2023 Electric Integrated Resource Plan

Technical Advisory Committee Meeting No. 6 Agenda

Wednesday, September 28, 2022

Microsoft Teams Virtual Meeting

Topic	Time	Staff
Introductions	12:30	John Lyons
Supply Side Resource Cost Assumptions, including DER	12:40	IRP Team
Variable Energy Resource Integration Study Update,	1:45	Lori Hermanson
Break		
All-Source RFP Update	2:30	Chris Drake
Global Climate Change Studies, Impacts to Avista Loads & Resources	2:45	Mike Hermanson
Adjourn	4:00	

IRP Introduction

2023 Avista Electric IRP

TAC 6 – September 28, 2022

John Lyons, Ph.D. Senior Resource Policy Analyst

Meeting Guidelines

- IRP team is working remotely and is available for questions and comments
- Stakeholder feedback form
  - Responses shared with TAC at meetings, by email and in Appendix
  - Would a form and/or section on the web site be helpful?
- IRP data posted to web site – updated descriptions and navigation are in development
- Virtual IRP meetings on Microsoft Teams until able to hold large meetings again
- TAC presentations and meeting notes posted on IRP page
- This meeting is being recorded and an automated transcript made

Virtual TAC Meeting Reminders

- Please mute mics unless commenting or asking a question
- Raise hand or use the chat box for questions or comments
- Respect the pause
- Please try not to speak over the presenter or a speaker
- Please state your name before commenting
- Public advisory meeting – comments will be documented and recorded

Integrated Resource Planning

The Integrated Resource Plan (IRP):

- Required by Idaho and Washington* every other year
  - Washington requires IRP every four years and update at two years
- Guides resource strategy over the next twenty + years
- Current and projected load & resource position
- Resource strategies under different future policies
  - Generation resource choices
  - Conservation / demand response
  - Transmission and distribution integration
  - Avoided costs
- Market and portfolio scenarios for uncertain future events and issues

Technical Advisory Committee

- Public process of the IRP – input on what to study, how to study, and review of assumptions and results
- Wide range of participants involved in all or parts of the process
  - Please ask questions
  - Always soliciting new TAC members
- Open forum while balancing need to get through topics
- Welcome requests for new studies or different modeling assumptions.
- Available by email or phone for questions or comments between meetings
- Due date for study requests from TAC members – October 1, 2022
- External IRP draft released to TAC – March 17, 2023, public comments due – May 12, 2023
- Final 2023 IRP submission to Commissions and TAC – June 1, 2023

Remaining 2023 Electric IRP TAC Meeting Schedule

- TAC 7: October 11, 2022, 9 am – 3:30 pm
- Technical Modeling Workshop: October 20, 2022
- Washington Progress Report Workshop: December 14, 2022
- TAC 8: February 16, 2023
- Public Meeting Gas & Electric IRPs: March 8, 2023
- TAC 9: March 22, 2023

Today's Agenda

12:30	Introductions, John Lyons
12:40	Supply Side Resource Cost Assumptions, Avista IRP Team
1:45	Variable Energy Resource Integration Study Update, Lori Hermanson
	Break
2:30	All-Source RFP Update, Chris Drake
2:45	Global Climate Change Studies, Impacts to Avista Loads & Resources, Mike Hermanson
4:00	Adjourn

Supply Side Resource Options
Resources Considered

Avista IRP Team
Electric IRP, 6th Technical Advisory Committee Meeting
September 28, 2022

Inflation Reduction Act

Tom Pardee, Natural Gas Planning Manager
Electric IRP, 6th Technical Advisory Committee Meeting
September 28, 2022

IRA Overview

- Signed August 16, 2022, and became Public Law No: 117-169
- New “technology-neutral” clean electricity production and investment credits
- Extension and expansion of the renewable electricity production tax credit (PTC) and energy tax credit (ETC)
- Zero-emissions nuclear power production credit
- Clean hydrogen production credit
- Expansion of the credit for carbon capture and storage
- Energy manufacturing credits

IRA Details

- $14,000 in direct consumer rebates for heat pumps or other energy efficient home appliances ($2,000 annual credit against tax liability)

- Up to $7,500 in tax credits for new electric vehicles and $4,000 for used electric vehicles

- Production Tax Credits
  - (Geothermal, Wind and Biomass)
  - $0.026 per kWh tax credit
  - Nuclear
  - $0.015 per kWh tax credit plus $0.003 base credit ($0.018 total per kWh credit)

- Investment Tax Credit (Battery Storage, Pumped Hydro, Solar)
  - Costs incurred in 2022 and 2032 qualify for a 30% tax credit
  - Credit falls to 26% in 2033, 22% in 2034, 10% in 2035/2036, and 0% in 2037
  - Extends to battery storage
  - Additional 10% low-income tax credit
  - Domestic production at 10%

https://www.congress.gov/bill/117th-congress/house-bill/5376/text

Not Modeled

- Renewable Natural Gas (RNG)
- Carbon Capture
- Synthetic Methane
- Biodiesel
- Non-Commercial Technologies

Modeled But Covered in TAC 7

- Ammonia
- Hydrogen

Supply Side Resource Options

Resources Considered

Michael Brutocao, Natural Gas Analyst

Electric IRP, 6th Technical Advisory Committee Meeting

September 28, 2022

Overview & Considerations

- The assumptions discussed are “today’s” estimates – likely to be periodically revised.
- IRP supply-side resources are commercially available technologies with potential for development within or near Avista service territory.
- Resource costs vary depending on location, equipment, fuel prices and ownership; while IRPs use point estimates, actual costs will be different.
- Certain resources will be modeled as purchase power agreements (PPA) while others will be modeled as Avista “owned”. These assumptions do not mean they are the only means of resource acquisition.
- No transmission or interconnection costs are included at this time.
  - Interconnect included for off-system resources.
- An Excel file has been distributed with all resources, assumptions and cost calculations for TAC members to review and provide feedback.

Proposed Natural Gas Resource Options

Peakers

- Simple Cycle Combustion Turbine (CT)
  - CT Frame
  - 180 MW

- Reciprocating Engines
  - 185 MW

Baseload

- Combined Cycle CT (CCCT)
  - 312 MW (1x1 w/DF)

Natural gas turbines are modeled using a 30-year life with Avista ownership

Renewable Resource Options - Solar

All Purchase Power Agreement (PPA) Options

Solar

- Residential (6 kW AC)
  - New & existing
  - With & without battery
- Commercial (1 MW AC)
  - With & without battery
- Fixed PV Array (5 MW AC)
  - With & without battery
- On-System Single Axis Tracking Array (100 MW AC)
  - With & without 100 MW 4-hour lithium-ion battery
  - With 100 MW 2-hour lithium-ion battery
  - With 50 MW 4-hour lithium-ion battery
- Off-system Single Axis Tracking Array (100 MW AC) located in southern PNW

Renewable Resource Options - Wind

All Purchase Power Agreement (PPA) Options

Wind

- On-system wind (100 MW)
- Off-system wind (100 MW)
- Montana wind (100 MW)
- Offshore wind (100 MW)
  - Share of a larger project

Other "Clean" Resource Options

- Geothermal PPA (20 MW)
  - Off-system PPA
- Biomass (58 MW)
  - i.e. Kettle Falls 3 or other
- Nuclear PPA (100 MW)
  - Off-system PPA share of a mid-size facility
- Renewable Hydrogen
  - Fuel Cell (25 MW)
- Ammonia (74 MW)
  - Natural Gas Turbine

Storage Technologies

Lithium-Ion

- Assumes: 86% round trip efficiency (RTE), 15-year operating life
- Assumes Avista ownership
- 5 MW Distribution Level
  - 4 hours (20 MWh)
  - 8 hours (40 MWh)
- 25 MW Transmission Level
  - 4 hours (100 MWh)
  - 8 hours (200 MWh)
  - 16 hours (400 MWh)

Other Storage Options

- Assumes Avista ownership
- 25 MW Vanadium Flow (70% RTE)
  - 4 hours (100 MWh)
- 25 MW Zinc Bromide Flow (67% RTE)
  - 4 hours (100 MWh)
- 25 MW Liquid Air (65% RTE)
  - 8 hours (400 MWh)
- 100 MW Iron Oxide (65% RTE)
  - 100 hours
- 100 MW Pumped Hydro
  - 16/24 hours (1,600/2,400 MWh)
- 400 MW Pumped Hydro
  - 8.5 hours (3,400 MWh)

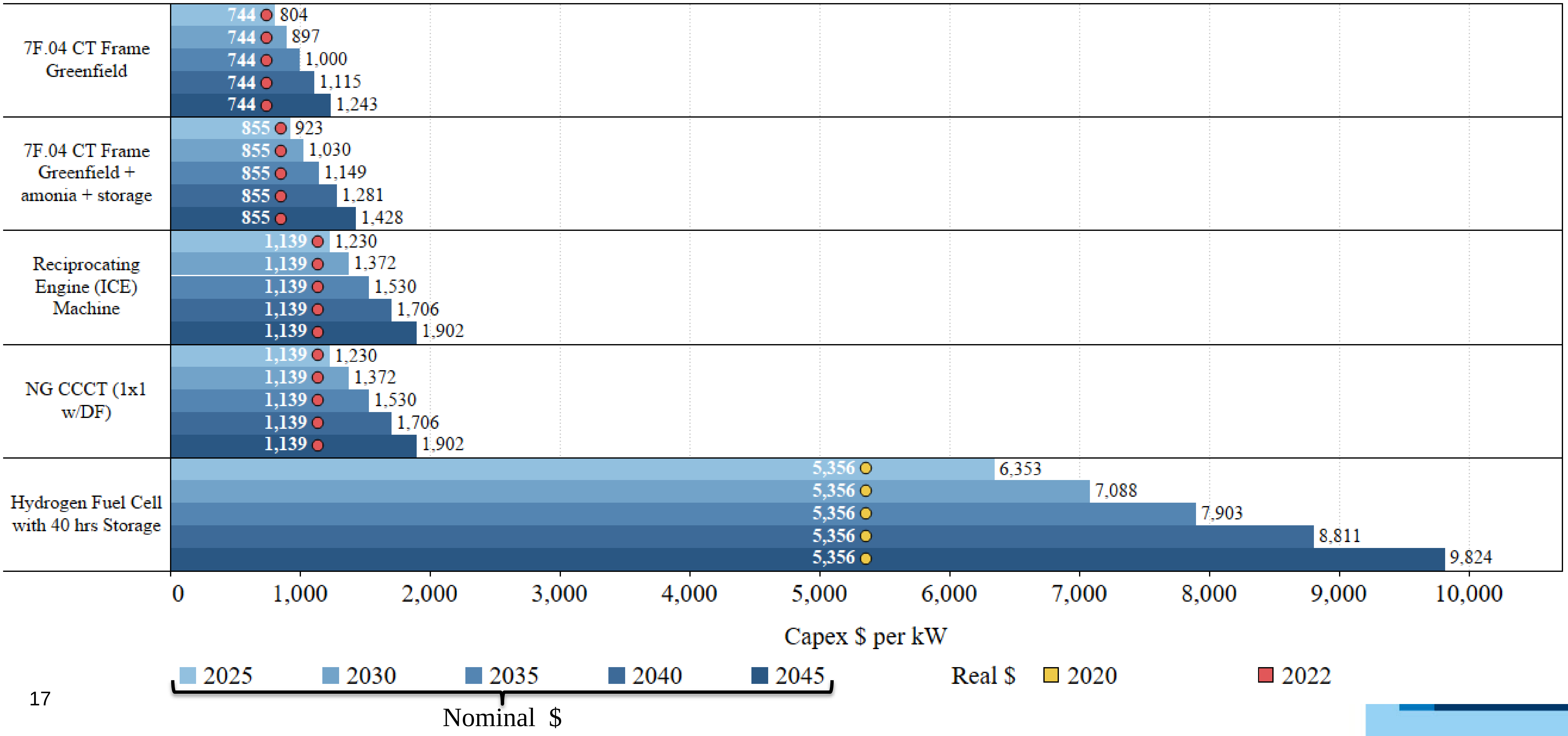
Resource Upgrades

- **Rathdrum CT** *[natural gas peaker]*
  - 5 MW by 2055 uprates
  - 10 MW Inlet Evaporation

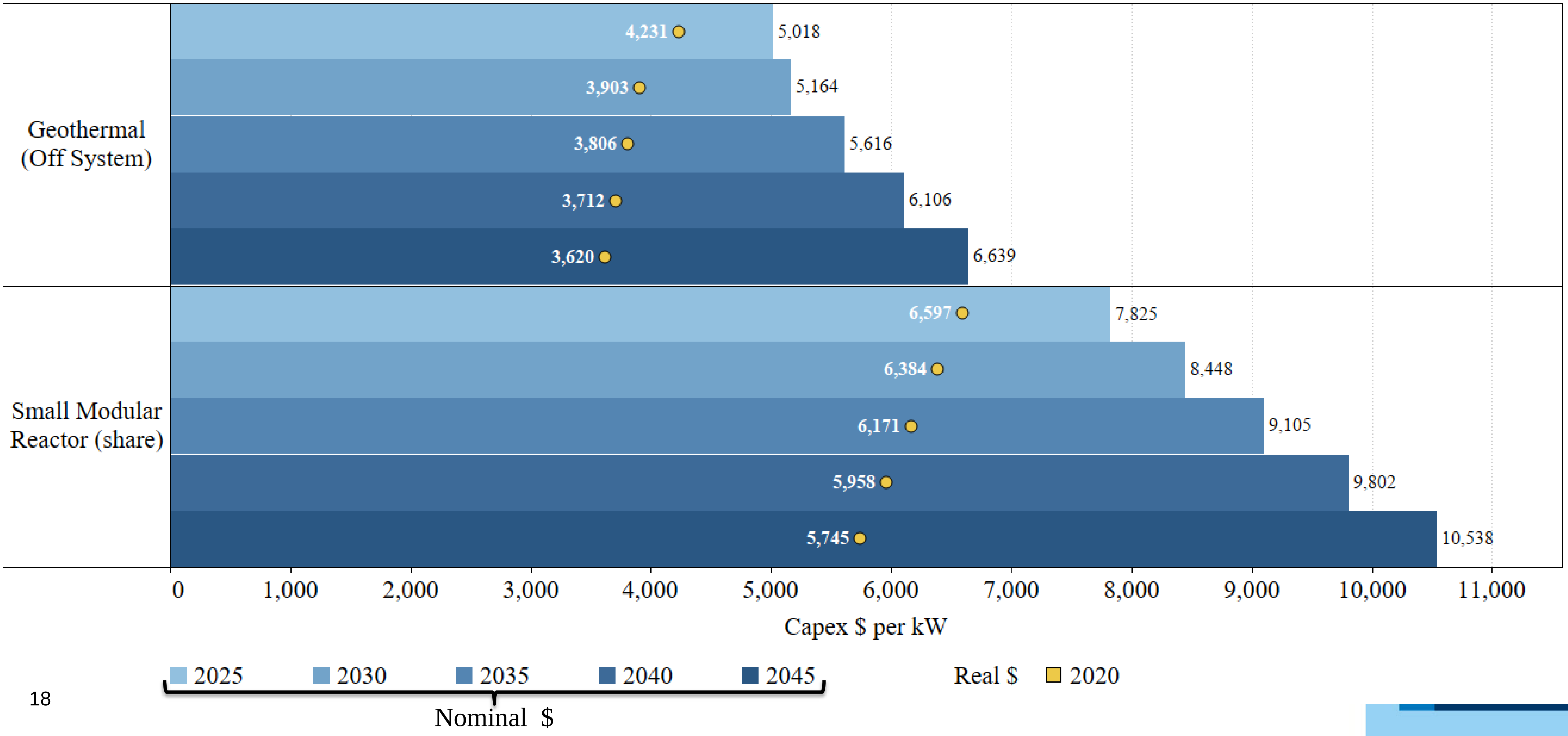
Supply Side Resource Options
Capital Costs

Michael Brutocao, Natural Gas Analyst
Electric IRP, 6th Technical Advisory Committee Meeting
September 28, 2022

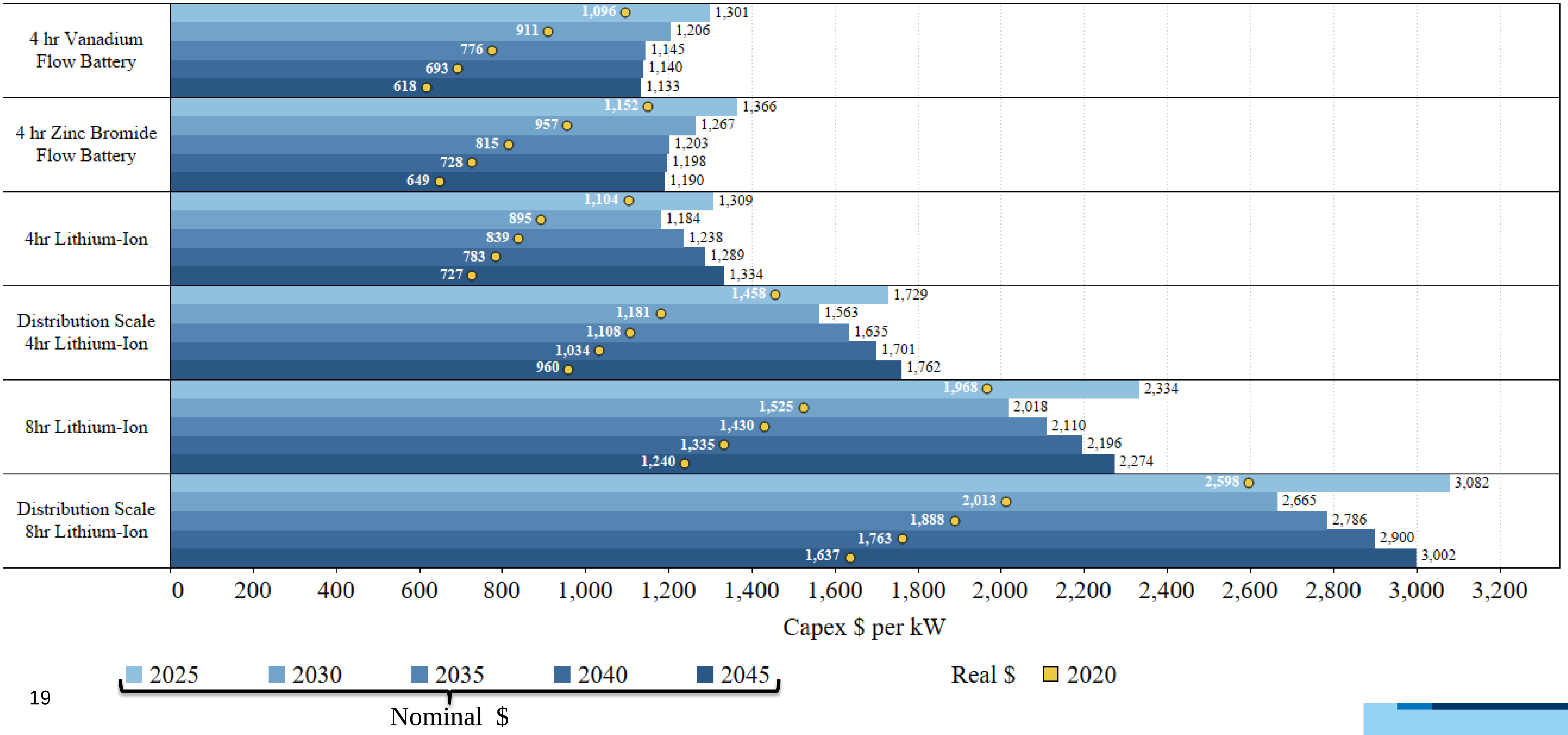
Fueled Generation



Geothermal & Nuclear

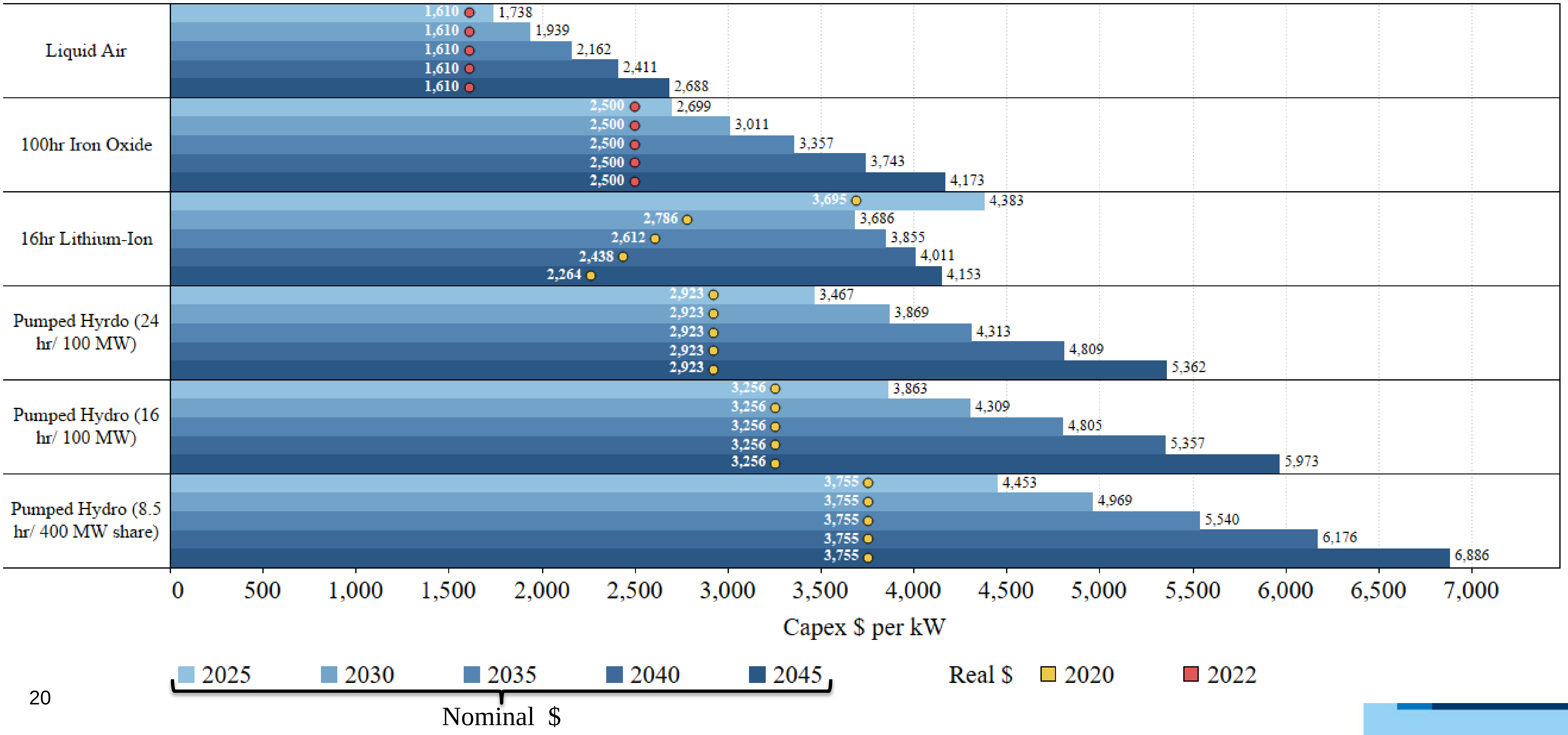


Storage

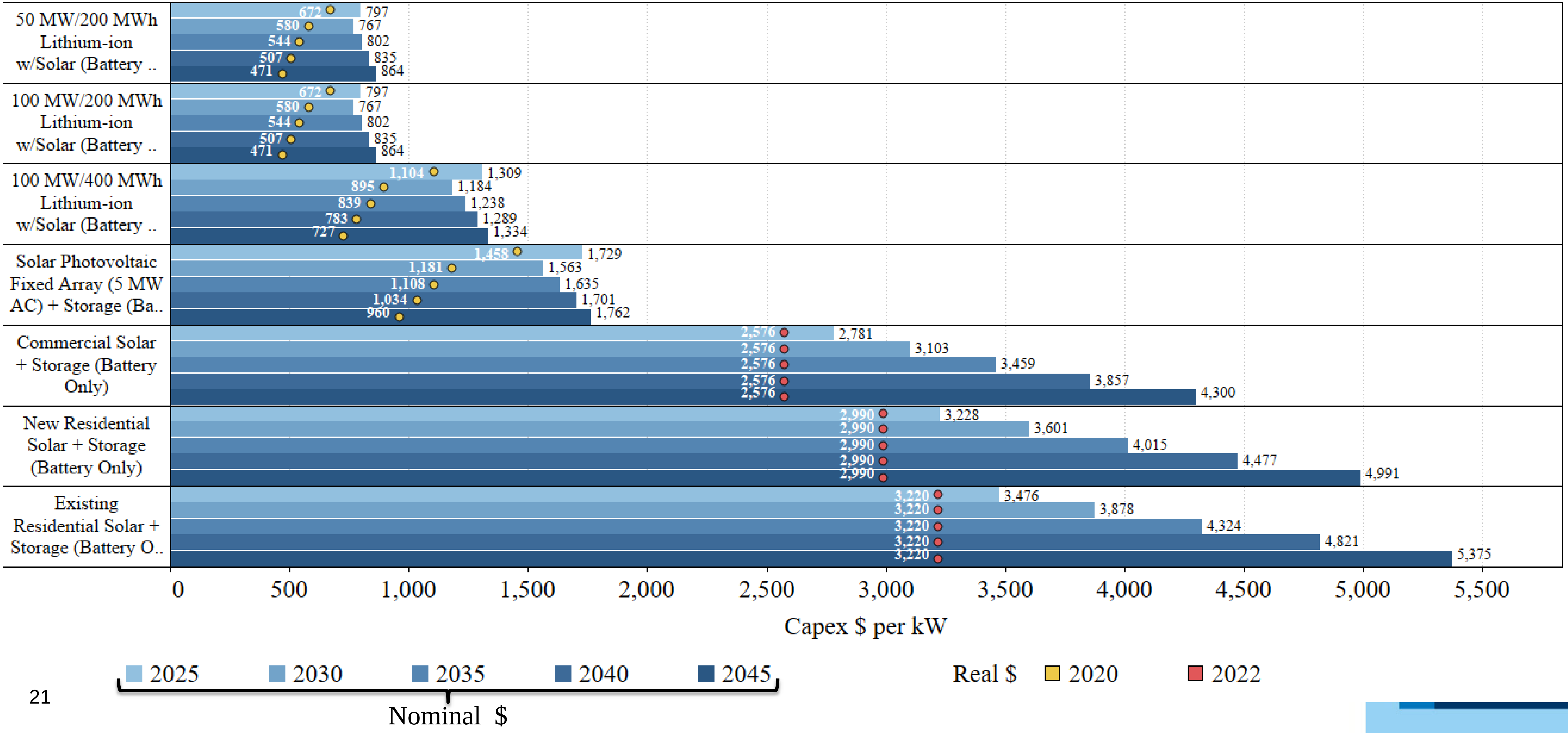


4 hr Vanadium Flow Battery
1,096 1,301
911 1,206
776 1,145
693 1,140
618 1,133
4 hr Zinc Bromide Flow Battery
1,152 1,366
957 1,267
815 1,203
728 1,198
649 1,190
4hr Lithium-Ion
1,104 1,309
895 1,184
839 1,238
783 1,289
727 1,334
Distribution Scale 4hr Lithium-Ion
1,458 1,729
1,181 1,563
1,108 1,635
1,034 1,701
960 1,762
8hr Lithium-Ion
1,968 2,334
1,525 2,018
1,430 2,110
1,335 2,196
1,240 2,274
Distribution Scale 8hr Lithium-Ion
2,598 3,082
2,013 2,665
1,888 2,786
1,763 2,900
1,637 3,002
0 200 400 600 800 1,000 1,200 1,400 1,600 1,800 2,000 2,200 2,400 2,600 2,800 3,000 3,200
Capex $ per kW
2025 2030 2035 2040 2045
Nominal $
Real $ 2020

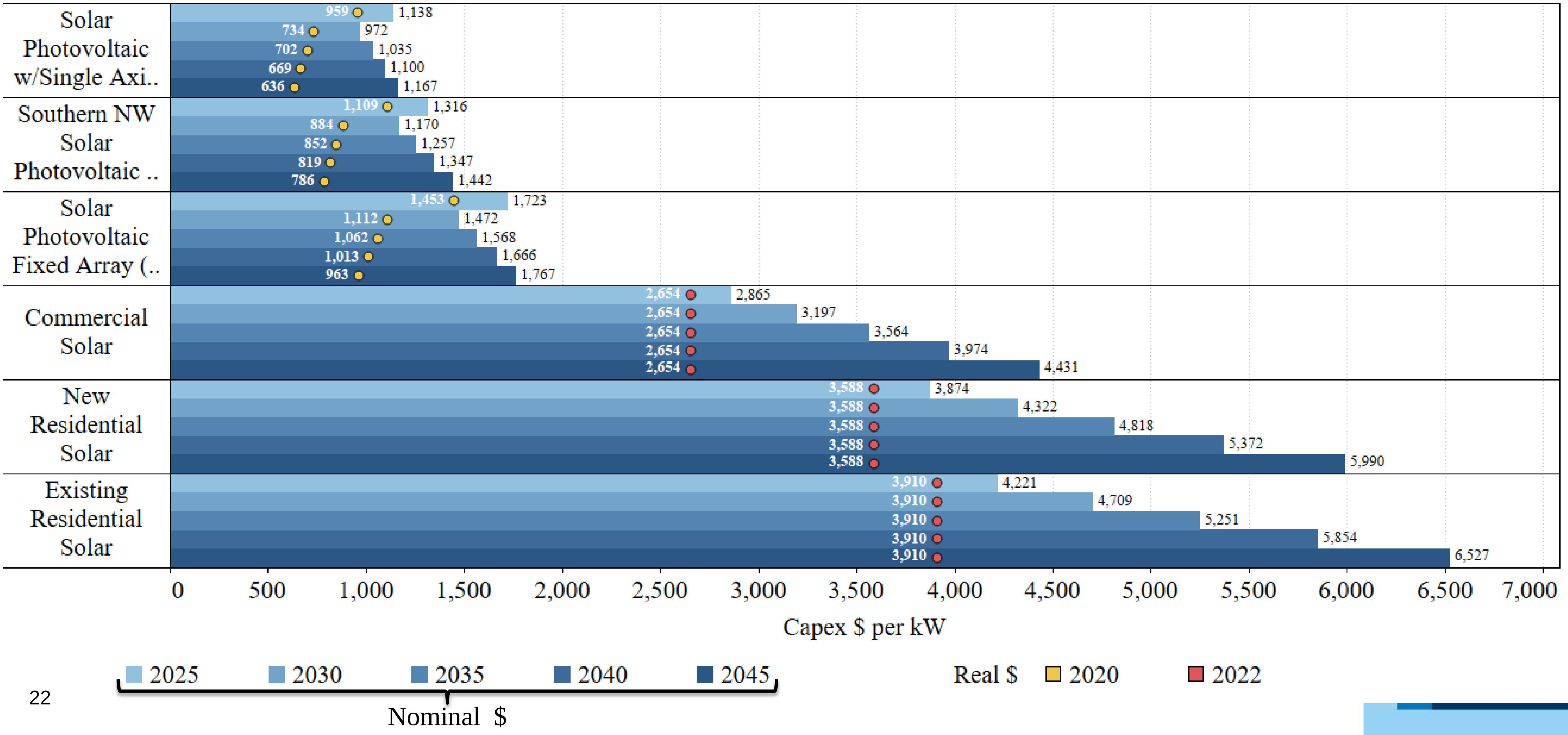
Storage Continued



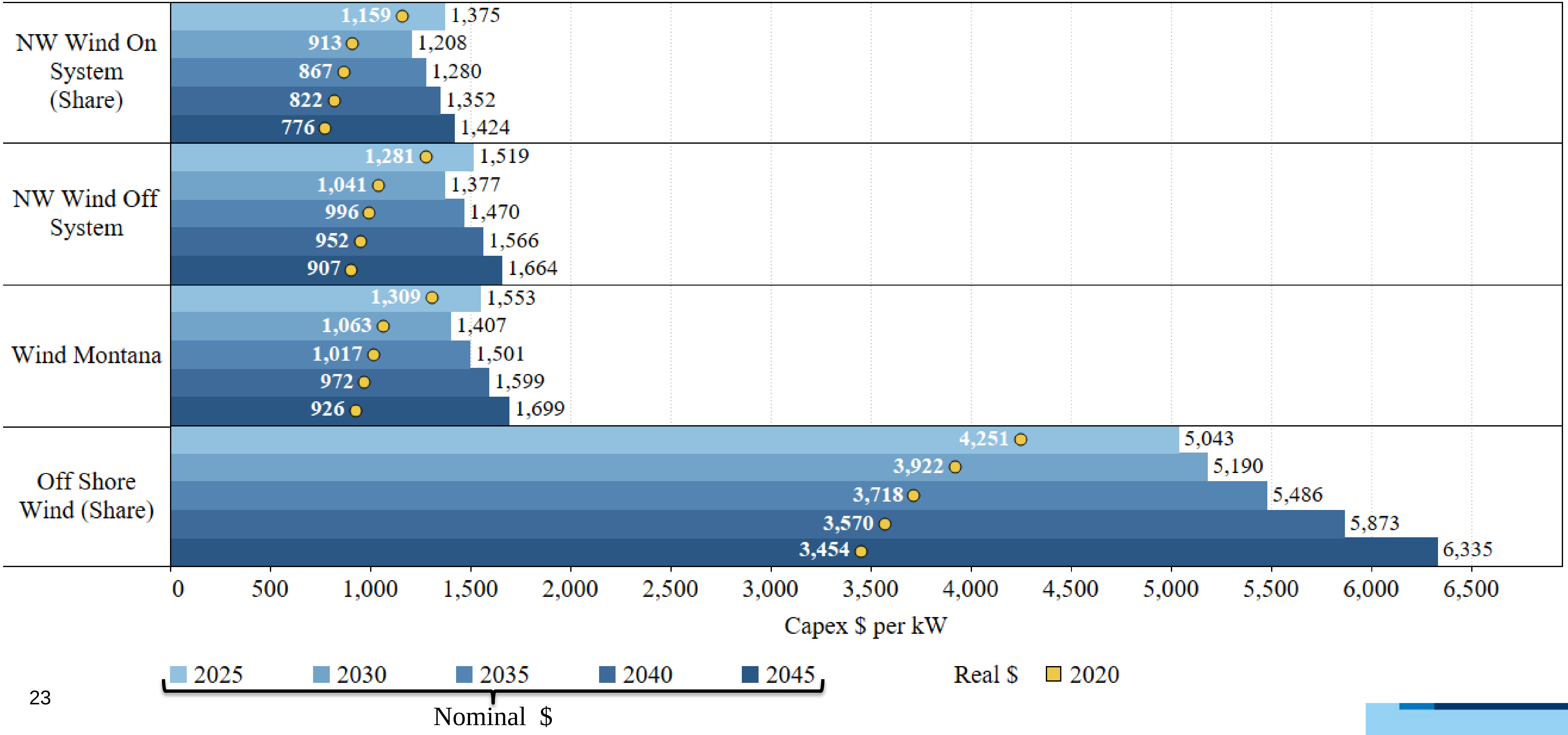
Solar + Storage



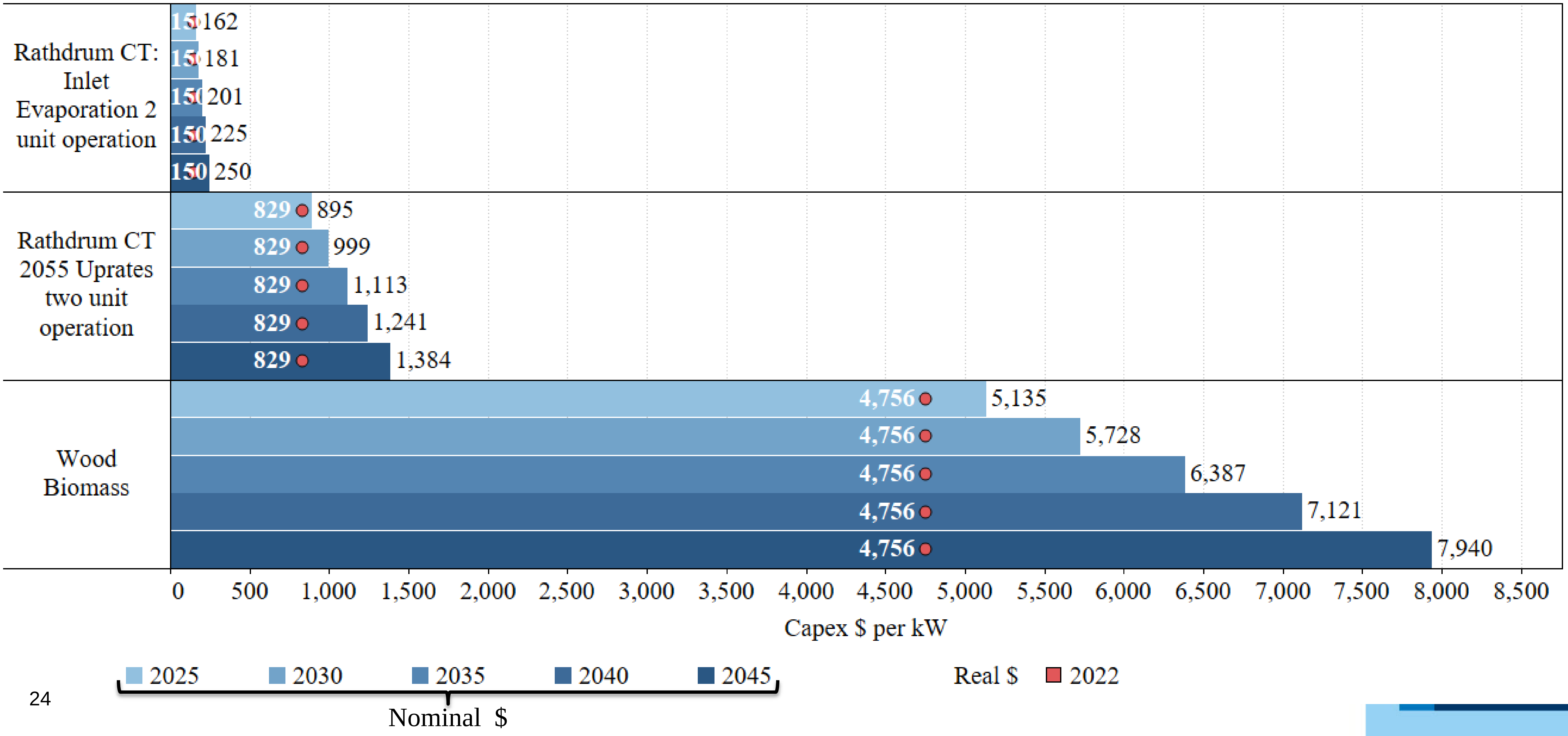
Solar PPA


Solar Photovoltaic w/Single Axi..
959 1,138
734 972
702 1,035
669 1,100
636 1,167
Southern NW Solar Photovoltaic ..
1,109 1,316
884 1,170
852 1,257
819 1,347
786 1,442
Solar Photovoltaic Fixed Array (..
1,453 1,723
1,112 1,472
1,062 1,568
1,013 1,666
963 1,767
Commercial Solar
2,654 2,865
2,654 3,197
2,654 3,564
2,654 3,974
2,654 4,431
New Residential Solar
3,588 3,874
3,588 4,322
3,588 4,818
3,588 5,372
3,588 5,990
Existing Residential Solar
3,910 4,221
3,910 4,709
3,910 5,251
3,910 5,854
3,910 6,527
0 500 1,000 1,500 2,000 2,500 3,000 3,500 4,000 4,500 5,000 5,500 6,000 6,500 7,000
Capex $ per kW
2025 2030 2035 2040 2045
Nominal $
Real $ 2020 2022

Wind PPA


NW Wind On System (Share)
1,159
1,375
913
1,208
867
1,280
822
1,352
776
1,424
NW Wind Off System
1,281
1,519
1,041
1,377
996
1,470
952
1,566
907
1,664
Wind Montana
1,309
1,553
1,063
1,407
1,017
1,501
972
1,599
926
1,699
Off Shore Wind (Share)
4,251
5,043
3,922
5,190
3,718
5,486
3,570
5,873
3,454
6,335
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
6,500
Capex $ per kW
2025
2030
2035
2040
2045
Nominal $
Real $
2020

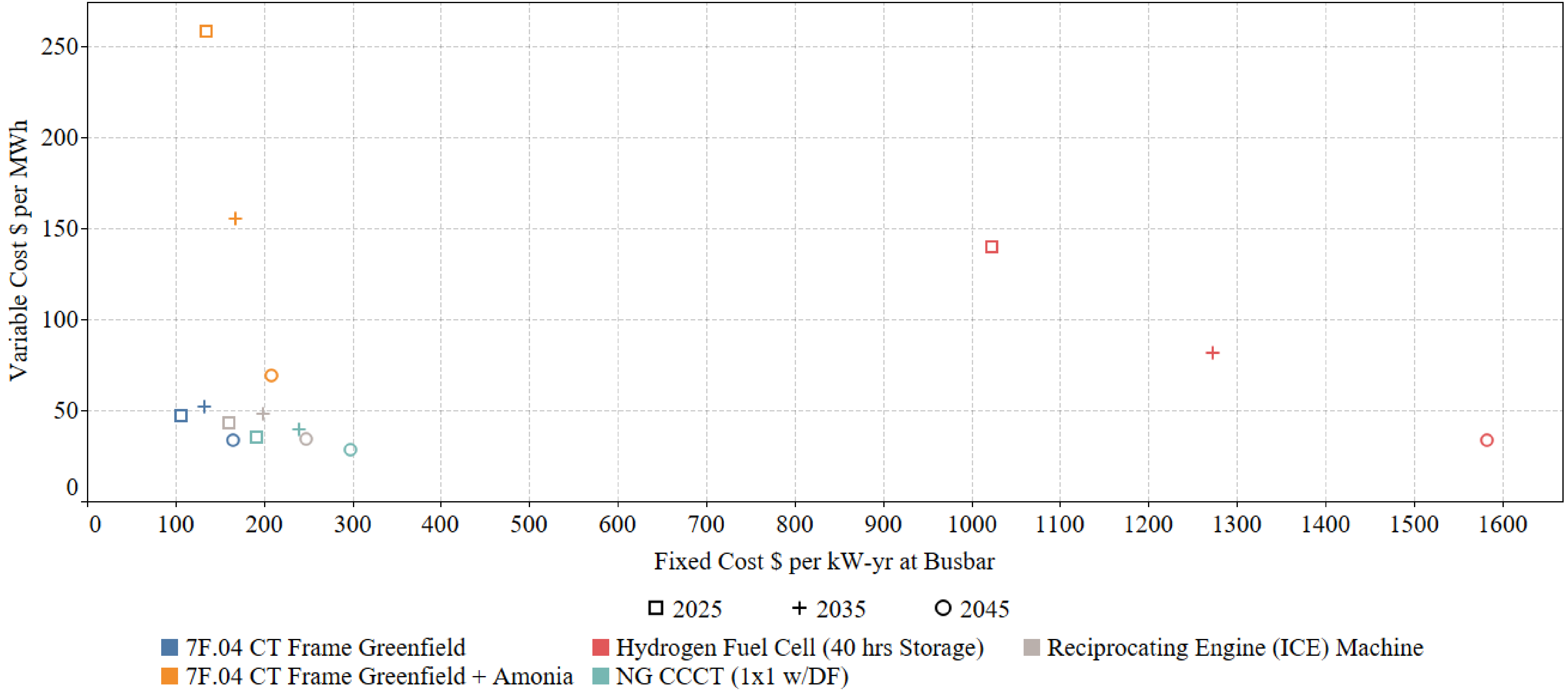
Upgrades & Biomass



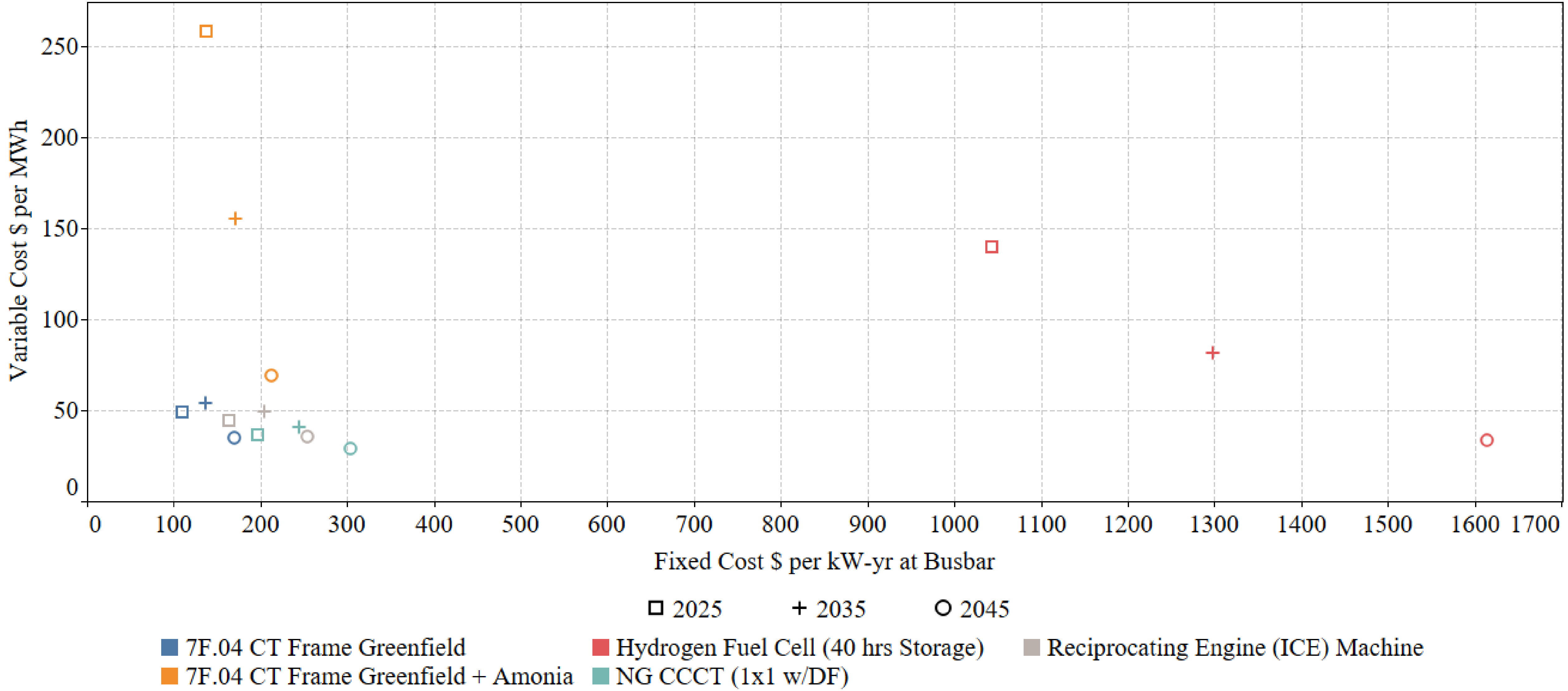
Supply Side Resource Options
Levelized Costs

Michael Brutocao, Natural Gas Analyst
Electric IRP, 6th Technical Advisory Committee Meeting
September 28, 2022

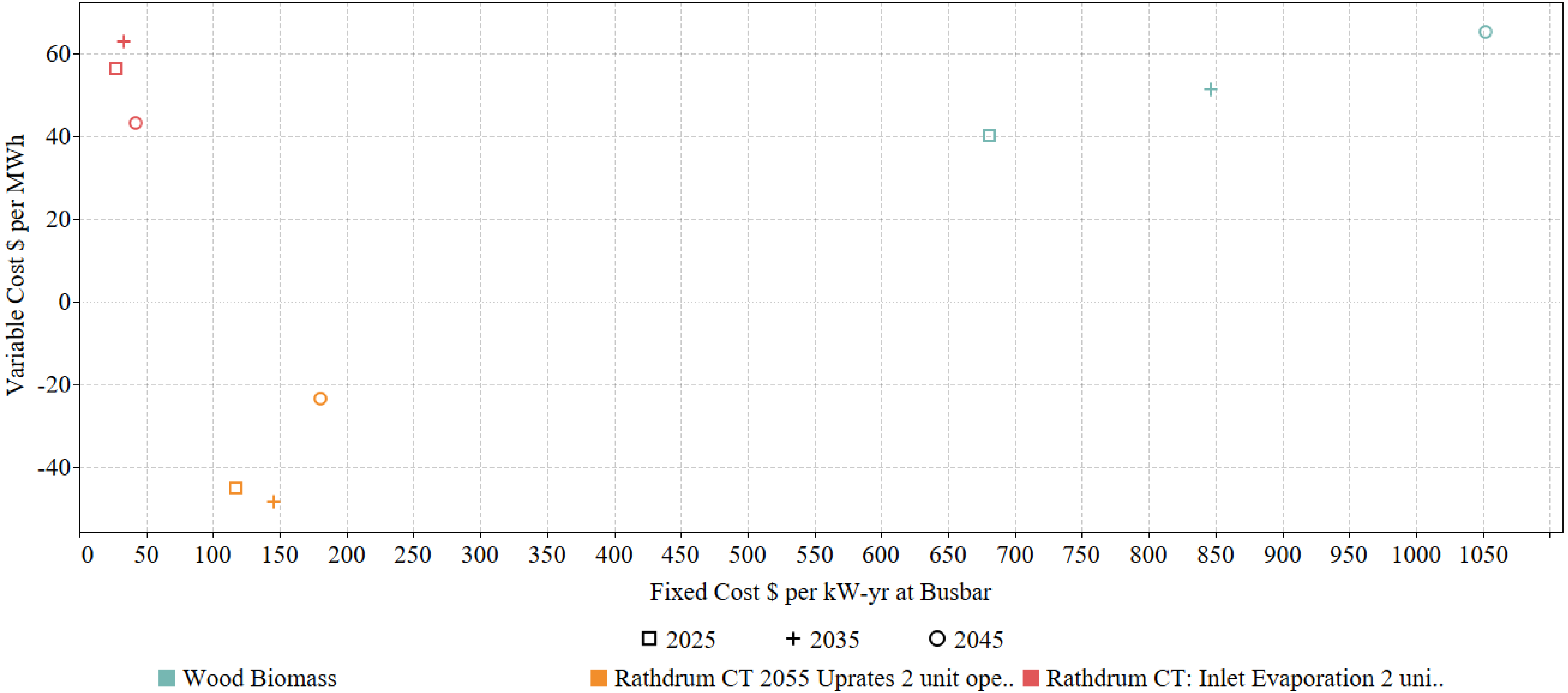
Natural Gas Fixed & Variable Costs – nominal $ (Idaho)



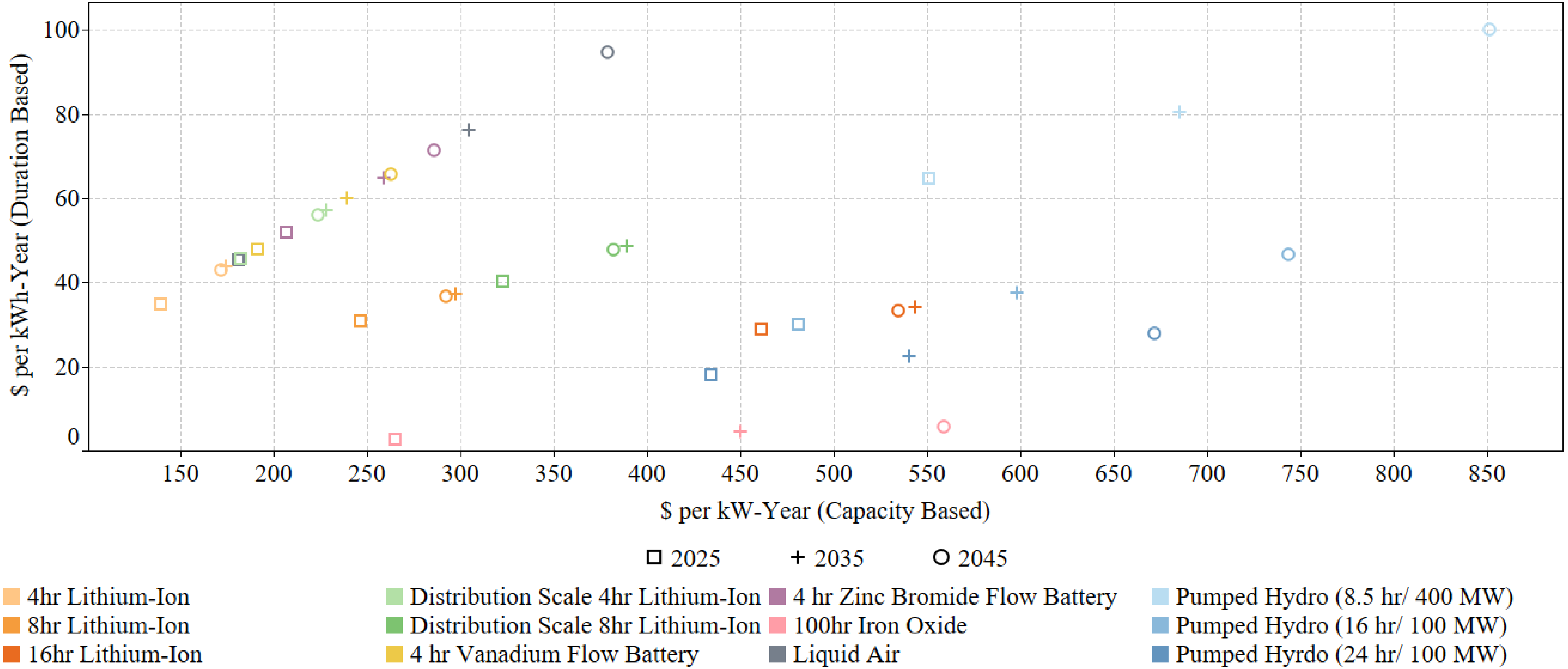
Natural Gas Fixed & Variable Costs – nominal $ (Washington)



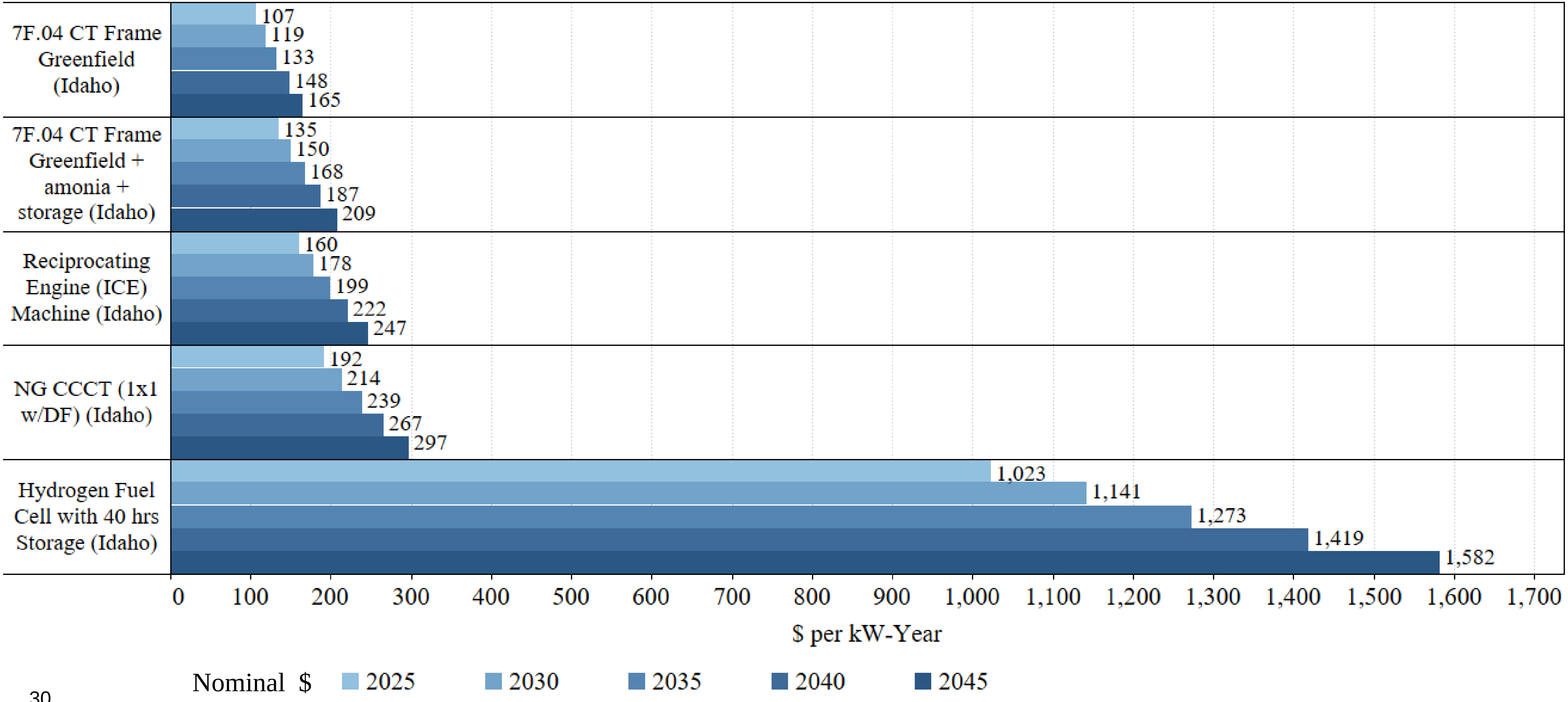
Facility Upgrade Cost Analysis – nominal $



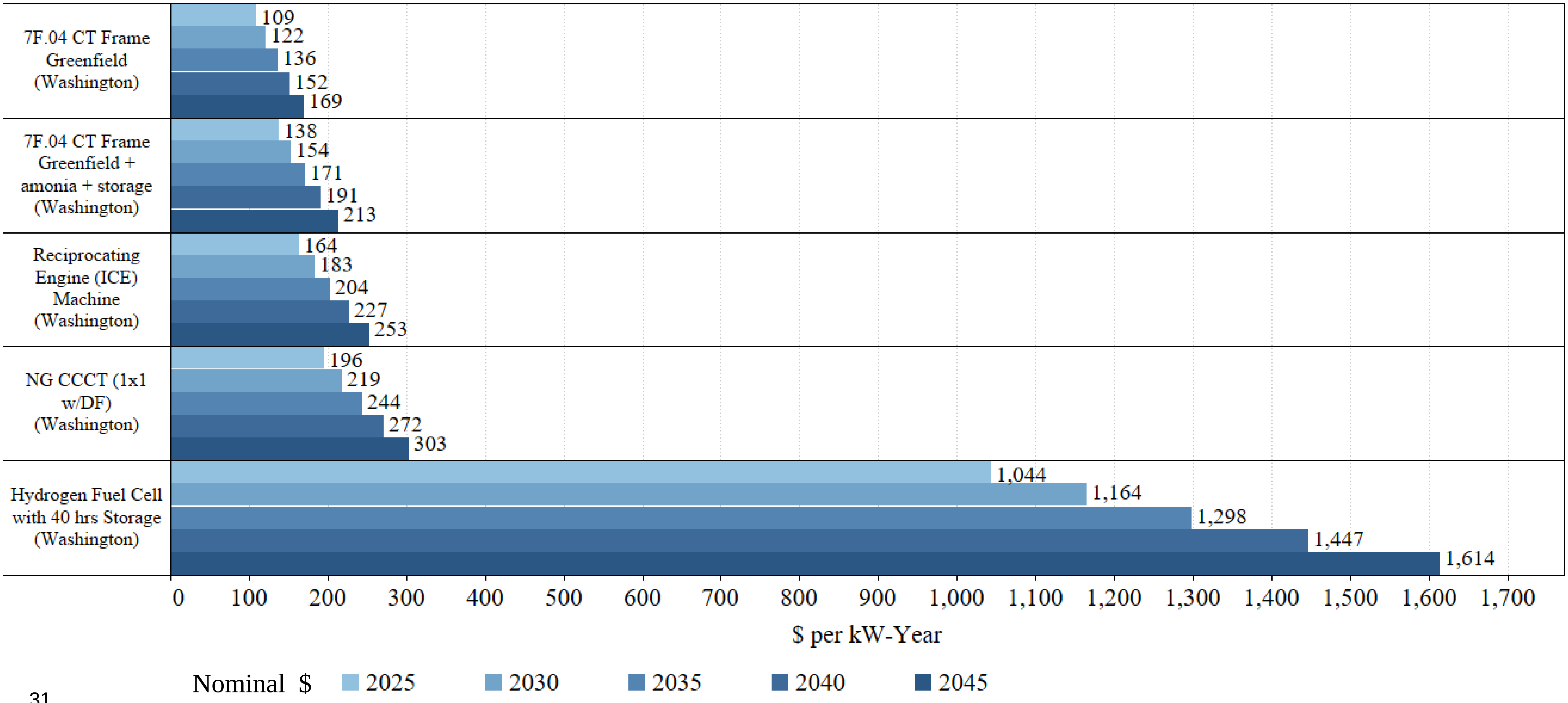
Storage Cost Analysis – nominal $



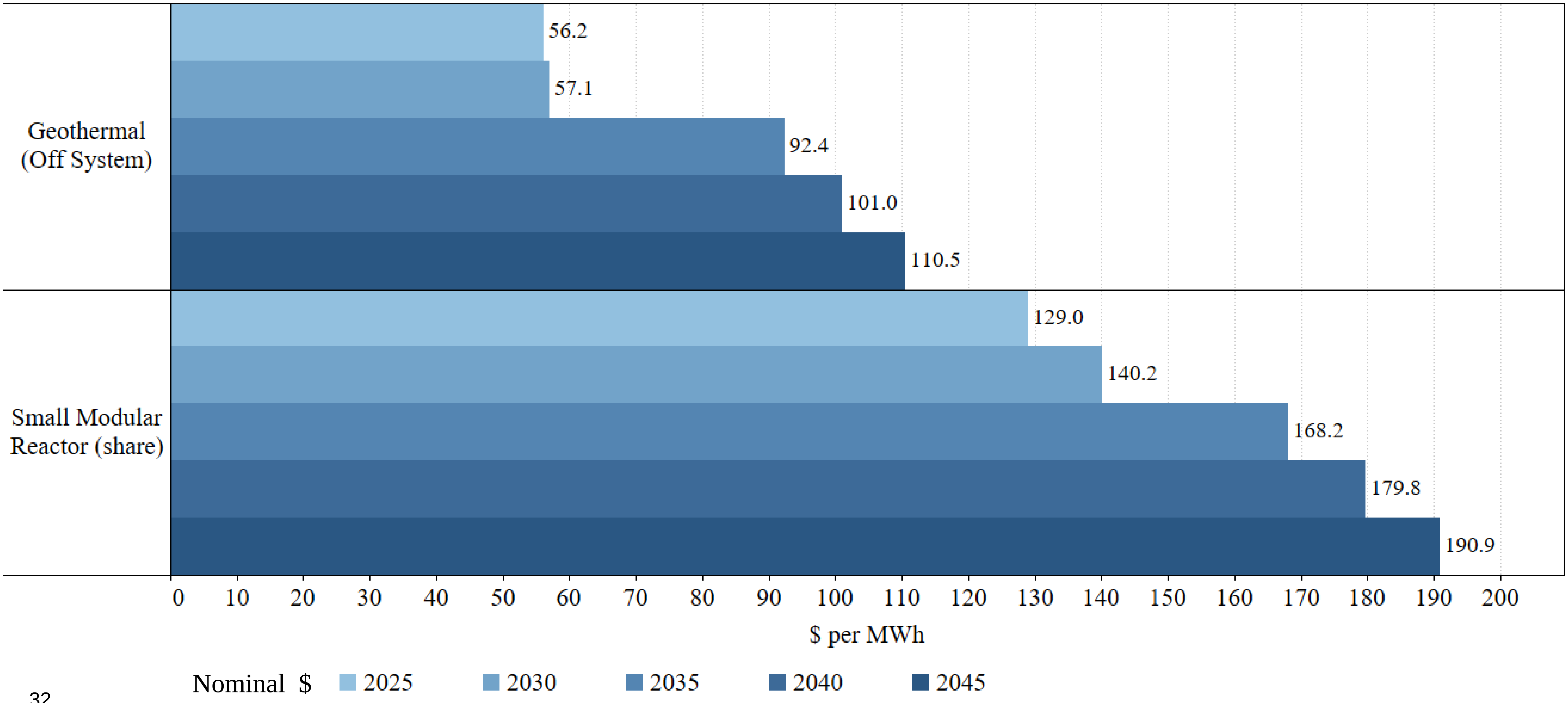
Fueled Generation Fixed Cost (Levelized) - Idaho



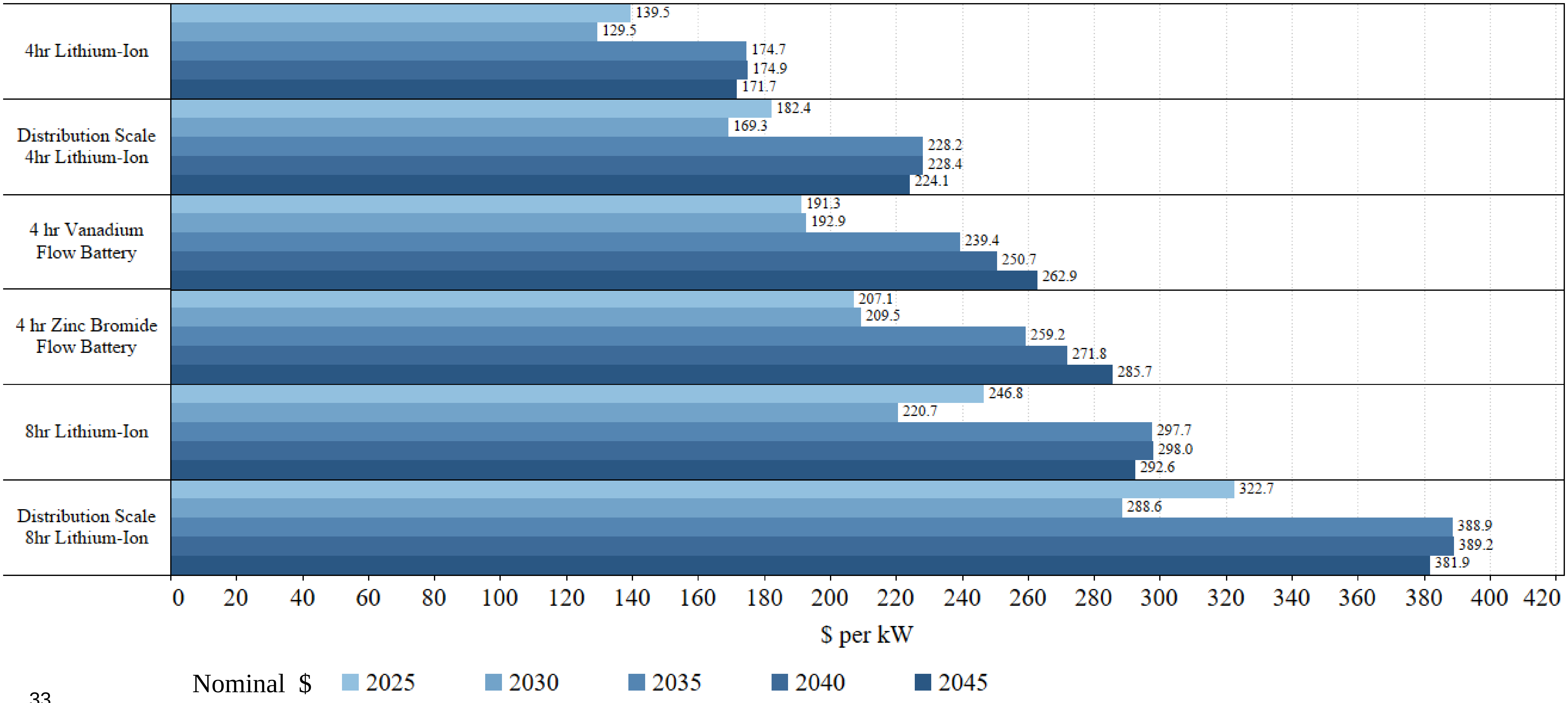
Fueled Generation Fixed Cost (Levelized) - Washington



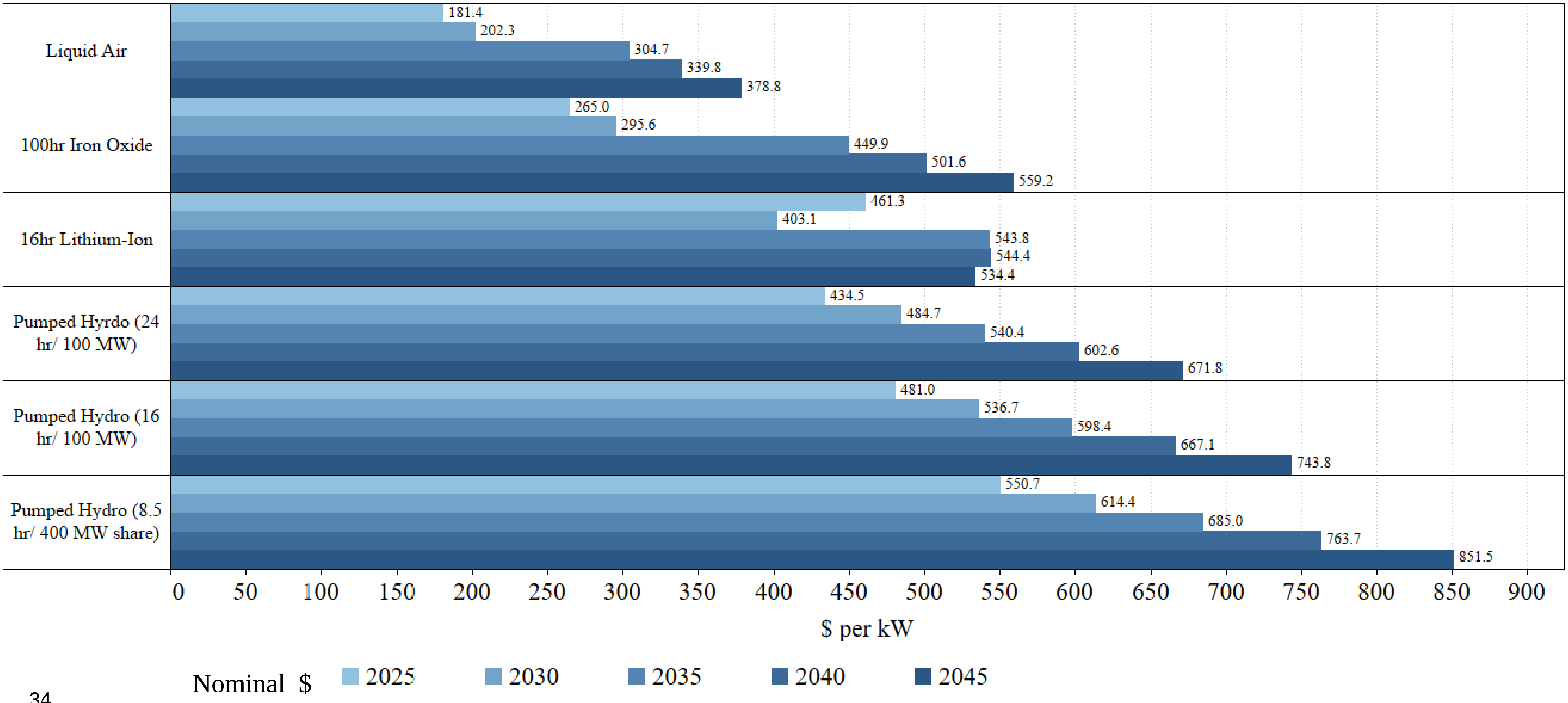
Geothermal/Nuclear Implied Energy Payment (Levelized)



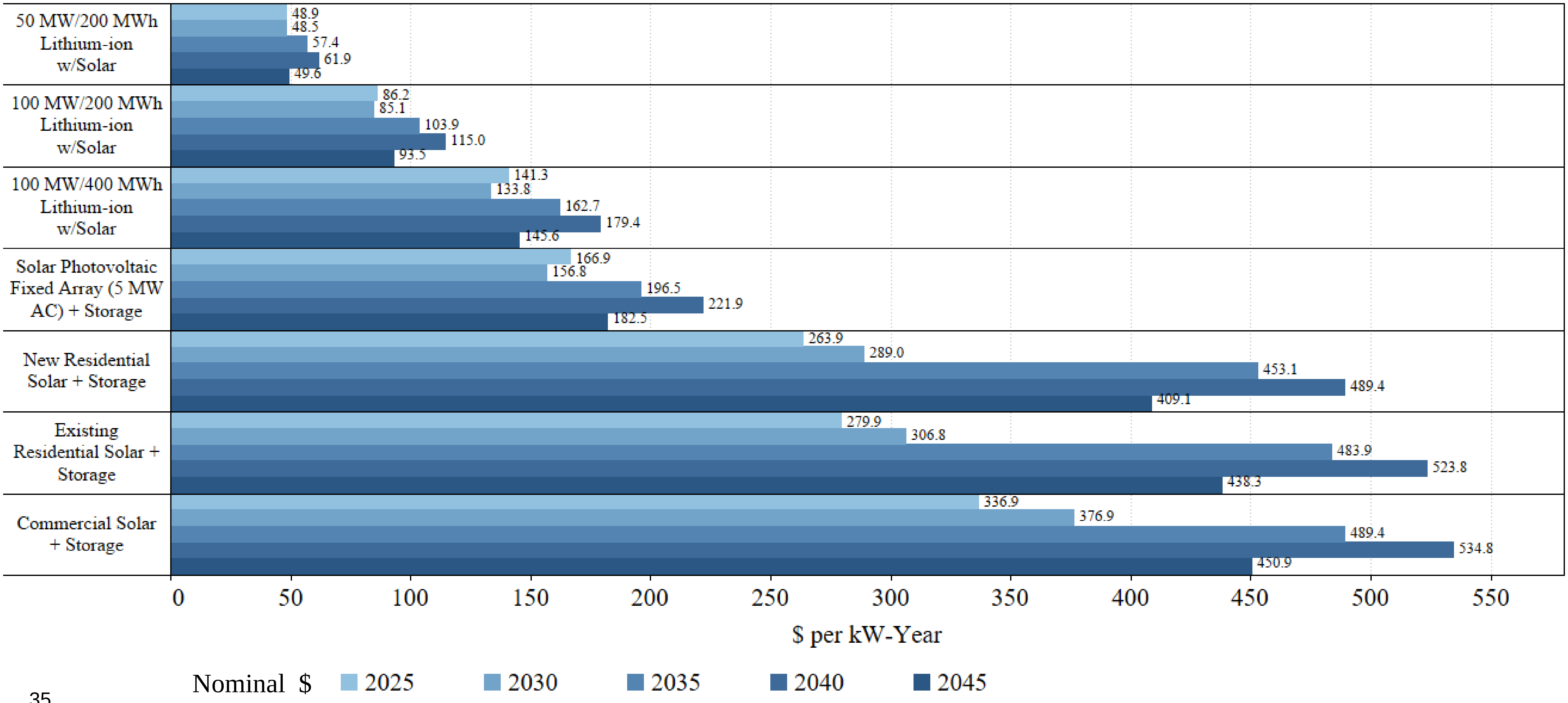
Storage Fixed Cost (Levelized)



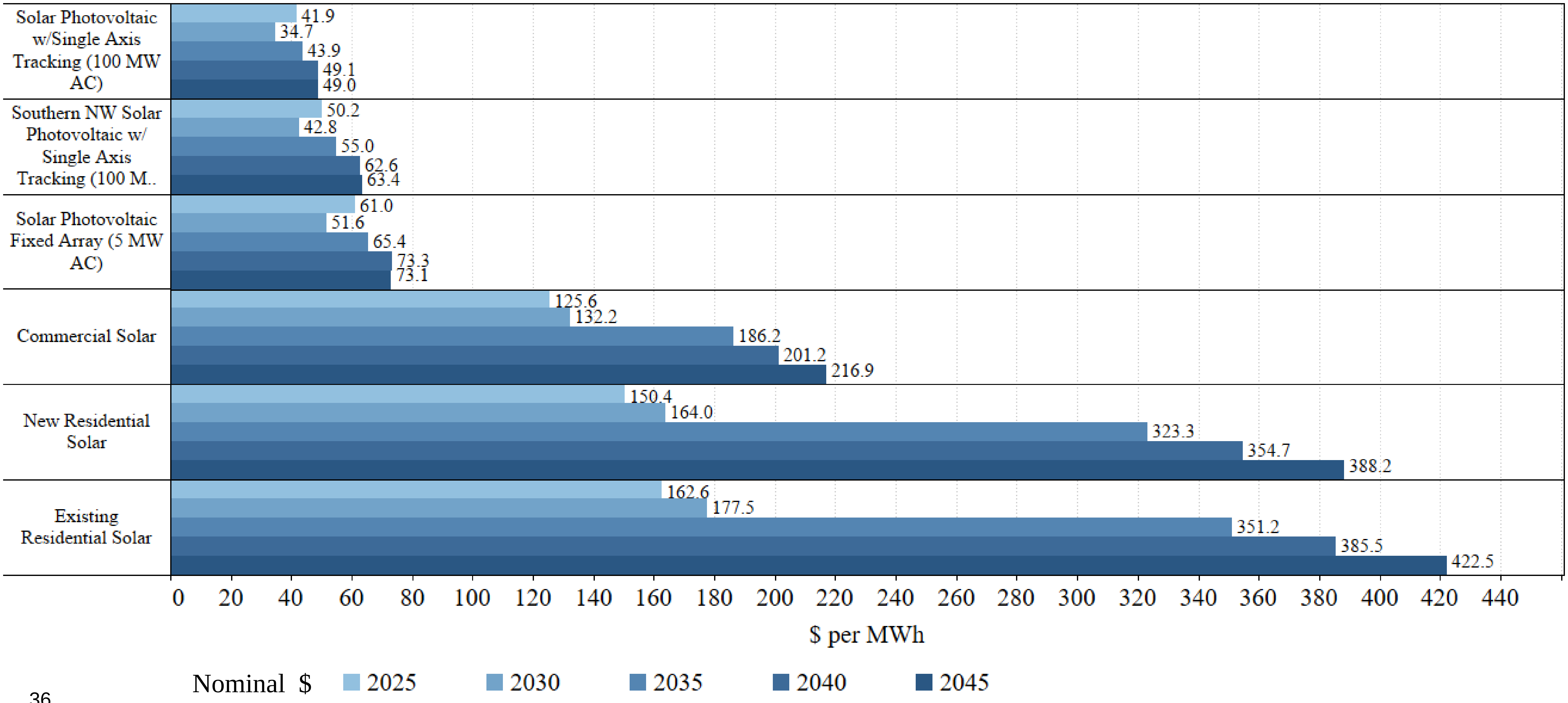
Storage Fixed Cost (Levelized) Continued…



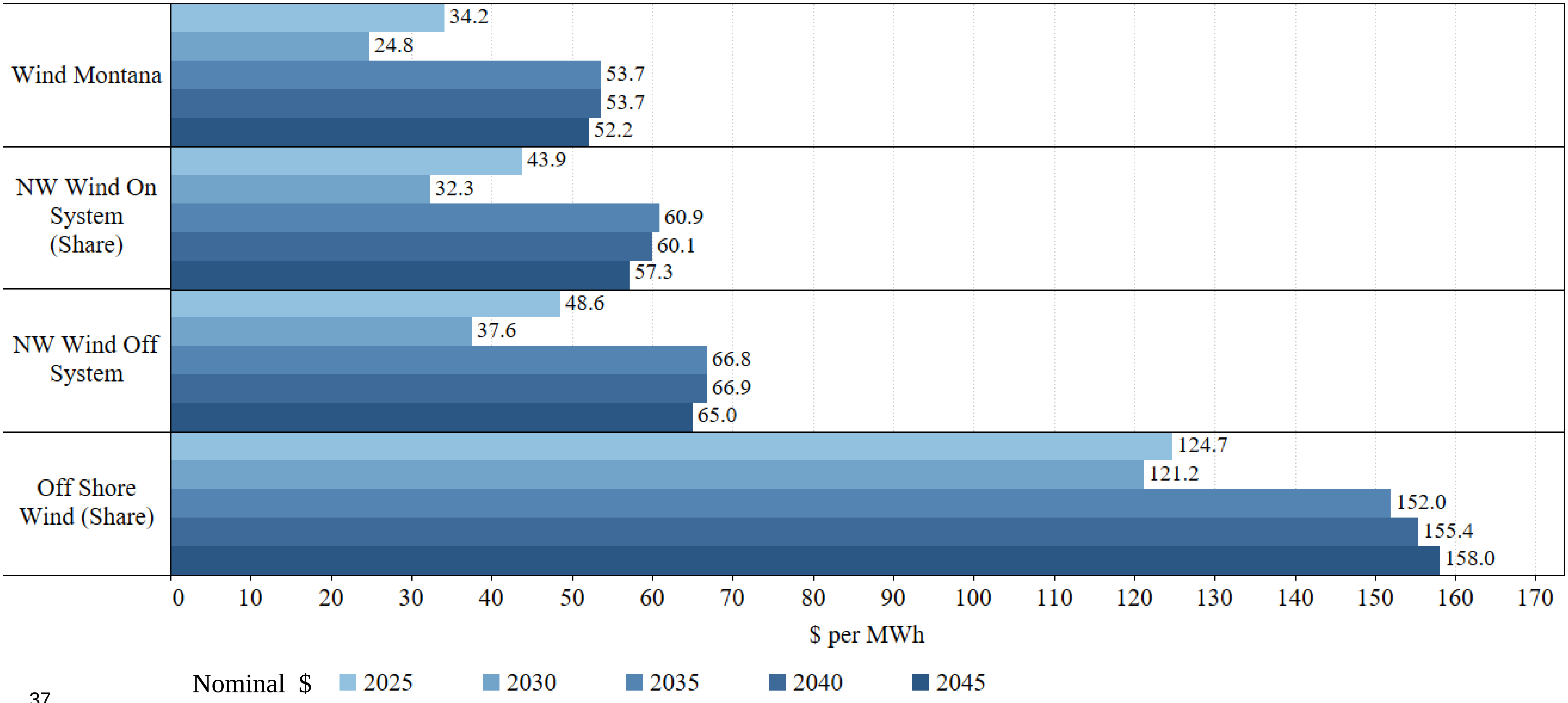
Storage Implied Capacity Payment (Levelized)



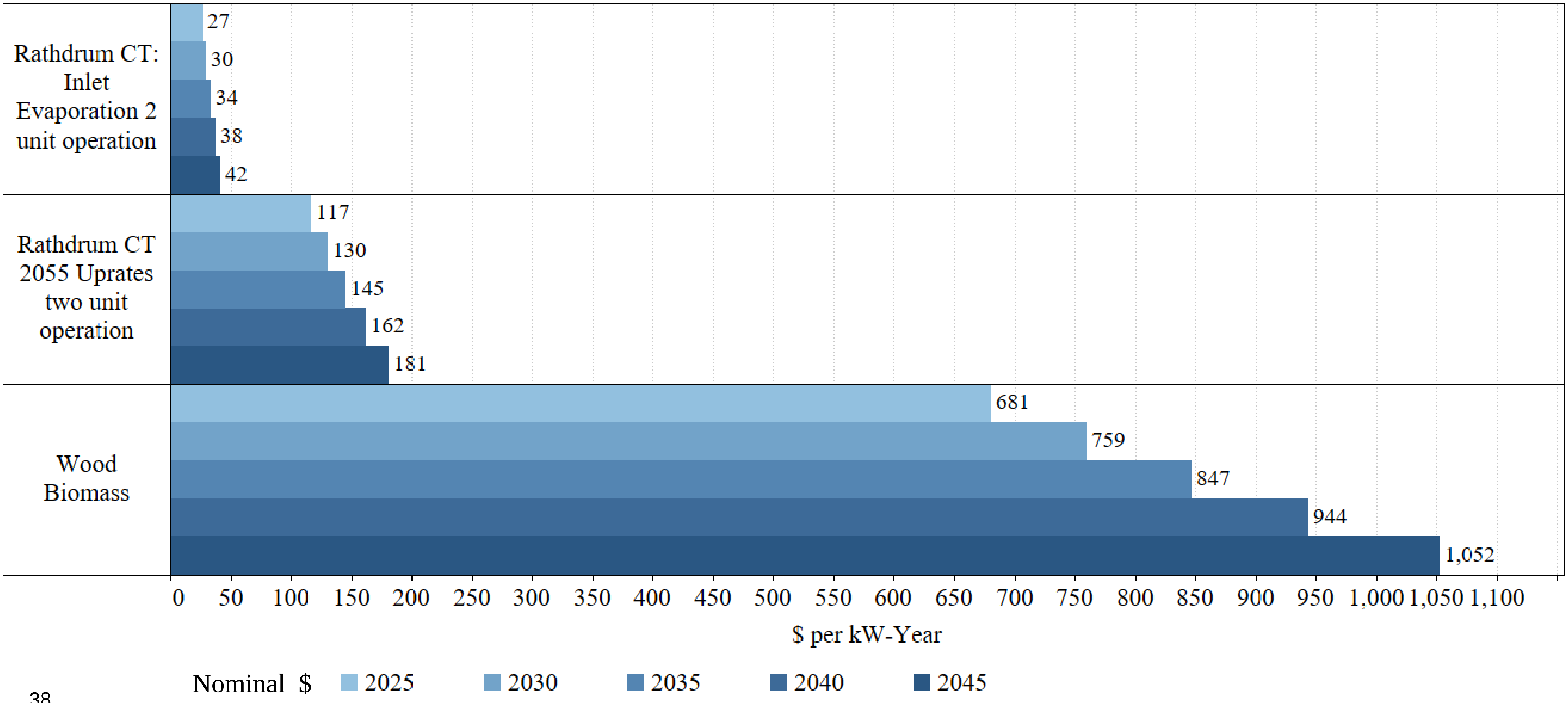
Solar PPA Price/Implied Energy Payment (Levelized)



Wind PPA Price/Implied Energy Payment (Levelized)



Upgrades & Biomass Fixed Cost (Levelized)



Supply Side Resource Options

Excel Workbook – Methodology and Navigation

Michael Brutocao, Natural Gas Analyst
Electric IRP, 6th Technical Advisory Committee Meeting
September 28, 2022

Variable Energy Resources Integration Study Update

2023 Avista Electric IRP

TAC 6 – September 28, 2022

Lori Hermanson, Senior Power Supply Analyst

VER Integration Study – Purpose and Overview

- Consistent application supporting varying analyses
  - Integrated Resource Planning
  - Resource acquisition processes (e.g., RFP)
  - Transmission tariff rates
  - PURPA avoided cost calculations
- Define "Consumptive Capacity" (CC) associated with incremental variable energy resources
- Determine Costs
  - Current costs under varying scenarios
  - Projected future costs under IRP Preferred Resource Strategy

VER Integration Study Scope

- Included
  - Consumptive capacity and its costs
  - Impacts of EIM (”fast”) markets
  - Potential future portfolio VER buildouts
  - Sensitivity scenarios
- Not included
  - Alternative capacity resources (e.g. batteries)
  - New utility-controlled storage
  - VER-driven investments in existing infrastructure
  - Distributed generation or response beyond what’s in IRP

Assumptions for ADSS Modeling

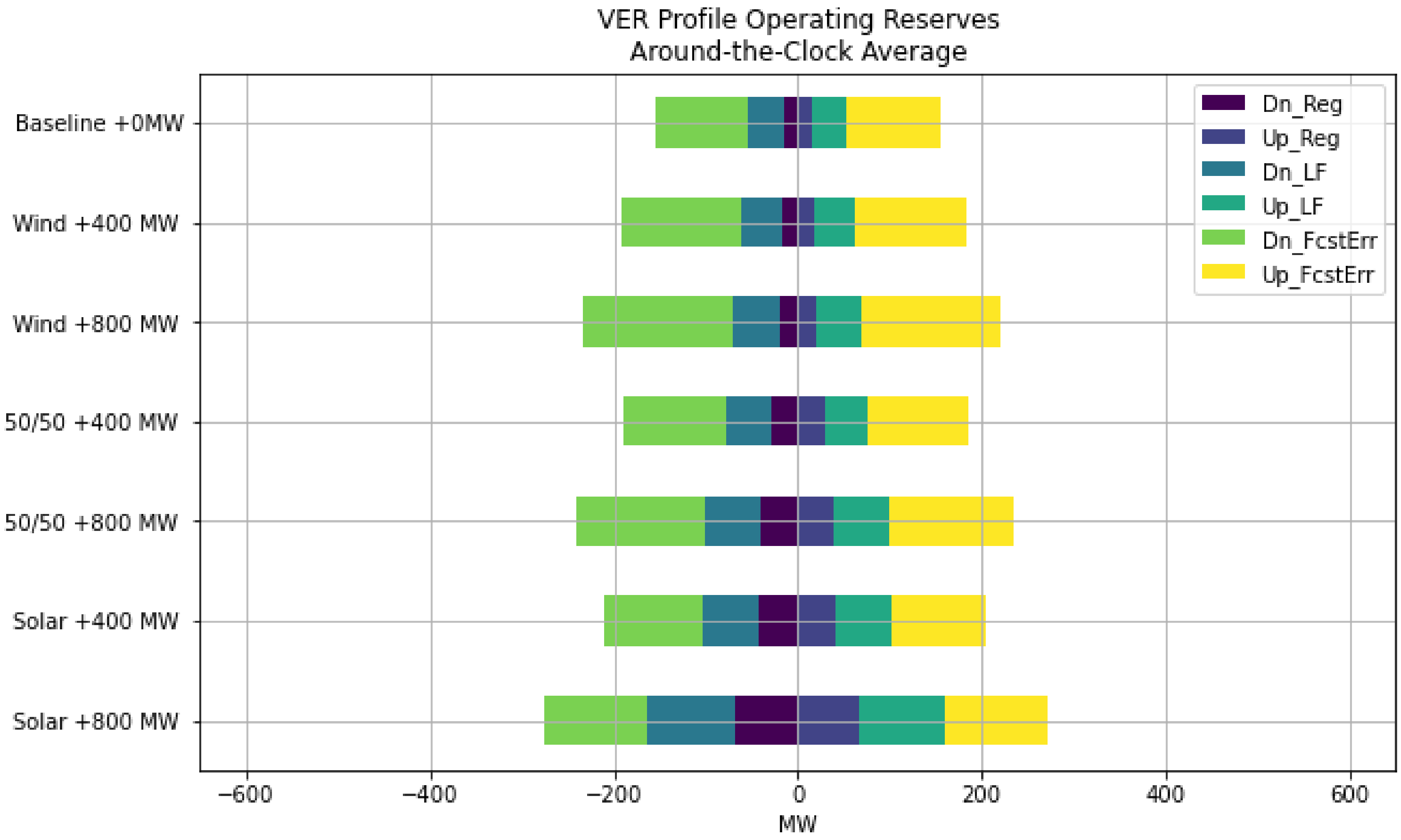
- Base case assumptions for all portfolio mixes (2-4 hours per run)
  - 13 VER portfolios (base + 12)
  - Include EIM regional diversity
  - Include carbon costs (CCA)

- Modeling sensitivities for 400 MW wind case
  - Addresses next 10+ years of PRS
  - Hydro (low/base/high)
  - Market prices (low/base/high)

VER Study Workplan Overview

- Phase I Results – Energy Strategies
  - VER scenarios and profiles – *completed*
  - VER reserve analysis – *completed*
  - VER Work group presentation– *completed*
  - Slides and recording of presentation on IRP website
- Production Cost Modeling (Avista ADSS) – 1Q23
- Phase II Deliverables (ES) – 2Q23
  - Finalize calculation of integration costs
  - Presentation and report with full analysis and results
  - Tool to calculate reserves for future scenarios/mixes

Phase I Results – Reserves



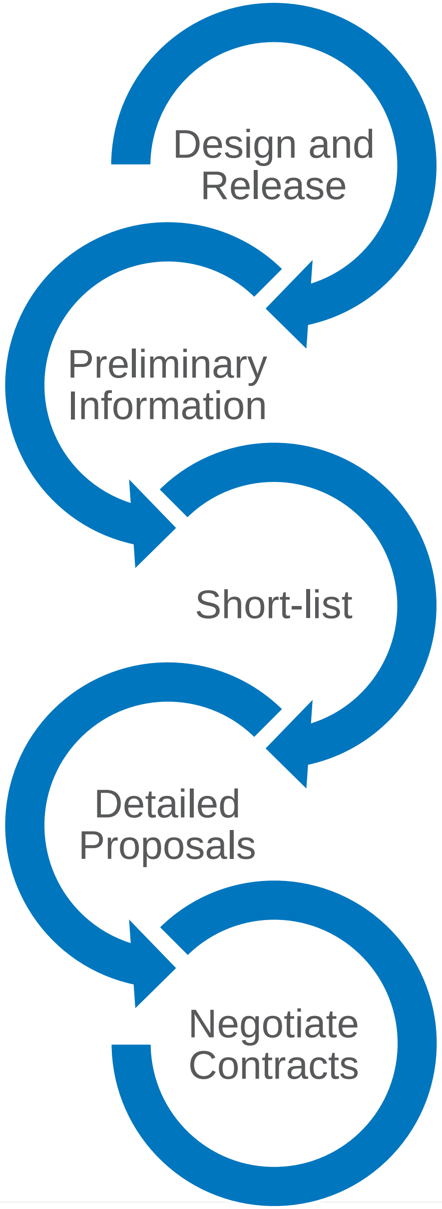
Avista Utilities
IRP TAC - RFP Update

2023 Electric IRP
6th Technical Advisory Committee Meeting
September 28, 2022

Chris Drake, Wholesale Marketing Manager

2022 All Source RFP Target Timeline

- February 18, 2022 – Avista releases All Source RFP
- February 28, 2022 – Bidders' conference
- March 25, 2022 – RFP bids due
- April 25, 2022 – Summary of Proposals posted
- June 10, 2022 – Short-listed Bid selection/notification
- July 18, 2022 – Detailed proposals due from Short-listed Bidders
- Sep 2, 2022 – Final price refresh request from Short-listed Bidders
- *Oct 2022 – Proposal(s) selected for negotiations*
- *Nov/Dec 2022 – IE report to commission*



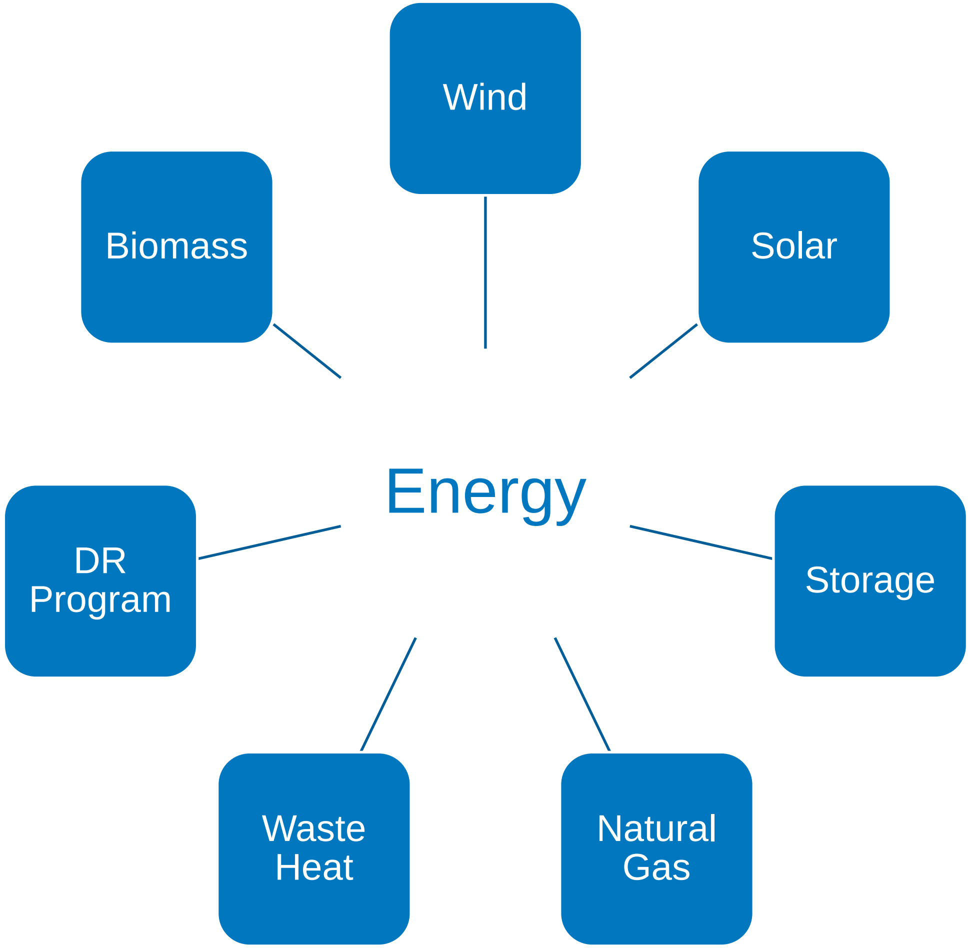
2022 All Source RFP and Proposal Highlights

Request for Proposals

- Shortfalls in 2026 (flexible CODs)
- 162 MW winter capacity
- 127 MW summer capacity
- Renewable and monthly energy resources also required

Responses

- 21 developers
- 11 technology types
- 32 proposals with options
- 56 total projects to analyze
- Avista and Sapere analysis completed mid-June to identify short list



2022 RFP Responses

Number of Proposals and Capacity by Type

Resource	Type	# of Proposals	Total Capacity (MW)[1]
Wind	Wind	12	1804.7
	Wind + Storage	6	856.2
	Wind + Solar	1	404
	Wind + Solar + Storage	4	2159.8
Solar	Solar	6	749.9
	Solar + Storage	7	660
Storage	Battery	6	643
	Pumped Storage Hydro	3	393.3
Other	Biomass	2	226
	Waste Heat	1	9.9
	Geothermal	1	8
	Hydro	1	38.7
	Demand Response	3	25.84
	Natural Gas	3	280

[1] Some bidders provided multiple bids or capacity options. Within each type only the initial capacity is included. Posted at www.myavista.com/AllSourceRFP.

Independent Evaluator (IE) – Sapere Consulting

- IE's role includes, but not limited to, the following:
  - Professional assistance in design and evaluation
  - Ensure RFP is conducted in accordance with Idaho and Washington resource acquisition rules
  - Ensure process is fair and transparent
  - Assess Avista's process of scoring bids and selection of shortlists is reasonable
  - Review all third party and Avista proposals
    - Non-Financial Scoring
    - Financial Modeling and Scoring

Evaluation Process – Short List Selection

Initial Screen Evaluation Scoring Matrix

Weighting						
20%	**40%**	**5%**	**20%**	**10%**	**5%**	**100%**
Risk Management	**Financial Energy Impact[1,2]**	**Price Risk**	**Electric Factors**	**Environmental[2]**	**Non-Energy Impact[2]**	**Total Score**
Developer Experience, Proven Technology, etc.	Financial Analysis of Price to include PPA/Ownership, capacity costs/value, transmission, cost of carbon, etc.	Potential for change in costs, fixed vs variable pricing, variable energy, etc.	Interconnection status and transmission plan	Permitting such as Conditional Use Permit, SEPA, Studies, etc.	Energy security, benefit to service territory, named communities, DEI, etc.	

[1]*Financial evaluation based on highest score of Capacity or Energy.*

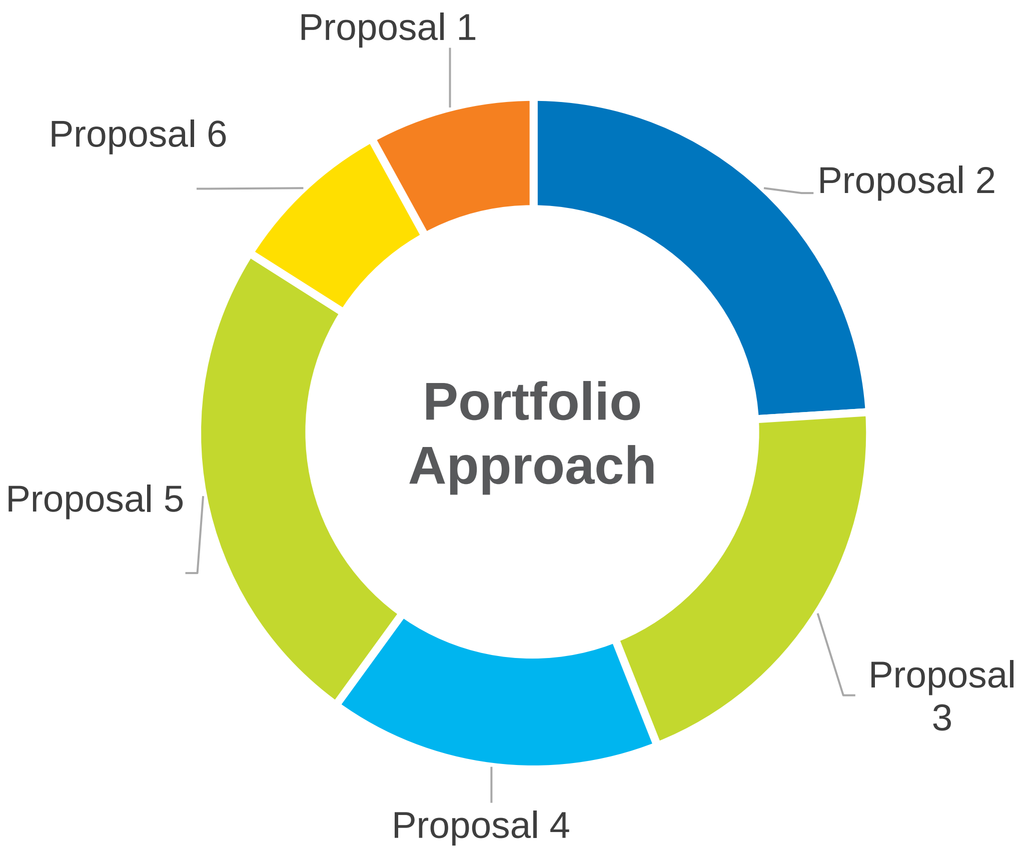
[2]*Clean Energy Implementation Plan Customer Benefit Indicators (where applicable) are included in Non-Energy Impact as well as Financial Energy Impact and Environmental criteria.*

Equity Considerations

Develop, strengthen, and support policies and procedures that distribute and prioritize resources to historically and currently marginalized customers, including tribes.

- RFP Stakeholder Input
  - Draft RFP filed with Washington Utilities and Transportation Commission (UTC) and shared with Idaho Public Utilities Commission (PUC), Avista's IRP TAC and Equity Advisory Group among others
  - RFP document including preliminary information requested from bidders, evaluation methodology and scoring incorporated stakeholder feedback
  - Final RFP approved by UTC
- Scoring matric included Customer Benefit Indicators (CBI)
  - Non-Energy Impacts – Energy resiliency, security, diversity, labor and location in named community
  - Financial Impacts – consideration for quantifiable cost impacts of economic, public health and safety
  - Environmental Factors – such as air quality impacts

Evaluation Process – Detailed Proposals



- Short list identified based on natural break points in scoring matrix
  - June 10, 2022
- Detailed proposals due from Short-listed Bidders
  - July 18, 2022
- Price refresh after Inflation Reduction Act
  - September 2, 2022
- Financial modeling
  - Portfolio approach (one or many resources selected)
  - Several scenarios to be modeled

Thank you…

IRP Climate Change Analysis

Impact of forecasted streamflow and temperature changes on hydrogeneration and load

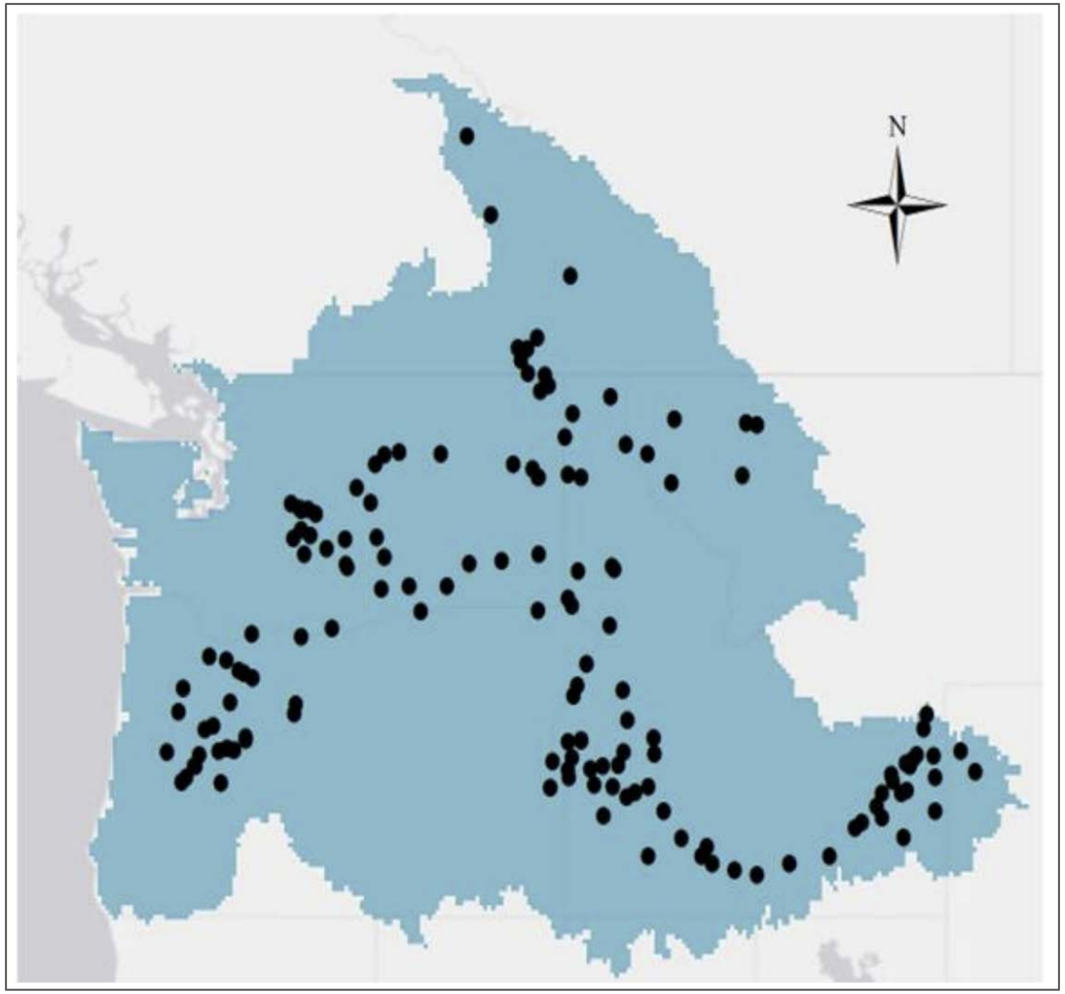
Mike Hermanson, Senior Power Supply Analyst
Electric IRP, 6th Technical Advisory Committee Meeting
September 28, 2022

Overview

- Data sources and methodology
- Hydrogeneration
- Load forecast
- Peak load forecast
- Use in IRP Modeling

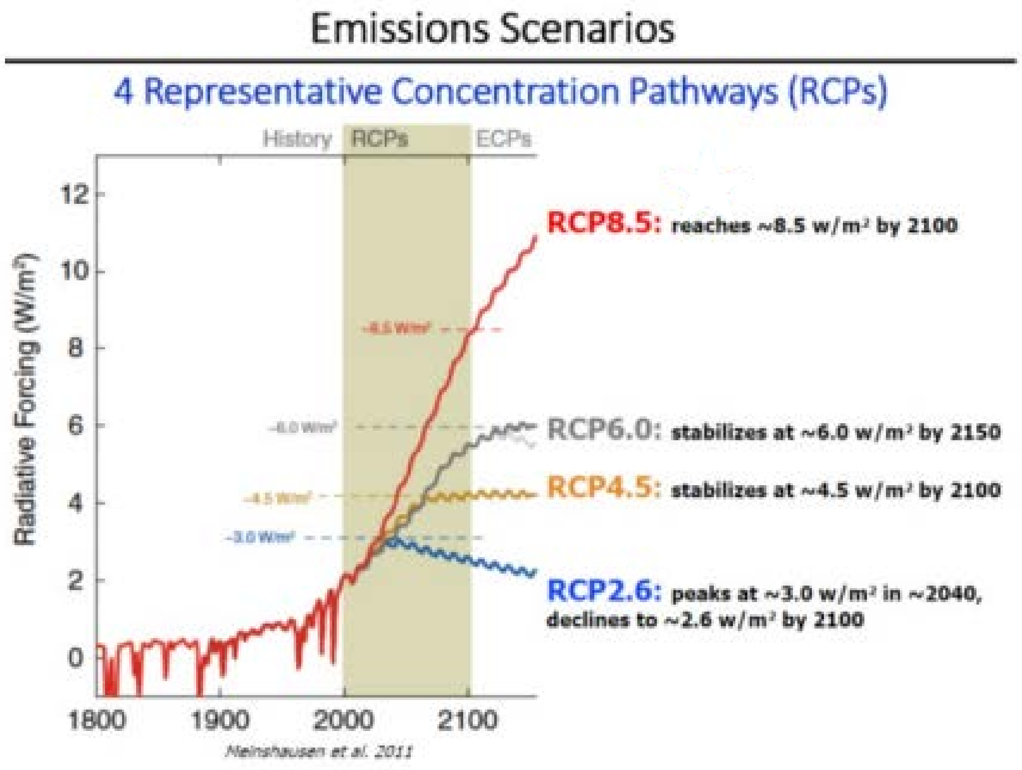
Data Sources

- Climate and Hydrology Datasets for RMJOC Long-Term Planning Studies: Second Edition
  - River Management Joint Operating Committee (RMJOC)
    - BPA, US Army Corps of Engineers, US Bureau of Reclamation
  - Research Team
    - University of Washington, Oregon State University
- Part I – Unregulated stream flows
- Part II – Reservoir Regulation and Operations



Global Climate Models

- Global Climate Models (GCMs)
  - Coarse resolution ranging from 75 to 300 km grid size
  - Provides projections of temperature and precipitation
  - Multiple Representative Concentration Pathways (RCP 4.5, RCP 6, RCP 8.5)
  - 10 GCM models used in study
    - CanESM2 (Canada)
    - CCSM4 (US)
    - CNRM-CM5 (France)
    - CSIRO-Mk3-6-0 (Australia)
    - GFDL-ESM2M (US)
    - HadGEM2-CC (UK)
    - HadGEM2-ES (UK)
    - inmcm4 (Russia)
    - IPSL-CM5-MR (France)
    - MIROC5 (Japan)



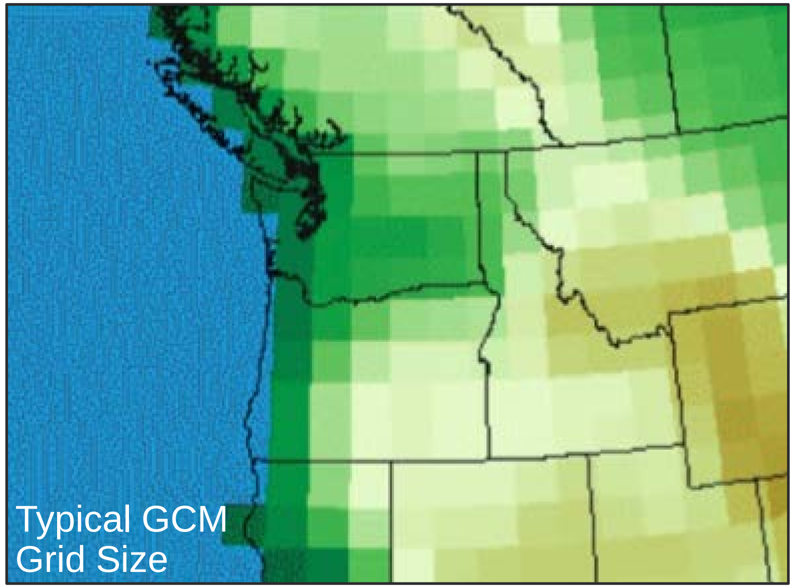
Representative Concentration Pathways

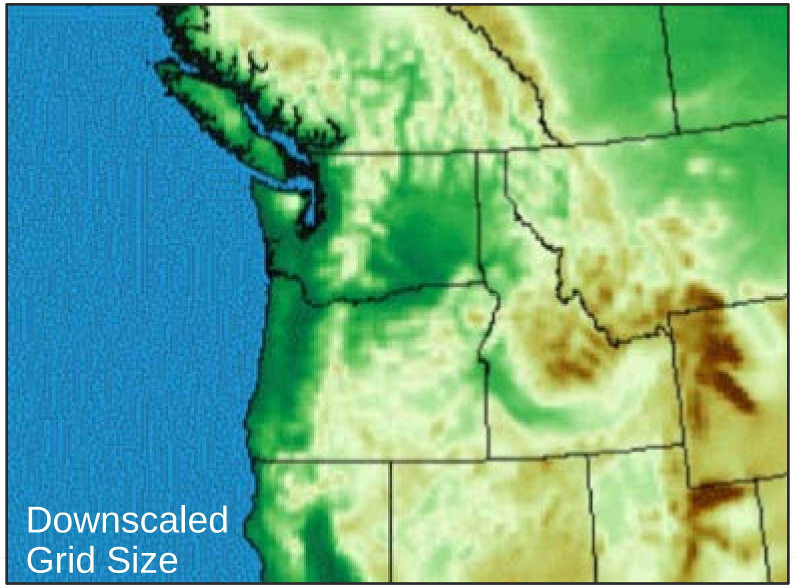
- Description by Intergovernmental Panel on Climate Change (IPCC)
  - RCP2.6 – stringent mitigation scenario
  - RCP4.5 & RCP6.0 – intermediate scenarios
  - RCP8.5 – very high GHG emissions
- RMJOCII Study evaluated RCP4.5 and RCP8.5
- RCP4.5 and RCP6.0 similar within the IRP planning horizon

	Scenario	2046-2065		2081-2100	
		Mean	Likely range	Mean	Likely range
Global Mean Surface Temperature Change (C°)	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	**1.4**	**0.9 to 2.0**	**1.8**	**1.1 to 2.6**
	RCP6.0	**1.3**	**0.8 to 1.8**	**2.2**	**1.4 to 3.1**
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8

Downscaling Techniques

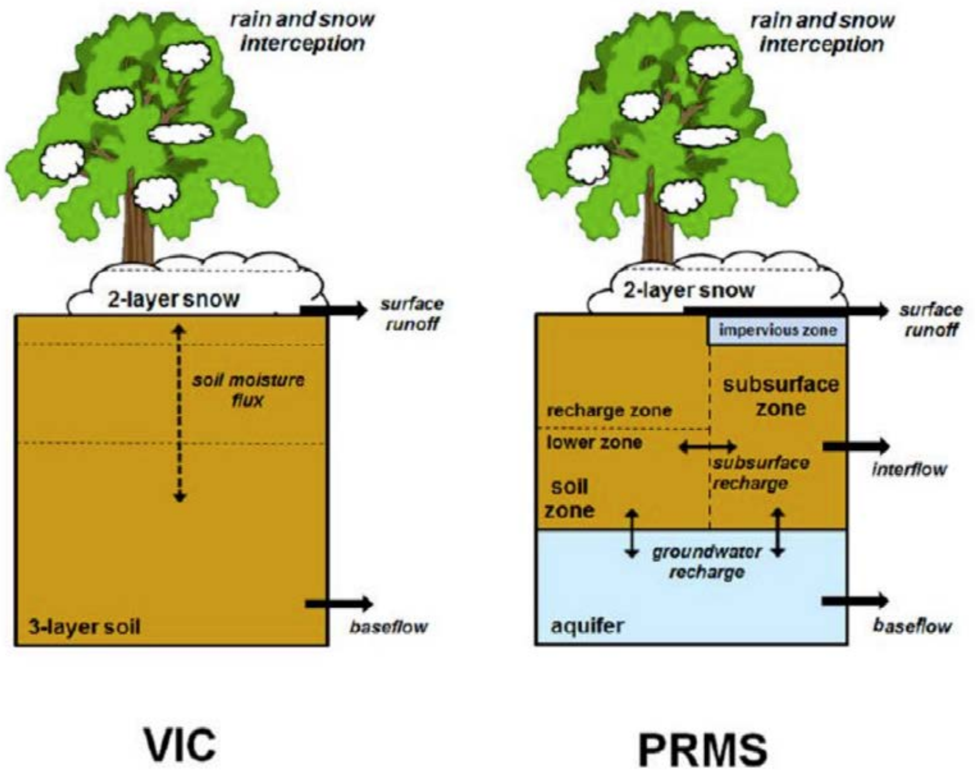
- Downscale GCM data to finer resolution necessary to model hydrology
  - Statistical methods to represent variation within large grid size
  - Two methods used (BCSD, MACA)
    - Bias Corrected Spatial Disaggregation
    - Multivariate Adaptive Constructed Analog



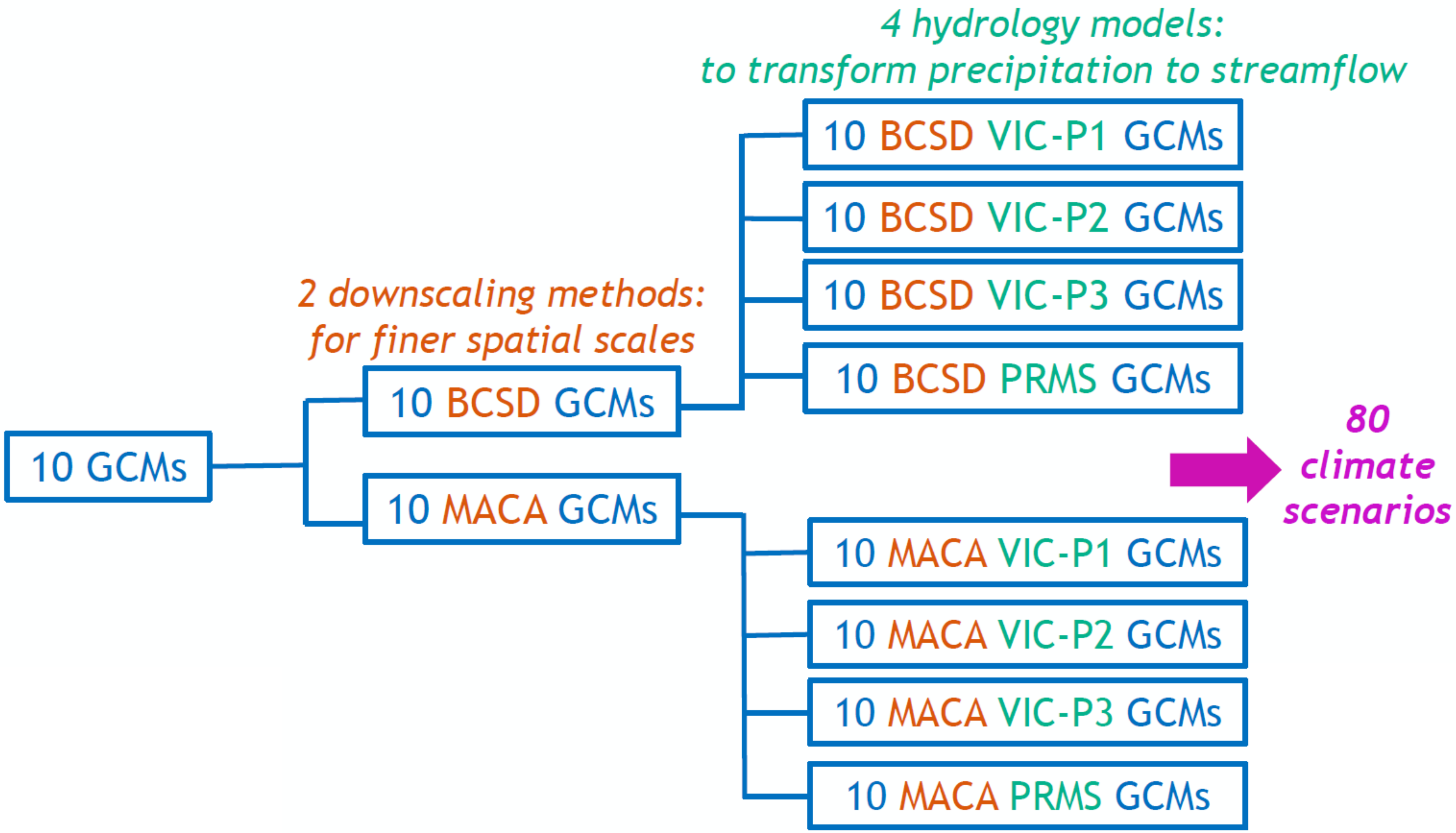


Modeling Climate Change Impacts on Hydrogeneration

- Hydrologic models
  - Downscaled temperature and precipitation is input to hydrologic models.
  - Hydrologic models use soil, geology, slope, vegetation, aspect, snow cover, etc. to model how precipitation translates into runoff and streamflow.
  - 2 different hydrology models used.
    - 1 version of PRMS model
    - 3 versions of VIC model
- Hydro regulation models
  - Unregulated streamflow is input to reservoir models of Columbia River system to generate regulated flows.



Modeling Climate Change Impacts on Hydrogeneration



Modeling Climate Change Impacts on Hydrogeneration

- Comparison of hydrogeneration used for previous IRP to estimated hydrogeneration based on stream flows from climate change modeling.
- Previous IRP utilized modeled regulated flows for water years 1929-2008 provided by BPA.
- BPA selected 19 of the 80 scenarios that encompass a sufficient range of uncertainty.
- Streamflows for 19 scenarios for the period of 2019-2049 were used to develop estimates of generation.
- Regression models based on relationship of baseline flows to generation for Avista projects.
- Mid-C generation from BPA Hydsim model of climate change scenarios.

Modeling Recent 30-Year Hydrogeneration

- BPA is moving to using recent 30-year period for planning purposes.
- BPA is finalizing 90-year (1928-2018) regulated flow data set and is not yet available.
- Utilized actual river flow data for 2009-2021in regression models utilized for climate change modeling to add to the current 80-year record and create a recent 30-year dataset.
- Used actual 2009-2021 Mid-C generation.

Results

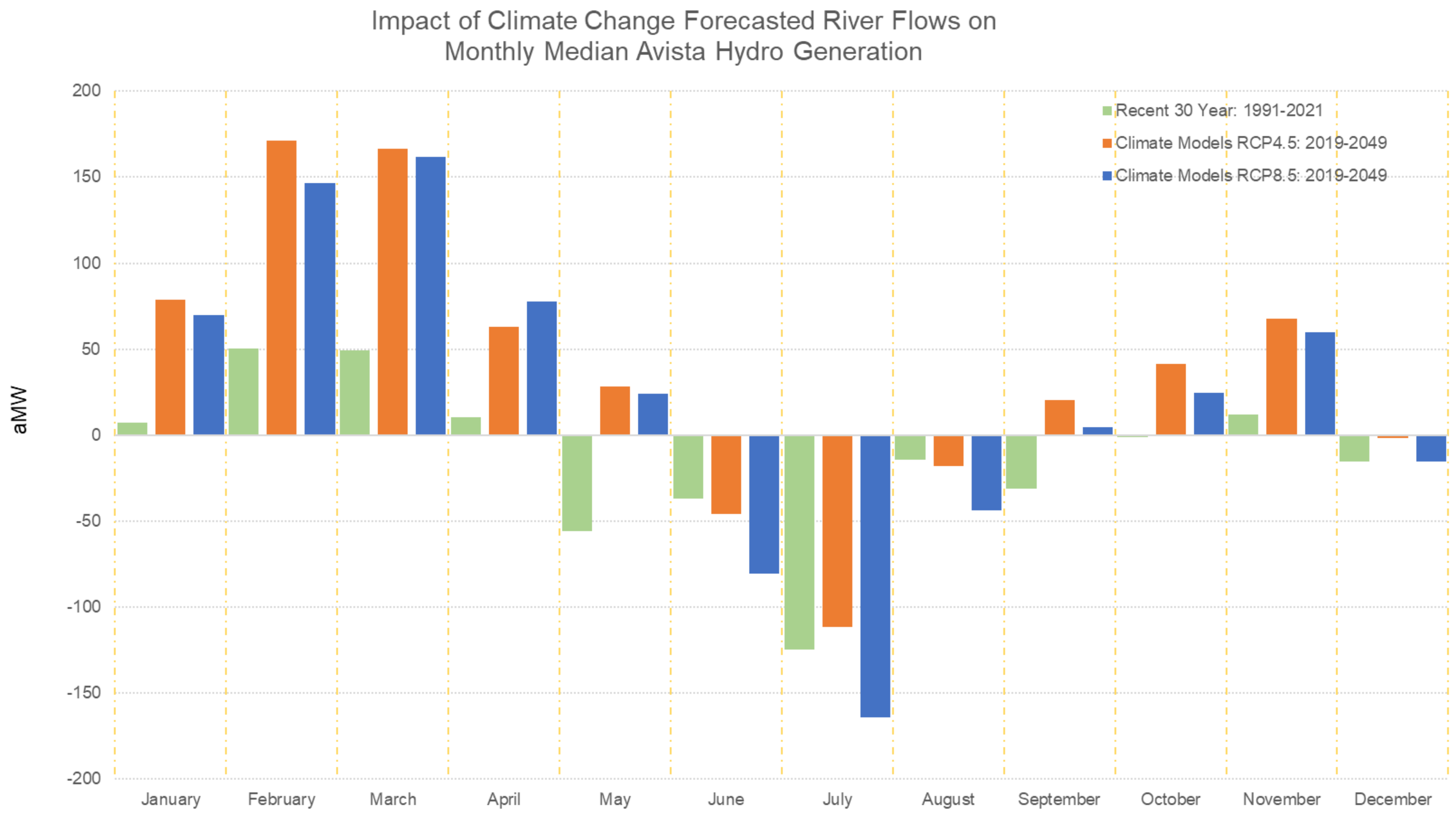
Comparison of Annual (aMW)

	80-Year Hydro (1929-2008)	Recent 30-Year (1991-2021)	Climate Change RCP8.5 (2019-2049)	Climate Change RCP4.5 (2019-2049)
Mean	598	595	628	645
Median	597	585	620	636
Standard Deviation	142	137	149	169
10^{th} Percentile	424	437	454	447

- Recent 30-year shows slight decrease in annual energy
- Climate change scenarios show an increase in annual energy consistent with the projection of overall increase in precipitation in the Northwest

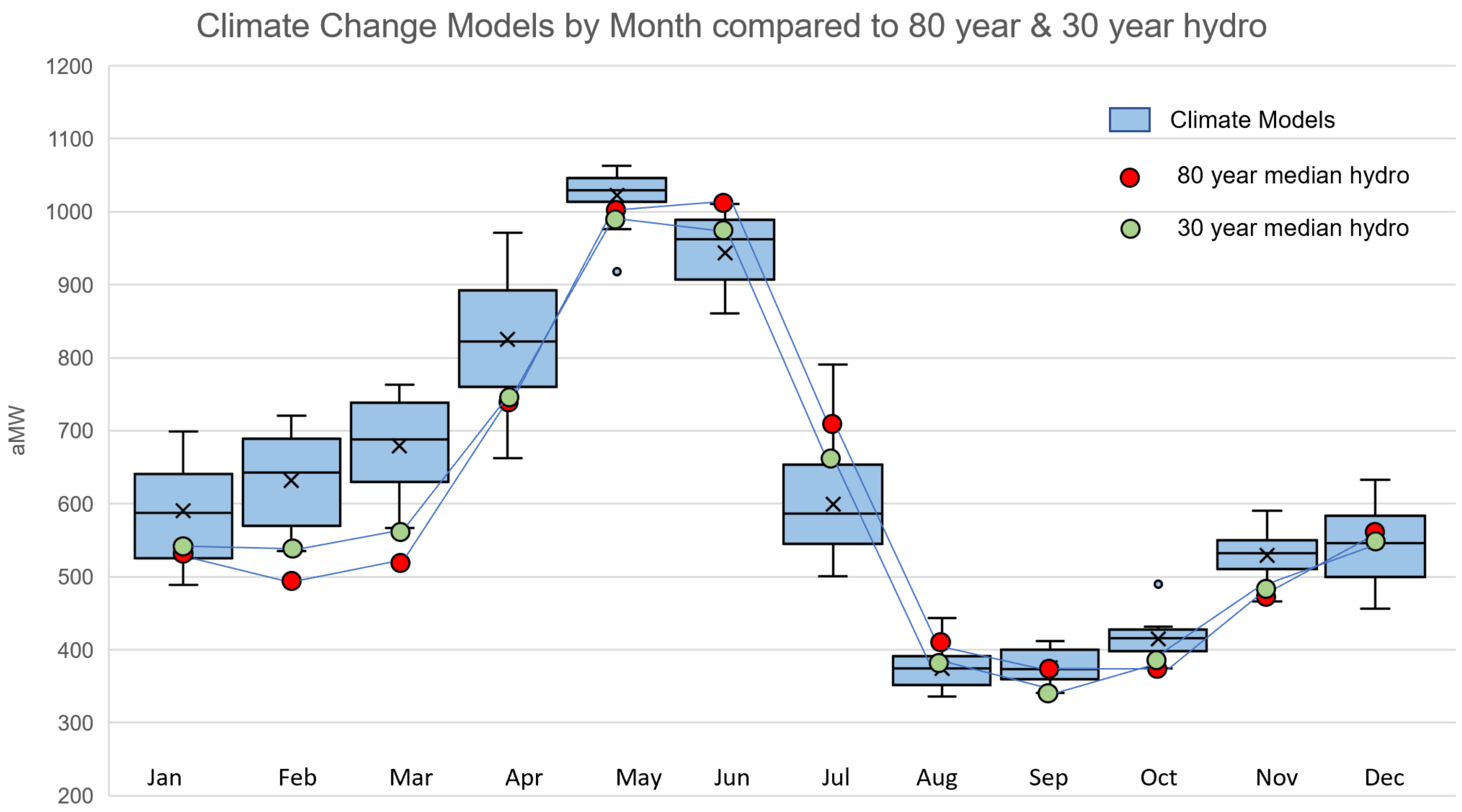
Results

Comparison of Monthly (aMW)



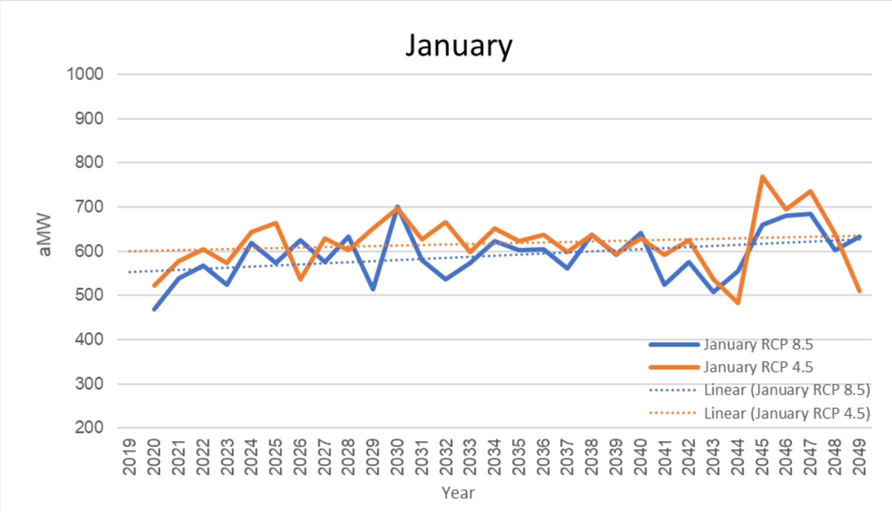
Results

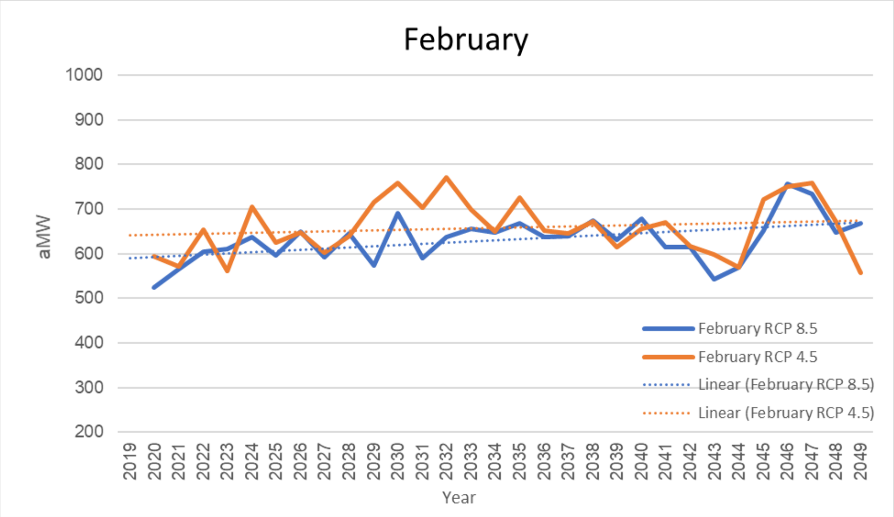
Variability of Climate Models

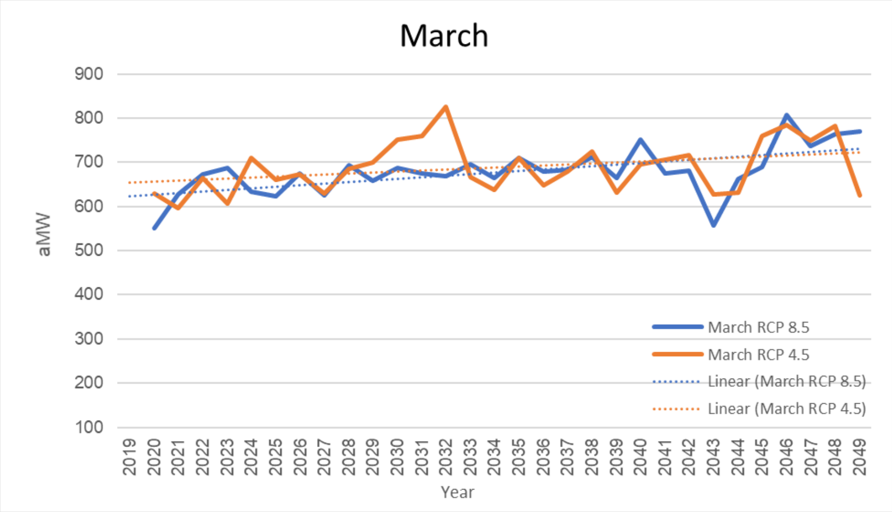


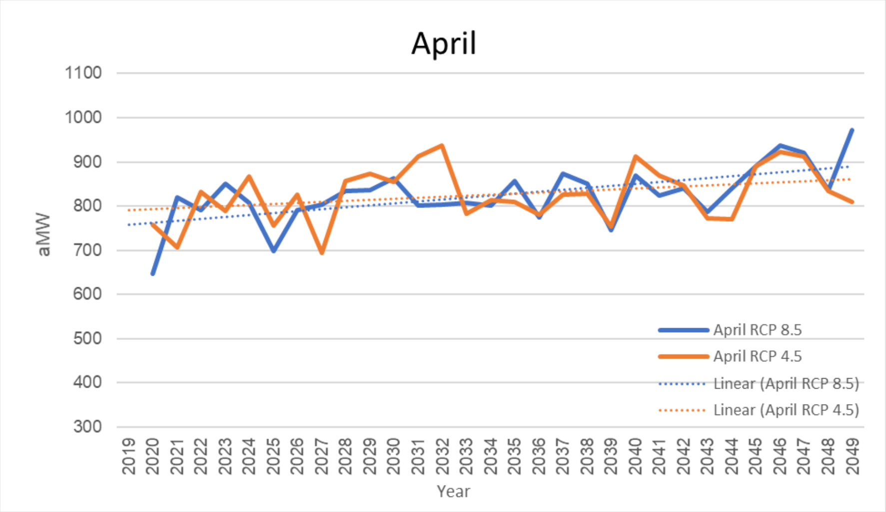
Results

2019-2049 Trend



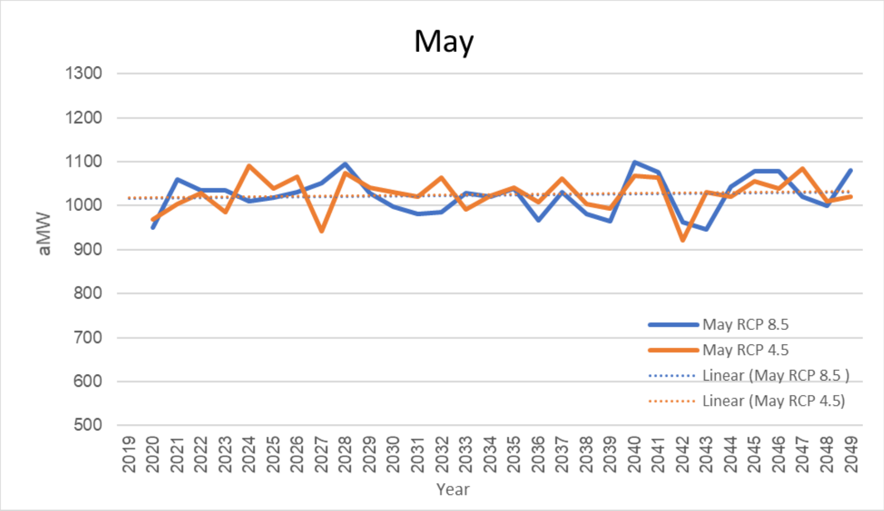


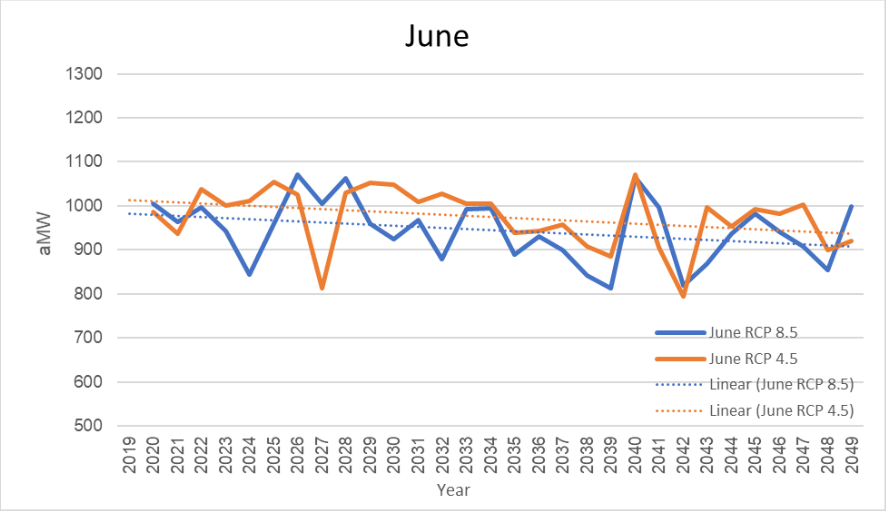


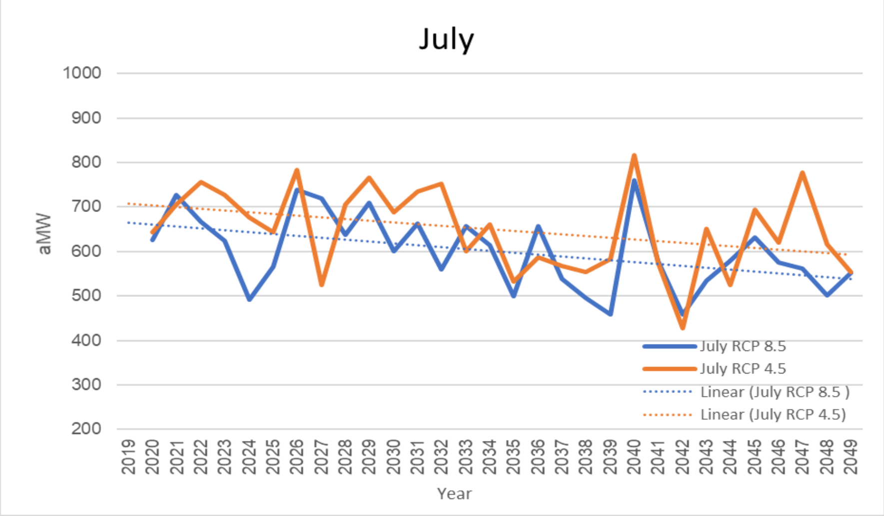


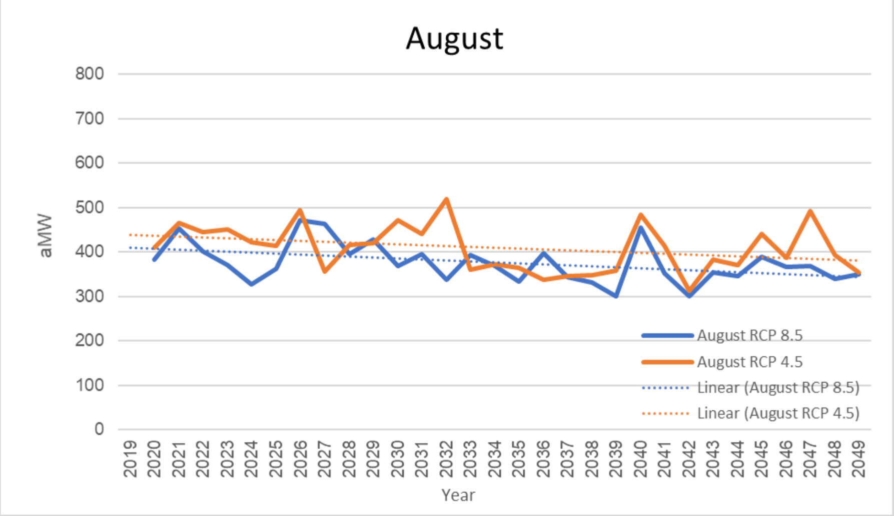
Results

2019-2049 Trend



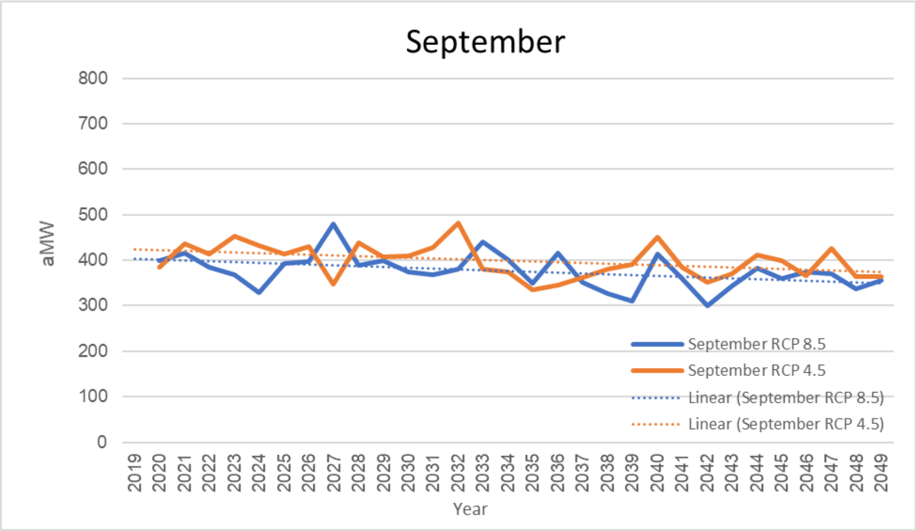


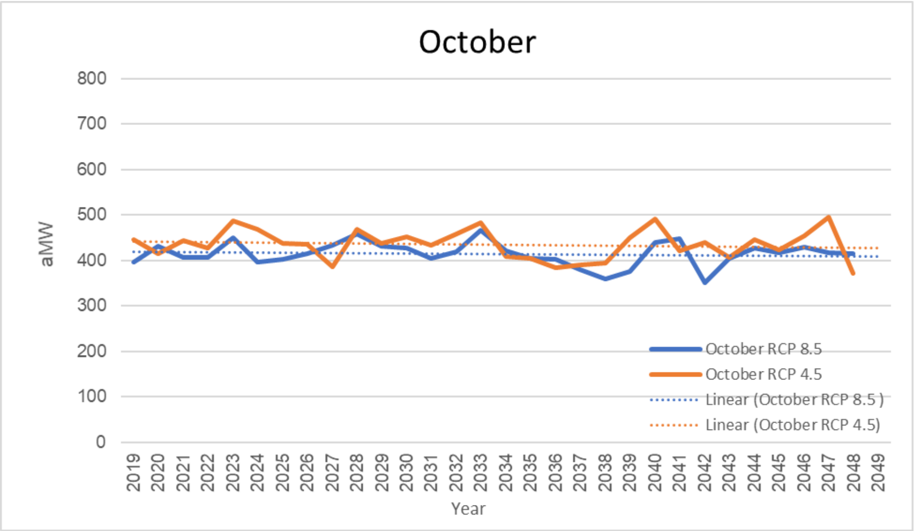


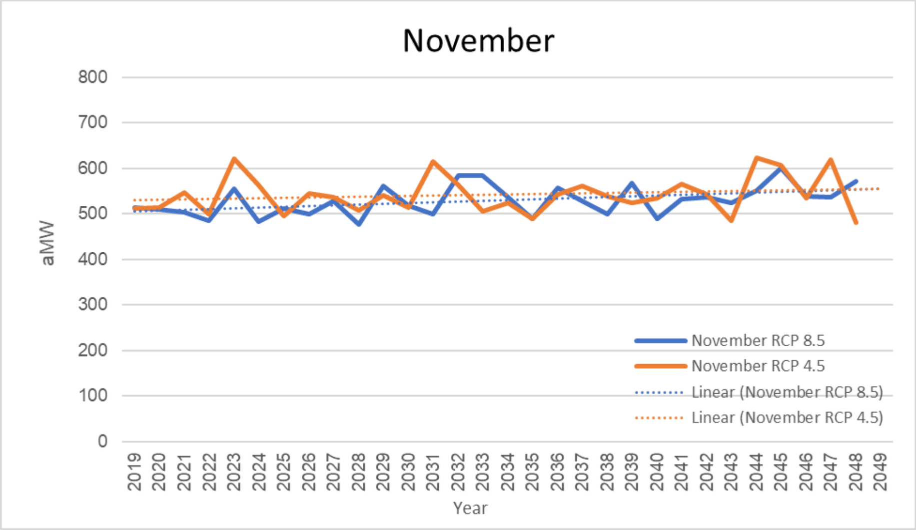


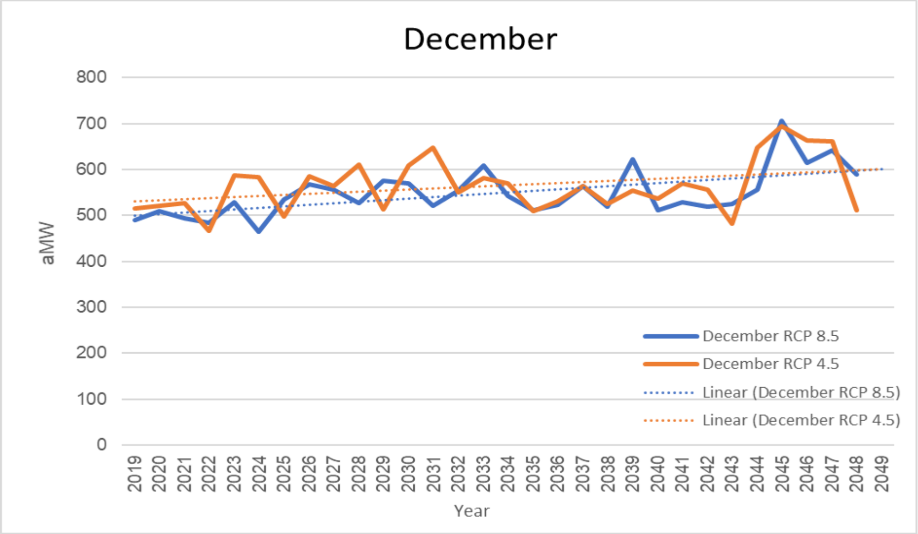
Results

2019-2049 Trend



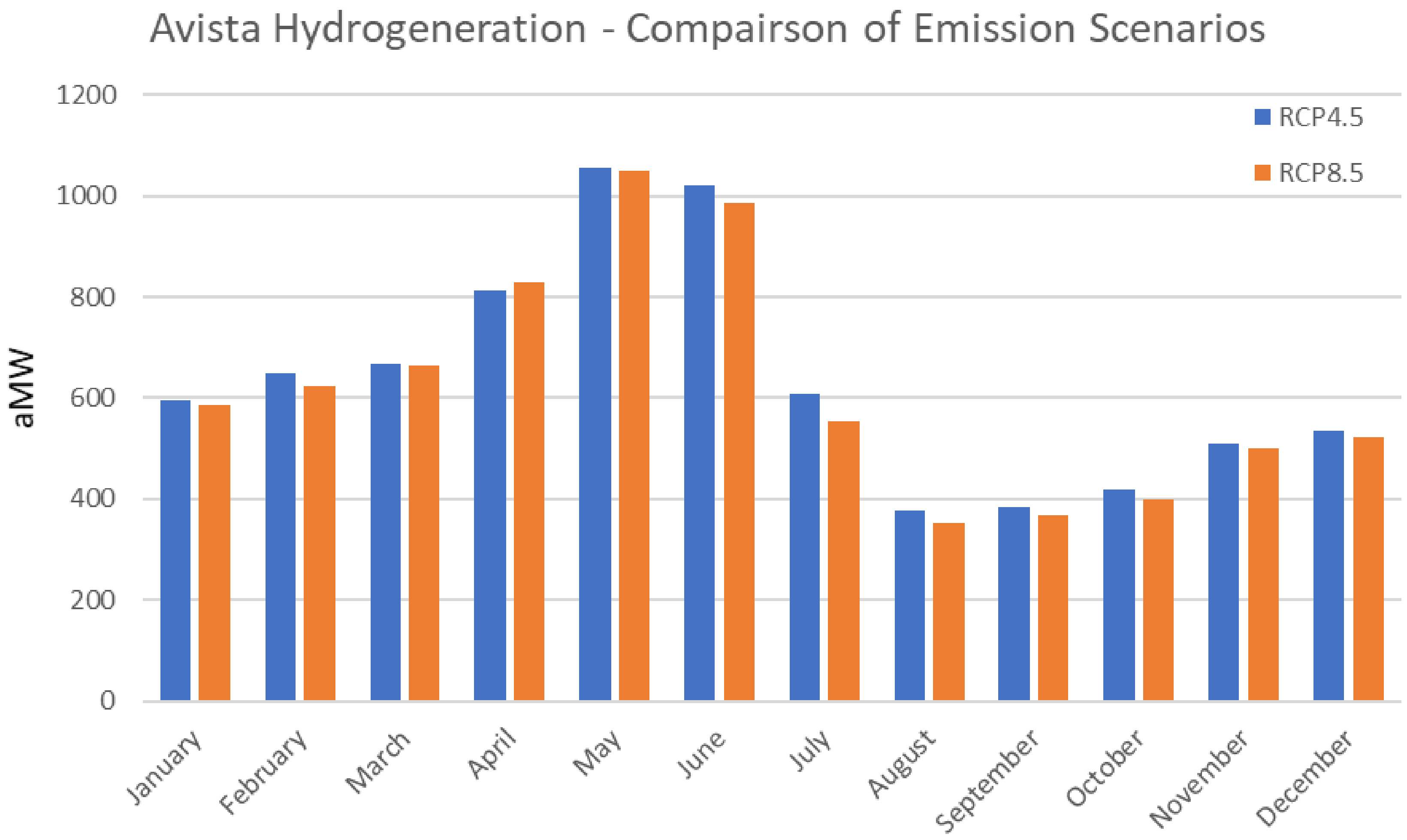






Results

Comparison of RCP4.5 and RCP8.5 for 2019-2049



Climate Change Impacts to Load

- Daily max and min temperature for Spokane airport through 2049 that correspond to the 19 BPA scenarios.

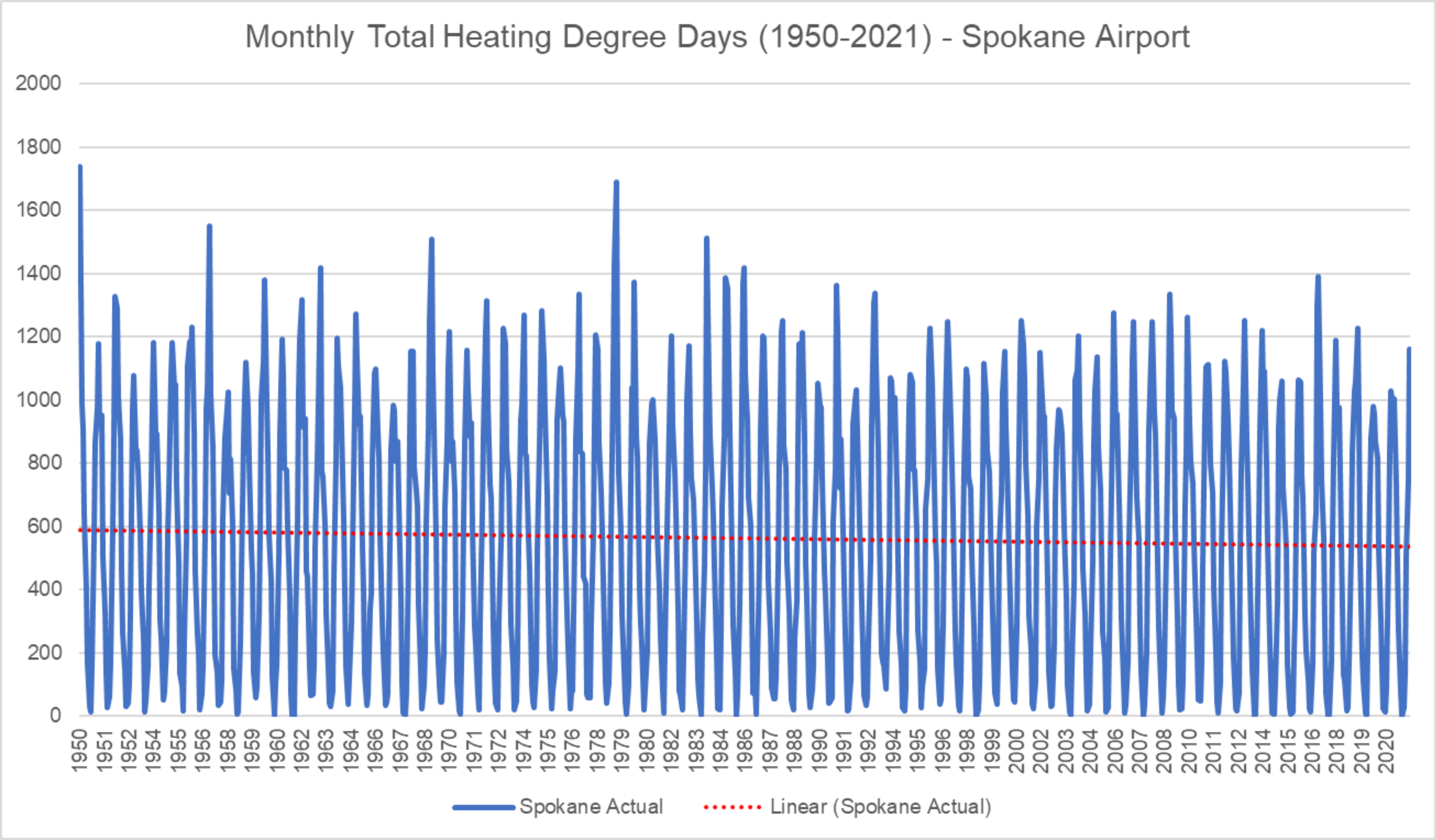
- Load forecasting model utilizes monthly heating degree days (HDDs) and cooling degree days (CDDs) as inputs to econometric model.

- Utilized the median average daily temperature of the climate models to calculate daily HDDs and CDDs and then summed monthly.

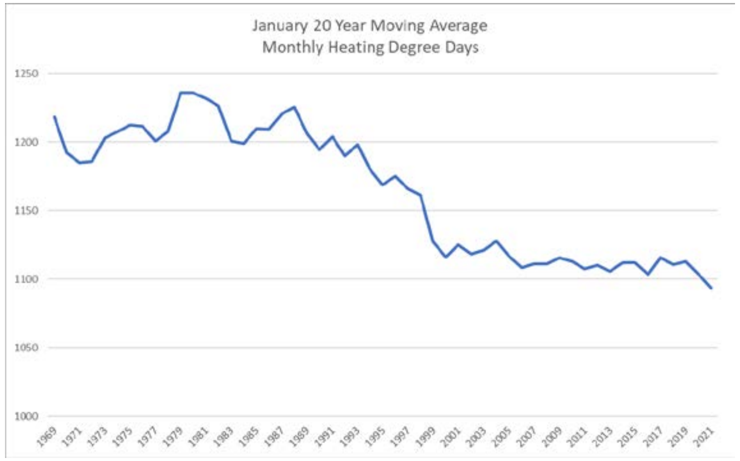
- Load forecast utilizes a 20-year moving average.

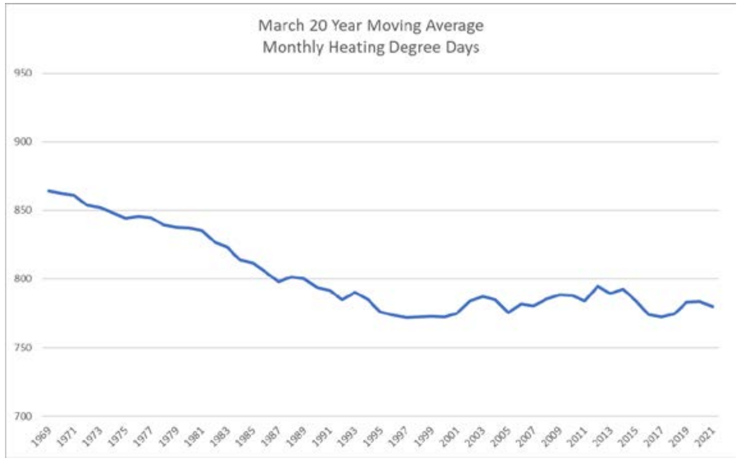
Climate Change Impacts to Load

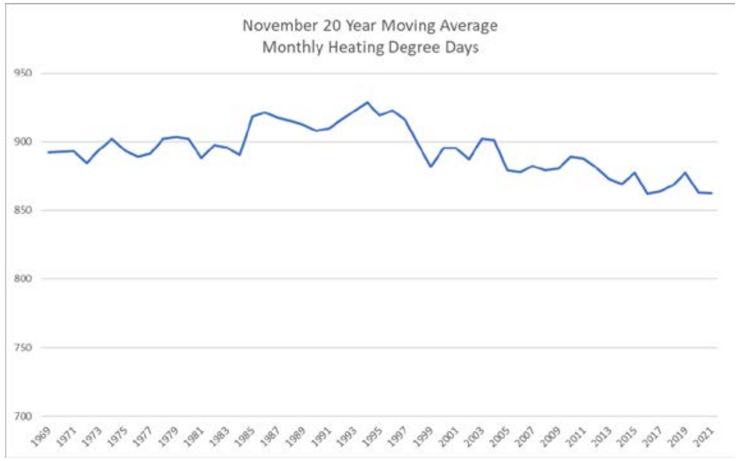
- Heating Degree Days Baseline Data

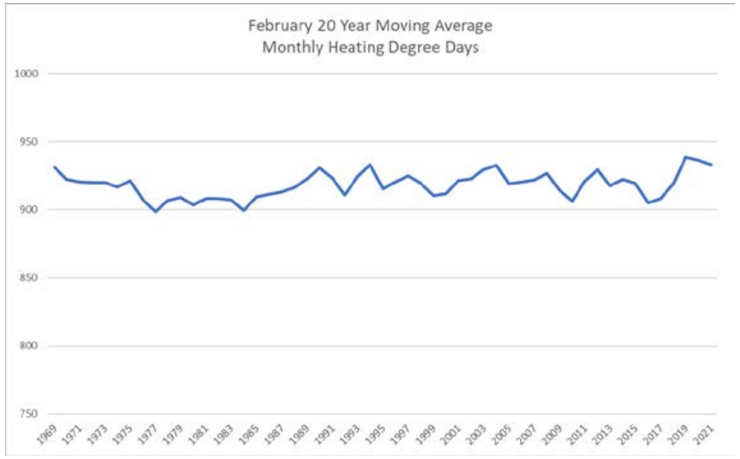


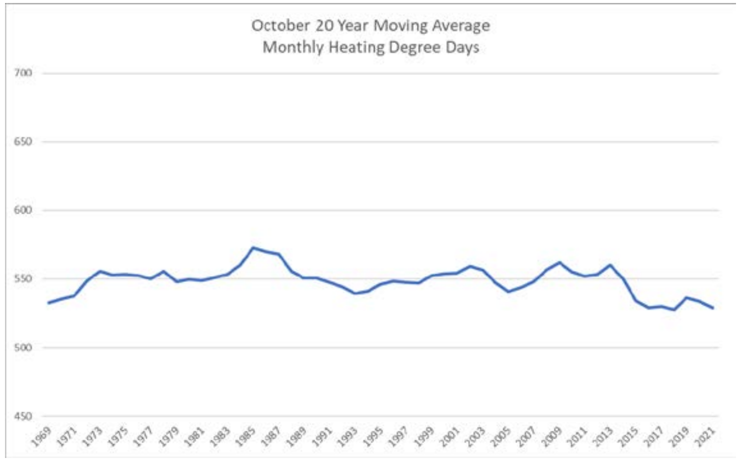
Climate Change Impacts to Load

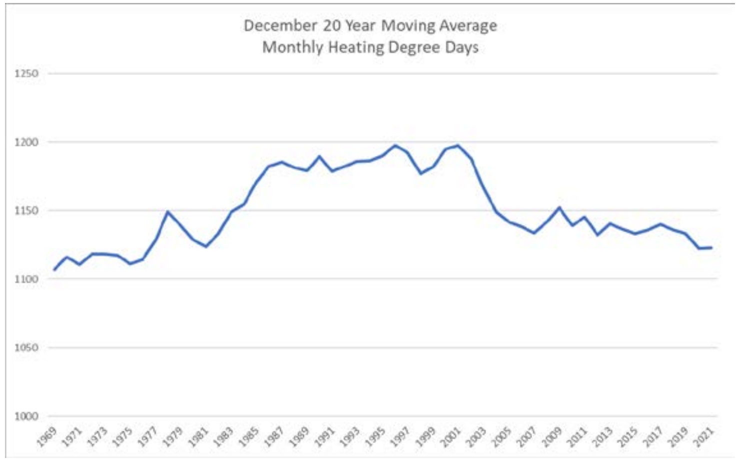






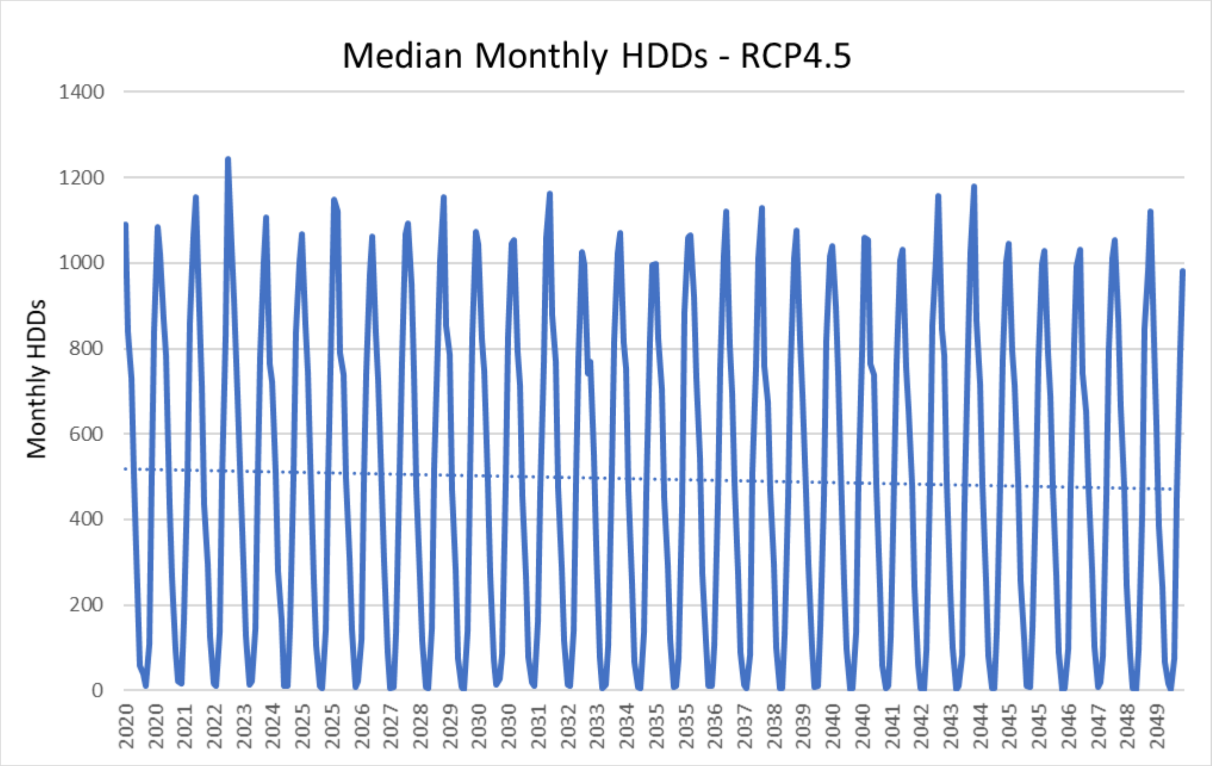


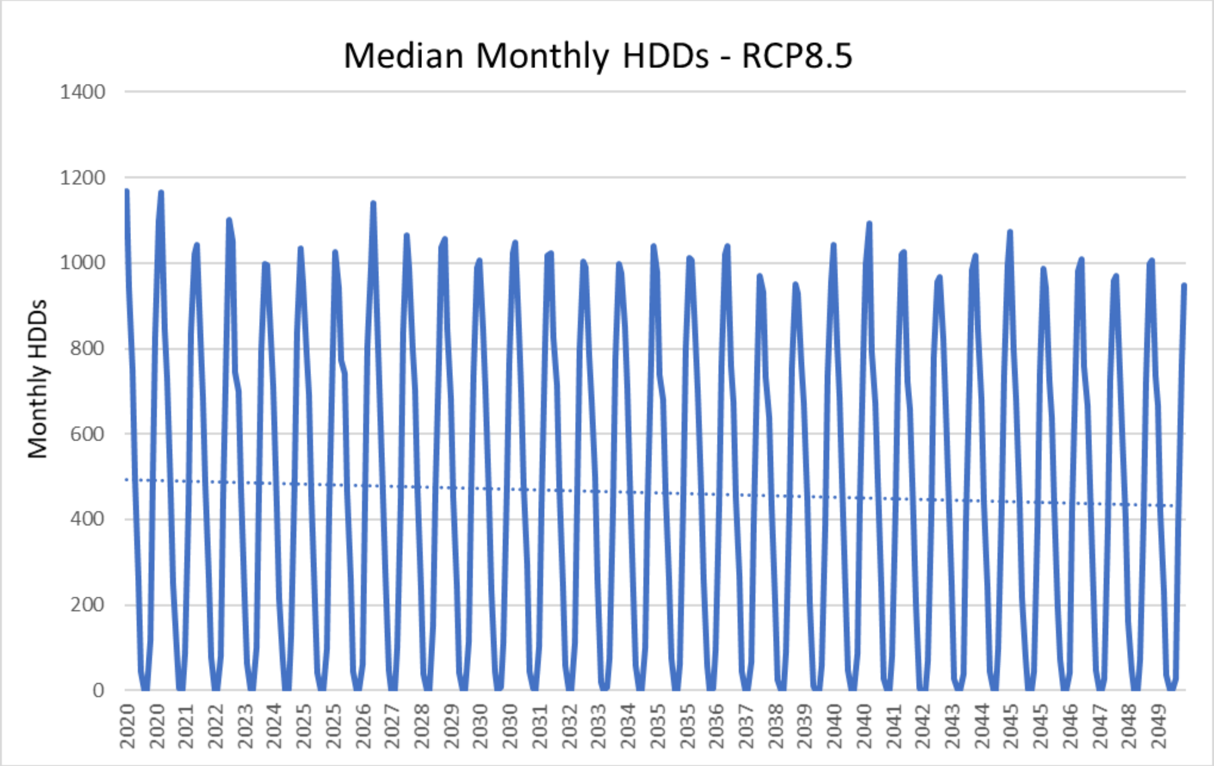




AVISTA

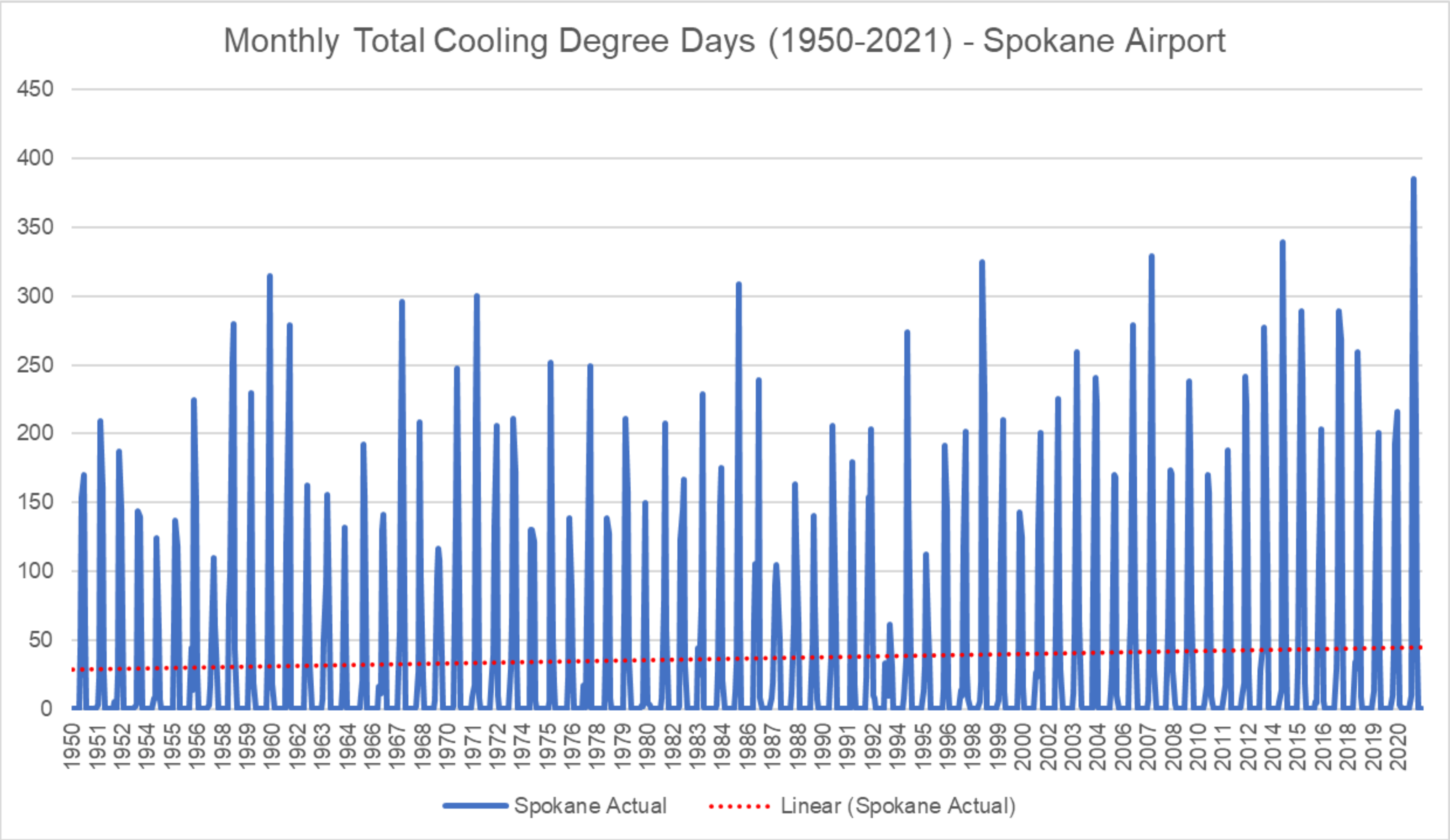
Climate Change Impacts to Load



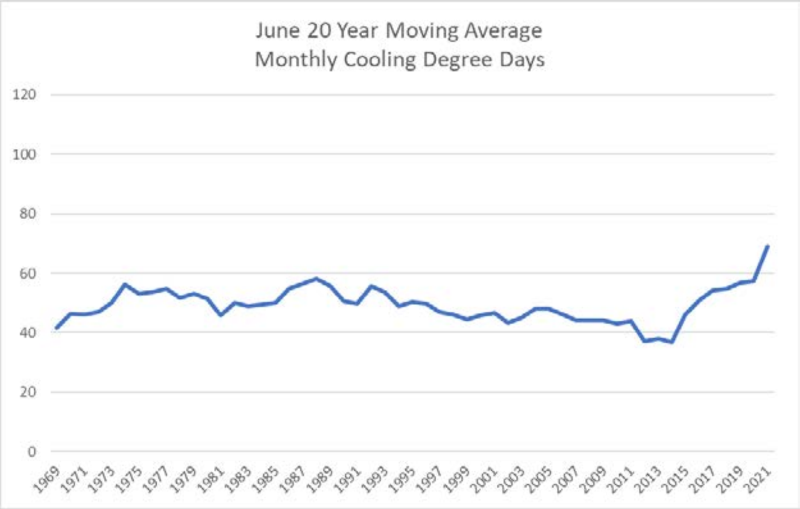


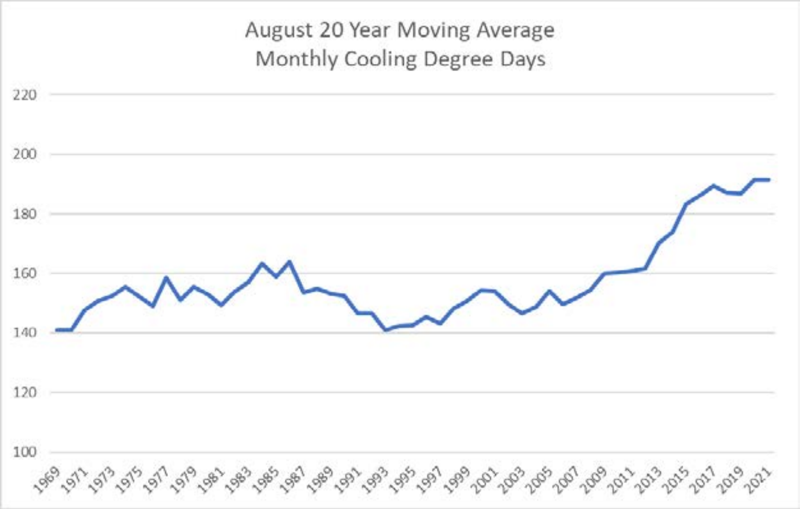
Climate Change Impacts to Load

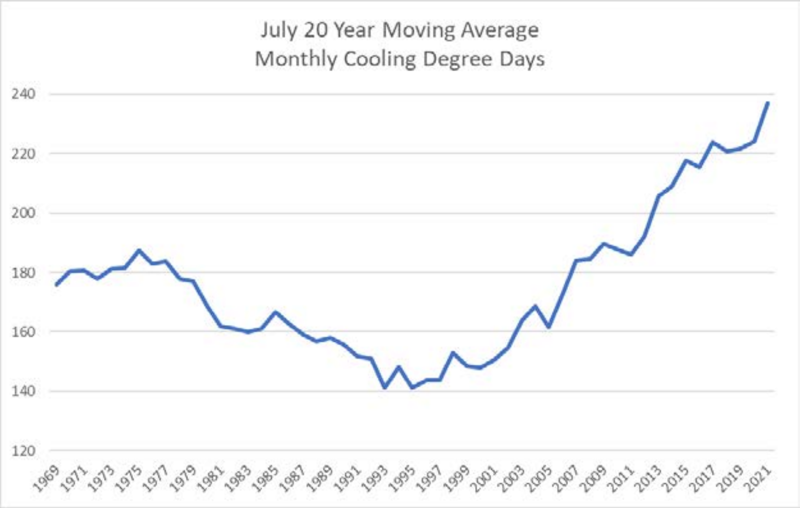
- Cooling Degree Days Baseline Data

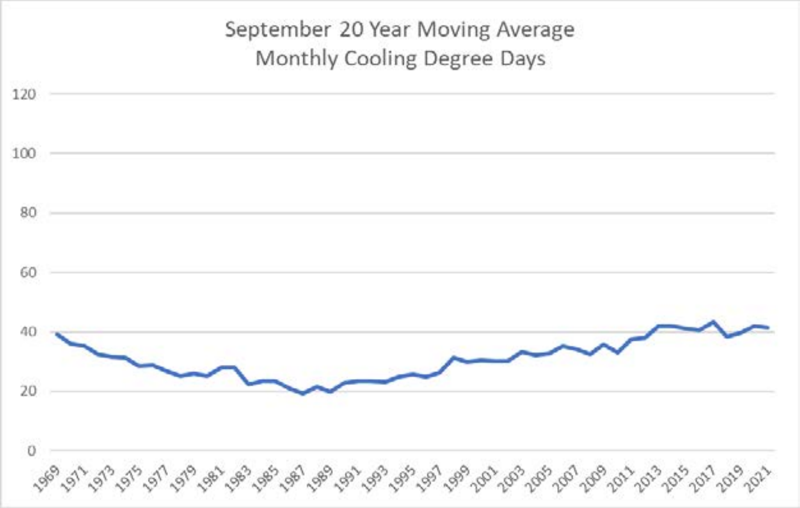


Climate Change Impacts to Load

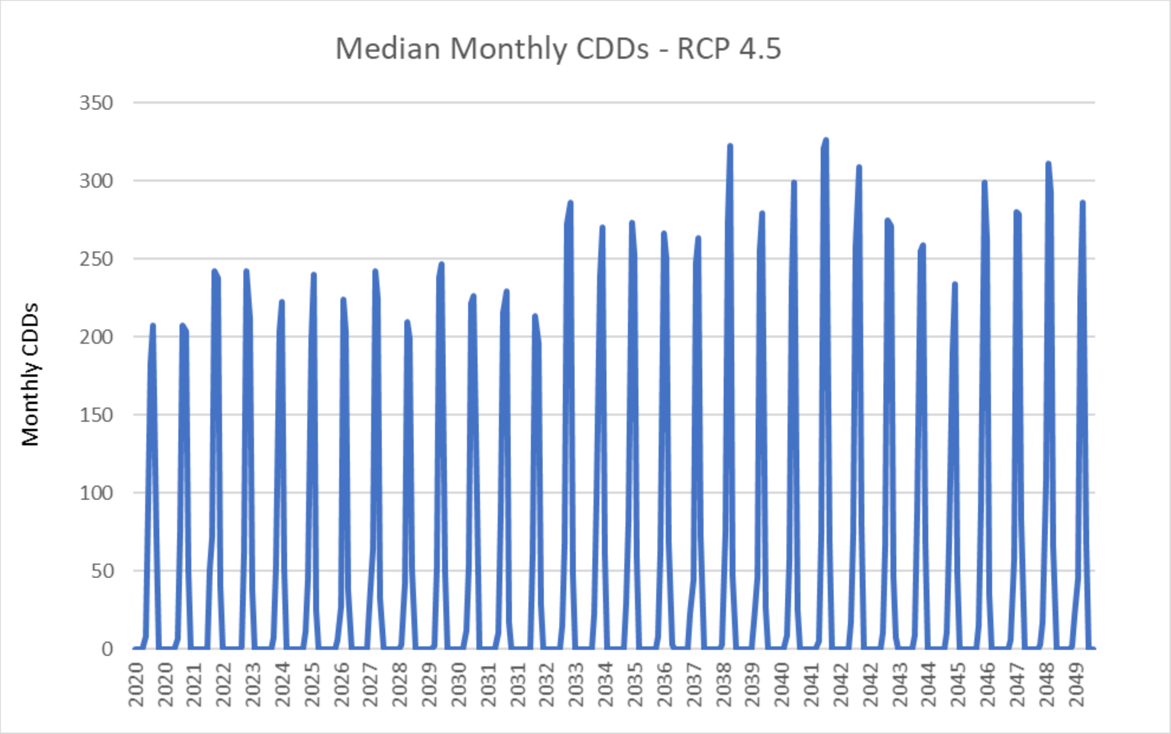


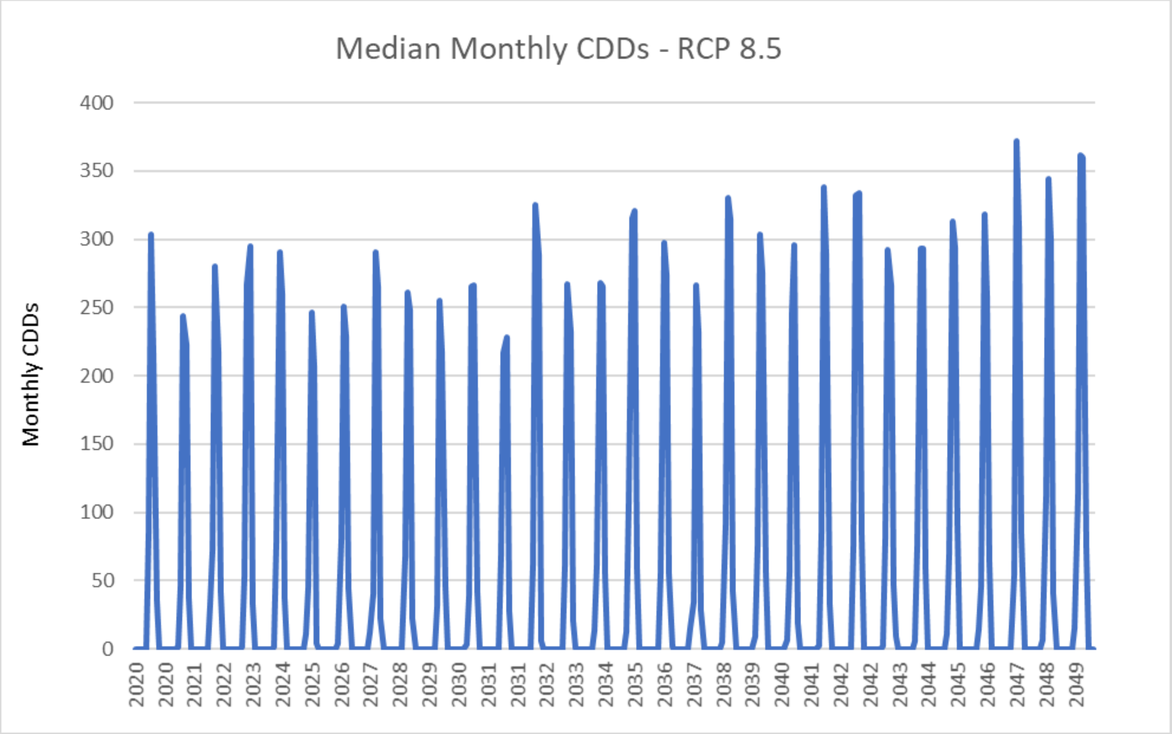






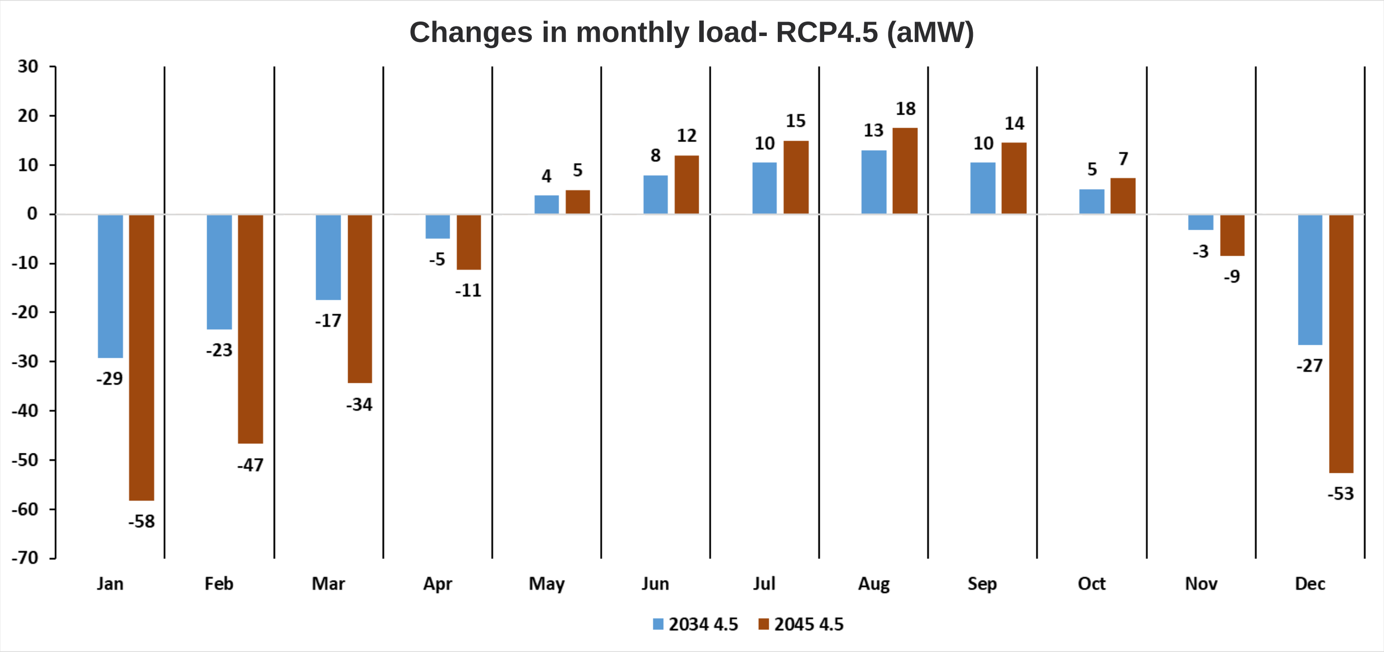
Climate Change Impacts to Load

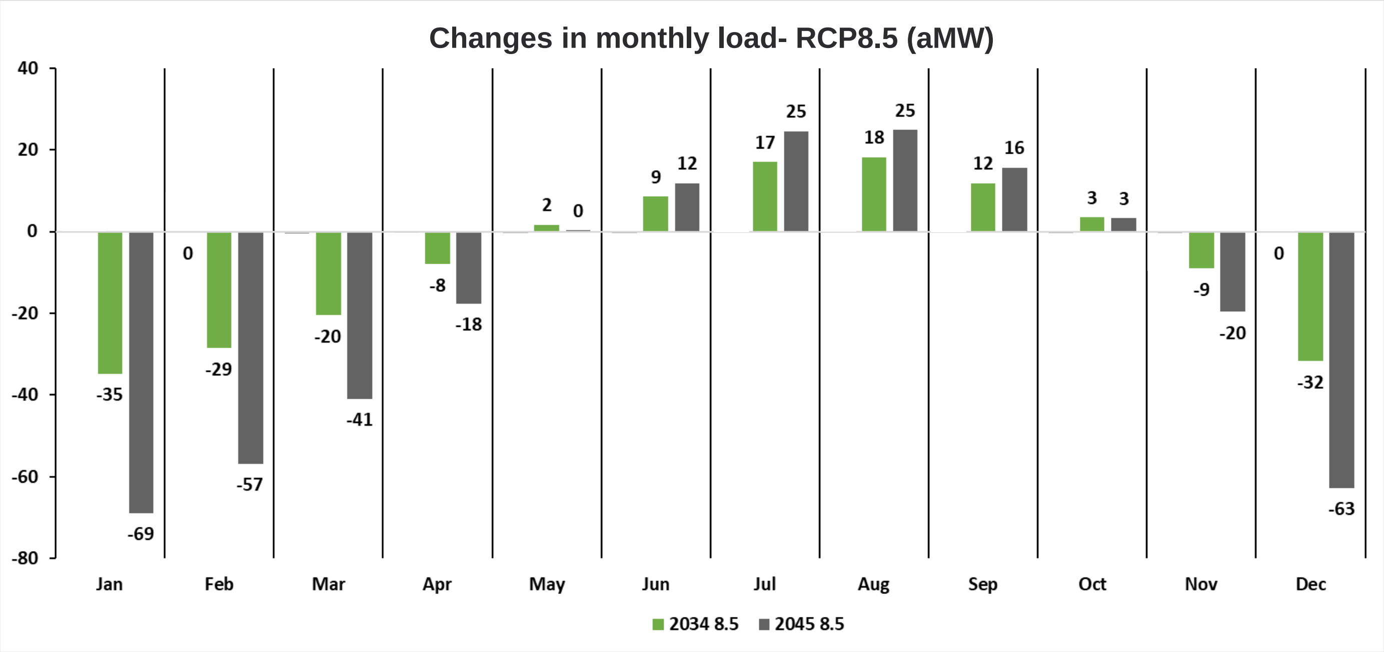




Impacts to Load

- Load forecast utilizes 20-year rolling average which phases into the climate change forecast.





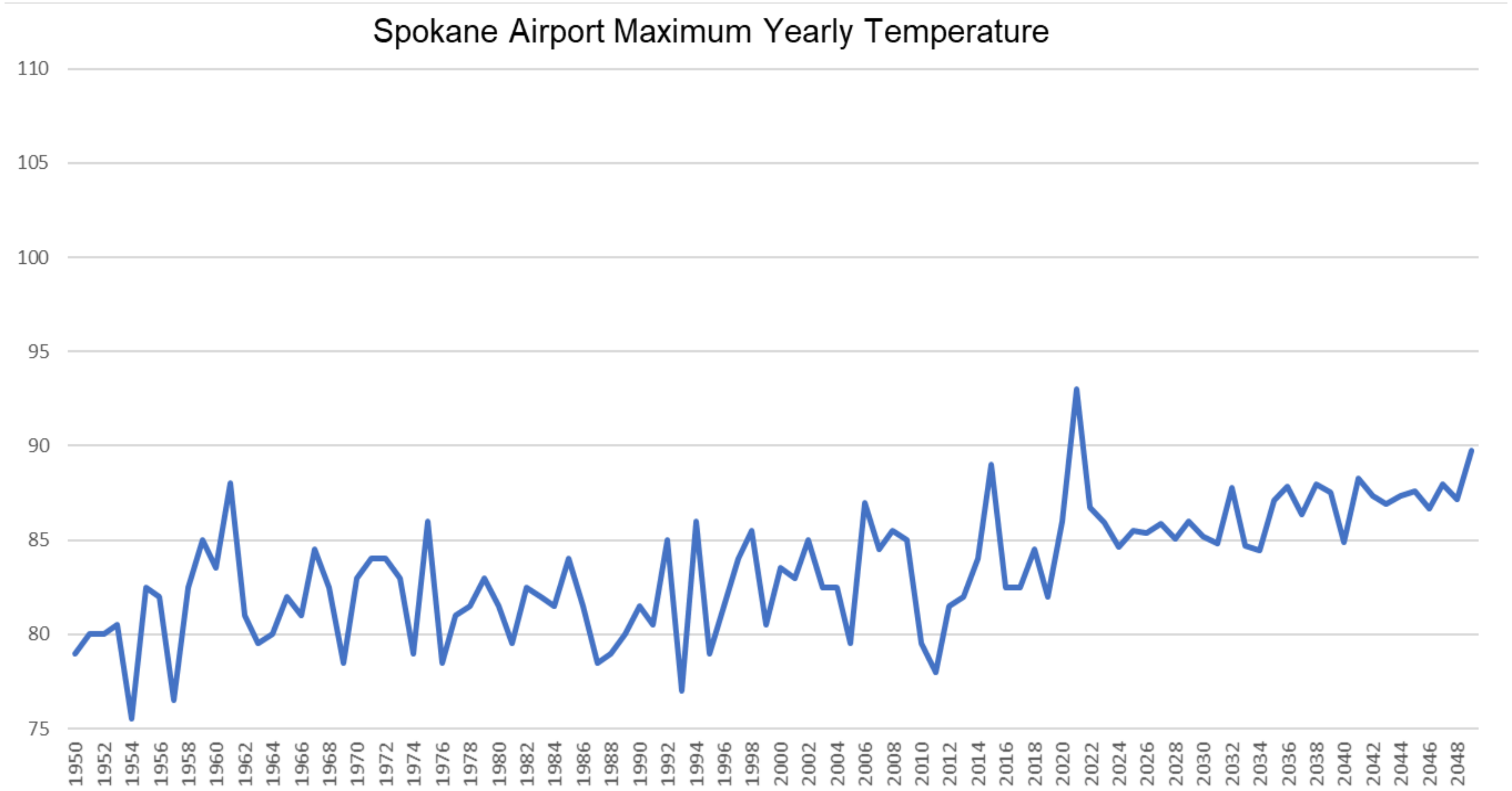
Climate Change Impacts to Peak Load

- Peak load model utilizes minimum/maximum daily average temperature for each month.
- Median of minimum/maximum average daily temperature for each month of all models.
- Summer and winter peak is the highest/lowest for each time period.
- Winter peak is based on a 76-year* moving average, summer peak is based on a 20-year moving average.

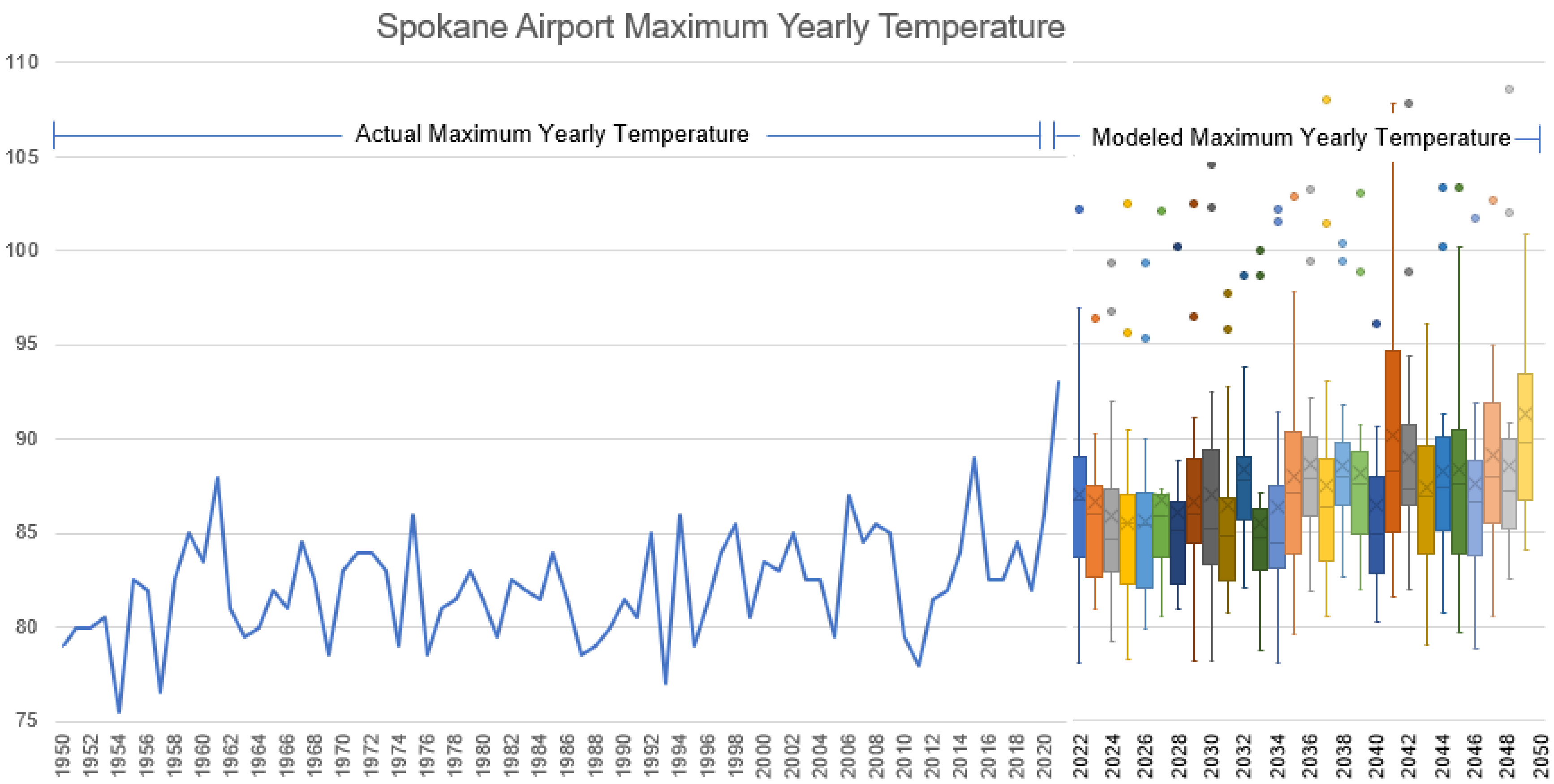
* Spokane temperature data changed in 1947.

AVISTA

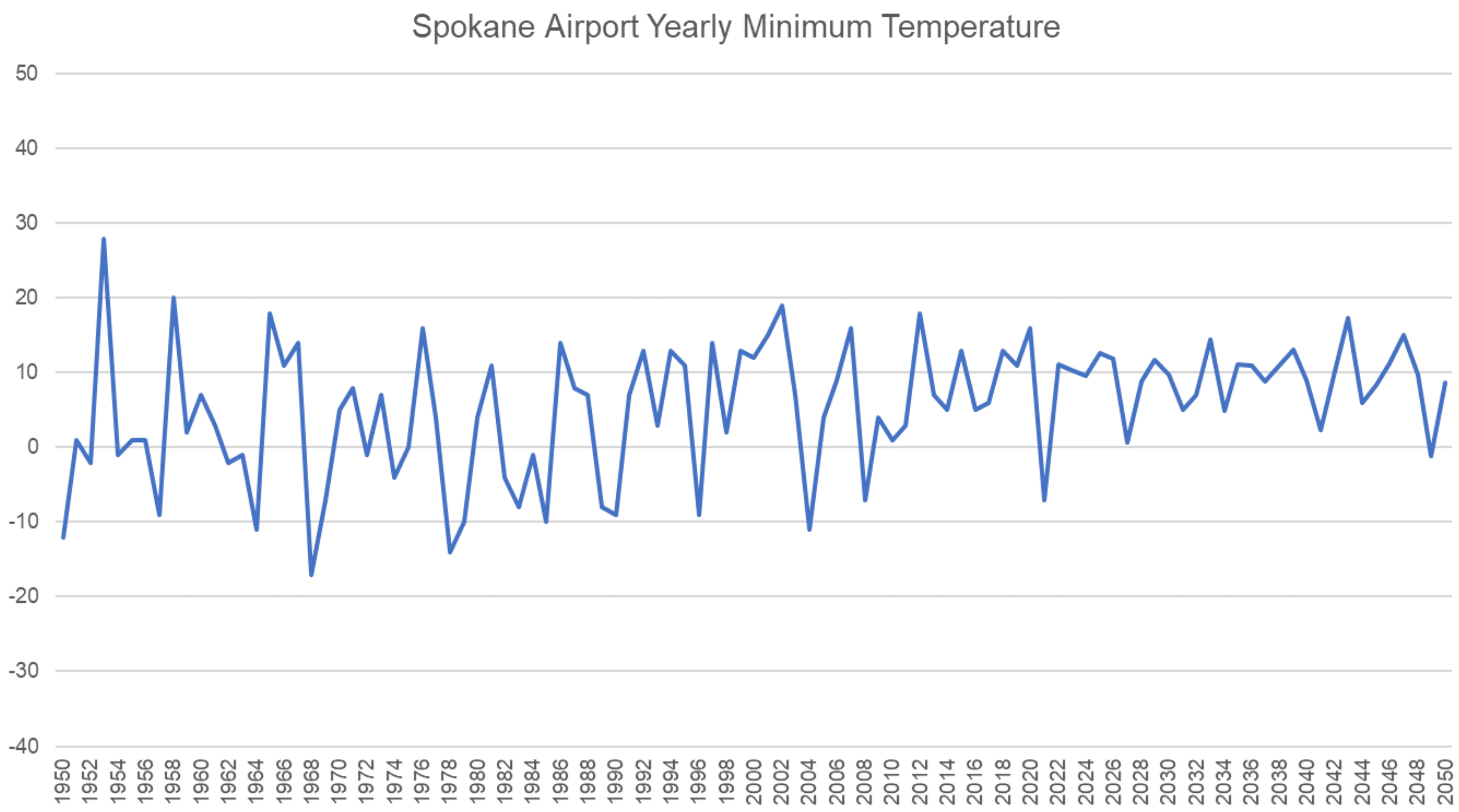
Climate Change Impacts to Peak Load



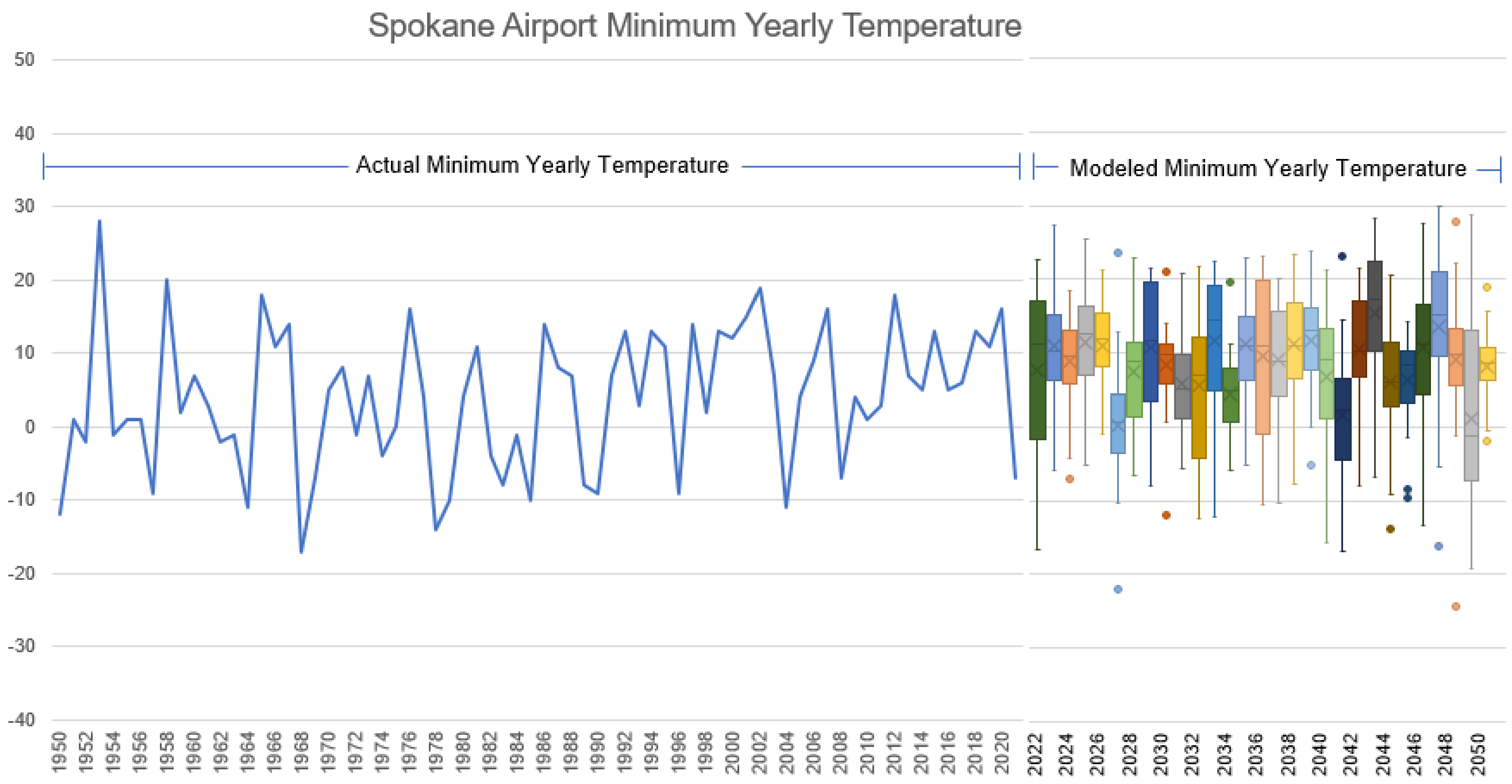
Climate Change Impacts to Peak Load



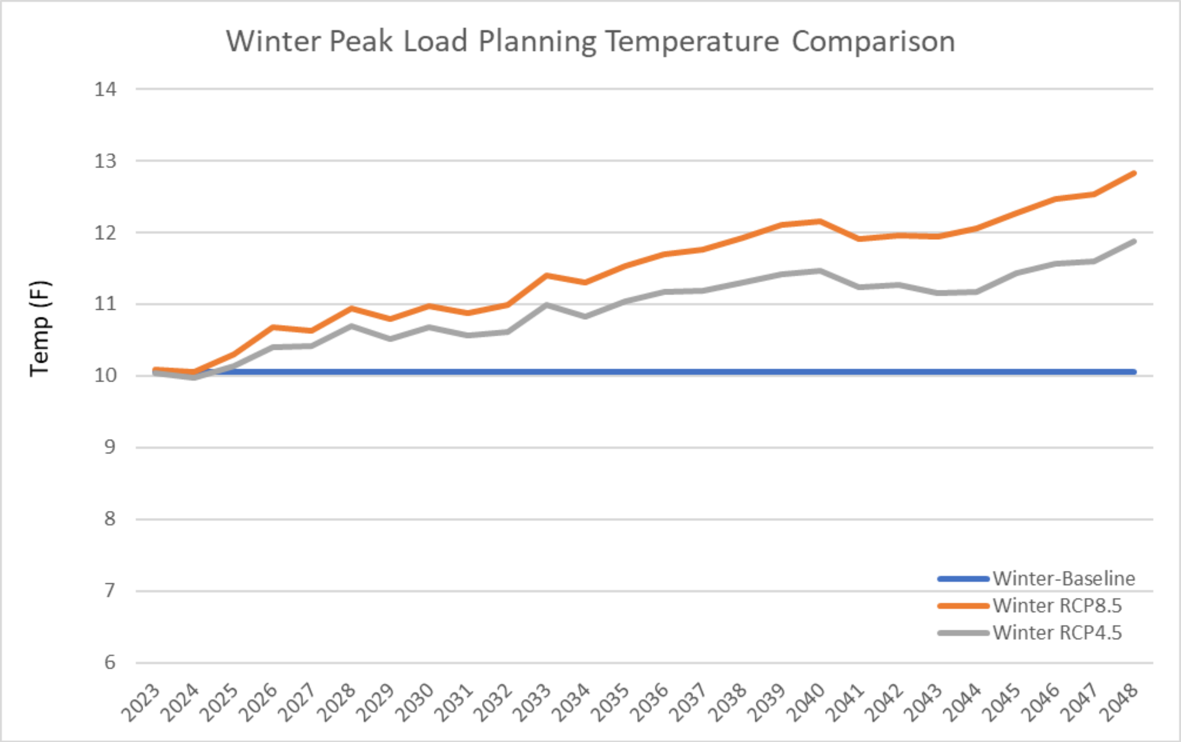
Climate Change Impacts to Peak Load

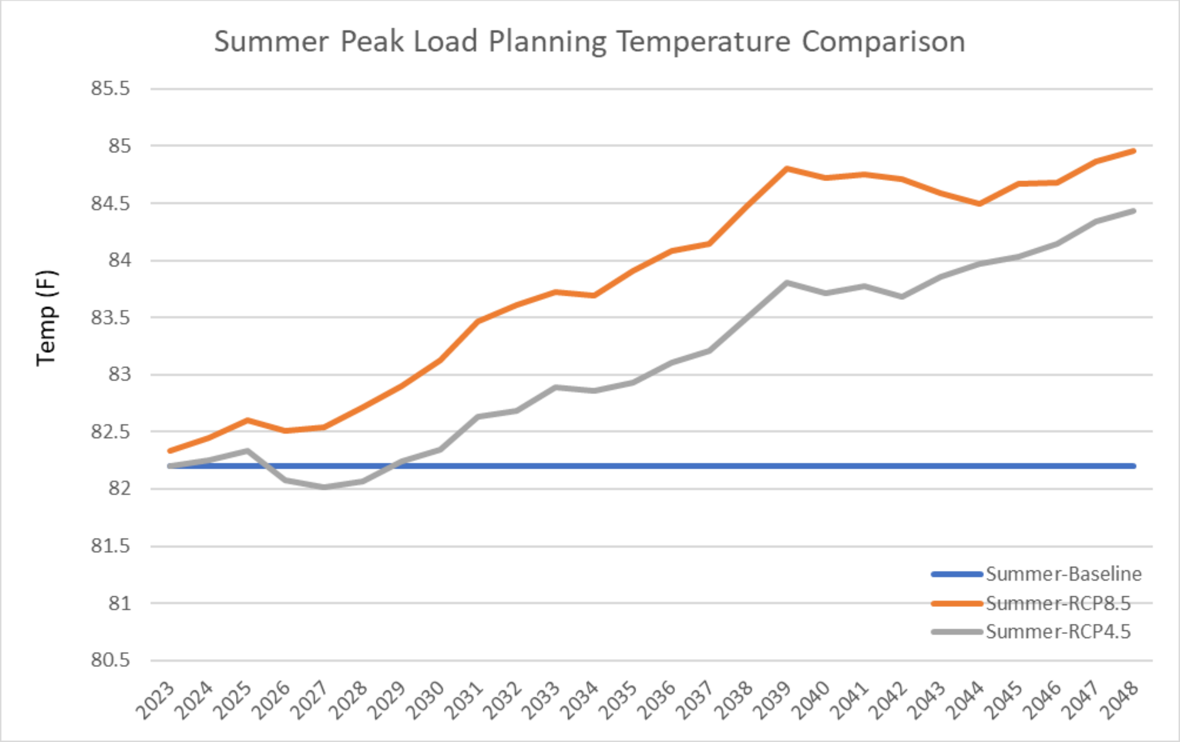


Climate Change Impacts to Peak Load

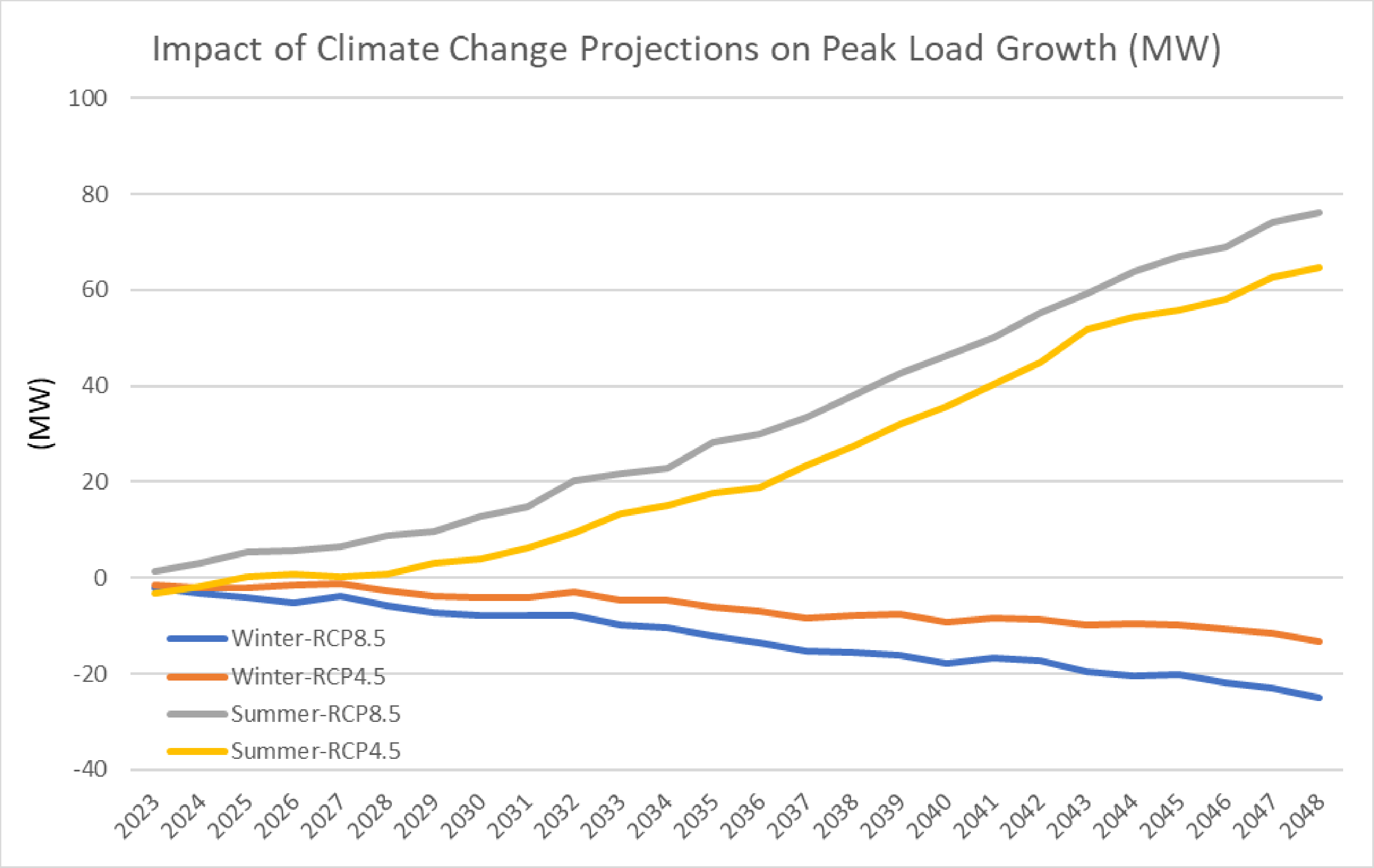


Climate Change Impacts to Peak Load

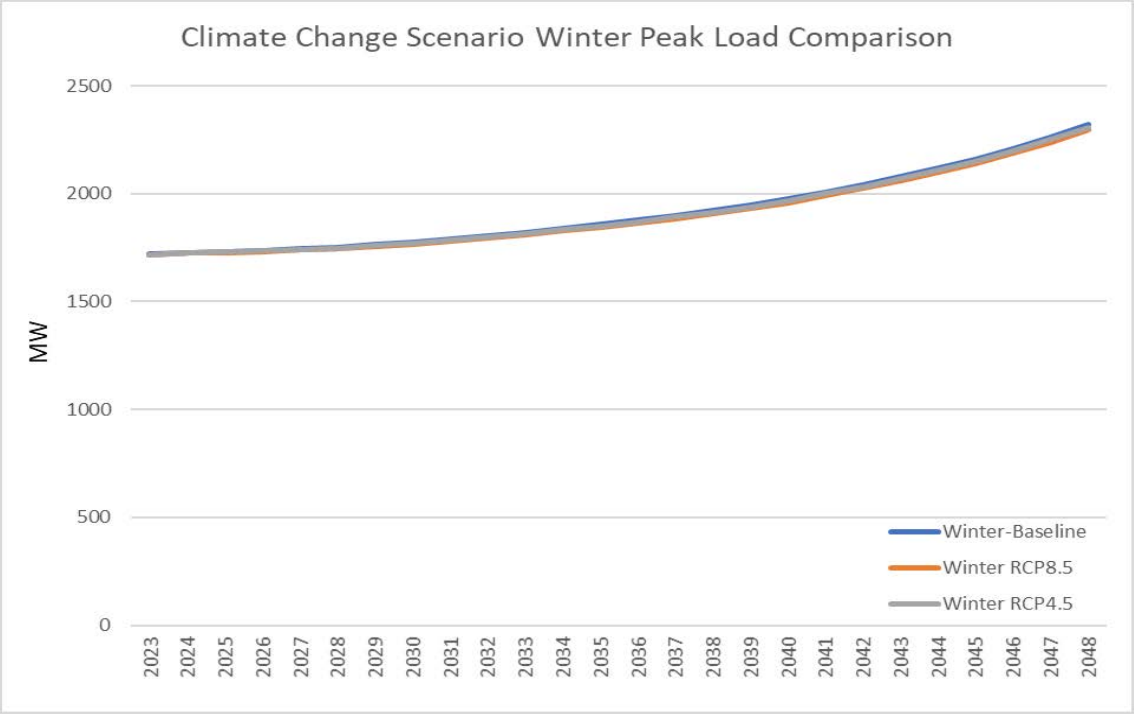


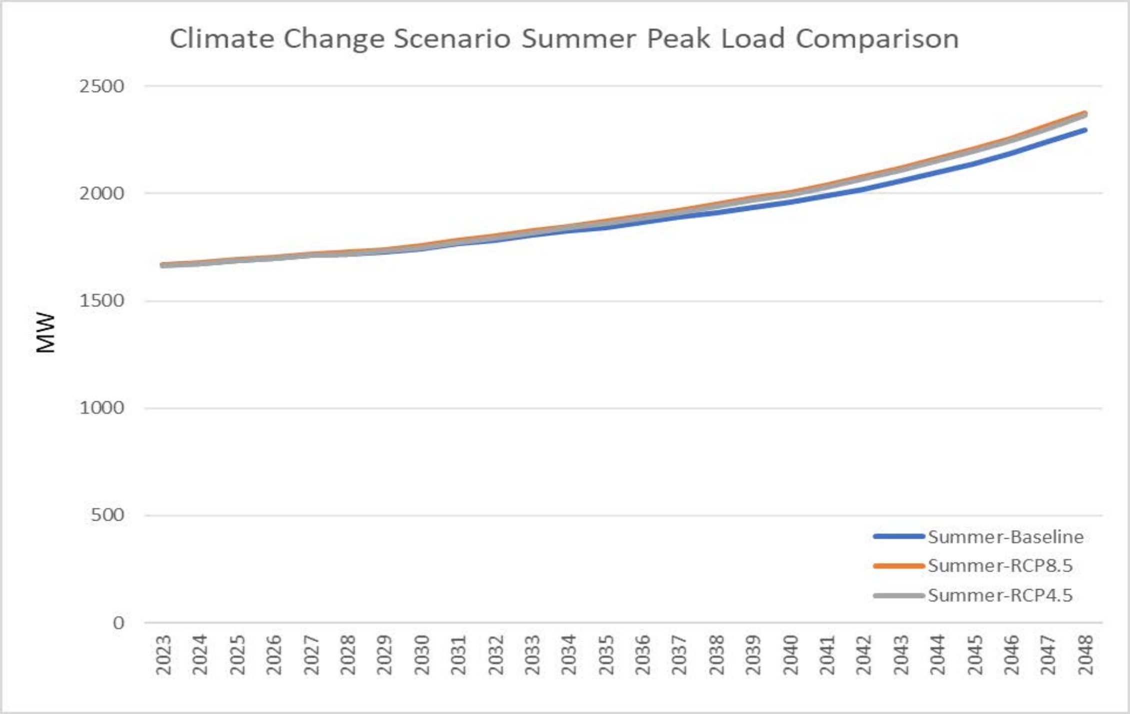


Climate Change Impacts to Peak Load



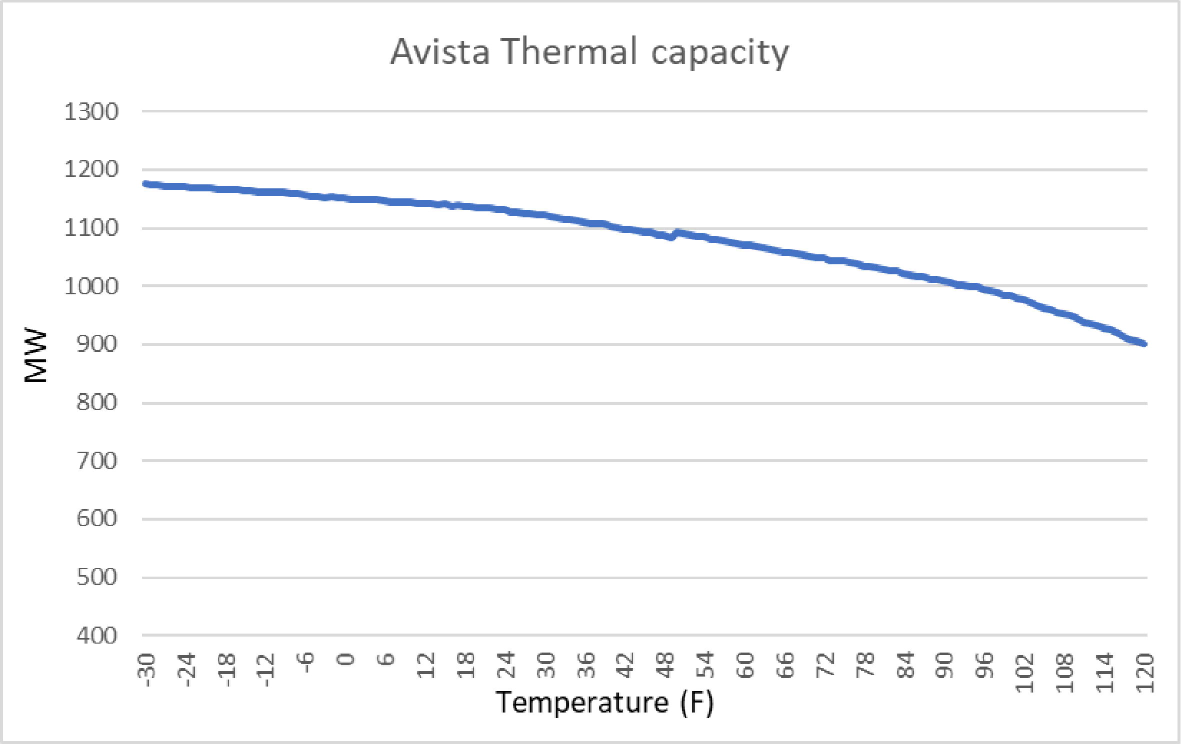
Climate Change Impacts to Peak Load





Climate Change Impacts to Peak Load

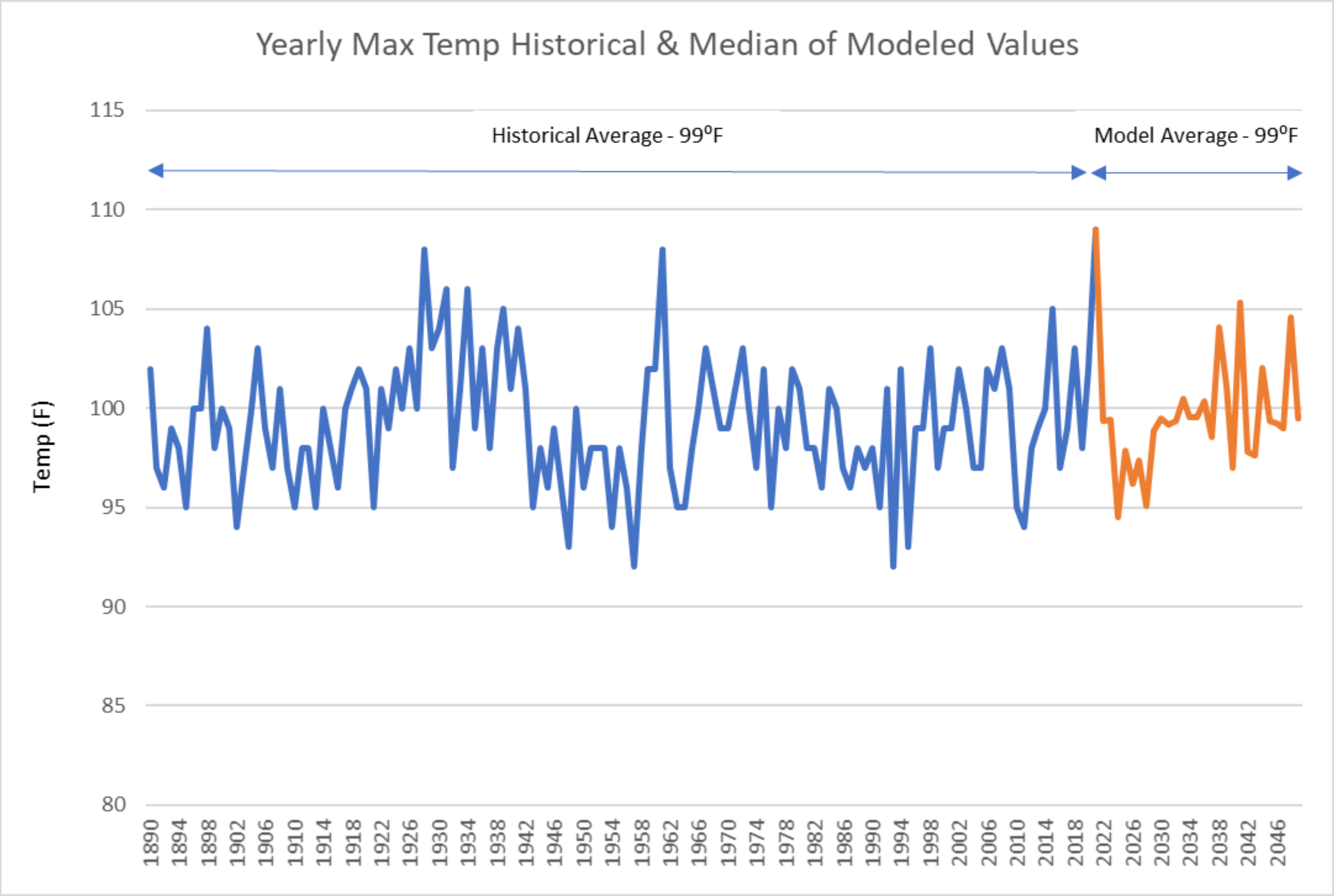
- Capacity of gas turbines decreases as temperature increases.



- Will increased maximum temperatures reduce capacity during extreme heat events?

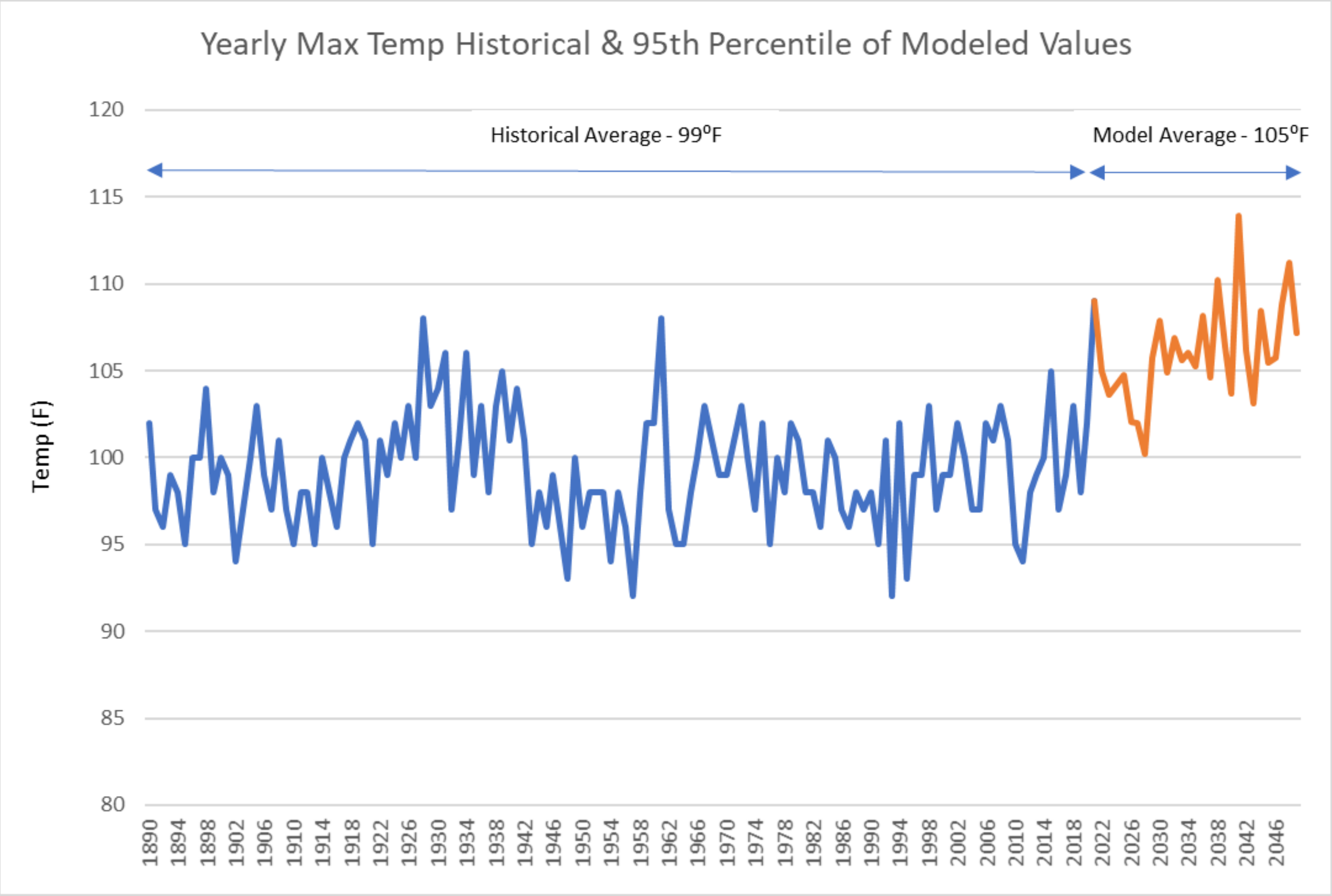
Climate Change Impacts to Peak Load

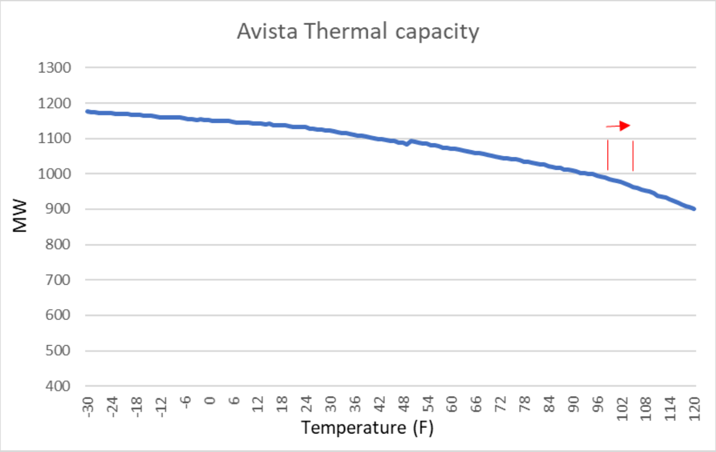
- Historical yearly maximum temperatures similar to median yearly maximum modeled temperatures
- No difference in thermal capacity when comparing historical data to median of climate models



Climate Change Impacts to Peak Load

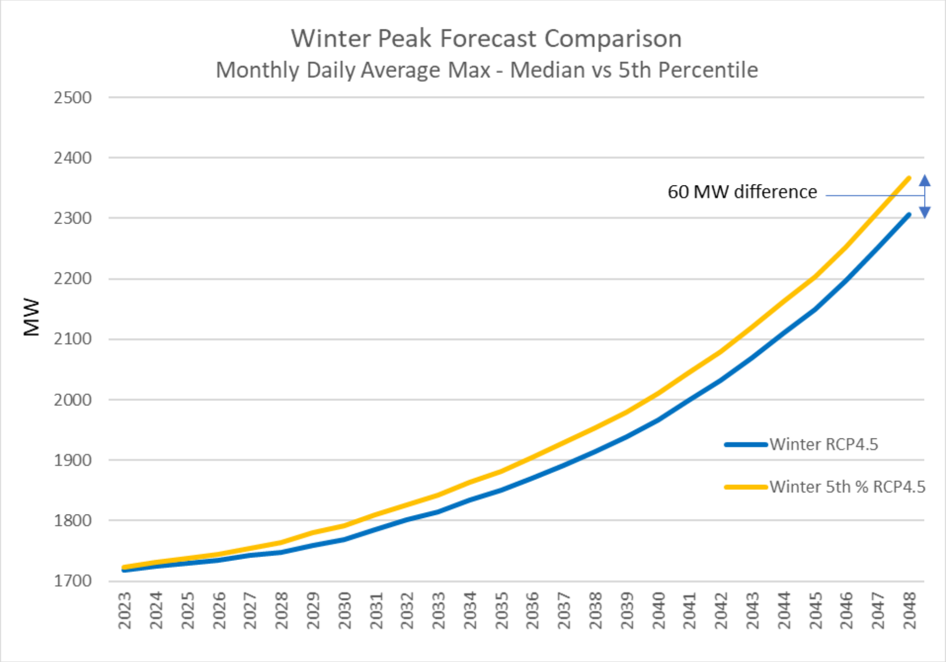
- Thermal capacity is reduced by 22 MW at the 95th percentile of yearly maximum, maximum temperatures

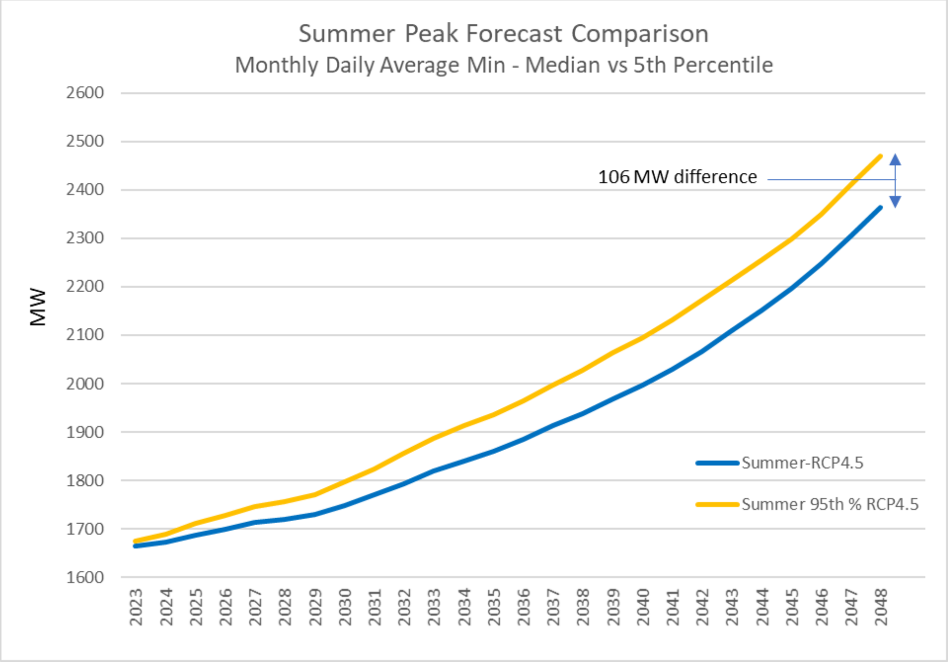




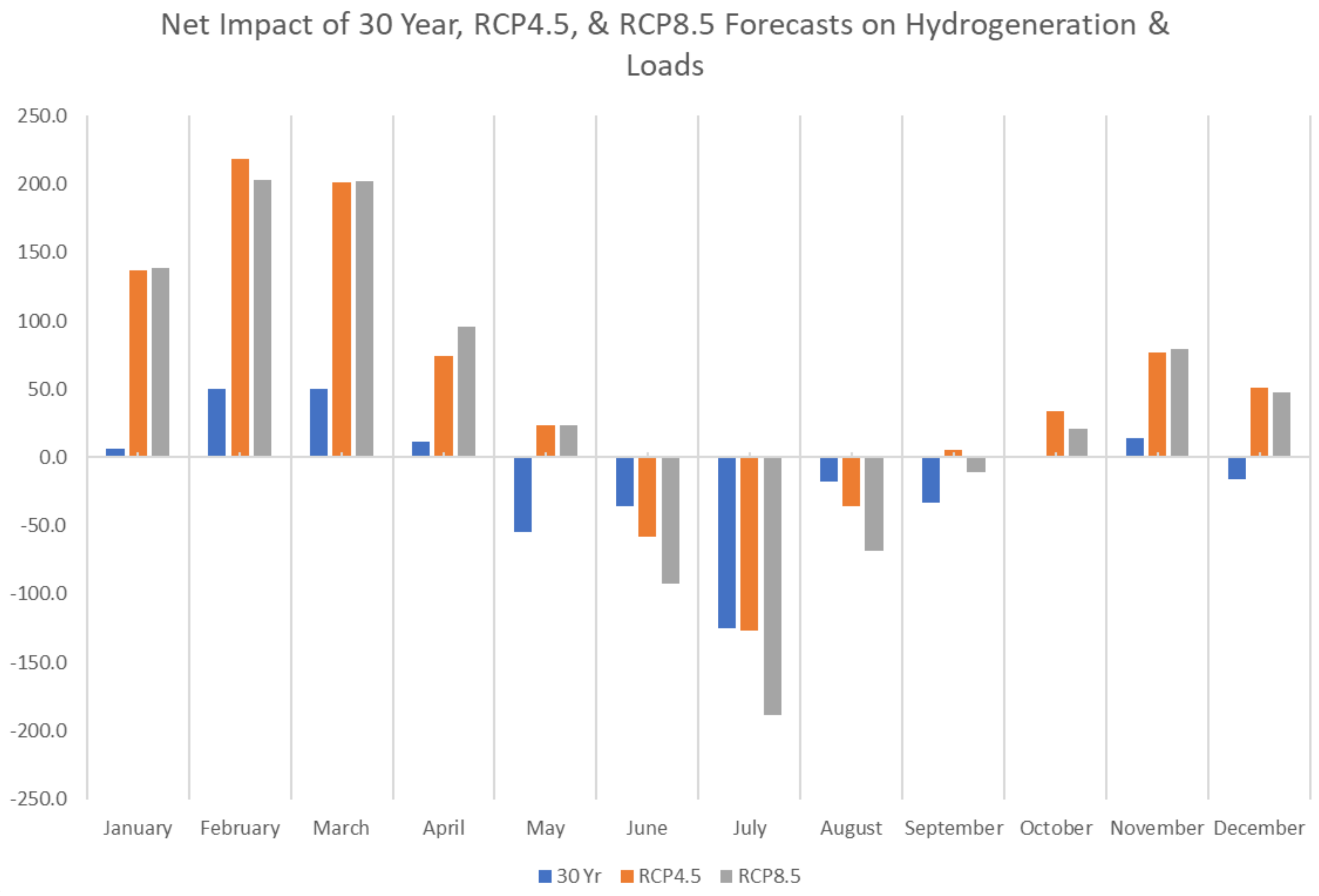
Climate Modeling and Peak Load Risk

- Capacity risk is addressed with the planning reserve margin.
- Given the variance of the climate change models, what is the risk associated with climate change at the extremes of the modeling, and does that risk increase over the planning horizon?





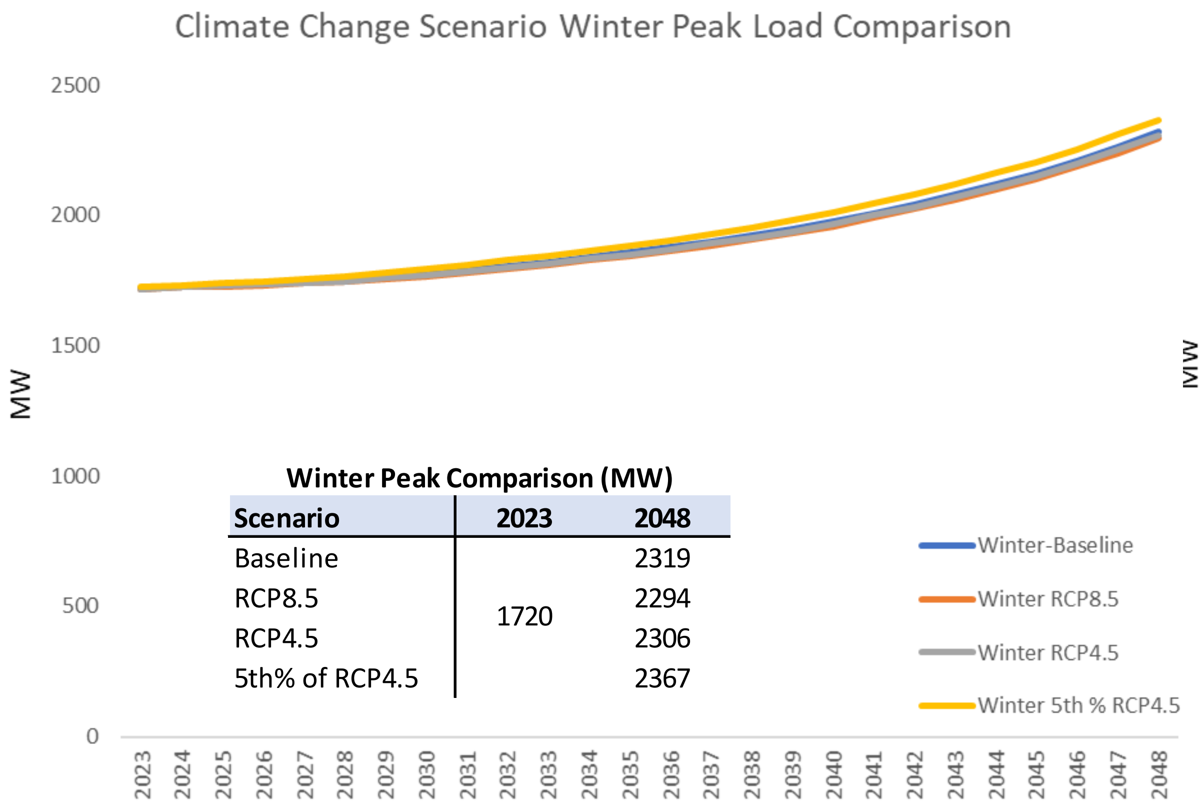
Climate Change – Net Impact



Difference from current 80 year hydro record

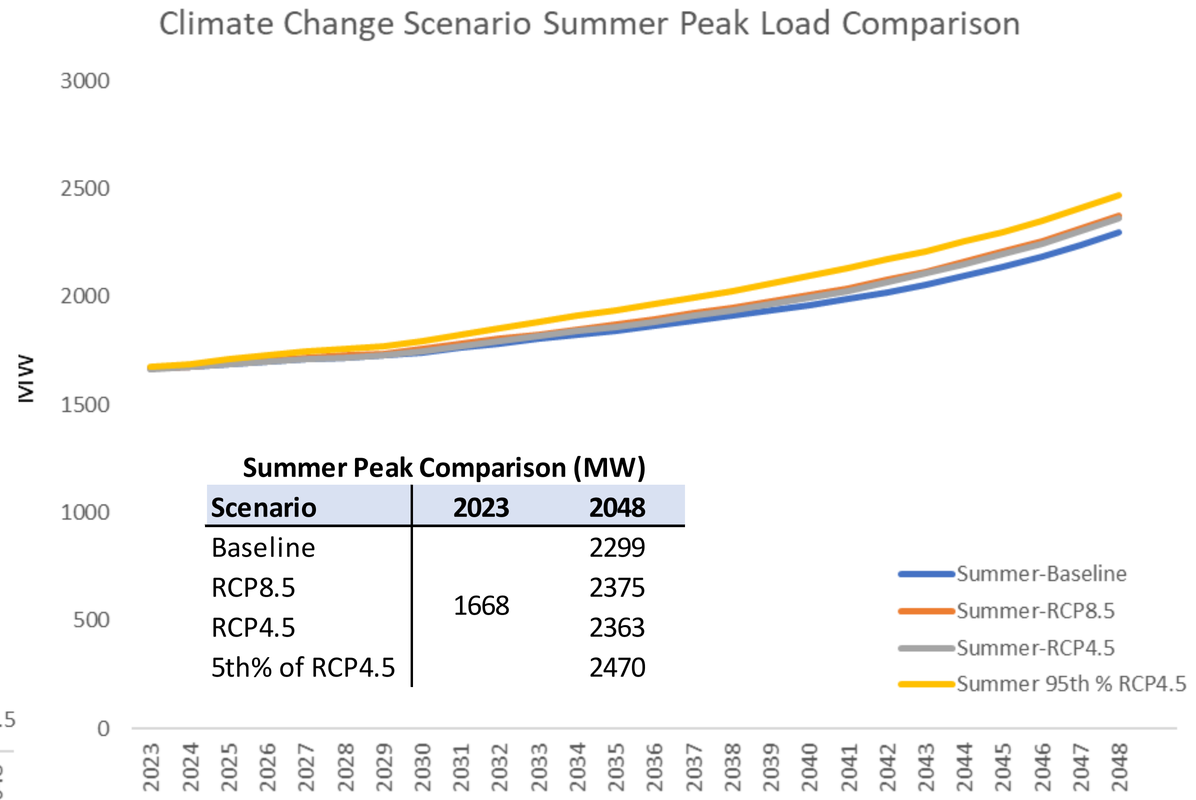
Month	30 Yr	RCP4.5	RCP8.5
January	6	137	139
February	50	218	203
March	50	201	202
April	11	74	96
May	-54	23	24
June	-36	-58	-92
July	-125	-127	-189
August	-17	-36	-69
September	-33	6	-11
October	0	34	21
November	14	76	80
December	-16	51	48

Climate Change – Net Impact



Winter Peak Comparison (MW)

Scenario	2023	2048
Baseline	1720	2319
RCP8.5		2294
RCP4.5		2306
5th% of RCP4.5		2367



Summer Peak Comparison (MW)

Scenario	2023	2048
Baseline	1668	2299
RCP8.5		2375
RCP4.5		2363
5th% of RCP4.5		2470

IRP Climate Change Approach

- Use RCP4.5 Scenario
  - Description by Intergovernmental Panel on Climate Change (IPCC)
    - RCP2.6 – stringent mitigation scenario
    - RCP4.5 & RCP6.0 – intermediate scenarios
    - RCP8.5 – very high GHG emissions
  - RCP4.5 & RCP6.0 are similar in IRP planning horizon
- Hydrogeneration – Move from median of 80-year (1929-2008) to median of previous 30 years throughout planning horizon
- Energy Load Forecast – move from static assumed temperature to moving average of previous 20 years throughout planning horizon
- Peak Load Forecast – move from static assumed temperature to moving average of previous 20 years (summer peak) and 76 years (winter peak)