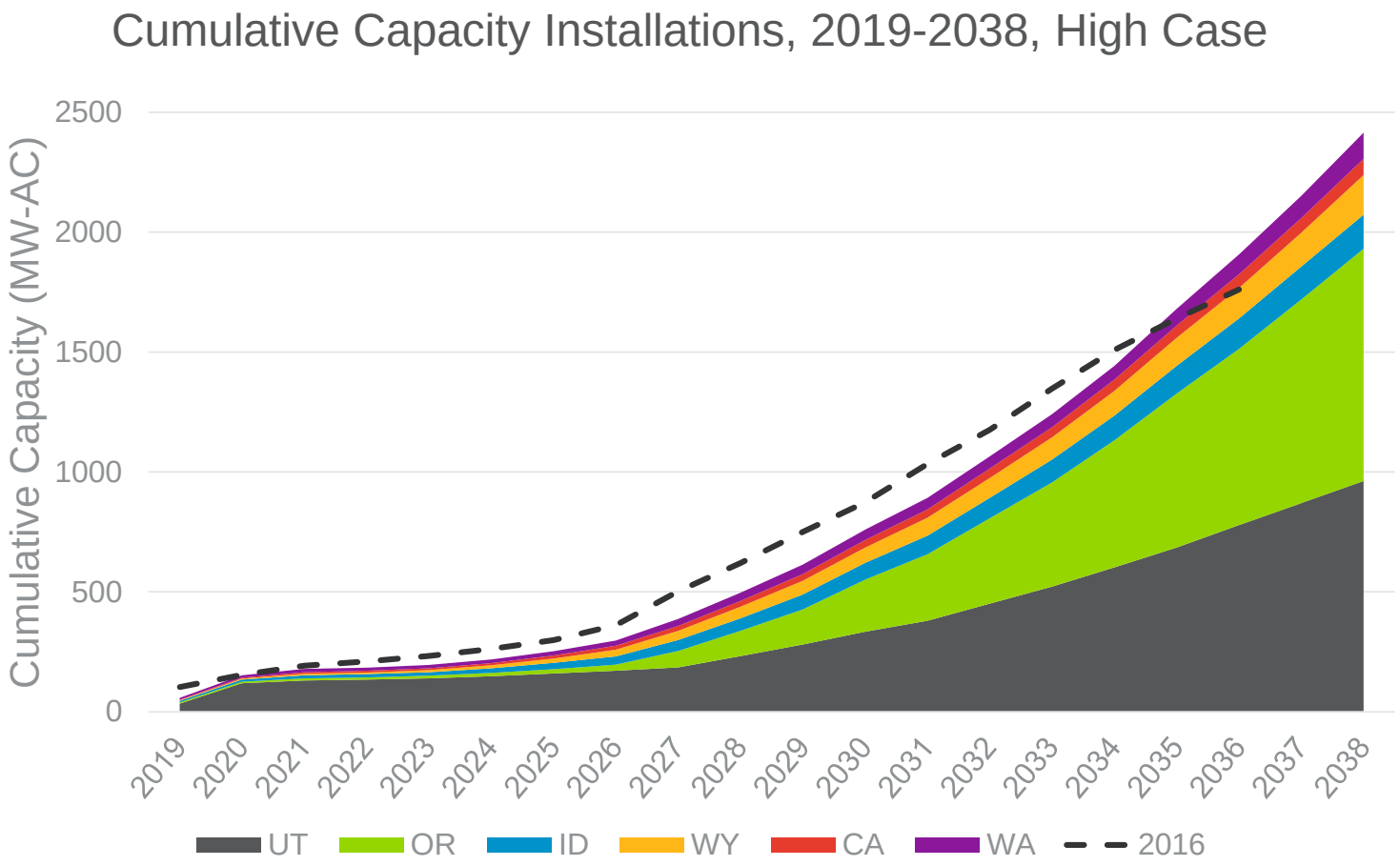
PRIVATE GENERATION – HIGH CASE



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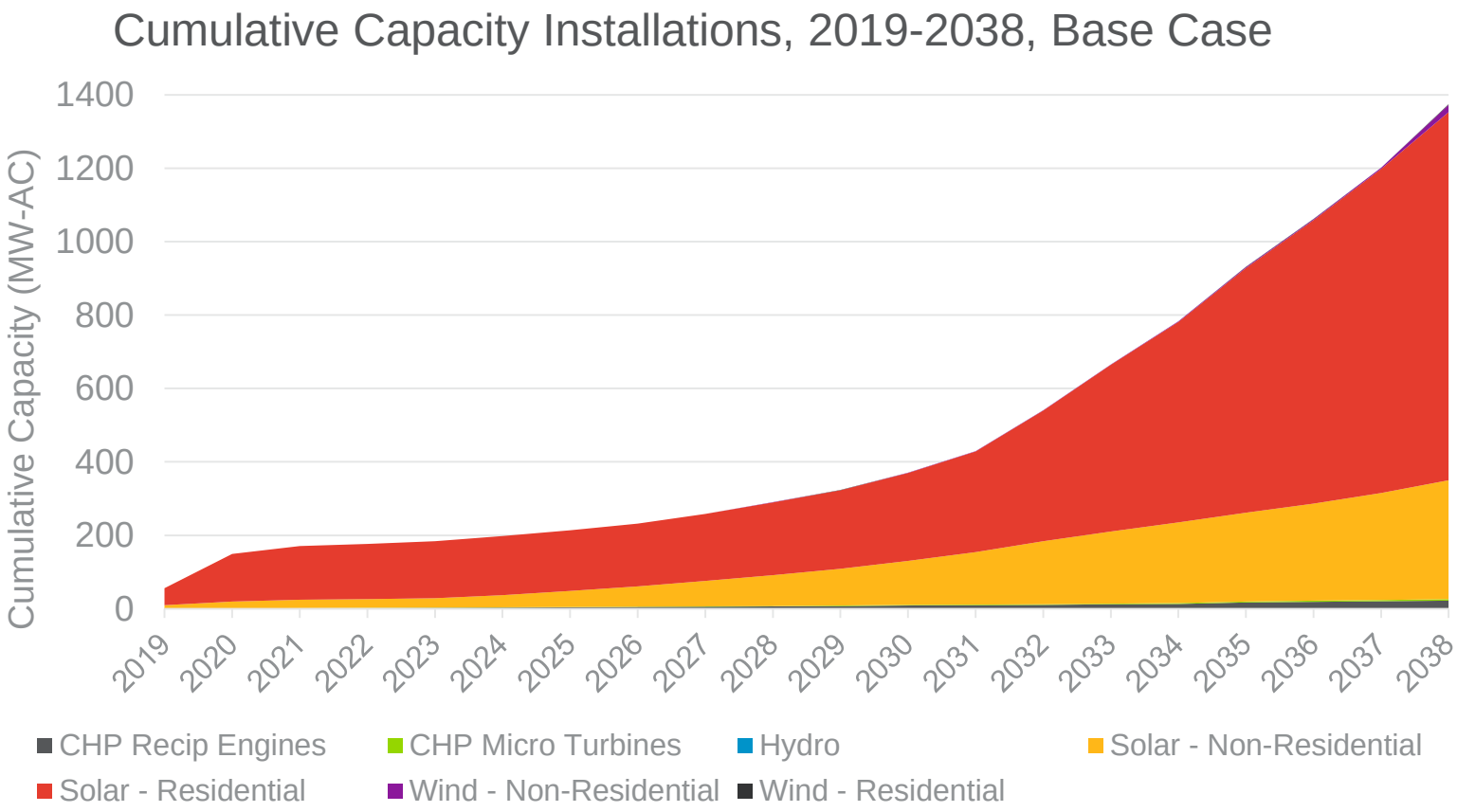
PRIVATE GENERATION – BASE CASE



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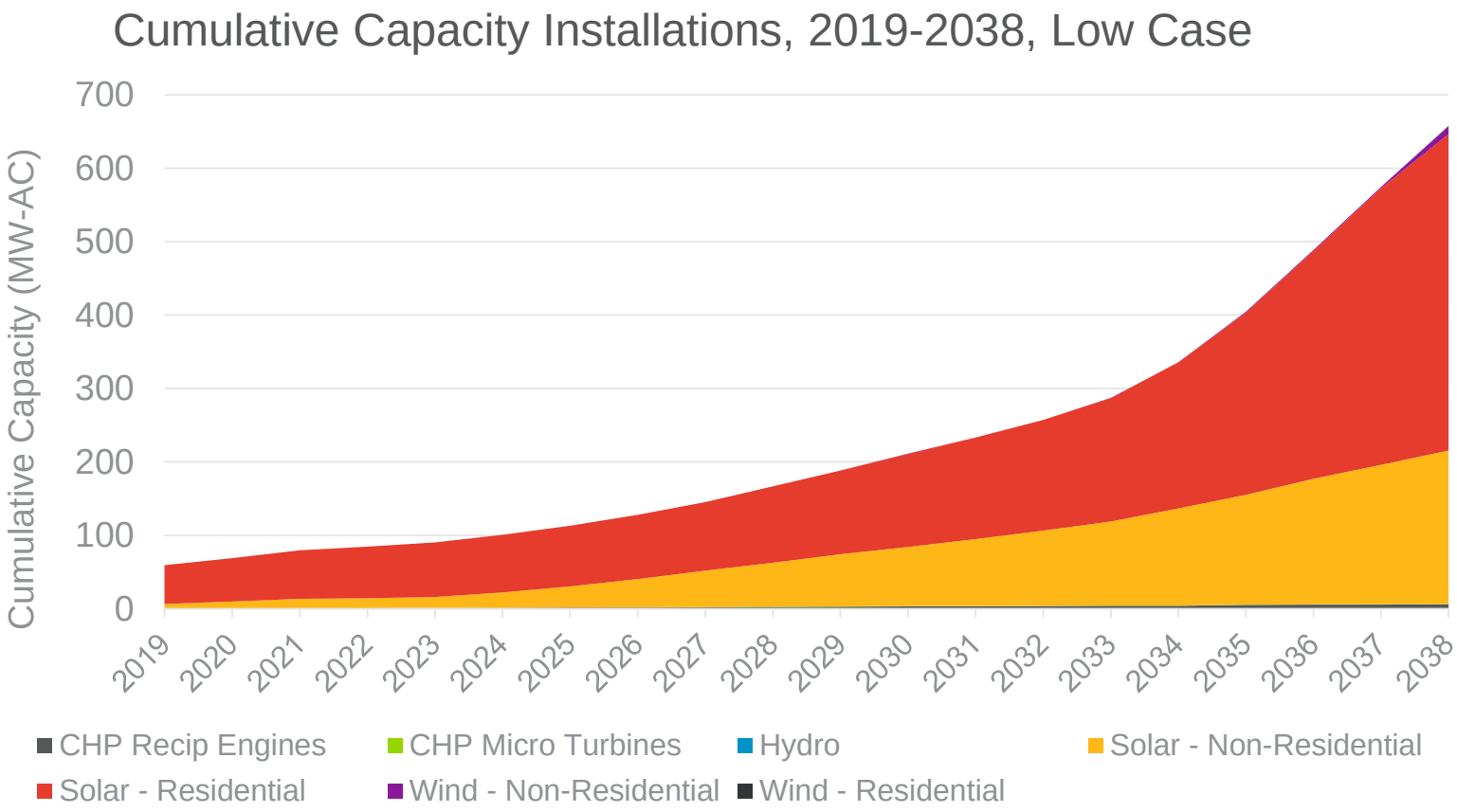
PRIVATE GENERATION – LOW CASE



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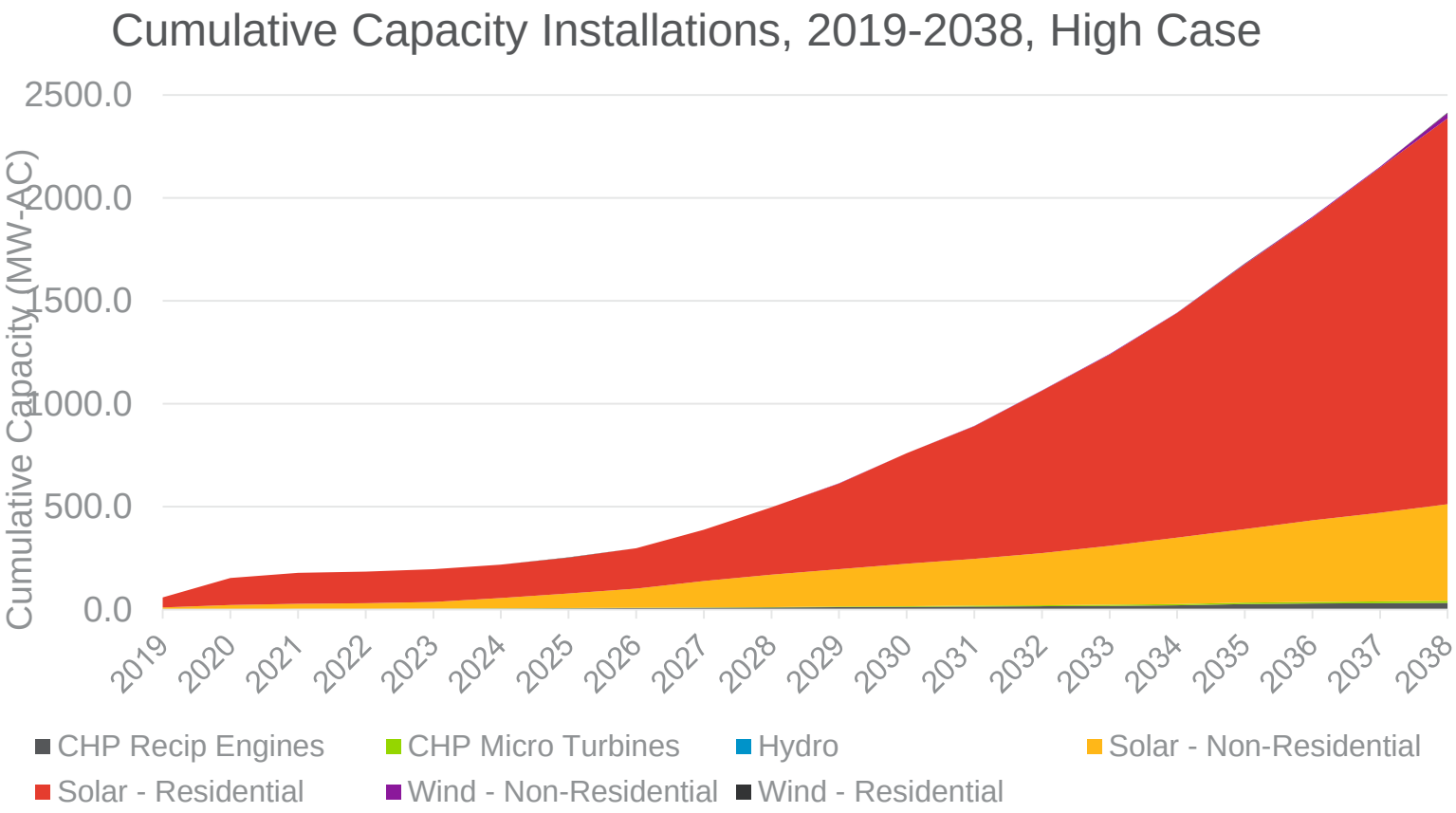
PRIVATE GENERATION – HIGH CASE



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COMPARISON TO 2016 STUDY

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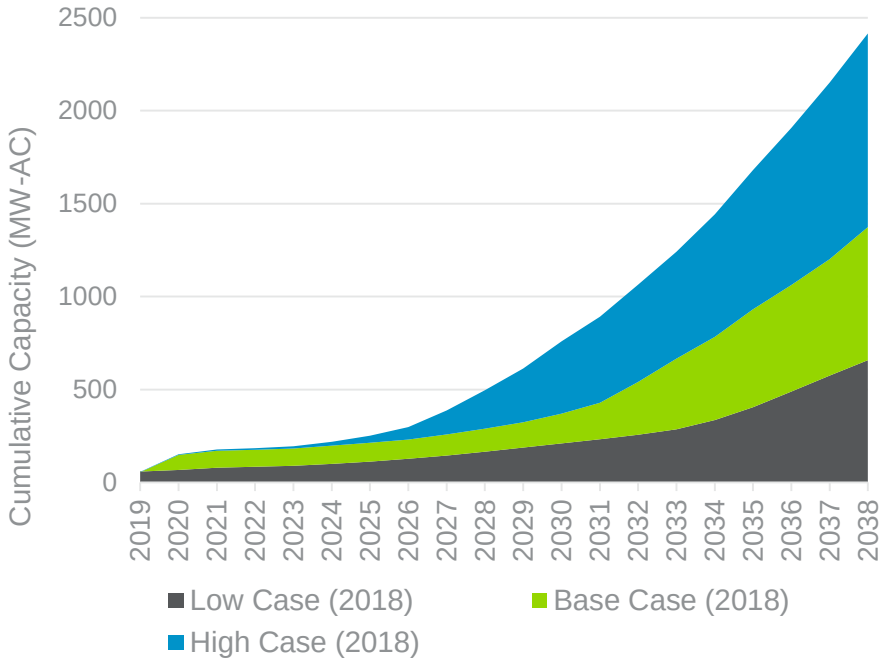
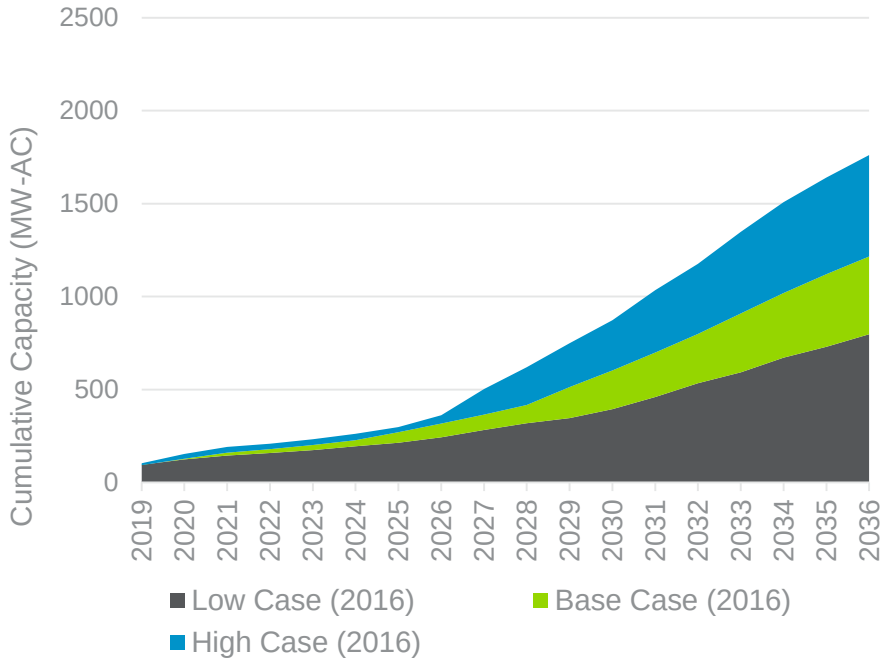
COMPARISON TO 2016 STUDY RESULTS

Since the 2016 study, projected PV capacity is expected to grow at a slower rate in the early years and at a faster rate towards the end of the forecast period. The main reasons include policy changes and costs declines, especially for solar PV.

Cumulative Market Penetration Results by Scenario (MW-AC), 2019 – 2038, Base Case (2018 Study)



Cumulative Market Penetration Results by Scenario (MW-AC), 2019 – 2038, Base Case (2016 Study)



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COMPARISON TO 2016 STUDY RESULTS

State	Estimated Adoption Change	Key Adoption Drivers
CA	**2036** – Market increased from 20 MW to 40 MW	• Rates: Increase (residential, commercial, industrial) • Solar PV Cost: Declines in the later years are more sustained • Policy: New mandatory solar for new building is included in the analysis
ID	**2036** – Market increased from 40 MW to 90 MW, primarily in the residential sector	• Rates: Increase (residential, commercial, industrial) • Solar PV Cost: Declines in the later years are more sustained • Policy: No change
OR	**2036** – Market remained relatively consistent, with adoption shifting to later years which seems reasonable given incentive declines offset by cost declines in future years	• Rates: Reduced net metering rates • Solar PV Cost: Declines in the later years are more sustained • Policy: Incentive and cap reduced for residential and C&I; Residential Energy Tax Credit – sunset in 2017
UT	**2036** – Market decreased from 800 MW to 470 MW. Decline seems reasonable given residential incentive declines, and commercial rate declines	• Rates: Decrease (commercial, irrigation) • Solar PV Cost: Declines in the later years are more sustained • Policy: Incentive for residential solar PV reduced from $2000 to $1600 in 2019 declining to $400 in 2023 and beyond; NEM reduction to around 90% of full rates • The report reflects the regulatory modifications to the PG program in Utah, as included in Schedule 136 (Utah Docket 14-035-114)
WA	**2036** – Market increased from 25 MW to 50 MW	• Rates: Small changes only • Solar PV Cost: Declines in the later years are more sustained • Policy: Solar and wind FiT reduced rate for an 8 year period
WY	**2036** – Market increased from 40 MW to 85 MW	• Rate: Small changes only • Solar PV Cost: Declines in the later years are more sustained • Policy: None

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APPENDIX

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FEDERAL INCENTIVES

Technology	2019	2020	2021	2022	2023	>2023
Recip. Engines	10%	10%	10%	0%	0%	0%
Micro Turbines	10%	10%	10%	0%	0%	0%
Small Hydro	0%	0%	0%	0%	0%	0%
PV - Com	30%	26%	22%	10%	10%	10%
PV - Res	30%	26%	22%	0%	0%	0%
Wind - Com	12%	0%	0%	0%	0%	0%
Wind - Res	30%	26%	22%	22%	0%	0%

Federal Investment Tax credit, http://energy.gov/savings/business-energy-investment-tax-credit-itc

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STATE INCENTIVES - UT

Technology	2019	2020	2021	2022	2023	>2023
Recip. Engines (%)	10	10	10	10	10	10
Micro Turbines (%)	10	10	10	10	10	10
Small Hydro (%)	10	10	10	10	10	10
PV – Com (%)	10	10	10	10	10	10
PV – Res ($)*	$1,600	$1,600	$1,600	$1,200	$800	$400
Wind – Com (%)	10	10	10	10	10	10
Wind – Res ($)*	$1,200	$800	$400	$0	$0	$0

*Renewable Energy Systems Tax Credit, Program Cap: Residential cap = $2,000; commercial systems <660kW, no limit

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STATE INCENTIVES - CA

Technology	2019	2020	2021	2022	2023	>2023
Recip. Engines	0	0	0	0	0	0
Micro Turbines	0	0	0	0	0	0
Small Hydro	0	0	0	0	0	0
PV - Com	0	0	0	0	0	0
PV - Res	0	0	0	0	0	0
Wind - Com	0	0	0	0	0	0
Wind - Res	0	0	0	0	0	0

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STATE INCENTIVES - OR

Technology	2019	2020	2021	2022	2023	>2023
Recip. Engines	0	0	0	0	0	0
Micro Turbines	0	0	0	0	0	0
Small Hydro	0	0	0	0	0	0
PV – Com ($/W)	$0.50-$0.20/W	$0.50-$0.20/W	$0.50-$0.20/W	$0.50-$0.20/W	$0.50-$0.20/W	$0.50-$0.20/W
PV – Res ($/W)	$0.55/W	$0.55/W	$0.55/W	$0.55/W	$0.55/W	$0.55/W
Wind – Com ($/kWh)	0	0	0	0	0	0
Wind – Res ($)	0	0	0	0	0	0

* Energy Trust of Oregon Solar Incentive (capped at $1.5M/year for residential)

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STATE INCENTIVES - WA

Technology	2019	2020	2021	2022	2023	>2023
Recip. Engines	0	0	0	0	0	0
Micro Turbines	0	0	0	0	0	0
Small Hydro	0	0	0	0	0	0
PV – Com ($/kWh)*	$0.04 (+$0.04)	$0.02 (+$0.03)	$0.02 (+$0.02)	0	0	0
PV – Res ($/kWh)*	$0.14 (+$0.04)	$0.12 (+$0.03)	$0.10 (+$0.02)	0	0	0
Wind – Com ($/kWh)*	$0.04 (+$0.04)	$0.02 (+$0.03)	$0.02 (+$0.02)	0	0	0
Wind – Res ($/kWh)*	$0.14 (+$0.04)	$0.12 (+$0.03)	$0.10 (+$0.02)	0	0	0

* Feed-in Tariff: $/kWh for all kWh generated through mid-2020; annually capped at $5,000/year, http://programs.dsireusa.org/system/program/detail/5698

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STATE INCENTIVES - WY

Technology	2019	2020	2021	2022	2023	>2023
Recip. Engines	0	0	0	0	0	0
Micro Turbines	0	0	0	0	0	0
Small Hydro	0	0	0	0	0	0
PV - Com	0	0	0	0	0	0
PV - Res	0	0	0	0	0	0
Wind - Com	0	0	0	0	0	0
Wind - Res	0	0	0	0	0	0

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STATE INCENTIVES - ID

Technology	2019	2020	2021	2022	2023	>2023
Recip. Engines	0	0	0	0	0	0
Micro Turbines	0	0	0	0	0	0
Small Hydro	0	0	0	0	0	0
PV - Com	0	0	0	0	0	0
PV – Res (%)*	40,20,20,20	40,20,20,20	40,20,20,20	40,20,20,20	40,20,20,20	40,20,20,20
Wind – Com	0	0	0	0	0	0
Wind – Res (%)*	40,20,20,20	40,20,20,20	40,20,20,20	40,20,20,20	40,20,20,20	40,20,20,20

* Residential Alternative Energy Income Tax Deduction: 40% in the first year and 20% for the next three years, http://programs.dsireusa.org/system/program/detail/137

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