2022 Integrated Resource Plan

Building the Long-Term Plan: May 16, 2022

SCL Team and IRP Advisory Group

Seattle City Light

WE POWER SEATTLE

Building the 2022 IRP: Agenda

- Today's Meeting Contributors
- Safety Moment
- Expectations from IRP
- Recap from April Meeting
- Review IRP Draft Top Portfolio
- Future Work
- Next steps

Today's Presenters, Contributors, and Sponsors

Name	Title	Business Unit/ Organization
Aliza Seelig	Manager, Resource Planning Forecasting & Analysis	Energy Innovation And Resources
Paul Nissley	Data Scientist, Resource Planning Forecasting & Analysis	Energy Innovation And Resources
Saul Villarreal	Data Scientist, Resource Planning Forecasting & Analysis	Energy Innovation And Resources
Verene Martin	Senior Power Analyst, Resource Planning Forecasting & Analysis	Energy Innovation And Resources
Rebecca Klein	Intern, Resource Planning Forecasting & Analysis	Energy Innovation And Resources
Andy Strong	Interim Director, Power Management	Energy Innovation And Resources
Emeka Anyanwu	Officer, Energy Innovation and Resources	Energy Innovation And Resources

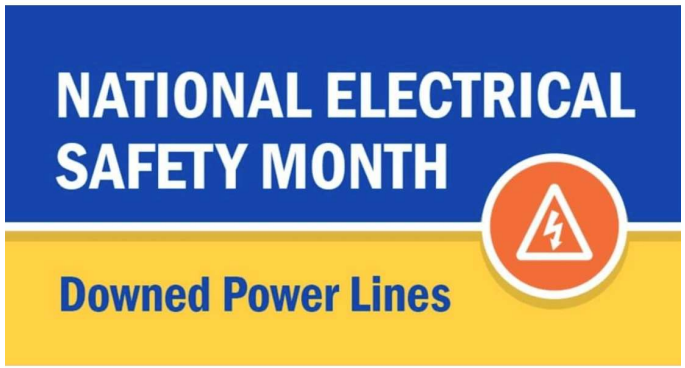
Safety Moment

Seattle City Light
1h ·

This week's #NationalElectricalSafetyMonth tip is for downed power lines! If you find yourself near a downed power line, don't walk or run...SHUFFLE! Keep your feet together and move at least 20 feet away. If a downed power line falls on your car, stay inside and call 911.

Remember:

Never touch or approach a downed wire or anything in contact with the wire.



2022 IRP Conclusions: What do they mean?

- RCW Chapter 19.280 RCW 'Electric Utility Resource Plans'
  - The legislature intends that information obtained from integrated resource planning under this chapter will be *used to assist* in identifying and developing: (1) New energy generation; (2) conservation and efficiency resources; (3) methods, commercially available technologies, and facilities for integrating renewable resources, including addressing any overgeneration event; and (4) related infrastructure to meet the state's electricity needs (**RCW 19.280.010**)
  - Will be updated at a minimum every two years (**RCW 19.280.030 (8)**)

Recap Since April Meeting

- Got internal & external feedback
- Created P35, P36
  - P35 is a portfolio with higher levels of energy conservation
  - P36 is a portfolio that includes utility scale solar+battery
- Dismissed P3, P24
  - Did not meet transmission constraints

2022 IRP Draft Top Portfolio (P11)

2022 Top Portfolio IRP Plan			
New Resource Additions By Time Period	**2022-2031**	**2032-2041**	**Total**
Solar (MW)	175	0	175
Wind (MW)	225	50	275
Energy Efficiency (aMW)	72	44	116
Customer Solar Programs (MW)	24	28	52
Summer Demand Response (MW)	47	31	78
Winter Demand Response (MW)	79	43	122

2022 IRP Draft Top Portfolios

All these portfolios follow the historical hydro generation and historical load temperature, for this 2022 IRP, we call this the **Base Lowest Cost** scenario.

Portfolio	Description
P1: LowestCost	Base Lowest Cost
P6: 2DR	Base Lowest Cost + 2 Demand Response
P7: 4DR	Base Lowest Cost + 4 Demand Response
P11: Balanced	**Base Lowest Cost + 2 Demand Response + Customer Solar**
P34: 2032 Elect	Base Lowest Cost + 2032 Electrification Loads Begin + 2DR
P35: HighEE	Base Lowest Cost + High Energy Conservation
P36: Solar+Batt	Base Lowest Cost + Utility Scale Solar with Battery

2022 IRP Draft Top Portfolios – New Supply Additions

Portfolio	2024	2026	2027	2032	2033	2034-2041	Total
P1: LowestCost	100	300	25	75			500
P6: 2DR	100	275	25	75	25		500
P7: 4DR	100	275	25	75	25		500
P11: Balanced	**100**	**300**		**25**	**25**		**450**
P34: 2032 Elect	100	300	100	325	250	300	1,375
P35: HighEE	100	300				75	475
P36: Solar+Batt	100	300	25	75			500

2022 IRP Draft Top Portfolios – Resource Mix

Portfolio	Wind (MW)	Solar (MW)	EE (aMW)	DR (MW)	Added Customer Solar (MW)
P1: LowestCost	275	225	116		
P6: 2DR	300	200	115	122	
P7: 4DR	300	200	116	141	
P11: Balanced	**275**	**175**	**116**	**122**	**52**
P34: 2032 Elect	1050	325	116	59	
P35: HighEE	300	175	150		
P36: Solar+Batt	275	225	116		

2022 IRP Draft Top Portfolios – Resource Mix

Portfolio	Wind (MW)	Solar (MW)	EE (aMW)	DR (MW)	Added Customer Solar (MW)
P1: LowestCost	275	225	116		
P6: 2DR	300	200	115	122	
P7: 4DR	300	200	116	141	
P11: Balanced	**275**	**175**	**116**	**122**	**52**
~~**P34: 2032 Elect**~~	~~1050~~	~~325~~	~~116~~	~~59~~	
P35: HighEE	300	175	150		
P36: Solar+Batt	275	225	116		

P34 eliminated because:

- high cost
- the pace of electrification penetration assumptions is uncertain
- transmission assumptions associated with meeting electrification loads are uncertain
- a City Light portfolio with a significant % of *only* wind & solar renewables (>50%) presents significant challenges to balance energy in real time
- future supply/demand resource technology could better fit future electrification needs in the 2030s

2022 IRP Draft Top Portfolios – Resource Mix

Portfolio	Wind (MW)	Solar (MW)	EE (aMW)	DR (MW)	Added Customer Solar (MW)
~~P1: LowestCost~~	~~275~~	~~225~~	~~116~~		
P6: 2DR	300	200	115	122	
P7: 4DR	300	200	116	141	
P11: Balanced	**275**	**175**	**116**	**122**	**52**
~~P34: 2032 Elect~~	~~1050~~	~~325~~	~~116~~	~~59~~	
~~P35: HighEE~~	~~300~~	~~175~~	~~150~~		
~~P36: Solar+Batt~~	~~275~~	~~225~~	~~116~~		

P1, P35, P36 eliminated because:

- No demand response programs
  - Important tool for reducing climate change and/or electrification load uncertainties for summer and winter
  - Important tool for minimizing financial impacts of wholesale power prices
  - Important option for customer energy solutions/reducing energy burden
  - Important to start demand response programs as soon as possible in order for ramp rates to take effect

2022 IRP Draft Top Portfolios – Resource Mix

Portfolio	Wind (MW)	Solar (MW)	EE (aMW)	DR (MW)	Added Customer Solar (MW)
~~P1: LowestCost~~	~~275~~	~~225~~	~~116~~		
~~P6: 2DR~~	~~300~~	~~200~~	~~115~~	~~122~~	
~~P7: 4DR~~	~~300~~	~~200~~	~~116~~	~~141~~	
P11: Balanced	**275**	**175**	**116**	**122**	**52**
~~P34: 2032 Elect~~	~~1050~~	~~325~~	~~116~~	~~59~~	
~~P35: HighEE~~	~~300~~	~~175~~	~~150~~		
~~P36: Solar+Batt~~	~~275~~	~~225~~	~~116~~		

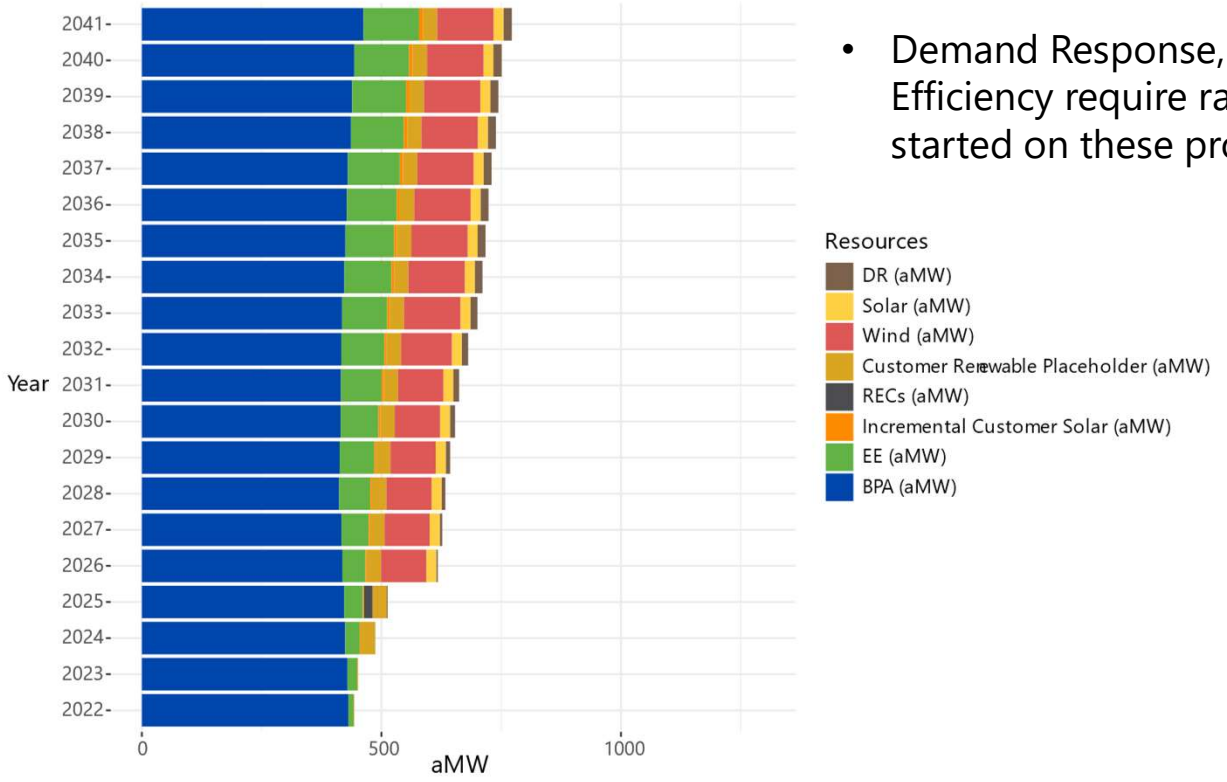
P7 eliminated because:

- The additional demand response programs are higher cost & lower potential
- Higher transmission risk than P11

P6 eliminated because:

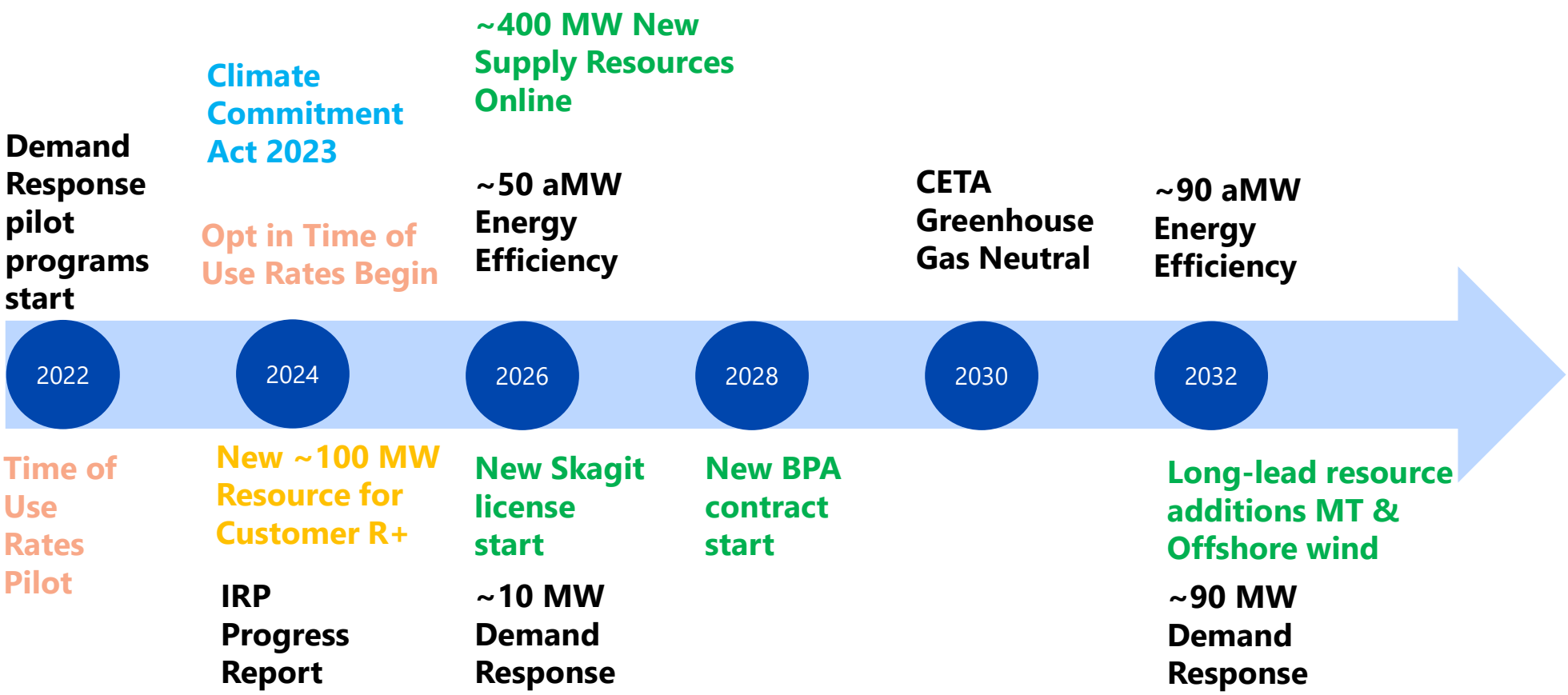
- Higher transmission risk than P11
- Less customer energy solution options than P11

2022 IRP Draft Top Portfolio (P11) – Resource Mix



- Demand Response, Customer Solar & Energy Efficiency require ramp up, so important to get started on these programs

10-Year Important Milestones



Future Work

- Look at slightly different BPA allocation and 100% clean energy product option for post 2028 contract given 2022 IRP scenario learnings.
- Work through the 2024 CPA Process to identify EE/DR/Customer Solar/Battery potential, incorporating climate change and electrification scenarios.
- Pursue equity value-streams for EE/DR/Customer Solar/Batteries.
- Additional analysis and modeling of potential electrification loads to incorporate into SCL's load forecast, CPA, and IRP.

Future Work (cont.)

- Study additional climate change scenarios to establish a more robust understanding and response.
- Continue to evaluate new resource options and technology potentials (e.g., hydrogen, additional battery configurations, geothermal, other 24/7 base load resources).
- Continue to refine portfolio metrics.

Next Steps

- Feel free to reach out to us at SCL.IRP@seattle.gov.

Milestone
Rough Draft of IRP Completed by EOD Wednesday, May 11th
Presentation to Debra – May 19th
Final Debrief with SCL – May 27th
SCL E-Team Presentation – June 1st
Mayor's Office Briefing – Week of June 6th?
Legistar Submittal – June 27th
Mayor's Office Transmit to Council – July 6th
IRC - July 19th
Committee Review – July 27th
Full Council Vote – August 8th
Internal SCL Target for IRP Submittal to Commerce – By August 15th
Statutory deadline for Commerce - By Sept 1st

Thank you!

- **2022 IRP Advisory Panel**
- Steve Gelb, Emerald Cities Collaborative
- Paul Munz, Bonneville Power Administration (BPA)
- Jeremy Park, P.E. University of Washington
- Yuri Rodrigues, Seattle Pacific University
- Mike Ruby, Ph.D., P.E., Envirometrics, Inc.
- Joni Bosh, NW Energy Coalition (Happy Retirement!)
- Amy Wheeless, NW Energy Coalition
- John Fazio, NW Power & Conservation Council
- Elizabeth Osborne, WA Department of Commerce
- Kelly Hall, Climate Solutions
- Joanne Ho

2022 Integrated Resource Plan (IRP) Recommendations

Executive Summary

Seattle City Light (City Light), our customers, partner City Departments, and the community of Seattle are embarking on an important phase of creating Seattle's energy future. The 2022 Integrated Resource Plan (IRP) is a long-term plan with a goal to meet anticipated customer energy needs over the next 20 years. It describes a 10-year clean energy action plan to meet City Light's goals to supply reliable electricity to customers at a reasonable cost, while protecting the environment, complying with regulatory requirements, and ensuring service equity.

The 2022 IRP portfolio of energy resources will have more wind and solar energy serving customer load, as well as new customer participation in demand response and more energy efficiency, than the 2022 Clean Energy Implementation Plan outlined. It will also look to prepare for the realities of ongoing transportation and building electrification.

New energy resources forecasted in the 2022 IRP shown in Table 1 were chosen for four main reasons:

- It meets City Light's resource adequacy and Washington state policy requirements
- Diversifying solar and wind supply resources can better balance variable production profiles and transmission uncertainties
- Additional energy efficiency and customer solar programs offer more local resources and more customer-based energy solutions
- Demand response programs can add value as a tool for reducing impacts from climate change, reducing wholesale power costs and energy burden outcomes, and adapting to electrification loads

Table 1: 2022 IRP Top Portfolio

2022 Top Portfolio IRP Plan			
New Resource Additions By Time Period	**2022-2031**	**2032-2041**	**Total**
Solar (MW)	175	0	175
Wind (MW)	225	50	275
Energy Efficiency (aMW)	72	44	116
Customer Solar Programs (MW)	24	28	52
Summer Demand Response (MW)	47	31	78
Winter Demand Response (MW)	79	43	122

The IRP is not meant to prescribe or implement resource related decisions. It is designed to inform about long-term and directional plans to best meet City Light's energy needs. City Light will continue to evaluate, at a minimum, every two years whether its plans should be updated.

List of Figures

Figure 1: 2022 IRP Top Seven Portfolio Annual Portfolio Costs 6
Figure 2: 2022 IRP Top Seven Portfolio December BPA Block Reductions Compared to the 2022 Clean Energy Implementation Plan 7
Figure 3: 2022 IRP Top Seven Portfolio Unspecified Purchase Emissions in Metric Tons of Carbon Dioxide Equivalent 8
Figure 4: 2022 IRP Top Seven Portfolio Expected December Net Surplus Under Base Load Scenario..... 10
Figure 5: Top Seven Portfolios Annual Transmission Costs..... 11

List of Tables

Table 1: 2022 IRP Top Portfolio 1
Table 2: 2022 IRP Top Seven Portfolio Names..... 4
Table 3: 2022 IRP Top Seven Portfolio Supply Additions (MW) 4
Table 4: 2022 IRP Top Seven Portfolio Energy Efficiency Incremental Additions (aMW) 4
Table 5: 2022 IRP Top Seven Portfolio Customer Solar Incremental Additions (MW)..... 4
Table 6: 2022 IRP Top Seven Portfolio Demand Response Incremental Additions (MW) 5
Table 7: 2022 IRP Top Seven Portfolio Performance Under Climate Change Scenarios CanESM2 & CCSM4 Models 7
Table 8: 2022 IRP Top Seven Portfolio Count of Demand Response, Energy Efficiency, and Customer Solar Program Options 9
Table 9: 2022 IRP Top Seven Portfolio Metric Performance Heat Map 11
Table 10: 2022 IRP Top Seven Portfolio Strengths and Weaknesses 11
Table 11: 2022 IRP Top Seven Portfolio Forecasted Resources Over the Next 20 years 13

Introduction to Portfolios

As part of the 2022 IRP, three scenarios were considered:

- Base load (i.e., 2020 corporate load forecast) with historical hydro and historical temperature,
- Climate change with simulated hydro and simulated load, and
- EPRI's Rapid Market Electrification with historical hydro and simulated electrification loads.

For planning purposes, the base load and historical hydro scenario was used as the baseline to plan for the 2022 IRP. The climate change and electrification scenarios were used as scenarios that help understand if different portfolios have attributes that could help with uncertain futures.

Over 20 different portfolios were considered and tested, but that number was reduced to seven after initial assessments were completed. These seven top portfolios align with the latest regional transmission assumptions, state and local clean energy policies, and City Light's resource adequacy metrics and resource options.

Top Seven Portfolio Facts:

- All seven portfolios are built to meet resource adequacy needs under the base load scenario with the metric of 0.2 monthly loss of load event, which is equivalent to two 'bad events' every 10 years for each January, July, August, and December months. These months were chosen as they represent traditionally challenging load coverage time periods. A 'bad event' is a situation in which all City Light's energy resources (i.e., contracts + owned generation + 200 MW market reliance) cannot meet load for greater than four hours[1] .
- All portfolios meet I-937 policy requirements and Clean Energy Transformation Act requirements under base hydro median conditions.
- Six of the seven portfolios are within 3.1% Net Present Value costs of each other.
- **None of the portfolios adequately achieve the resource adequacy metric of 0.2 monthly loss of load event under climate change scenarios and are much less adequate under the rapid market electrification scenario. However, both the climate change and electrification scenarios have preliminary assumptions that need further exploration.**
- All of City Light's portfolios are greater than 90% clean from an emissions perspective under hydro median water conditions.
- Customer programs (i.e., demand response, energy efficiency, and customer solar) are a meaningful factor in differentiating portfolios, especially if the climate change and electrification scenario uncertainties are considered.

[1] this assumption was determined through interviews with City Light Power Marketing Operations and System Operations Center staff where our hydro flexibility is assumed to be able to meet deficits for this length of time

For the 2022 IRP, the top seven portfolios are identified and described in Table 2.

Table 2: 2022 IRP Top Seven Portfolio Names

Portfolio	Description
P1	Base Lowest Cost
P6	Base Lowest Cost + 2 Demand Response
P7	Base Lowest Cost + 4 Demand Response
P11	Base Lowest Cost + 2 Demand Response + Customer Solar
P34	Base Lowest Cost + 2032 Electrification Loads Begin
P35	Base Lowest Cost + High Energy Conservation
P36	Base Lowest Cost + Utility Scale Solar with Battery

These portfolios bring incremental utility scale supply resources in MW as shown in Table *3*.

Table 3: 2022 IRP Top Seven Portfolio Supply Additions (MW)

Portfolio	2024	2026	2027	2032	2033	2034-2041	Total
P1	100	300	25	75			500
P6	100	275	25	75	25		500
P7	100	275	25	75	25		500
P11	100	300		25	25		450
P34	100	300	100	325	250	550	1,375
P35	100	300					475
P36	100	300	25	75			500

The top seven portfolios all have greater energy efficiency forecasts than the 2022 Conservation Potential Assessment and the 2022 Clean Energy Implementation Plan. Table 4 provides each portfolio's cumulative energy conservation resources in aMW.

Table 4: 2022 IRP Top Seven Portfolio Energy Efficiency Incremental Additions (aMW)

Portfolio	2025	2031	2041
P6	39	84	115
P1, P7, P11, P34, P36	39	85	116
P35	44	101	150

The top seven portfolios have cumulative customer solar resources in MW as shown in Table 5.

Table 5: 2022 IRP Top Seven Portfolio Customer Solar Incremental Additions (MW)

Portfolio	2025	2031	2041
P11	14	29	52
P1, P7, P11, P34, P35, P36	0	0	0

The assumed customer solar resources would be in addition to programs currently available, with incremental additions up to 52 MW capacity by 2041. A new program with a goal of rapid incremental growth in customer solar capacity would likely target a variety of customer types, center equitable access to renewables, and may require legislative action to appropriately incentivize. Synergies and complementary benefits may be found with programs incorporating storage solutions, demand response, and ongoing transportation electrification efforts.

These portfolios have cumulative demand response potential in MW as indicated in Table 6.

Table 6: 2022 IRP Top Seven Portfolio Demand Response Incremental Additions (MW)

Portfolio	DR Programs	2025	2031	2041
P1, P35, P36	Nothing	0	0	0
P34	Residential Thermostat Residential Heat Pump Water Heating	4	44	59
P6, P11	Residential Thermostat Residential Electric Water Heating	10	88	122
P7	All DR Programs[2]	13	104	141

Introduction to Metrics

The portfolios were looked at according to six different metrics. These metrics were developed as part of the 2022 IRP process to account for costs (Net Present Value), the climate change scenarios studied (Climate Change), portfolio unspecified purchases (Emissions), diversity of customer options (Customer Programs), the Rapid Market Electrification scenario studied (Electrification), and transmission cost and uncertainty (Transmission). All these metrics were equally weighted.

Net Present Value: The net present value is reported in 2021 real dollars (in billions$). Net present value contains the sum of all portfolio costs for resources (e.g., supply, energy conservation, demand response, customer solar, renewable energy credit purchases), BPA block power contract, and social cost of greenhouse gas, and net wholesale revenue from 2022 to 2041. The Net present values for the top seven portfolios are shown in Table 9 of the Conclusions section.

[2] P7 features four DR programs: Industrial/Commercial Curtailment, residential thermostat, residential electric resistance water heating, & residential heat pump water heating

Figure 1: 2022 IRP Top Seven Portfolio Annual Portfolio Costs

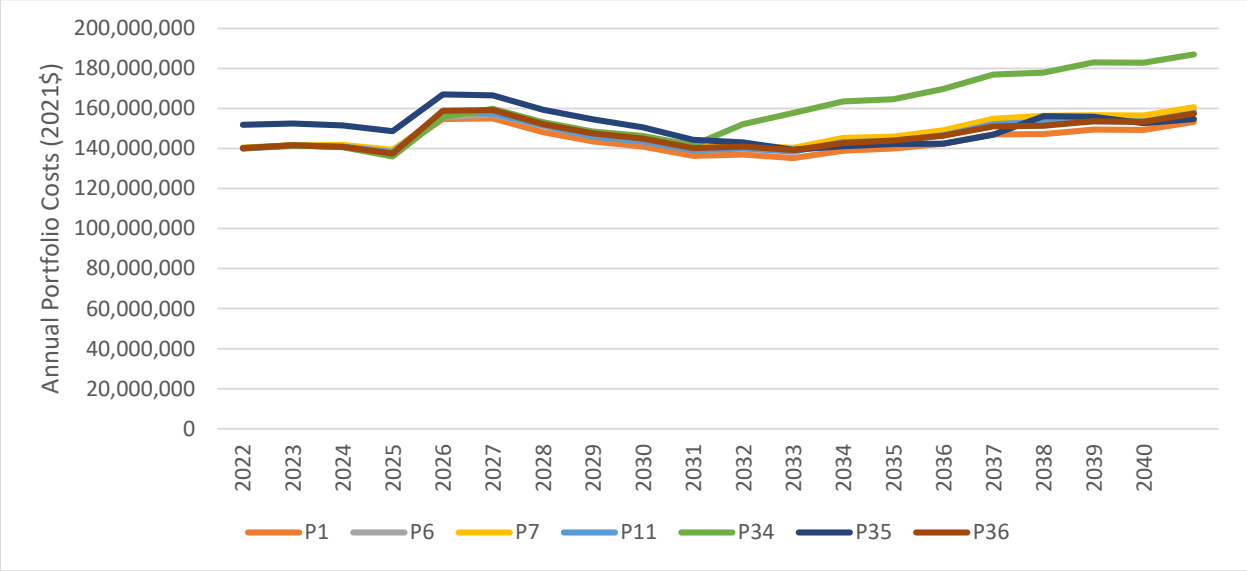


Figure 1 shows the annual net portfolio costs of the top seven portfolios, that are a part of the net present value calculation. P35 has high annual costs prior to the 2030s due to the higher conservation programs associated with this run (this energy efficiency program path was identified as the preferred path under the electrification scenario). P34 is a portfolio influenced by higher electrification loads starting in 2032. The rest of the portfolios follow similar patterns and very similar net present value costs, including P1 or the lowest portfolio with builds in the 2020s for resource adequacy, and some builds in the 2030s for I-937 compliance.

Climate Change: The climate change metric measures the difference in distance (i.e., delta) of each climate change portfolio loss of load event compared to City Light's established resource adequacy metric of 0.2 loss of load event for the months of January, July, August, and December for the years 2030 and 2040. Two global climate models, CanESM2 and CCSM4, were selected to represent the changing temperature effects on load and hydrology effects on supply. These two models best represented future variability rather than the average climate change projections. The final loss of load event distance was the average of the monthly differences for each of the two years and two models. It is important to mention that both CanESM2 and CCSM4 have well recognized periods of wintertime cold bias (i.e., colder than observations) in their Seattle temperature projections. This in turn would also bias how these portfolios' resources meet (or do not meet) the Seattle wintertime loads associated with these climate models.

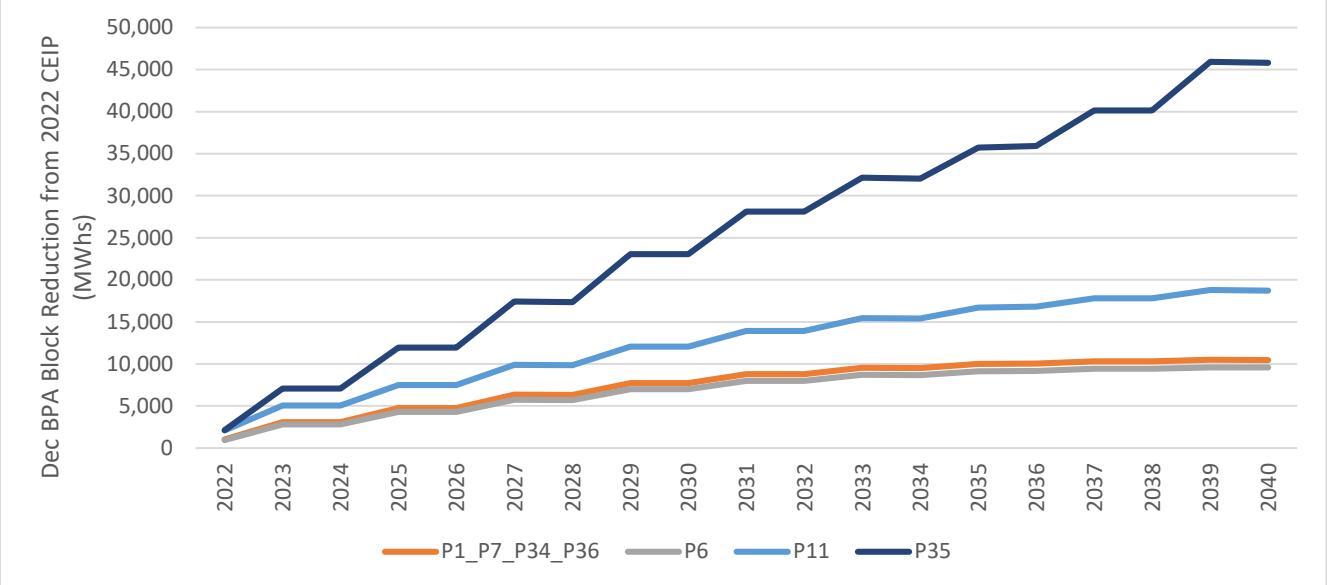
Table 7: 2022 IRP Top Seven Portfolio Performance Under Climate Change Scenarios CanESM2 & CCSM4 Models

Portfolio	Description	Loss of Load Event Distance from 0.2
P34	Base Lowest Cost + 2030s Electrification Loads	1.27
P11	Base Lowest Cost + 2 DR + Customer Solar	2.28
P7	Base Lowest Cost + 4 DR	2.29
P6	Base Lowest Cost + 2 DR	2.37
P36	Base Lowest Cost + Utility Scale Solar/Battery	2.93
P1	Base Lowest Cost	2.97
P35	Base Lowest Cost + High Energy Conservation	2.97

From Table 7, a smaller distance means greater resource adequacy performance. For example, 1.27 distance for P34 means that its loss of load event was ~1.5, which is well above the 0.2 loss of load event target. Given that all the distance measurements are greater than zero, none of the portfolios can perform at the current resource adequacy metric of 0.2 loss of load event in a climate change future. P34 performs the best of all the portfolios, due to it having the most resources in its portfolio, so it would be much better positioned to absorb the increased loads and altered stream flows as a result of climate change.

P11, P6, and P7 are the next best (these portfolios have similar conservation and demand response programs), the rest of the portfolios perform the worst. It is important to note that energy efficiency and customer solar reduce our load, which may in turn reduce our annual Bonneville Power Administration (BPA) allocation. This is especially true in in the wintertime, which is when City Light receives the most energy from its BPA block contract.

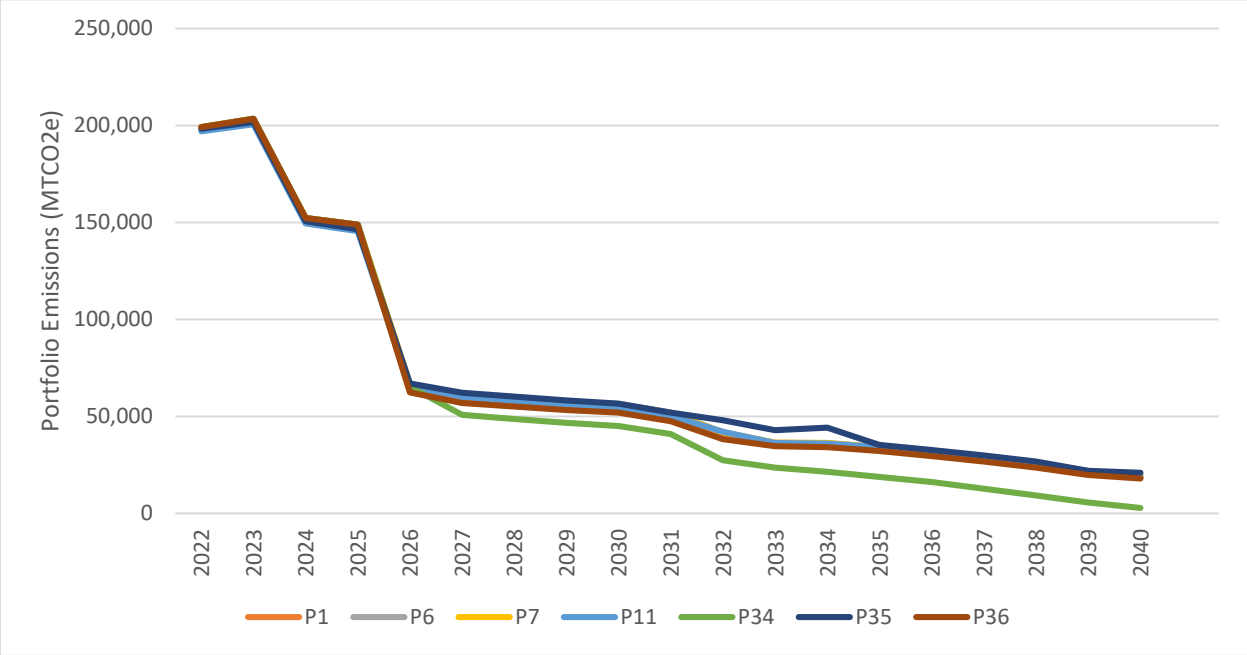
Figure 2: 2022 IRP Top Seven Portfolio December BPA Block Reductions Compared to the 2022 Clean Energy Implementation Plan



The December BPA Block in Figure 2 is a reduction compared with the 2022 Clean Energy Implementation energy efficiency path. It shows that all the seven portfolios use a higher energy efficiency forecast and/or customer solar value compared to the 2022 Clean Energy Implementation Plan, which reduces the BPA block allocation in December. This can be a risk for City Light, especially for portfolios P11 and P35, because the electrification scenario shows more resource adequacy needs in the winter months. For this reason, the 2022 IRP assumes that the customer solar incremental additions shown in Table 5 do not reduce the BPA block contract. In other words, the customer solar program will behave like a supply side resource where customer participation can be tracked and accounted for.

Emissions: The emissions metric calculates the total metric tons of carbon dioxide equivalent from 2022 to 2041 for any given portfolio.

Figure 3: 2022 IRP Top Seven Portfolio Unspecified Purchase Emissions in Metric Tons of Carbon Dioxide Equivalent



A portfolio's total emissions of Metric Tons of Carbon Dioxide Equivalent ($MTCO_2e$) in Figure 3 includes three sources of emissions: emissions from unspecified market purchases, emissions from non-BPA power contracts, and emissions from the BPA power contract. Any source of unspecified power is assigned an emissions rate of 0.437 $MTCO_2e$ per MWh, which is the emissions rate specified in the Clean Energy Transformation Act.

P34, despite its significant quantity of clean resources as compared to the other portfolios, does not result in significant reductions in emissions. This is because the BPA block contract is the more significant source of emissions post-2026 and is always brought to load. Outside of the BPA contract, there are no assumed specified clean market purchases.

Customer Programs: A customer program metric was created to measure each portfolio's ability to carry out City Light's vision of providing more flexibility in how customers can meet their energy needs, and to further advance equitable community connections. Furthermore, the Washington State Clean Energy Transformation Act specifically emphasizes equitable customer involvement in a clean energy future. The customer program metric considers the number of customer programs available in each of the seven IRP top portfolios. The number of demand response options available, the amount of energy efficiency programs, and customer solar are all factored into this metric and are identified for each portfolio as depicted in Table 8.

Table 8: 2022 IRP Top Seven Portfolio Count of Demand Response, Energy Efficiency, and Customer Solar Program Options

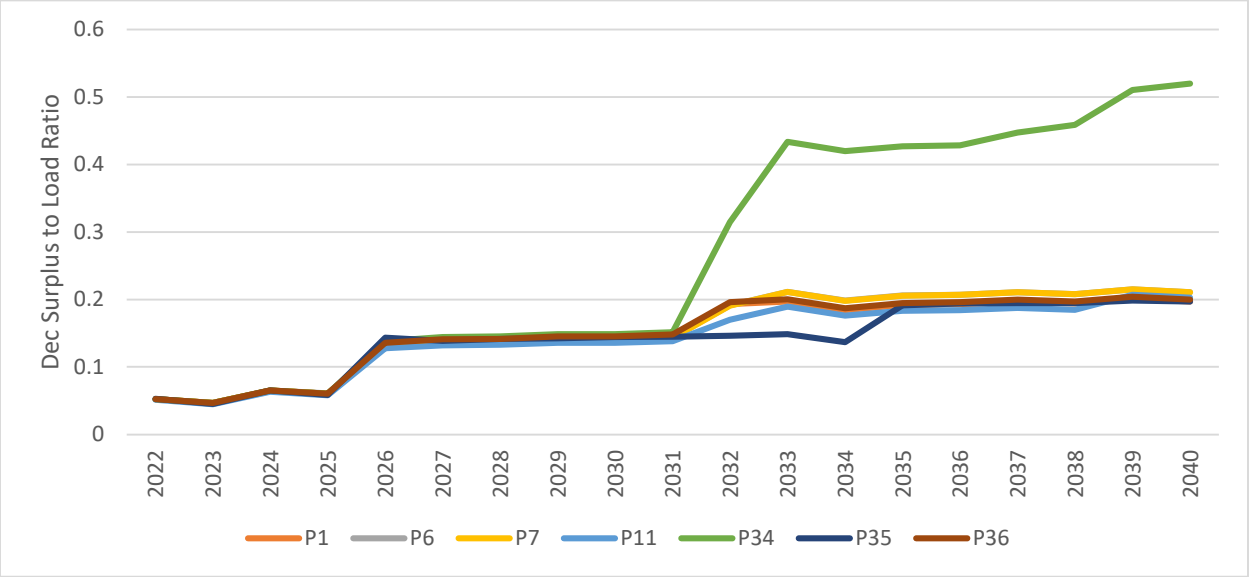
Portfolio	Demand Response # Programs (4 possible programs)	Energy Efficiency (23 possible programs)	Customer solar (1 possible program)
P1	0	16	0
P6	2	15	0
P7	4	16	0
P11	2	16	1
P34	2	16	0
P35	0	21	0
P36	0	16	0

The customer metric gives equal weight to energy efficiency, demand response, and customer solar programs, as defined:

$$\left(\frac{Demand\ Response\ Count}{4} + \frac{Energy\ Efficiency\ Count}{23} + \frac{Customer\ Solar\ Count}{1}\right) \div 3$$

Electrification: The electrification metric looks at how surplus/deficit the month of December is for each of the seven IRP portfolios. In other words, the net hourly surplus/deficit MWhs of City Light's resources as a fraction of the total MWhs of City Light's load for December. Recent electrification studies show future building and vehicle electrification can increase City Light's load, especially in the winter, and most significantly in December.

Figure 4: 2022 IRP Top Seven Portfolio Expected December Net Surplus Under Base Load Scenario



While the electrification metric only looks at the years 2030 and 2040, Figure 4 covers all years and details the December net position as a fraction of load for the years 2022 to 2040. P34, which is the portfolio that plans resource additions according to rapid market electrification loads starting in 2032, performs very well in the post 2032 years compared to the others in this category of metrics. Though none of the portfolios can meet the rapid market electrification needs for *all* years from 2022 through 2041, P34 does meet the electrification needs starting in 2032 until 2041.

The electrification metric is:

$$\left(\frac{Dec\ Net\ Position\ 2030 + Dec\ Net\ Position\ 2040}{Dec\ Net\ Load\ 2030 + Dec\ Net\ Lad\ 2040}\right)$$

Transmission: The transmission metric looks at the total estimated cost of transmission in each of the seven IRP portfolios. Due to uncertainty in future transmission capacity, this metric can not only serve as a cost metric for transmission for the portfolios, it can also be viewed as a transmission risk level for each of the portfolios.

Figure 5: Top Seven Portfolios Annual Transmission Costs

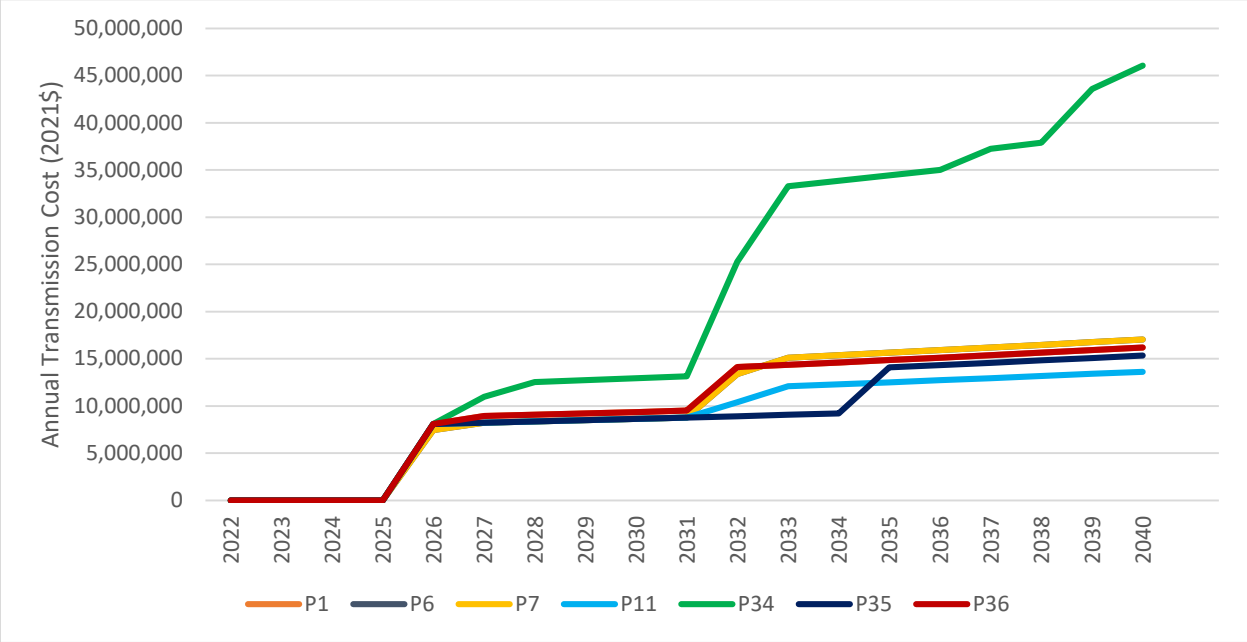


Figure 5 shows how P34, which is the portfolio that plans resource additions such as Montana and Offshore wind according to rapid market electrification loads starting in 2032, has a lot of transmission costs. Rapid electrification aside, P11 and P35, which rely more on local and demand side resources, do not have as much exposure to transmission costs over time.

Conclusions

A summary of the performance of the seven top portfolios across all the metrics is shown in Table *9*. The heat map coloring is used to indicate the relative performance of different portfolios for each metric; green is better performing than red.

Table 9: 2022 IRP Top Seven Portfolio Metric Performance Heat Map

Portfolio	NPV (bil$)	Climate	SCL_MTCO2e	Customer	Electrification	Transmission (bil$)
P1	2.83	2.97	1,407,960	0.2	0.17	0.23
P6	2.88	2.37	1,447,275	0.4	0.18	0.24
P7	2.90	2.29	1,445,311	0.6	0.18	0.24
P11	2.90	2.28	1,448,246	0.7	0.17	0.19
P34	3.87	1.27	1,160,274	0.4	0.34	0.59
P35	2.90	2.97	1,460,613	0.3	0.17	0.22
P36	2.92	2.93	1,396,117	0.2	0.17	0.23

Table 10: 2022 IRP Top Seven Portfolio Strengths and Weaknesses

Portfolio Name	Strengths	Weaknesses
P1: Lowest Cost	• Lowest cost portfolio	• No demand response programs or customer solar resources • Lowest RA performance under climate change or electrification scenarios

Portfolio Name	Strengths	Weaknesses
P6: Base Lowest Cost + 2 DR	• Includes 2 highest potential demand response programs • Good customer optionality	• 1.7% more costly compared to P1 • Doesn't adequately meet resource adequacy under climate change or electrification scenarios
P7: Base Lowest Cost + 4 DR	• Includes all 4 IRP demand response programs, • Provides 2nd most customer optionality	• 2.4% more costly compared to P1 • Includes 2 demand response programs that currently don't have much value • Doesn't adequately meet resource adequacy under climate change or electrification scenarios
P11: Base Lowest Cost + 2 DR + Customer Solar	• Includes 2 highest potential DR programs • Provides the most customer optionality • Lowest supply side transmission reliance	• 2.4% more costly compared to P1 • Doesn't adequately meet resource adequacy under climate change or electrification scenarios
P34: Base Lowest Cost + 2032 Electrification Loads Begin	• Meets resource adequacy metric for electrification loads starting in 2032 • Performs the best under climate change scenario • Lowest emissions	• 27% more expensive compared to P1 • Relies heavily on uncertain wind transmission starting in 2032 • More than half of the portfolio composition by 2041 would be wind + solar renewables • Doesn't adequately meet resource adequacy under climate change or electrification scenarios before 2032
P35: Base Lowest Cost + High Energy Conservation	• Prepares for future Electrification loads by making large energy efficiency investments early • Plans on less supply side resources compared to P1	• 2.4% more expensive compared to P1 • Ignores demand response and customer solar programs • Lowest resource adequacy performance under climate change or electrification scenarios

Portfolio Name	Strengths	Weaknesses
P36: Base Lowest Cost + Utility Scale Solar/Battery	• Overbuilds summer resource adequacy with batteries paired with solar resources	• 3.1% more expensive compared to P1 • Ignores demand response and customer solar programs • Lowest resource adequacy performance under climate change or electrification scenarios

Table 11: 2022 IRP Top Seven Portfolio Forecasted Resources Over the Next 20 years

Portfolio	Wind (MW)	Solar (MW)	EE (aMW)	DR (MW)	Added Customer Solar (MW)
P1	275	225	116		
P6	300	200	115	122	
P7	300	200	116	141	
P11	275	175	116	122	52
P34	1050	325	116	59	
P35	300	175	150		
P36	275	225	116		

Recommendation

City Light feels the portfolio attributes of P11 would be the best fit, and the minimum in magnitude, direction for the utility at the time of the 2022 IRP. Below we will discuss the reasons why City Light feels this way. We recognize that the circumstances could change, and City Light will continue to evaluate every two years whether its plans should be altered.

All the portfolios, aside from P34, score similarly in most of the metrics. We feel uncomfortable with recommending P34 because:

- the pace of electrification penetration assumptions is very uncertain
- transmission assumptions associated with meeting electrification loads are very uncertain
- a City Light portfolio with a significant % of *only* wind & solar renewables (>50%) presents significant challenges to balance energy in real time
- future supply/demand resource technology could better fit future electrification needs in the 2030s

P1, P35, and P36 do not contain any demand response programs. Demand response programs add value as a tool for reducing climate change and/or electrification load uncertainties for both summer and winter, as well as minimizing financial impacts of wholesale power prices. At a customer level, it offers an important option in energy solutions. Therefore, we do not recommend portfolios P1, P35, and P36.

Portfolios P6, P7, and P11 all contain demand response programs. P6 and P11 contain two demand response programs: the residential thermostat program and the residential electric resistance water heating program. P7 contains two additional demand response programs (for a total of four programs): an Industrial/Commercial curtailment program and a residential heat pump water heating program, of which together only provide up to ~18MW of potential by 2041. The Industrial/Commercial curtailment program only has potential of up to ~11MW by 2041 and it is a summer peaking program, which isn't as valuable in an electrification scenario, where the biggest need is in the winter. The Industrial/Commercial curtailment program will not be a part of the demand response pilot program set to begin in January of 2023 due to low potential, high administration costs, and more limited equity value. Therefore, P6 and P11 are the two best portfolios with demand response to consider for the 2022 IRP.

The customer programs metric, which measures optionality for customers, is the one metric that creates the most differentiation among the two remaining portfolios, and it points to the P11 portfolio. P11 has both demand response programs and customer solar programs to further enhance resource diversity and less transmission reliance. The high potential demand response programs in P11 (residential thermostats and residential water heating) help the City Light portfolio to prepare for climate change and electrification uncertainties.

While each successive City Light IRP has its own set of assumptions such as load forecasts, contracted energy, price of new resources, and state policies influencing resource decisions, the 2022 IRP portfolio P11 contains the largest amount of solar, as a percentage of the total portfolio as compared to previous IRPs. Solar energy has experienced significant decreases in price over the last several years, as well as improvements in efficiencies. Spring of 2022 has experienced high inflation and supply chain troubles, as well as the U.S. Department of Commerce's review of alleged circumvention of solar panel tariffs in some countries. This investigation could pause manufacturing and shipping of solar panels, and hence delay solar energy projects. Long term, solar energy from eastern Washington or Oregon can provide City Light affordable summer power when the hydroelectric resources run dry. The risk of summer forest fires and heavy smoke in the PNW as our climate changes make wind resources a valuable energy hedge with solar.

Wind has been a continuous theme since 2016 in City Light's IRP forecasted portfolios. Wind has also seen price decreases and efficiency increases the last several years. Like solar, wind resources in the Columbia River Gorge also tend to experience peak production during the summer months. Montana wind and offshore wind, both of which can see up to 50% capacity factors, are winter peaking, which will benefit City Light as electrification progresses. The 2022 IRP P11 anticipates all of City Light's wind resources prior to 2030 to be from the Columbia River Gorge area, while after 2030 it is possible that new transmission infrastructure would allow for City Light to benefit from a Montana wind resource, and perhaps even an Offshore wind resource off the coast of Washington or Oregon.

Comparing energy efficiency forecasts between the previous few IRPs is much more difficult due to technology adoption rates over time outside of the programmatic ones. The 2022 IRP

portfolio P11 is forecasting about 50 aMW of energy conservation measures by 2026, which is about 10 aMW higher than the 2022 Conservation Potential Assessment. The 2022 IRP portfolio P11 is the first time demand response programs will be recommended in the top portfolio, due to its abilities to not only manage extremes, but to reduce customer energy burden outcomes.

There is always the risk of the wind not blowing, the sun not shining, and energy conservation or demand response reaching its limits on helping with resource adequacy. As City Light's electrification loads begin to show up, and we see more extremes associated with climate change, other base load dispatchable resources such as batteries, hydrogen, small modular/advanced nuclear, etc. need to be part of the discussion to maintain current levels of grid reliability. Given these uncertainties, it is crucial to develop plans in partnership with our customers, community and interest groups that have the right degree of flexibility to be consistent with their expectations.

Future Work

As the 2022 IRP analysis portion wraps up, discussions about future energy resources continue. Over the past several months, both internal and external discussions have resulted in additional things to analyze going forward:

- Can the next BPA contract allow for different monthly shaping? In other words, more energy in December and/or August even as other utilities reach for the same resource? These months will be important as electrification and climate change begin to influence City Light's load and resource balance.
- Can the next BPA contract have the option for 100% clean energy option? The increasing calls from City Light's customers and stakeholders to reduce emissions, as well as the Climate Commitment Act starting in 2023, put reductions in resource emissions as a higher priority.
- Further study energy efficiency/demand response/batteries/customer solar potential under a combined climate change *and* electrification load scenario to learn insights about their interactions.
- Further study energy efficiency/demand response/batteries/customer solar program equity components that could help inform program design to account in future IRP modeling.
- Study Electrification and Grid Modernization programs in future IRP modeling, to make sure policy, cost and resource adequacy benefits inform program design decision-making.
- Study additional climate change scenarios (e.g., additional global climate models) and metrics to help establish a more robust climate change understanding and response.
- Study new large 24/7 loads such as hydrogen production facilities (200MW-500MW), existing steam plant conversions to electric or other large base loads remain to be considered.
- Other WA utilities have started looking at small modular/advanced nuclear base load resources, and it will be necessary for City Light to monitor and continue to evaluate the

development of those technologies, and any other emerging concepts that might provide similar base load attributes.