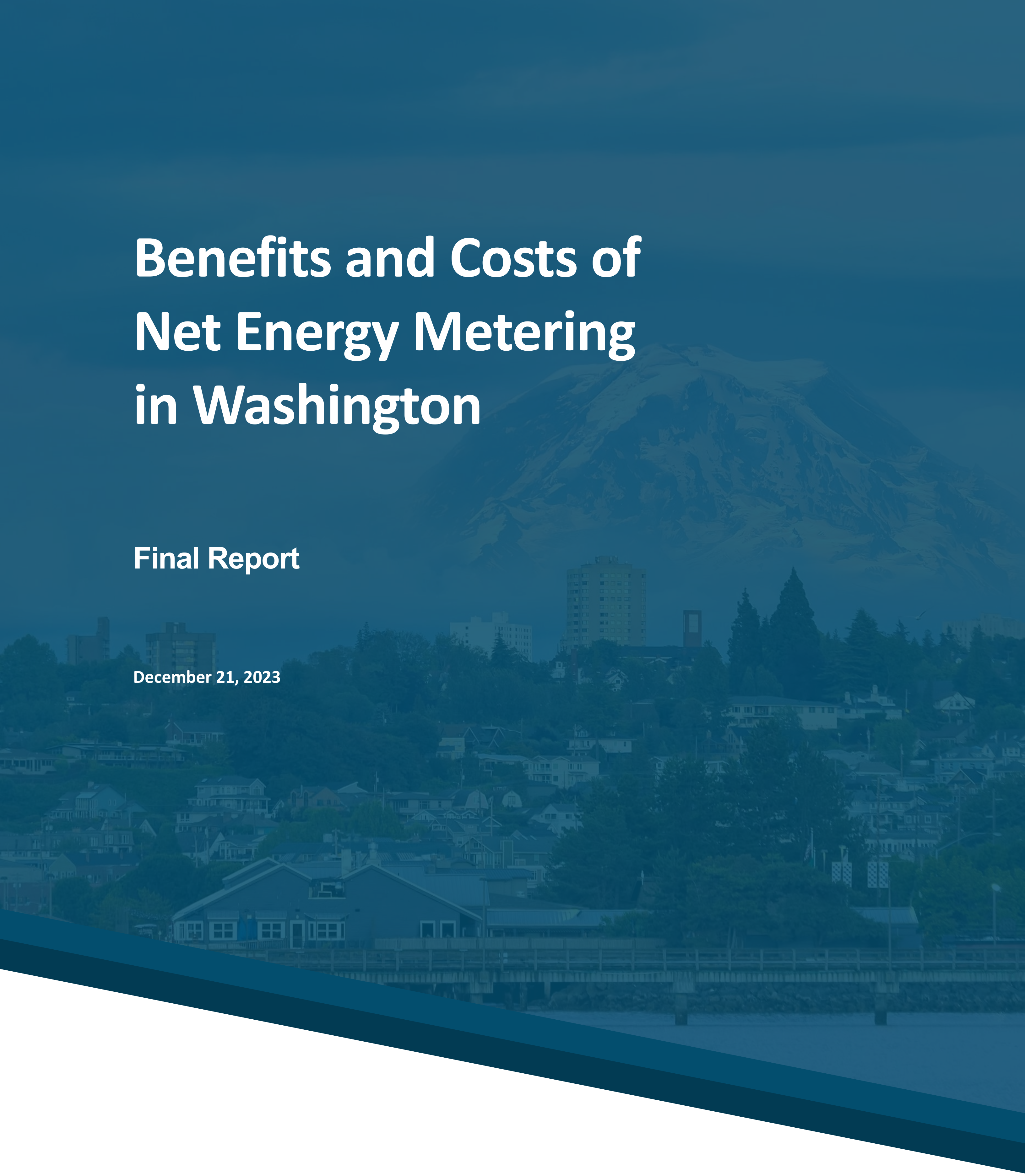

Benefits and Costs of Net Energy Metering in Washington

Final Report

December 21, 2023

Energy+Environmental Economics

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Acronym Definitions

Acronym	Definition
AC	Alternating Current
ACC	Avoided Cost Calculator
AMI	Area Median Income
(NREL) ATB	(National Renewable Energy Laboratory) Annual Technology Baseline
AVERT	Avoided Emissions and Generation Tool
BPA	Bonneville Power Administration
Btu	British Thermal Unit
CAGR	Compound Annual Growth Rate
CCA	Climate Commitment Act
CETA	Clean Energy Transformation Act
CHWM	Contract High Water Mark
COBRA	CO-Benefits Risk Assessment (Health Impacts Screening and Mapping Tool)
CPUC	California Public Utilities Commission
DER	Distributed Energy Resources
DERMS	Distributed Energy Resource Management Systems
DSIRE	Database of State Incentives for Renewables & Efficiency
EIA	Energy Information Administration
ELCC	Effective Load Carrying Capability
EPA	Environmental Protection Agency
EV	Electric Vehicle
GHG	Greenhouse Gas (emissions)
HELP	Home Energy Lifetime Program
HLH	High Load Hours
IRP	Integrated Resource Plan
IOU	Investor-Owned Utility
ITC	Investment Tax Credit
kW	Kilowatt
kWh	Kilowatt hour
kW-yr	Kilowatt-year
LCOC	Levelized Cost of Capacity
LCOE	Levelized Cost of Energy
LLH	Low Load Hours
MMBtu	Million British thermal unit
MW	Megawatt
MWh	Megawatt hour
NEB	Net Energy Billing
NEM	Net Energy Metering

NOx	Nitrogen Oxides
NPV	Net Present Value
NREL	National Renewable Energy Laboratory
O&M	Operations & Maintenance
PCAF	Peak Capacity Allocation Factor
PCT	Participant Cost Test
PM2.5	Particulate Matter <= 2.5-micron diameter
PNW	Pacific Northwest
PSE	Puget Sound Energy
PTC	Production Tax Credit
PUD	Public Utility District
PV	Photovoltaic (solar)
RHWM	Rate Period High Water Mark
RIM	Ratepayer Impact Measure
SCC	Social Cost of Carbon
SCT	Societal Cost Test
SCL	Seattle City Light
SMUD	Sacramento Municipal Utility District
SnoPUD	Snohomish County Public Utility District
SOx	Sulfur Oxides
SPM	Standard Practice Manual
TAG	Technical Advisory Group
T&D	Transmission & Distribution
TMY	Typical Meteorological Year
TOCA	Tier One Cost Allocator
TOU	Time of Use
TRC	Total Resource Cost (test)
TRL	Total Retail Load
UDP	Utility Discount Program
UTC	Utilities and Transportation Commission
VAR	Volt-Ampere Reactive
VDER	Value of Distributed Energy Resources
VPP	Virtual Power Plant
WASEIA	Washington Solar Energy Industry Association
WPUDA	Washington Public Utilities District Association
WRAP	Western Resource Adequacy Program
WSU	Washington State University

Executive Summary

E3 was retained by a group of Washington utilities[1] and the Washington Public Utility District Association (WPUDA) to evaluate Washington's current net energy metering (NEM) programs. Under Washington State Law RCW 80.60, electric utilities must offer NEM to eligible customer-generators on a first-come, first-served basis until the earlier of either: 1) June 30, 2029, or 2) the first date upon which the cumulative generating capacity of net metering systems equals four percent of the utility's peak demand during 1996.[2] When a utility reaches this threshold, they may continue offering retail rate NEM, or develop or propose a new tariff. As of June 30, 2023, five utilities have exceeded the legislative minimum capacity requirement for NEM.[3]

E3's evaluation of Washington's NEM programs addresses three key questions:

1. What are the benefits and costs of a new solar system interconnected today under NEM?
2. What are the benefits and costs of the full population of NEM solar and how do they evolve over time as more customers adopt NEM solar?
3. Does NEM result in cost shifts from NEM to non-NEM customers, and if so, what is the size of the cost shift today and in the future?

Since this evaluation is focused on Washington's current NEM programs, it does not consider existing or future non-NEM tariffs, time-of-use (TOU) rates, or solar paired with battery storage. While the evaluation includes a brief qualitative review of customer generation tariff design in other jurisdictions, it does not include evaluations of, or proposals for, a new tariff. The results of this evaluation will help inform future policy proposals for customer solar in Washington.

Due to the large number of utilities in Washington, E3 performed a detailed analysis for six "detailed study utilities" and then leveraged that analysis to estimate statewide impacts. Table 1 lists the detailed study utilities for this evaluation. These utilities reflect different utility ownership structures as well as geographic locations.

Table 1. Detailed Study Utilities for Evaluation

Utility	Ownership Type	Location (Relative to Cascades)
Avista	Investor-owned utility	East
Inland Power and Light Company	Cooperative	East
Kittitas PUD	Public utility district	East
Puget Sound Energy (PSE)	Investor-owned utility	West
Seattle City Light (SCL)	Municipal	West
Snohomish PUD	Public utility district	West

[1] Supporting utilities include: Avista, City of Richland, City of Tacoma, PacifiCorp, Puget Sound Energy, Seattle City Light, Snohomish PUD, Washington Rural Electric Cooperative Association

[2] Washington State Legislature, Chapter 80.60 RCW Net Metering of Electricity, https://apps.leg.wa.gov/rcw/default.aspx?cite=80.60&full=true

[3] Washington State University, Net Metering, June 30, 2023, https://www.energy.wsu.edu/RenewableEnergy/NetMetering.aspx

To support a robust evaluation of the benefits and costs of NEM in Washington, the Washington Department of Commerce retained Gridworks to convene a Technical Advisory Group (TAG) consisting of representatives from different stakeholder groups. The TAG included stakeholders with a variety of perspectives including utilities, labor, environmental advocates, solar industry advocates, business advocates, and the Department of Commerce. During three TAG meetings and through written comments, the TAG provided feedback on proposed benefits and costs of NEM solar, study inputs, proposed methodology, key metrics, results, and contextualization.

The TAG identified a list of benefits and costs to evaluate as part of this study, and E3 augmented this list after comparison to other studies to ensure it was comprehensive. Using data provided by the detailed study utilities as well as input from the TAG, E3 evaluated the benefits and costs associated with customer solar systems interconnected under Washington's current NEM programs. E3 quantified benefits and costs where possible and provided a qualitative evaluation of the remaining benefits and costs. To evaluate benefits and costs, E3 considered different perspectives commonly utilized in utility customer program evaluation:

- **NEM Solar Customers (Participants)**: this perspective captures all benefits and costs that accrue directly to customers who install a NEM solar system.
- **Utility Ratepayers**: this perspective captures all benefits and costs that accrue to electric ratepayers of the utility.
- **Societal Perspective**: this perspective captures all benefits and costs that accrue to residents in the State of Washington.

Customer solar systems interconnected under Washington's current NEM programs can provide significant benefits to participants through bill savings. This study focuses on residential customers, who represent 85% of installed NEM solar capacity for the six detailed study utilities. The study estimates first-year bill savings for residential customers ranging from $750 to nearly $1,200 per year among the utilities studied, based on a representative residential 7 kW-AC system. Figure 1 shows the Participant Cost Test (PCT) results based on an example 7 kW-AC system. The benefit-cost ratio ranges from 0.72 (Inland Power) to 0.99 (Seattle City Light), indicating that, assuming a 7% nominal discount rate and 25-year lifetime, lifecycle benefits are less than or nearly equal to lifecycle costs for a customer solar adopter across the six detailed study utilities. While at face value this metric would indicate it is not cost-effective for customers to adopt solar under NEM in Washington, participants may see additional non-monetary benefits that are not captured in this figure, and these benefits may influence solar adoption decisions. Additionally, customer discount rates and financial opportunity costs may be different from the 7% discount rate assumed for this study.

Figure 1. Participant Cost Test (PCT) by Utility for an Example 7 kW-AC System

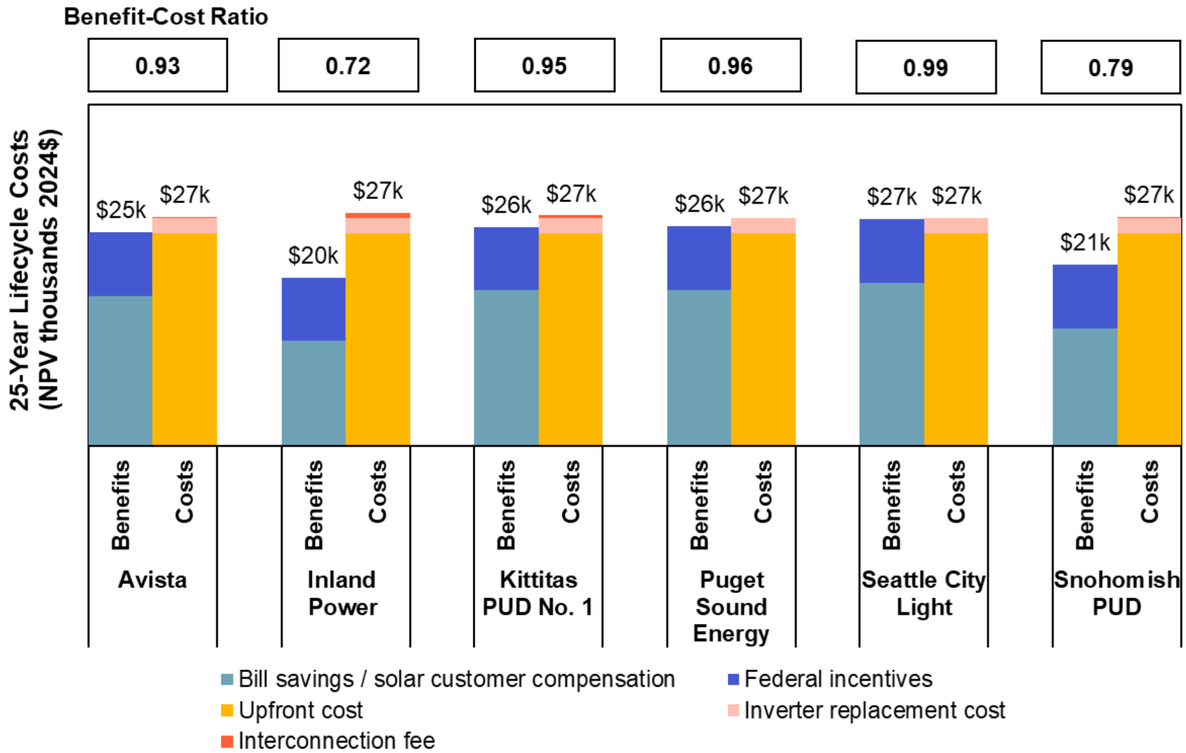
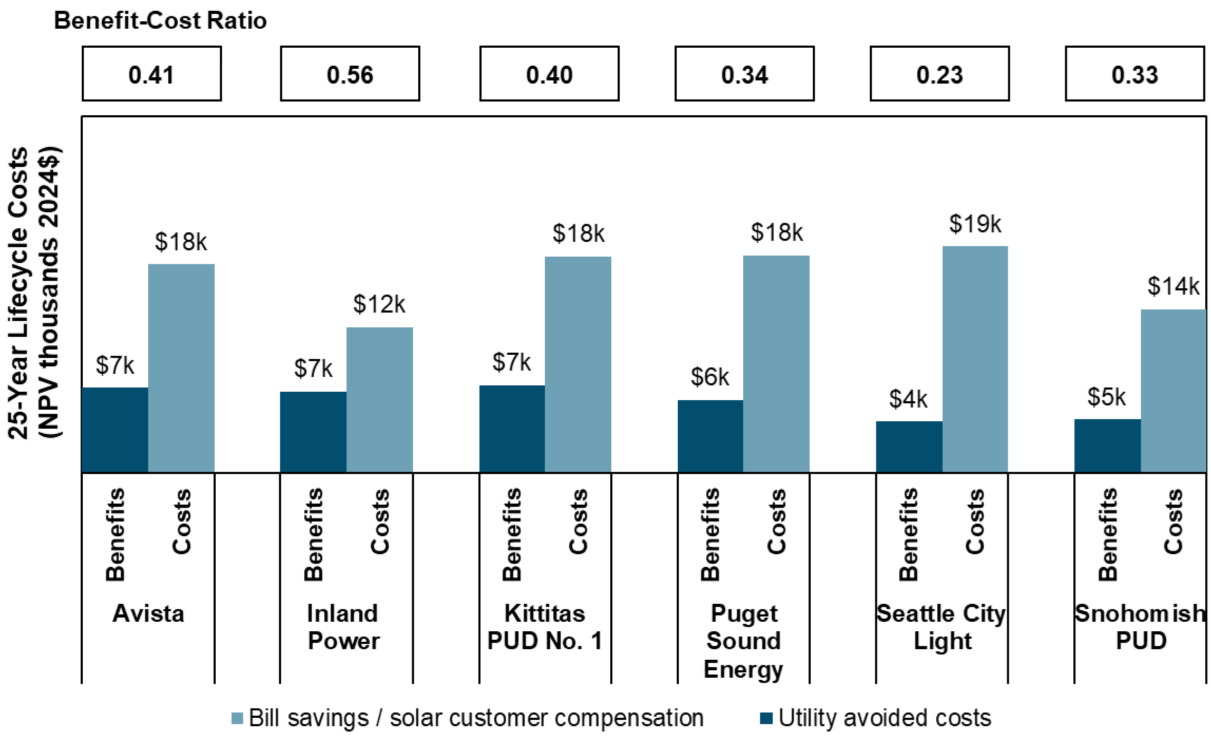


Figure 2 shows the Ratepayer Impact Measure (RIM) results based on an example residential 7 kW-AC system. The benefit-cost ratio ranges from 0.23 (Seattle City Light) to 0.56 (Inland Power), indicating that, from the ratepayer perspective, the lifetime benefits from NEM solar adoption are less than the lifetime costs. This outcome indicates that retail rate compensation under NEM is higher than the cost savings that NEM solar provides for the electricity system.

Figure 2. Ratepayer Impact Measure (RIM) by Utility for an Example 7 kW-AC System



Solar customer compensation through NEM significantly exceeds the value of customer solar to the electricity system, resulting in a cost shift from solar to non-solar customers. The total residential cost shift is estimated to be $39M/year by the end of 2024, and is estimated to grow to $49M/year by 2030 under a linear growth rate and assuming the current legislative NEM minimum remains in place.

If the legislative NEM minimum were removed and utilities were required to offer NEM to all customer solar, the NEM cost shift would grow significantly. Figure 3 shows a forecast of the total statewide residential cost shift from 2024 to 2030 for solar adoption forecasts with the legislative NEM minimum removed under a linear growth rate and under a compound annual growth rate. The solar adoption forecast under a compound annual growth rate assumes a much higher level of adoption by 2030, leading to a higher residential cost shift by 2030. This scenario models 1,375 MW-AC of 2030 adoption with a cost shift of $136 million/year by 2030, compared to 678 MW-AC of 2030 adoption and a $67 million/year cost shift under a solar adoption forecast with a linear growth rate.

Figure 3. Total Residential Cost Shift Forecast with Legislative NEM Minimum Removed Under Linear Growth Rate and Compound Annual Growth Rate

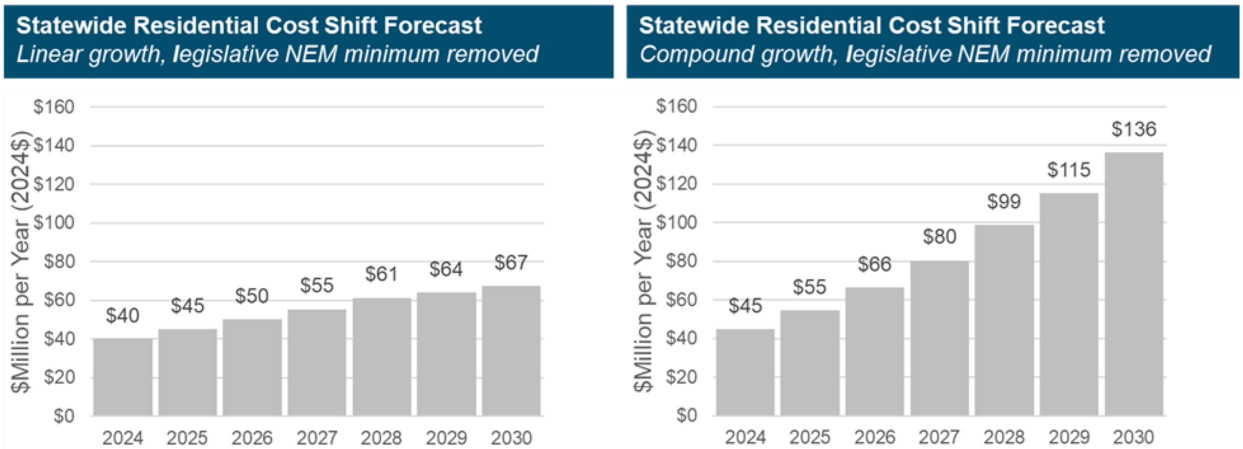


Table 2 shows the residential rate impact and low-income bill impact in 2024 as well as in 2030 for the three solar adoption forecasts explored in this study. Among the six utilities studied, compensation to NEM solar customers is projected to cause a residential rate increase of 0.3-1.4% in 2024, and a bill increase of $0.39-$2.27/month in 2024 for representative low-income customers. Higher levels of NEM solar adoption by 2030 lead to higher rate and bill impacts by 2030.

Table 2. NEM Solar Capacity, Residential Rate Impact, and Representative Low-income Bill Impact in 2024 and 2030 under Different NEM Solar Adoption Forecasts (All Monetary Values in 2024$)

	Avista	Inland Power	Kittitas PUD No. 1	Puget Sound Energy	Seattle City Light	Snohomish PUD
2024						
Total Residential NEM Solar Capacity (kW-AC)	21,240	3,408	723	115,946	44,452	26,130
Residential Rate Impact (c/kWh)	0.0655	0.0244	0.1309	0.0911	0.1726	0.0686
Percentage Increase Due to NEM (%)	+0.6%	+0.3%	+1.0%	+0.8%	+1.4%	+0.6%
Low-Income Bill Impact ($/month)	$0.63	$0.39	$2.27	$0.65	$1.22	$0.66
2030 Adoption Forecast: No Changes to NEM Minimum, Linear Growth Rate						
Total Residential NEM Solar Capacity (kW-AC)	41,331	6,780	723	151,981	65,617	46,366
Residential Rate Impact (c/kWh)	0.1449	0.0593	0.1490	0.1320	0.2148	0.1017
Percentage Increase Due to NEM (%)	+1.3%	+0.7%	+1.1%	+1.0%	+1.6%	+0.9%
Low-Income Bill Impact ($/month)	$1.39	$0.95	$2.59	$0.95	$1.51	$0.98
2030 Adoption Forecast: NEM Minimum Removed, Linear Growth Rate						
Total Residential NEM Solar Capacity (kW-AC)	41,331	6,780	4,093	243,491	82,313	46,366
Residential Rate Impact (c/kWh)	0.1449	0.0593	0.9524	0.2148	0.2720	0.1017
Percentage Increase Due to NEM (%)	+1.3%	+0.7%	+7.0%	+1.7%	+2.0%	+0.9%
Low-Income Bill Impact ($/month)	$1.39	$0.95	$16.52	$1.54	$1.91	$0.98
2030 Adoption Forecast: NEM Minimum Removed, Compound Growth Rate						
Total Residential NEM Solar Capacity (kW-AC)	143,283	12,360	5,772	482,636	148,249	81,733
Residential Rate Impact (c/kWh)	0.5540	0.1105	1.4299	0.4436	0.5085	0.1825
Percentage Increase Due to NEM (%)	+4.9%	+1.2%	+10.4%	+3.4%	+3.8%	+1.6%
Low-Income Bill Impact ($/month)	$5.32	$1.77	$24.80	$3.19	$3.58	$1.76

NEM solar provides additional societal value beyond that which accrues directly to ratepayers. Figure 4 shows the Societal Cost Test (SCT) results based on an example residential 7 kW-AC system. Federal incentives, upfront costs, and inverter replacement costs do not vary by utility, while utility avoided costs and other societal benefits do vary, with utility avoided costs primarily driving the differences in results by utility. The "other societal benefits" category includes the following societal benefits that were quantified in this study: reduced criteria pollutant emissions, reduced greenhouse gas emissions, and reduced land use impacts. The benefit-cost ratio ranges from 0.50 (Seattle City Light) to 0.66 (Avista), indicating that on average, the lifetime benefits of NEM solar are less than the lifetime costs from a societal perspective.

Figure 4. Societal Cost Test (SCT) by Utility for an Example 7 kW-AC System

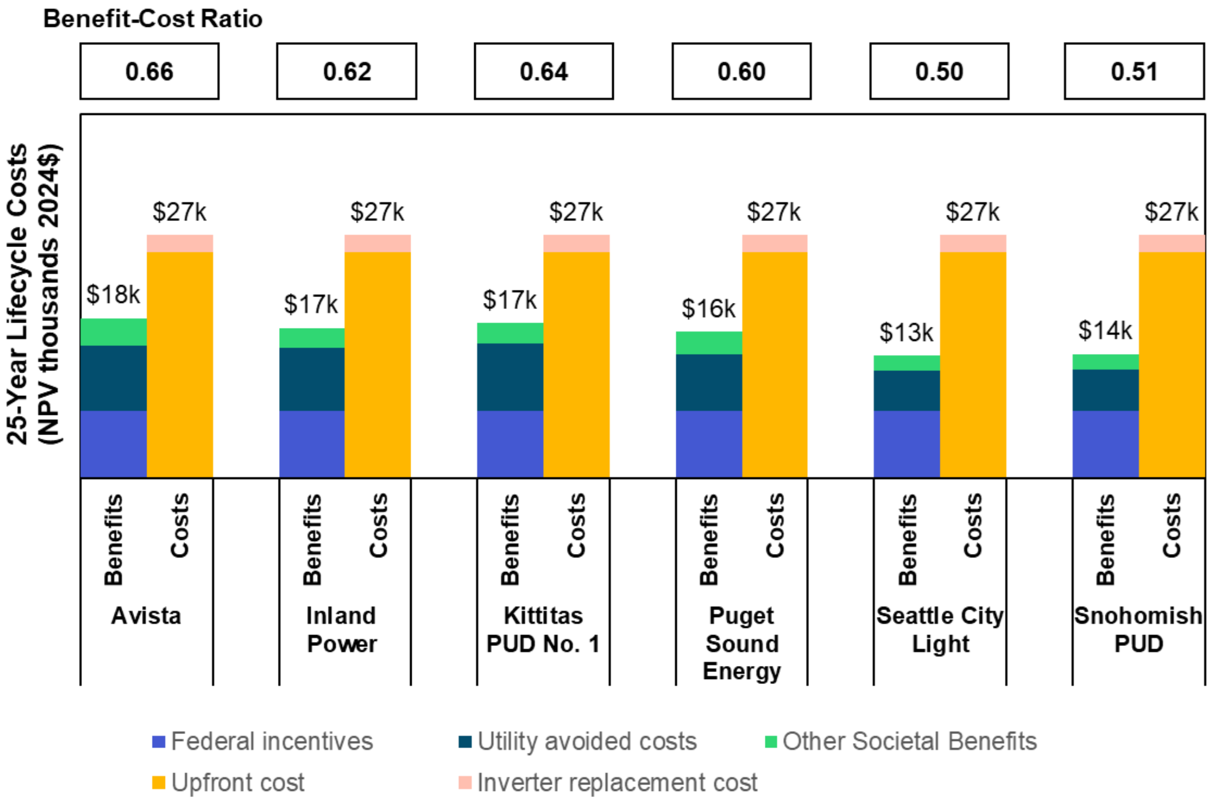


Table 3 shows a comparison of the utility avoided costs, societal benefits, and NEM compensation in 2024. Residential NEM solar generates benefits for the utility and its ratepayers (*i.e.*, utility avoided costs) of about 2.0-4.8 cents/kWh. NEM solar generates additional societal benefits of about 1.2-3.6 cents/kWh. Under NEM, participants are compensated at about 7.0-13.5 cents/kWh.

Table 3. 2024 Utility Avoided Costs, Societal Benefits, and NEM Compensation (2024 cents/kWh)

(2024 c/kWh)	Category	Utility: Avista	Utility: Inland Power	Utility: Kittitas PUD	Utility: Puget Sound Energy	Utility: Seattle City Light	Utility: Snohomish PUD
Utility Avoided Costs	Wholesale Energy Market Purchases	1.18	0.24	0.09	1.27	0.00	0.00
	Generation Capacity	0.10	0.02	0.01	0.10	0.00	0.00
	Clean Energy Purchases	2.50	3.78	3.99	2.39	0.00	0.00
	Fuel Price Risk	0.25	0.00	0.00	0.27	0.00	0.00
	BPA Tier 1	0.00	0.00	0.00	0.00	4.00	3.96
	BPA Energy Balancing Adjustment	0.00	0.00	0.00	0.00	-0.87	-0.65
	BPA Generation Capacity Adjustment	0.00	0.00	0.00	0.00	-1.34	-1.09
	Transmission and Distribution	0.34	0.14	0.15	0.45	0.19	0.15
	Clean Energy Transmission	0.36	0.54	0.57	0.34	0.00	0.00
	Total: Utility Avoided Costs	**4.73**	**4.72**	**4.81**	**4.81**	**1.98**	**2.35**
Societal Benefits	Reduced Criteria Pollutant Emissions	0.47	0.10	0.04	0.51	0.03	0.04
	Reduced Land Impacts	0.63	0.95	1.01	0.60	1.01	1.01
	GHG Savings (Societal)	2.39	0.49	0.19	2.53	0.15	0.18
	Total: Additional Societal Benefits	**3.49**	**1.55**	**1.24**	**3.64**	**1.19**	**1.22**
Compensation Under NEM	**NEM Customer Bill Savings**	**10.13**	**7.00**	**9.78**	**12.63**	**13.46**	**9.95**

Introduction

E3 was retained by a group of Washington utilities[4] and the Washington Public Utility District Association (WPUDA) to evaluate Washington's current net energy metering (NEM) programs. Under Washington State Law RCW 80.60, electric utilities must offer NEM to eligible customer-generators on a first-come, first-served basis until the earlier of either: 1) June 30, 2029, or 2) the first date upon which the cumulative generating capacity of net metering systems equals four percent of the utility's peak demand during 1996.[5] When a utility reaches this threshold, they may continue offering retail rate NEM, or develop or propose a new tariff. Investor-owned utilities can submit a new tariff to the Utilities and Transportation Commission (UTC) for approval, while consumer-owned utilities can develop a new tariff without submitting a filing to the UTC. As of June 30, 2023, five utilities have exceeded the legislative minimum capacity requirement for NEM.[6]

For the evaluation of Washington's NEM programs, E3 worked with six utilities and a technical advisory group (TAG) to collect information to evaluate the benefits and costs associated with NEM solar systems interconnected under Washington's current NEM programs. This evaluation addresses three key questions:

1. What are the benefits and costs of a new solar system interconnected today under NEM?
2. What are the benefits and costs of the full population of NEM solar and how do they evolve over time as more customers adopt NEM solar?
3. Does NEM result in cost shifts from NEM to non-NEM customers, and if so, what is the size of the cost shift today and in the future?

Since this evaluation is focused on Washington's current NEM programs, it does not consider existing or future non-NEM tariffs, time-of-use (TOU) rates, or solar paired with battery storage. Results of the evaluation illustrate the impacts of current NEM programs on participants, non-participating ratepayers, the full class of utility ratepayers, and society at large. While the evaluation includes a brief qualitative review of customer generation tariff design in other jurisdictions, it does not include evaluations of, or proposals for, a new tariff. The results of this evaluation will help inform future policy proposals for customer solar in Washington.

Modeling for this study is focused on the residential class. There are a number of reasons for this residential focus:

1. Based on the NEM Systems Database, 85% of NEM solar capacity (kW) installed by customers of the six detailed study utilities is in the residential class.

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[4] Supporting utilities include: Avista, City of Richland, City of Tacoma, PacifiCorp, Puget Sound Energy, Seattle City Light, Snohomish PUD, Washington Rural Electric Cooperative Association

[5] Washington State Legislature, Chapter 80.60 RCW Net Metering of Electricity, https://apps.leg.wa.gov/rcw/default.aspx?cite=80.60&full=true

[6] Washington State University, Net Metering, June 30, 2023, https://www.energy.wsu.edu/RenewableEnergy/NetMetering.aspx

2. Per kWh of generation, NEM is associated with a greater cost shift for residential customers than for non-residential customers. This is because residential rates often have higher volumetric charges leading to greater $/kWh solar customer compensation under NEM, while non-residential electric rates often have larger fixed and/or demand charges and smaller volumetric charges, reducing the $/kWh solar customer compensation under NEM for non-residential customers.
3. E3's expectation is that cost shifting predominantly affects customers within a given customer class. For this reason, impacts on residential rates and residential bills due to NEM, which are key metrics for this study, would be predominantly driven by the cost shift from residential NEM solar.

For these reasons, the results in this study are focused on residential NEM solar. Because 85% of Washington's NEM capacity is estimated to be in the residential class, these results are expected to be broadly reflective of statewide impacts from NEM solar. With that said, the specific impacts for non-residential NEM solar systems may look different, and non-residential customers may have lower upfront costs due to economics of scale for larger solar systems as well as lower $/kWh solar compensation due to retail rates with higher fixed and/or demand charges and lower volumetric charges.

Methodology Overview

The evaluation of Washington's current NEM programs included five tasks:

1. **Engage with diverse stakeholders through a technical advisory group (TAG)**
2. **Develop a database of interconnected NEM solar projects**
3. **Calculate representative benefits, costs, and cost shifts of NEM customer solar**
4. **Evaluate existing NEM programs**
5. **Review rate design options in other U.S. jurisdictions**

These tasks are described in detail in the subsections that follow. Due to the large number of utilities in Washington, E3 performed a detailed analysis for six "detailed study utilities" and then leveraged that analysis to estimate statewide impacts. Table 4 lists the detailed study utilities for this evaluation. These utilities reflect different utility ownership structures as well as geographic locations.

Table 4. Detailed Study Utilities for Evaluation

Utility	Ownership Type	Location (Relative to Cascades)
Avista	Investor-owned utility	East
Inland Power and Light Company	Cooperative	East
Kittitas PUD	Public utility district	East
Puget Sound Energy (PSE)	Investor-owned utility	West
Seattle City Light (SCL)	Municipal	West
Snohomish PUD	Public utility district	West

Stakeholder Engagement and Technical Advisory Group

To support a robust evaluation of the benefits and costs of net energy metering in Washington, the Washington Department of Commerce retained Gridworks to convene a Technical Advisory Group (TAG) consisting of representatives from different stakeholder groups. The TAG included stakeholders with a variety of perspectives including utilities, labor, environmental advocates, solar industry advocates, business advocates, and the Department of Commerce.

During three TAG meetings and through written comments, the TAG provided feedback on proposed benefits and costs of NEM solar, study inputs, proposed methodology, key metrics, results, and contextualization. The TAG identified a list of benefits and costs to evaluate as part of this study, and E3 augmented this list after comparison to other studies to ensure it was comprehensive. E3 considered TAG comments when developing study inputs, the evaluation methodology, and results.

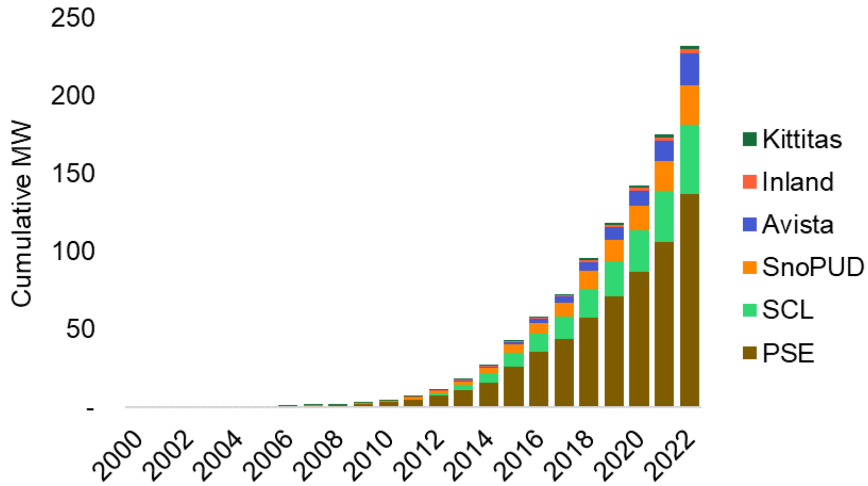
Section **Appendix A.3. Technical Advisory Group Comments** includes the TAG comments and E3's responses describing how the comments were considered to produce the final analysis and report.

Database of NEM Solar Systems

To evaluate the impact of current NEM programs in Washington, E3 worked with the detailed study utilities to develop a NEM systems database with key data regarding each customer solar system interconnected under the existing NEM programs. Each detailed study utility provided data including solar system size, interconnection year, customer class, property type, and census tract ID, among other items. Figure 5 shows one of the charts in the database, which summarizes the cumulative installed capacity by utility. The database was provided to the TAG and will also be hosted publicly.[7] E3 used the customer solar system data from the database to evaluate the costs and benefits of current NEM programs for this evaluation.

[7] E3 is temporarily hosting the database on Box at the following location: https://willdan.box.com/s/nkhiu03oo2w5l81v267xl5p9mfe4xdng

Figure 5. Chart from NEM Solar Systems Database, Cumulative Installed Capacity by Utility



To develop statewide results, E3 collected additional data from 33 other utilities in Washington State. This data included total interconnected NEM solar capacity, annual sales by customer class, and average solar system size.

Evaluation of NEM Solar Benefits and Costs

Using the data provided by the detailed study utilities as well as input from the TAG, E3 evaluated the benefits and costs associated with customer solar systems interconnected under Washington's current NEM programs. E3's evaluation included 32 different benefits including multiple categories of utility "avoided costs," which are cost savings to electric utilities that are passed on to electricity customers. These avoided costs represent the system value of marginal load reduction or customer generation. To support the development of utility avoided costs, the detailed study utilities provided data related to energy, generation capacity, transmission and distribution capacity, and greenhouse gas (GHG) avoided costs. E3 used the provided data and other industry resources to develop a forecast of utility avoided costs over the 25-year period from 2024-2048. This forecast of avoided costs is important to accurately reflect the value of incremental customer solar to the electric system over time.

NEM solar may also generate other societal benefits, including reduced GHG and criteria pollutant emissions, land use benefits, reduced water consumption, and others. These benefits would accrue to residents of Washington but would not result in rate reductions for utility ratepayers.

E3 considered different perspectives commonly utilized in utility customer program evaluation:

- **NEM Solar Customers (Participants)**: this perspective captures all benefits and costs that accrue directly to customers who install a NEM solar system.
- **Utility Ratepayers**: this perspective captures all benefits and costs that accrue to electric ratepayers of the utility.
- **Societal Perspective**: this perspective captures all benefits and costs that accrue to residents in the state of Washington.

E3 worked with the TAG to develop a robust list of the benefits and costs of NEM solar, and then classified these benefits and costs based on who benefits or who incurs costs. E3 also grouped avoided costs into appropriate categories. E3 quantified benefits and costs where possible and provided a qualitative evaluation of the remaining benefits and costs. Table 5 and Table 6 list each benefit and cost identified by the TAG and E3, the classification for each benefit and cost, and an indication of whether the benefit or cost was evaluated quantitatively or qualitatively in this evaluation.

Table 5. Benefits Identified by E3 and the Technical Advisory Group

TAG Benefit Description	Utility Avoided Cost Category	Benefit Classification			Evaluation	
		NEM Customer	Ratepayer	Societal	Quantitative	Qualitative
NEM customer bill savings – reduced energy bills for system owners	N/A	X			X	
Federal incentives		X		X	X	
NEM customer hedge against fossil fuel volatility (commodity prices, technology costs, utility bills)		X				X
Resilience benefit from rooftop solar alone		X		X		X
Avoided purchase of energy that would otherwise be needed, including obligations to comply with emissions standards under the Washington Clean Energy Transformation Act (CETA)	Energy		X	X	X	
Energy production from NEM solar systems			X	X	X	
Decreased thermal power plant operations decrease variable operating costs (i.e., water, waste, etc.)			X	X	X	
Avoided transmission and distribution line losses – NEM solar generated locally avoids line losses			X	X	X	
Hydroelectricity relief – reduces the draw from dams, leaving more hydroelectricity for utilities to sell regionally or keep in reserve			X	X	X	
Utility fuel price risk reduction			X	X	X	
Diversity of resources – NEM solar contributes to portfolio benefits			X	X		X
Secondary effects that customers use more electricity at optimal times for the grid (electric vehicle charging) or increases electrification in the home			X	X		X
Progress toward state/community clean energy goals - supports utility progress toward Washington's Clean Energy Transformation Act and other community clean energy goals	Greenhouse Gas		X	X	X	
Avoided greenhouse gas emissions – NEM solar displaces fossil fuel emissions			X	X	X	
Peak capacity – reduced peak capacity needs and deferral of new generation resources	Generation Capacity		X	X	X	
Avoided plant fixed operations and maintenance (O&M) – deferred or avoided generation O&M costs			X	X	X	
Driver for new technology - will enable virtual power plants			X	X		X

TAG Benefit Description	Utility Avoided Cost Category	Benefit Classification: NEM Customer	Benefit Classification: Ratepayer	Benefit Classification: Societal	Evaluation: Quantitative	Evaluation: Qualitative
Deferred or avoided investment – benefits of deferring or reducing the size of transmission and distribution investments (including lines, substations, and equipment - new and/or upgrades). Level of solar penetration, location of solar install, and adoption of storage may dampen this benefit.	Transmission and Distribution Capacity		X	X	X	
Frequency regulation – new inverter technology increasingly supports frequency regulation	Ancillary Services		X	X		X
Voltage support – providing voltage support (VAR), including inverter "ride through" ability, is a direct benefit of inverter resources			X	X		X
Reduced water consumption – less water used for fossil fuel cooling	N/A			X		X
Reduced water consumption – potential for solar panels to shade irrigation canals and thereby reduce evaporation and water loss; also a source of electricity for canal pumps, reducing canals' electric draw from the grid				X		X
Reduced criteria pollutants – NEM solar reduces criteria pollutants from fossil fuel plants				X	X	
Reduced land impacts – value of putting NEM solar in the built environment; preserves land for agriculture, commercial and housing needs. Preserves natural habitats and reduces the need for transmission lines.				X	X	
Preserves tribal lands and resources – less solar being forced onto tribal lands. Self-generation can preserve tribal resources and increase tribal sovereignty.				X		X
Reduced wildfire risk – NEM solar reduces urban loads and allows for de-energizing transmission and distribution lines. Also allows for islanding remote rural customers.				X		X
Increased awareness – raises public awareness for energy issues; onsite generation might encourage residential storage, driver for electrification, reduce the need for demand reduction				X		X
Local employment – green jobs, apprenticeship opportunities, local living wage employment and training in the electrical field				X		X
Federal funds as an economic development engine – attract federal funds to Washington State, particularly the Local Solar for All grant program that will support low- and moderate-income households. Also the tax credits and rebates from the Inflation Reduction Act will help to grow the Washington economy.				X		X
Leverage private capital – private capital deployed to support clean energy development				X		X
Investment in disadvantaged communities – jobs and local spending in disadvantaged communities				X		X
Equity – reduced energy burden for low-income customers				X		X

Table 6. Costs Identified by E3 and the Technical Advisory Group

TAG Cost Description	Cost Category	Cost Classification			Evaluation	
		NEM Customer	Ratepayer	Societal	Quantitative	Qualitative
Upfront system costs	N/A	X			X	
Inverter replacement costs		X			X	
O&M costs		X			X	
Solar Customer Compensation	Solar Customer Compensation		X		X	
Solar integration costs	Energy		X	X		X
Grid modernization – the costs of tools and infrastructure used by the utility to support distributed energy resources (DER) at the distribution level	Distribution Capacity		X	X		X
Utility program administration costs (marketing, administration, evaluation, incentives)	Program Costs		X	X		X

A detailed description of the evaluation methodology for each benefit and cost is provided in the **Participant Benefits and Costs**, **Ratepayer Benefits and Costs**, and **Societal Benefits and Costs** sections of this report.

NEM Evaluation Model

E3 developed a NEM evaluation model to evaluate the benefits and costs of Washington's existing NEM programs. The model estimates 25-year benefits and costs due to customer solar adoption starting in 2024 for residential customers on existing NEM tariffs for the detailed study utilities. The model also estimates benefits and costs for the rest of Washington State by extrapolating the results for the detailed study utilities. Finally, the model calculates the size of the cost shift from NEM to non-NEM customers.

The model includes three key input categories:

- **Annual Customer Bill Impacts:** Average bill savings for each detailed study utility.
- **Annual Utility Avoided Costs:** Reductions in utility costs due to customer solar adoption.
- **Annual Societal Avoided Costs:** Quantified benefits to society from customer solar adoption due to avoided land use and emissions reductions.

The NEM evaluation model produces several results metrics to illustrate the impacts of current NEM programs on participants, non-participating ratepayers, the full class of utility ratepayers, and society as a whole. These metrics include a set of standardized cost-effectiveness metrics from the Standard Practice Manual (SPM) as well as other metrics that describe participant and non-participant impacts.

The model includes four SPM cost-effectiveness tests that reflect four different perspectives: participants (i*.e.*, customer solar adopters), non-participating ratepayers, all utility ratepayers, and society at large:

- **Participant Cost Test (PCT)**
- **Ratepayer Impact Measure (RIM)**
- **Total Resource Cost Test (TRC)**
- **Societal Cost Test (SCT)**

These four cost-effectiveness tests compare the lifecycle benefits and costs over the lifetime of the solar system installation (modeled to be 25 years, spanning 2024-2048). As shown in Figure 6, the inclusion of various benefits and costs in each test varies depending on the perspective considered. The lifecycle (net present value) benefits and costs are calculated assuming a nominal discount rate of 7%,[8] except for the societal cost test, which are assumes a nominal discount rate of 5%. The resulting ratio of lifecycle total benefits to total costs is provided for each test. Note that the TRC results are shown in **Appendix A.1.** .

Figure 6. Mapping of Benefit-Cost Components to each Cost-Effectiveness Test

	Participant Cost Test (PCT)		Ratepayer Impact Measure (RIM)		Total Resource Cost (TRC)		Societal Cost Test (SCT)	
	Benefits	Costs	Benefits	Costs	Benefits	Costs	Benefits	Costs
Bill Savings / Solar Customer Compensation	X			X				
Upfront Cost		X				X		X
Inverter Replacement Cost		X				X		X
Interconnection Fee		X						
Federal Incentives	X				X		X	
Utility Avoided Costs			X		X		X	
Other Societal Benefits							X	

Washington uses the TRC as the primary test to evaluate demand-side programs such as energy efficiency programs.[9] The PCT, RIM, and SCT results are often included in program evaluation, and are included in this report, to provide additional information based on different perspectives.

As noted by the TAG, load reduction measures including energy efficiency generally result in higher rates for non-participating customers (RIM value <1). However, these measures may still be approved where they provide net benefits to the body of utility ratepayers as a whole (TRC value >1).

In addition to the lifecycle cost-effectiveness tests, E3 developed other metrics focused on participating and non-participating ratepayers.

Participant metrics include:

- **Participant Cost Test:** lifecycle benefit-cost ratio from the participant perspective
- **Bill savings (NEM customer compensation):** Average customer bill savings for customer solar generation
- **Simple payback period:** upfront system costs (net of incentives) divided by first-year bill savings

Non-participant metrics include:

- **Ratepayer Impact Measure:** lifecycle benefit-cost ratio from the ratepayer perspective

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[8] Intended to approximate utility weighted average cost of capital (WACC). Approved nominal WACCs at the end of 2022 were 7.16% for PSE and 7.03% for Avista.

[9] https://database.aceee.org/state/evaluation-measurement-verification

- **Utility avoided costs:** Average electric system value of customer solar generation
- **Residential electric rate impact:** ¢/kWh rate increase for residential ratepayers due to compensation to NEM solar customers
- **Low-income bill impact:** Monthly bill increase for an average low-income customer due to compensation to NEM solar customers
- **Residential cost shift forecast**: total annual residential NEM cost shift accounting for all interconnected NEM systems based on three solar adoption forecasts
  - No changes to the legislative NEM minimum, linear kW/year growth per utility based on 2018-2022 data
  - Legislative NEM minimum removed, linear kW/year growth per utility based on 2018-2022 data
  - Legislative NEM minimum removed, compound annual growth per utility based on 2018-2022 data

Total cost metrics include:

- **Total Resource Cost test:** lifecycle benefit-cost ratio from the perspective of all utility ratepayers, including participants and nonparticipants. The Total Resource Cost test is provided in the section **Appendix A.1. Total Resource Cost Test Results**

Societal metrics include:

- **Societal Cost Test:** lifecycle benefit-cost ratio from the perspective of Washington State residents. The Societal Cost Test is the key societal metric evaluated in this study. It is similar to the Total Resource Cost test but also includes quantified benefits to Washington residents that do not directly accrue as financial savings to utility ratepayers. These additional benefits include:
  - **Reduced criteria pollutant emissions:** Reductions in NOx, SOx, and PM2.5 due to reduced combustion of fossil fuels in power plants
  - **Reduced greenhouse gas emissions:** Additional value of reduced greenhouse gas emissions using federal estimates of the social cost of carbon
  - **Reduced land use impacts:** Estimate of the value of putting NEM solar in the built environment, preserving land for agriculture, commercial and housing needs, or natural habitats

Kittitas County PUD

Kittitas County PUD has exceeded the legislative requirement for the NEM tariff. As of June 30, 2023, their installed solar capacity is 335% of the legislative requirement for NEM.[10] Solar systems data from Kittitas County PUD (through 2022) reflect two categories of customer solar:

1. 750 kW-AC of total customer solar on retail rate NEM ("Legacy NET" tariff)

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[10] Washington State University (WSU) Energy Program Net Metering Report, https://www.energy.wsu.edu/documents/Net%20Metering%20Reporting_20230630.pdf

2. 1,340 additional kW-AC of total customer solar on a net billing tariff ("NET – No Banking" tariff)

The results in this evaluation only reflect customer solar on retail rate NEM. For Kittitas County PUD, customer solar on the newer "NET – No Banking" tariff is not reflected in the evaluation results, except in forecasts of the cost shift that assume the legislative NEM minimum is removed.

Review of Customer Generation Tariff Design in Other U.S. Jurisdictions

E3 completed a brief qualitative review of tariff design for customer generation in other U.S. jurisdictions. Broadly speaking, two different types of rate reform can be used to reduce cost shifting associated with customer solar:

1. **New tariffs for customer-generators**: This option is commonly described as "NEM reform." Examples of alternative tariff designs for customer-generators include net energy billing (NEB) and "buy-all, sell-all."
2. **General residential tariffs aligned with utility costs:** While not exclusively focused on NEM, an alternative approach to reducing cost shifts from customer solar is to develop default residential tariffs with volumetric rates that are more aligned with marginal utility costs. Under such a tariff, customer solar under NEM would be compensated at a rate that is more closely aligned with the system value it provides.

The review of tariff design is summarized in the section **Review of Customer Generation Tariff Design in Other U.S. Jurisdictions**. This study does not include an evaluation of, or any specific proposals for, potential future tariff designs for customer solar in Washington.

Participant Benefits and Costs

Methodology

The Participant Cost Test (PCT) compares participant benefits (bill savings/solar customer compensation and federal incentives) to participant costs (upfront costs, inverter replacement costs, and interconnection fees) over an assumed 25-year lifetime of the solar system.

Figure 7. Benefits and Costs Included in the Participant Cost Test (PCT)

	Participant Cost Test (PCT)	
	Benefits	Costs
Bill Savings / Solar Customer Compensation	X	
Upfront Cost		X
Inverter Replacement Cost		X
Interconnection Fee		X
Federal Incentives	X	
Utility Avoided Costs		
Other Societal Benefits		

Bill Savings (Solar Customer Compensation)

E3 calculated average annual customer bill savings from NEM solar for each residential NEM solar customer in the NEM systems database, nearly 30,000 customers across the six detailed study utilities. Bill savings vary based on three key factors: utility rates (in this case, published 2023 rates), customer loads, and customer solar generation. Bill savings are calculated monthly as the difference between the estimated monthly bill without NEM solar and the estimated monthly bill with NEM solar. The bill without NEM solar is based on monthly consumption before solar interconnection (*i.e.*, without any customer solar generation), while the bill with NEM solar is based on monthly load after solar interconnection, with customer solar compensated at the retail rate. The bill impacts account for the different rate structures among the detailed study utilities, including both simple volumetric rates and tiered rate designs. Monthly customer charges and minimum monthly bills are applied annually, assuming monthly banking of bill credits. Table 7 summarizes the rate structures by utility as well as the resulting average bill savings in cents per kWh for each of the detailed study utilities.

Table 7. Utility Rate Structures and Resulting Average Bill Savings

Utility	Rate Structure	Average Bill Savings (2023 cents/kWh)
Avista	Tiered	9.84
Inland Power	Simple c/kWh	6.80
Kittitas PUD No. 1	Simple c/kWh	9.50
Puget Sound Energy	Tiered	12.26
Seattle City Light	Tiered	13.07
Snohomish PUD	Simple c/kWh	9.66

Solar generation is estimated based on reported solar system sizes from the detailed study utilities and assuming utility-average solar capacity factors derived from the National Renewable Energy Laboratory (NREL)'s PVWatts tool.[11] For each utility, a profile is assumed based on the utility zip code with the most installed solar capacity. The PVWatts profiles reflect a representative Typical Meteorological Year, which is intended to be broadly representative of typical solar output rather than being drawn from a single historical year. The assumed annual capacity factors for each utility are shown in Table 8, along with annual generation for an example 7 kW-AC system, which was approximately the average residential system size across the utilities and is used for several metrics described later in this report. Note that a higher capacity factor will lead to higher bill savings due to greater solar generation, as well as higher avoided costs (described in the **Utility Avoided Cost Framework** section) and cost shifts.

[11] https://pvwatts.nrel.gov/

Table 8. Annual Solar Generation (Example 7 kW-AC System)

Utility	Avg. Annual Capacity Factor (% AC)	Annual Generation for a 7 kW-AC System (kWh)
Avista	17.2%	10,600
Inland Power	17.4%	10,700
Kittitas PUD No. 1	18.5%	11,300
Puget Sound Energy	14.4%	8,800
Seattle City Light	14.1%	8,600
Snohomish PUD	13.7%	8,400

E3 leveraged annual customer loads provided by the utilities to estimate consumption with and without an interconnected solar system. For customers without load data available, E3 estimated the load based on average customer solar system size as a percent of annual load. Using this annual load, E3 estimated monthly loads for each customer based on monthly load profiles provided by the utilities. Monthly loads are necessary for bill calculations on tiered rates. In cases where monthly customer solar generation exceeds customer load, the net exports are assumed to roll over to the next month, though customers must pay a customer charge or minimum bill where applicable. If annual generation exceeds annual consumption, the annual bill is modeled to be equal to the annual customer charge or minimum bill amount (the monthly minimum bill multiplied by 12 months).

Beyond calculating utility-average bill savings for each of the deep dive utilities, “rest-of-state” bill savings were approximated using a solar capacity-weighted average electricity rate for the eight Washington utilities that are not detailed study utilities with the highest amount of NEM solar installed.[12] E3 estimated an average capacity factor for the “rest-of-state” to be 15.8%, equal to the simple average of the capacity factors modeled for Avista and Puget Sound Energy, intended to represent a simplified average of eastern and western Washington solar profiles. Average bill savings for all of Washington State are then calculated by averaging bill savings among the detailed study utilities and “rest-of-state” using a solar capacity-weighted average.

Bill savings calculated for 2023 (for each utility and rest-of-state) are assumed to escalate over time based on historical growth rates (~3%/year nominal[13]) over the 25-year solar system lifetime and assume no degradation of the solar system.

Other Participant Benefits and Costs

The methodology and assumptions used for the other key participant benefits and costs are as follows:

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[12] Average utility rates were calculated based on EIA Form 861; utility solar production was calculated based on Washington State University-reported statewide capacity, https://www.energy.wsu.edu/RenewableEnergy/NetMetering.aspx. These utilities include: PacifiCorp, Clark County PUD, Tacoma Power, Benton County PUD, Franklin County PUD, Orcas Power & Light Co, City of Richland, Jefferson County PUD.

[13] Based on 10-year compound average growth rate (CAGR) of average revenues per sales (~2%), plus assumption of expected ongoing costs (~1%)

- **Upfront cost:** Assumes customers who install solar in 2024 pay $3,558/kW-AC before incentives for the system upfront cost, based on average residential installed cost data for Washington from EnergySage.[14] EnergySage is a marketplace for customer solar and this number reflects actual pricing paid by customers in Washington State. Note that the participant perspective is only evaluated for 2024 installations; thus, this study does not forecast the cost of solar installations in future years.
- **Inverter replacement cost**: Assumes customers who install solar in 2024 pay a $463/kW-AC inverter replacement cost after 12 years (*i.e.*, inverter replacement in 2036 for a 2024 adopter).[15]
- **Interconnection fee:** Assumes customers who install solar in 2024 pay the interconnection fees shown in Table 9, which are calculated by dividing absolute interconnection fees (provided by the detailed study utilities) by utility average solar capacities.
- **Federal incentives:** Assumes all customers who install solar in 2024 receive a 30% investment tax credit (ITC),[16] equivalent to $1,068/kW-AC based on the assumed upfront cost. Note that it may be optimistic to assume that all customers receive the federal ITC because customers without tax liability may not qualify for the full tax credit. Participant payback periods are presented both with and without the federal ITC.

Table 9. Solar System Interconnection Fees by Utility

Utility	Interconnection Fee ($/kW)
Avista	$15
Inland Power	$80
Kittitas PUD	$41
Puget Sound Energy	$0
Seattle City Light	$0
Snohomish PUD	$12

In addition to the Participant Cost Test, E3 evaluated two other NEM participant metrics for each of the six detailed study utilities and all of Washington State:

- **2024 bill savings for an example 7 kW-AC system ($/year):** A 7 kW-AC system is the approximate average residential system size across the six detailed study utilities.
- **Simple payback period (years):** The simple payback period is calculated as the upfront cost (net of incentives) divided by the first-year bill savings. This version of the payback period is described as “simple” because it does not consider future rate escalation, nor the discounting of future bill savings. Given the uncertainty of customer tax credit eligibility, the simple payback period is calculated both with and without federal incentives.

[14] https://www.energysage.com/local-data/solar-panel-cost/
[15] https://www.nrel.gov/docs/fy23osti/87303.pdf
[16] https://www.energy.gov/eere/solar/homeowners-guide-federal-tax-credit-solar-photovoltaics

E3 also conducted a qualitative evaluation for benefits identified by the TAG that are not included quantitatively in the PCT, including customer hedging against price volatility and resilience benefits. The qualitative impact of these benefits is discussed in the **Qualitative Evaluation** section.

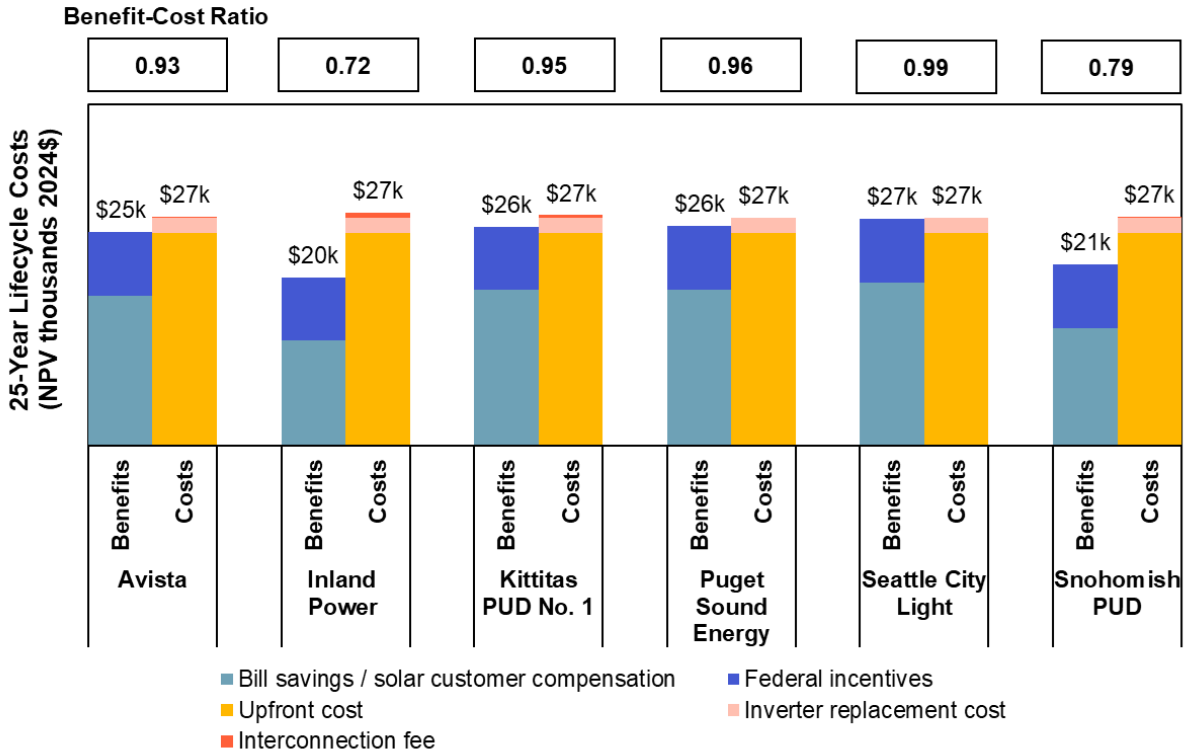
Participant Results

Participant Cost Test Results

Figure 8 shows the Participant Cost Test results based on an example residential 7 kW-AC system. Benefits and costs are lifecycle net present value (NPV) $/system values over the assumed 25-year lifetime of the solar system and based on a 7% nominal discount rate. Of the cost test components, federal incentives, upfront costs, and inverter replacement costs do not vary by utility, while bill savings and interconnection fees do vary, with bill savings primarily driving the differences in results by utility. Two key factors driving differences in bill savings among utilities are the volumetric electricity rates and solar capacity factor. A higher electricity rate leads to greater bill savings from solar, and tiered rate structures (Avista, Puget Sound Energy, Seattle City Light) will also result in higher average bill savings due to solar generation largely being compensated at the higher-tier rate(s). Similarly, higher solar capacity factors lead to higher bill savings, as greater solar generation will lead to greater bill savings.

The resulting benefit-cost ratio ranges from 0.72 (Inland Power) to 0.99 (Seattle City Light), indicating that, assuming a 7% nominal discount rate and 25-year lifetime, lifecycle benefits are less than or nearly equal to the lifecycle costs for a customer solar adopter across the six detailed study utilities. While at face value this metric would indicate it is not cost-effective for customers to adopt solar under NEM in Washington, participants may also see additional non-monetary benefits that are not captured in this figure, and these benefits may influence solar adoption decisions. Additionally, customer discount rates and financial opportunity costs may be different from the 7% discount rate assumed for this study.

Figure 8. Participant Cost Test (PCT) by Utility for an Example 7 kW-AC System



First-Year Bill Savings and Payback Period

Figure 9 shows the first-year annual bill savings for a 2024 solar adopter based on an example 7 kW-AC system. First-year bill savings range from around $750 to nearly $1,200 for the representative system, reflecting bill savings of around $100 to $170 per kW-AC. Key factors driving differences in bill savings across utilities are described above in the **Participant Cost Test Results** section.

Figure 9. 2024 Bill Savings for an Example 7 kW-AC System

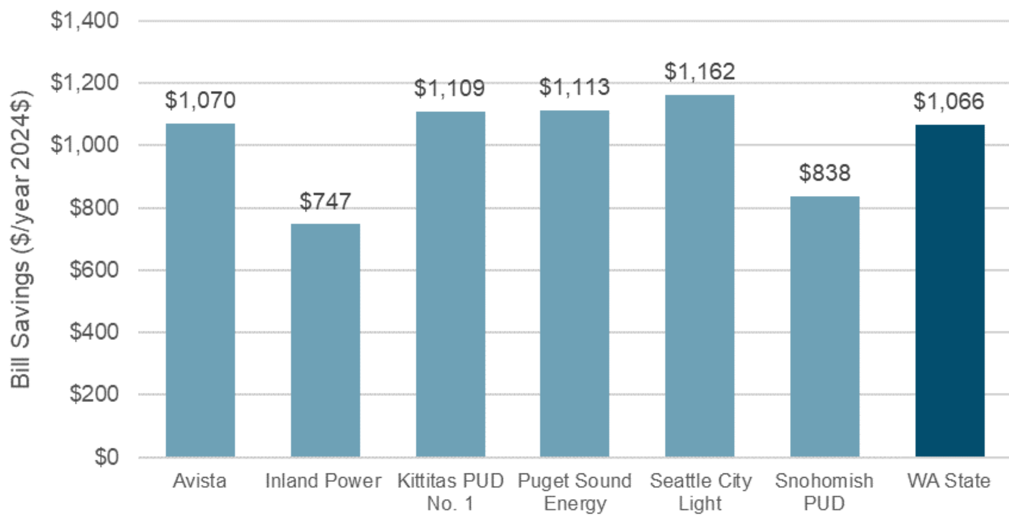
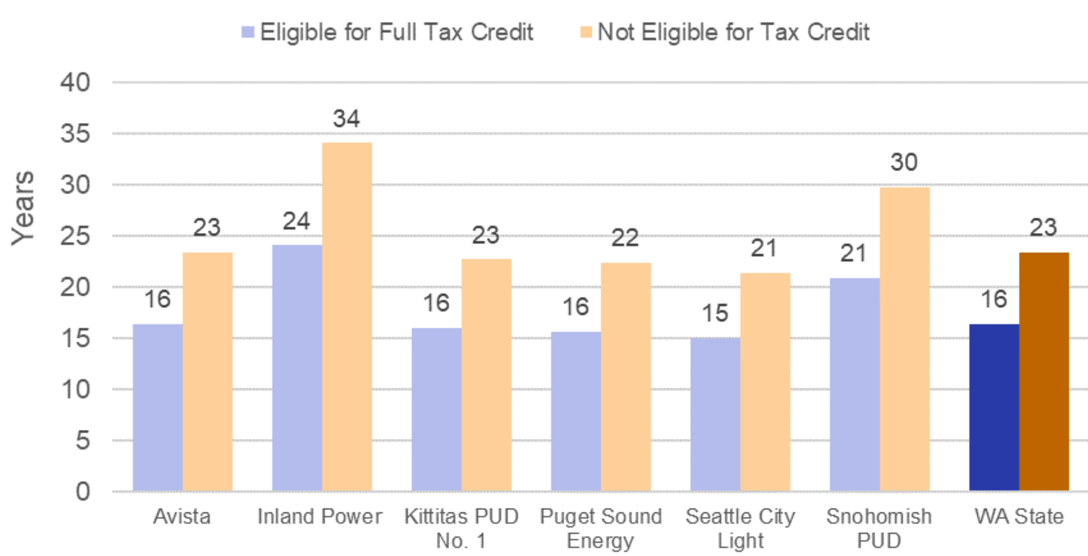


Figure 10 shows the simple payback period, which is calculated as the upfront cost (net of incentives) divided by first-year bill savings. A version of the payback period without incentives is also provided to capture a lower bound for customers who may not be eligible to receive the federal investment tax credit. It may be optimistic to assume that all customers receive the federal investment tax credit (ITC) because customers without tax liability may not qualify for the full tax credit. The modeling assumes a solar system cost of $3,558/kW-AC before incentives and about $2,500/kW-AC after accounting for the federal ITC. With full tax credit eligibility, the modeled simple payback period ranges from 15-24 years (all less than the assumed 25-year system lifetime). Without any tax credit eligibility, the payback period range increases to 21-34 years, with the state average remaining under 25 years.

Figure 10. Simple Payback Period by Utility, with and without Federal ITC



Environmental Health Disparities of NEM Participants

Using data from the six detailed study utilities, E3 analyzed the geospatial distribution of existing NEM customers using data from the Washington State Department of Health's Environmental Health Disparities Map.[17] The Environmental Health Disparities Map is a geospatial tool that ranks the environmental health risk of each census tract in Washington. These rankings are calculated for overall environmental health disparities as well as for other determinants of environmental health, including socioeconomic disparities. The overall environmental health disparities model uses a "Risk = Threat x Vulnerability" framework to consider both environmental exposures and socioeconomic vulnerabilities.

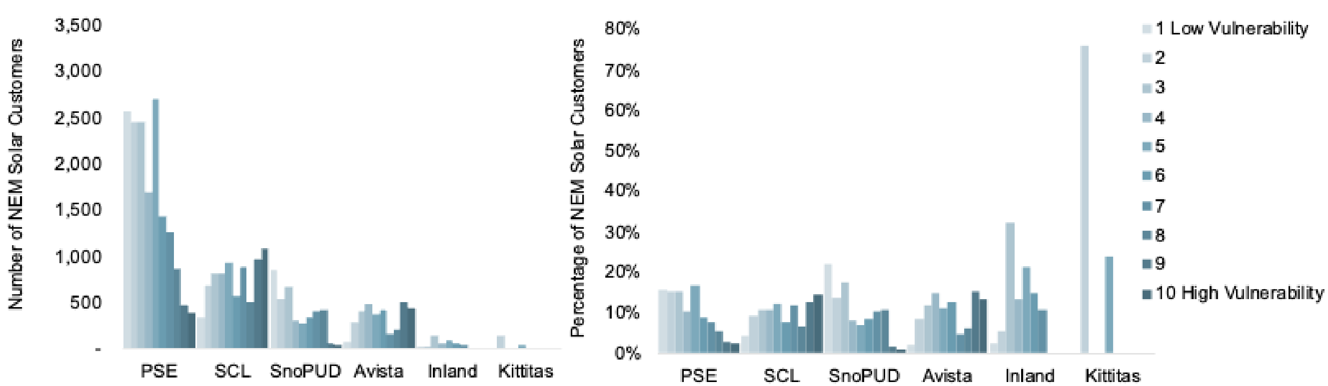
Geographic data on each NEM solar system comes from the NEM Systems Database. More information on the NEM Systems Database is provided in the section **Database of NEM Solar Systems**.

This study looks at both the *overall ranking* and the *socioeconomic ranking* to analyze the demographics of existing NEM solar customers. The resulting ranking is based on deciles of Washington census tracts; for example, a score of 1 means the census tract is in the lowest 10% for risk.

Figure 11 shows the overall environmental health disparity ranking of existing NEM customers. In general, NEM customers are disproportionately located in communities with lower environmental health risks, *i.e.*, NEM customers are more likely than the average customer to live in an area that ranks low on the Environmental Health Disparities ranking.

Figure 11. NEM Customer Overall Environmental Health Disparity Rankings.

Left figure shows number of NEM customers, right figure shows % of NEM customers by utility



The Clean Energy Transformation Act requires Washington utilities to identify "highly impacted" communities using the overall environmental health ranking on the Washington Environmental Health Disparities Map. "Highly impacted" communities are defined as census tracts with a score of nine or greater in the overall health ranking. While about 20% of the general population falls into communities that are designated as "highly impacted," only 12% of NEM customers are in those areas. The share of

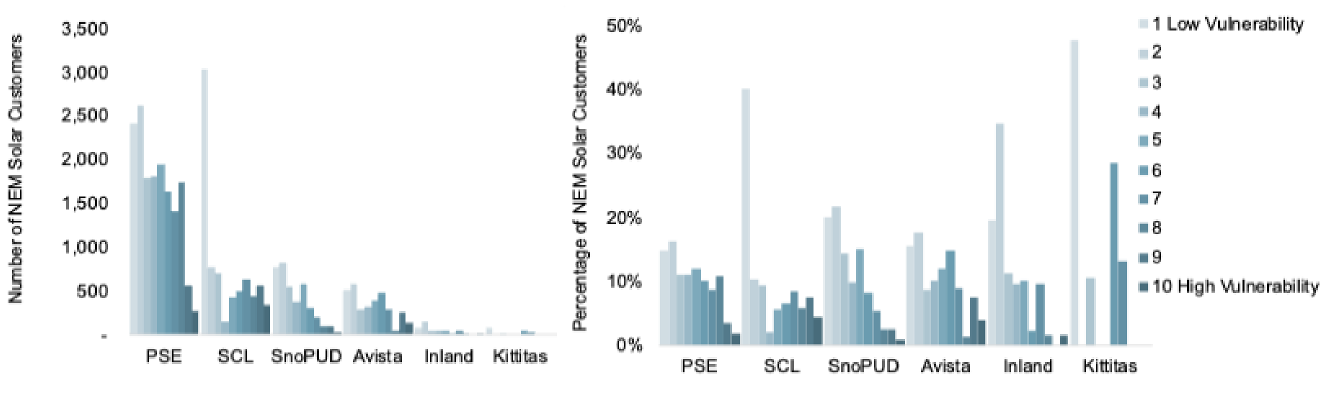
[17] Washington State Department of Health, Environmental Health Disparities Map, https://doh.wa.gov/data-and-statistical-reports/washington-tracking-network-wtn/washington-environmental-health-disparities-map.

customers in highly impacted communities varies greatly across the state. Urban areas, like Seattle (SCL), have a much greater number of highly impacted communities due to greater local environmental burdens and threats. In these areas, NEM customers are also more likely to live in communities that are highly impacted than the state average. However, while NEM solar can provide bill savings to the participant, environmental benefits from NEM solar are not localized. Corresponding pollution reduction will occur at fossil generators with no locational tie to the NEM system itself.

Figure 12 shows the socioeconomic component of the Washington Environmental Health Disparities Map data. Almost 40% of existing NEM customers are in the highest 20th percentile of Washington census tracts by socioeconomic status and only 7% of existing NEM customers are in the lowest 20th percentile. While these metrics are not a perfect indicator of household income, the results are aligned with other data sources that suggest that customers with NEM solar are generally higher income. For example, a 2022 analysis from the Lawrence Berkeley National Laboratory shows that 27% of solar adopters in Washington have a household income less than the area median income (AMI) and 60% of adopters earn more than 120% of the AMI.[18]

Figure 12. NEM Customer Socioeconomic Environmental Health Disparity Ranking.

Left figure shows number of NEM customers, right figure shows % of NEM customers by utility



The comparison between the Washington Environmental Health Disparities overall ranking and socioeconomic ranking shows that 12% of NEM customers are in census tracts with the highest environmental burdens (top 2 deciles), but only 7% are in census tracts with the highest socioeconomic burden (top 2 deciles). This is most clearly seen in urban areas, such as Seattle, which is represented in the figures with the SCL service area. NEM customers in the SCL service area show relatively high environmental burden, but very low socioeconomic vulnerability.

[18] Solar Demographics Tool, Lawrence Berkeley National Lab, https://emp.lbl.gov/solar-demographics-tool

Qualitative Evaluation

Customer Hedge Against Fossil Fuel Volatility

For individual participants in Washington's NEM program, the installation of solar can provide benefits as a hedge against utility rate increases tied to fossil fuel volatility. As electricity rates fluctuate over the multiple decade lifetime of a solar installation, NEM participants may be able to avoid some impact of those fluctuations because the rates they pay to utilities will only apply to a fraction of the energy they use.[19] However, while overall bills will be lower, month-to-month bill volatility may increase due to the weather dependence of solar generation. Additionally, most Washington utilities are less vulnerable to volatility caused by natural gas price fluctuations than utilities in other regions because hydropower provides the vast majority of the region's power supply. Rates of publicly-owned utilities are likely to vary inversely with the price of natural gas; higher gas prices result in higher revenues for secondary sales of surplus hydropower by BPA or other hydro-owning utilities. The quantitative participant analysis captures impacts of anticipated rate escalation but does not quantify additional value from avoiding rate volatility. Note that, based on TAG feedback, a quantitative *ratepayer* benefit for avoided fuel price risk has been included in the analysis. More details are below in the section **Fuel Price Risk Avoided Costs**.

Resilience

The TAG requested that E3 evaluate resilience from NEM solar as a potential benefit for NEM participants. An example scenario considered for this benefit would be NEM solar providing the participant with electricity during a utility outage. This benefit is not quantified in this evaluation because standalone NEM solar is not typically configured for personal energy use in the event of an electricity outage (i.e., plugging in an appliance or electric vehicle directly to the solar system when the grid infrastructure is down). Other configurations, such as adding storage or backup thermal generation to a NEM solar system, may provide a degree of resilience, but that benefit would come from the addition of storage or backup generation and would not exist in standalone solar installations. There may be niche instances where participants experience resilience benefits, in which case the value of resilience would vary widely between customers.

Ratepayer Benefits and Costs

Methodology

Ratepayer benefits are changes that lead to a reduction in electricity rates. NEM solar provides ratepayer benefits in the form of "utility avoided costs," *i.e.*, electricity system cost savings that reflect the system

[19] From 2013-2022, average residential rates in Washington have varied annually by an average of 2.0% year-over-year (YOY), or 0.19 cents per kilowatt hour, with a monthly standard deviation of 0.57 cents per kWh (all in nominal dollars). On average, rates have risen more slowly than inflation during this period. U.S. Energy Information Administration, https://www.eia.gov/electricity/data/browser/#/topic/7?agg=0

value of marginal load reduction or customer generation. Reductions in system costs are passed on to electricity customers via rate reductions.

Conversely, ratepayer costs are changes that lead to an increase in electricity rates. These costs may reflect increased utility costs, which lead directly to increased rates. They may also reflect reductions in utility revenues due to reduced bill payments, as reduced revenues would need to be recovered through higher rates.

If the reduction in utility revenues exceeds the utility avoided costs, this will have a net effect of increasing electric rates. This effect is captured in the cost shift metric, which is defined as the difference between participant bill reductions and net utility avoided costs. If participant bill reductions are greater than utility system cost savings, rates will need to increase to recover the utility revenue requirement. This reflects a cost shift from participants to non-participants.

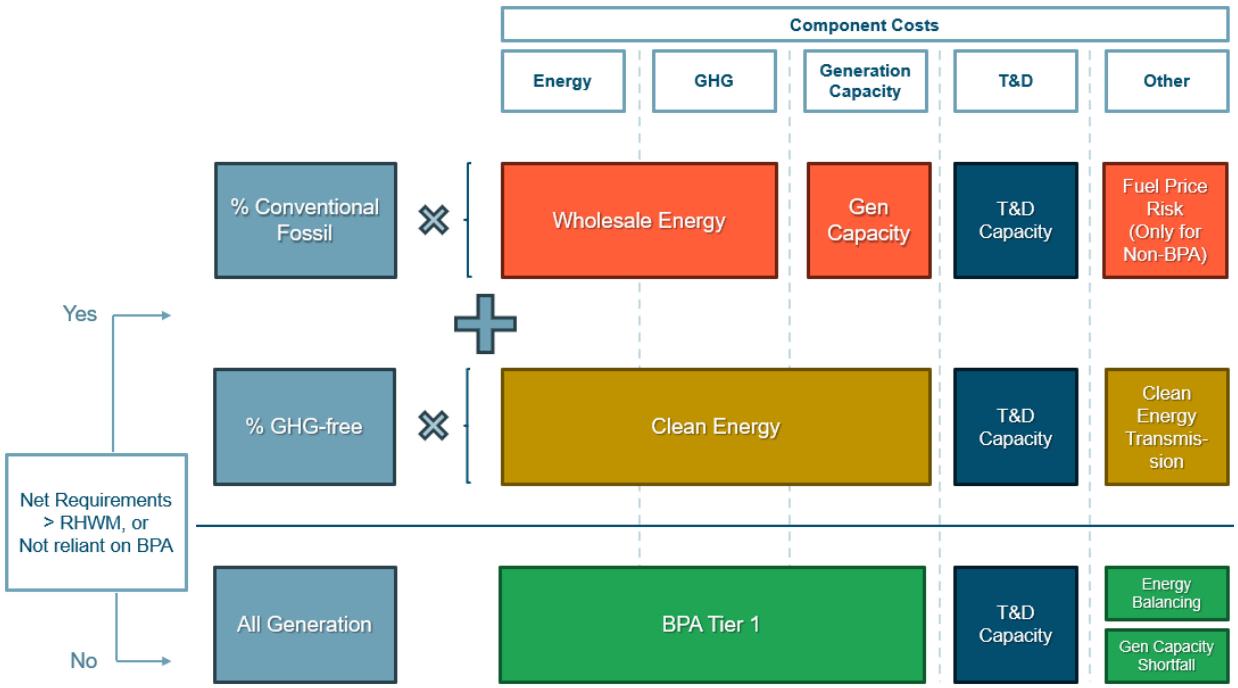
Note that, from a utility avoided cost perspective, there is no difference between solar generation that is "consumed" behind the meter vs. solar generation that is "exported" to the grid. The impact to the utility avoided costs occurs because customer generation reduces the need for the utility to procure energy and other grid services. While customer solar may affect the distribution grid, hour-by-hour changes in whether solar generation is consumed on-site vs exported to the grid should not affect the distribution grid: as part of the interconnection process for a customer solar system, a utility will ensure that the distribution system can handle the full export from the solar system.

Utility Avoided Cost Framework

The installation of NEM solar reduces ratepayer costs tied to energy, monetized greenhouse gas (GHG) emissions, generation capacity, transmission and distribution (T&D) capacity, and other cost categories. The marginal resource used by each utility will impact how each of these costs are determined. For utilities that are reliant on utility-scale renewables or purchases from the Bonneville Power Administration (BPA), other components need to be considered.

Figure 13 shows the framework for the determination of which avoided costs apply to which utilities. The following section outlines this framework and then describes the specific methodology used for each individual avoided cost component.

Figure 13. Utility Avoided Cost Framework



The first determinant for whether an individual component applies to a given utility is whether each detailed study utility is reliant on BPA to provide energy and generation capacity. If so, avoided costs for those utilities are encompassed by the rates that they pay to BPA. It is important to note that the BPA rates may be relevant for the calculation of avoided costs regardless of whether the utility owns or procures some generation from other sources, if BPA power is the utility's marginal resource and thus reflects the cost that could be avoided by customer NEM solar generation. Of the six detailed study utilities, four rely on BPA for some or all of their energy and capacity needs.

The second consideration in applying the avoided cost framework is whether a BPA-reliant utility's Net Requirement exceeds or is within the threshold of its Tier 1 allocation from BPA (known as the Rate Period High Water Mark or RHWM).[20,21] If a utility exceeds its Tier 1 allocation, it pays BPA's Tier 2 rates for any marginal resource need. Inland Power and Light and Kittitas PUD currently fall into this category, and Seattle City Light and Snohomish PUD are both expected to be in this category by the end of this decade.

[20] While specific BPA terms are defined in this report, extensive documentation on BPA's existing contracts with utilities (called the Regional Dialogue Contracts) can be found on BPA's website including the Regional Dialogue Guidebook (https://www.bpa.gov/-/media/Aep/power/provider-of-choice/2010-06-04-rdproductsratesguidebook-revised.pdf) and Tiered Rate Methodology (https://www.bpa.gov/-/media/Aep/rates-tariff/rhwm/FY-2022-2023-RHWM-Process/Tiered-Rate-Methodology--TRM.pdf).

[21] A utility's Net Requirement refers to the amount of federal power that a utility is entitled to purchase from BPA to serve its Total Retail Load (TRL) minus amounts of its Dedicated Resources. TRL is the utilities' net load, while Dedicated Resources are non-federal resources which serve the utility's load. A utility's Rate Period High Water Mark (RHWM) is their allocation of Tier 1 energy for the rate period. It is based on their Contract High Water Mark (CHWM), which allocated Tier 1 energy at the beginning of the contract period (2011). The CHWM is adjusted to get the RHWM based on changes in output of the federal system.

The utilities have indicated that BPA's Tier 2 rate trends toward wholesale energy prices. Avoided costs in this category are treated the same as those for the non-BPA reliant utilities. For this reason, Figure 13 condenses the first and second methodology considerations: "Does a utility's Net Requirement exceed its RHWM, or is the utility not reliant on BPA?"

If the answer is "yes", the next consideration is: "What would be the replacement resource for NEM solar?" In other words, if a utility had slightly less NEM solar, what resource(s) would make up the difference? E3 assumes that the replacement resource is a weighted average of (1) wholesale electricity purchases, and (2) utility-scale renewable resources, with the weights determined by the utility's current shares of conventional and clean energy and what will be required under Washington's Clean Energy Transformation Act (CETA) in the future. CETA requires all Washington utilities to achieve a carbon-neutral electricity supply by 2030.

For the share of energy from conventional fossil fuel resources, the avoided costs of energy and GHG emissions are determined by the wholesale price of electricity, and the avoided generation capacity cost is calculated separately. For the share of energy that utilities procure from clean energy resources, E3 uses utility-scale solar as a proxy resource. The avoided costs of energy and generation capacity are combined in the levelized cost of energy (LCOE) of a utility-scale solar resource. As there are no incremental reductions in GHG emissions by substituting NEM solar for another clean resource, there is no additional GHG value included. Transmission and distribution capacity avoided costs are applicable regardless of the marginal resource.

Based on feedback from the TAG, E3 has included an additional avoided cost component to value the ability of NEM solar to reduce fuel price risk borne by utilities when procuring energy at wholesale rates from conventional fossil resources. This component is only applicable for utilities not reliant on BPA, because the BPA contracts provide greater price stability. Also based on TAG feedback, E3 added an avoided cost component for transmission network upgrades required for delivering energy from large-scale renewable resources to load centers. This is labeled as "clean energy transmission" and is incremental to the T&D capacity category. Similar to LCOE, this component is only applicable for the share of energy that utilities procure from clean resources.

The percentage share of energy initially procured from clean vs. conventional fossil fuel resources is drawn from the utility disclosures to the Washington Department of Commerce.[22] Because CETA requires that utilities transition to a carbon-neutral supply of electricity by 2030, this share of energy from clean resources is scaled linearly up to 100% by 2030.[23] After 2030, the avoided costs of energy and generation capacity for all utilities are fully encompassed by the price of clean energy.

Where utilities are both reliant on BPA and have their Net Requirement below their RHWM, the costs of energy, GHG emissions, and generation capacity are included under the BPA Tier 1 rate. This is relevant to Seattle City Light and Snohomish in early years. However, the Tier 1 energy rate does not represent the entire avoided cost of NEM solar, because Tier 1 energy is sold in a block with a fixed shape. These utilities

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[22] https://www.commerce.wa.gov/wp-content/uploads/2023/08/2022-FMD-Report.pdf

[23] https://www.utc.wa.gov/regulated-industries/utilities/energy/conservation-and-renewable-energy-overview/clean-energy-transformation-act

must also procure additional energy balancing and generation capacity to compensate for changes in load shape due to NEM solar.

Finally, all utilities will see avoided costs for transmission and distribution capacity (T&D Capacity) to the extent that solar generation aligns with high-load hours.

Regardless of the marginal resource, each of the supply-side avoided costs – that is, all components except T&D capacity – is adjusted upwards for transmission and distribution system losses that can be avoided when a customer generates power on-site.[24] Based on data from the Western Resource Adequacy Program (WRAP), transmission losses are assumed to be 2.30% and distribution losses are assumed to be 4.70%. These values are applied to all detailed study utilities.

Utility Avoided Cost Components

The following sections detail more specific methodology for each of the avoided cost components.

Wholesale Energy Avoided Costs

The avoided cost of energy for conventional fossil fuel resources is calculated by multiplying hourly wholesale energy market price forecasts by the utility-specific solar generation profiles. Hourly market price forecasts for the Mid-Columbia (Mid-C) region were provided by Avista and Puget Sound Energy from their respective Integrated Resource Plan (IRP) modeling. For this component calculation, E3 utilized PSE's market price forecasts, where are higher and thus result in greater benefits for NEM solar.

Utility-specific solar profiles used in this calculation are described in the **Bill Savings (Solar Customer Compensation)** section.

GHG Avoided Costs

In the context of utility avoided costs, greenhouse gas avoided costs only include emissions costs that are monetized within the utility revenue requirement. This is distinct from the larger societal benefit of avoided GHG emissions. NEM solar provides GHG avoided cost value to the extent that it reduces energy production from fossil fuel resources that incur a cost under Washington's Climate Commitment Act cap-and-invest program. This means that the GHG avoided costs are incremental only for the portion of each utility's electricity supply that comes from conventional fossil fuel resources, which in turn only applies prior to 2030. This value is incorporated within PSE's forecast of energy market prices via is already reflected in the forecast of wholesale avoided energy costs.[25]

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[24] Because the T&D capacity components are combined in this analysis and more detailed data was not available to separate each, transmission capacity avoided costs are not adjusted upward for distribution system losses. This would have a negligible effect on the results.

[25] The monetized GHG cost can be broken out from the energy market price forecast using the utility estimation of avoided carbon costs under the Climate Commitment Act. These are cited in PSE's 2023 Electric Progress Report, Appendix H.

Generation Capacity Avoided Costs

Generation capacity refers to the ability of a resource or a portfolio of resources to reliably meet electricity demand at all times including during peak load conditions. For utilities whose marginal resource is the BPA Tier 1 rate or clean energy resources, the generation capacity value is included within the BPA Tier 1 rate or the cost of the marginal clean resource, so no additional capacity value calculation is needed. For utilities where NEM solar avoids wholesale electricity purchases, generation capacity avoided costs are calculated separately based on a proxy avoided capacity resource.

Avista, Puget Sound Energy, and Snohomish PUD each provided cost projections for a proxy firm resource used in their IRPs. Avista and PSE recommended using an ammonia combustion turbine using hydrogen and a biodiesel peaker turbine, respectively. A levelized cost of capacity (LCOC) is calculated using PSE's expected costs of $135.69/kW-year for a biodiesel peaker,[26] which also closely align with Avista's proxy resource values, starting at $137.52 in 2025.[27] In the Pacific Northwest, thermal resources are generally modeled as proxy generation capacity resources because they are well suited to handle the longer-duration reliability events that are likely to occur in a heavily hydropower-reliant region. Costs are escalated over time according to the compound annual growth rate (CAGR) used in NREL's Annual Technology Baseline (ATB) tool for a natural gas combustion turbine.[28]

To determine the solar capacity contribution of NEM solar in each utility service territory, E3 uses Effective Load-Carrying Capability (ELCC) values for utility-scale solar provided by WRAP,[29] scaled by the ratio of NEM solar capacity factors to the capacity factor of eastern Washington utility-scale solar.[30] Each utility is expected to remain primarily winter peaking in the foreseeable future, so the WRAP winter ELCC of 3% is used.[31]

Fuel Price Risk Avoided Costs

The TAG requested that E3 evaluate utility fuel price risk reduction, or the value to utilities of NEM solar reducing reliance on volatile wholesale electricity prices driven by fossil fuel price volatility. This value would only be relevant for the Avista and PSE, as the other detailed study utilities rely on contracted BPA rates for their energy supply. Once utility-scale renewables become the marginal energy resource by 2030, there would be no avoided cost for fuel price risk for any utility.

To determine the avoided fuel price risk, E3 first calculated the hourly implied heat rates for wholesale electricity, assuming that natural gas is generally the conventional resource on the margin. The implied heat rate is derived by dividing the $/MWh hourly energy price forecast by the $/MMBtu natural gas price

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[26] PSE 2023 Electric Progress Report, Appendix I

[27] Avista 2023 Electric Integrated Resource Plan

[28] NREL 2023 Annual Technology Baseline, https://atb.nrel.gov/electricity/2023/2023/data

[29] Effective load carrying capability (ELCC) is a measure of a resource's ability to meet demand in specific hours of need. This is expressed as a percentage applied to the resource's nameplate capacity.

[30] Per NREL's PVWatts tool, customer solar capacity factors range from 13.7%-17.4% within the utility service territories. E3 used a 23.4% capacity factor for eastern Washington utility-scale solar, sourced from the NREL ATB.

[31] WRAP September 20, 2022 Preliminary Presentation: simple average of winter solar ELCCs for the VER1 region

forecast.[32] In the calculations, the implied heat rate is bound using a minimum of zero and maximum of 12.5 MMBtu/MWh, with any values below 3.5 MMBtu/MWh set to zero and any values between 3.5 and 7 MMBtu/MWh set to 7 MMBtu/MWh. This is based on the assumption that lower values represent hydro or other clean resources that have zero reliance on fuel, while the bounds of 7.0-12.5 MMBtu/MWh represent the range of heat rates for natural gas generators.

To value the risk of uncertainty in fuel prices, E3 evaluated the impact that an additional cost of $1 per MMBtu, representing the cost for hedging, would have on electricity prices. The TAG provided citations including a study by the Rocky Mountain Institute that included case studies on how much utilities pay to hedge variability in fuel prices.[33] The study noted that long-term (5-10 year) hedging is rare as it can lead to significant costs for ratepayers. Instead, the study indicates that short-term hedging (1-3 years) is much more common among utilities. The study provides an example, indicating that Public Service of Colorado spends up to $0.91/MMBtu on short-term hedging strategies.

Based on this data point, the analysis here uses $1/MMBtu as the implied value of fuel price risk reduction. This $1/MMBtu value is multiplied by the hourly implied heat rate to find the incremental increase in hourly energy prices that would result from the price premium on natural gas. This increase is then multiplied by utility-specific NEM solar profiles to determine the portion of costs avoidable by NEM solar and by the share of energy procured from conventional fossil resources by each utility in each year.[34]

Clean Energy Avoided Costs

The levelized cost of energy of a marginal clean resource can be used to estimate the combined avoided costs of energy, GHG emissions, and generation capacity for the share of utility generation coming from clean sources. The detailed study utilities indicated in data requests and discussions that their marginal clean energy resource would consist of some blend of resources, but predominantly wind and solar. For simplicity, E3 assumes that the avoided clean resource is eastern Washington utility-scale solar. The characteristics of utility scale solar align well with NEM solar in terms of both the generation shape and environmental lifecycle costs – the latter being a point of comparison raised by the TAG. This approach overestimates the avoided cost value because an optimal portfolio with a blend of different clean energy resources would cost less, or at least no more, than a portfolio of 100% utility-scale solar.

For the LCOE of eastern Washington utility-scale solar, E3 uses values provided by NREL's ATB "Conservative Market Scenario" forecast with a 30-year capital recovery.[35] The Market Scenario is used to incorporate incentives and market impacts, and specifically the value of the federal production tax credit (PTC). The "Conservative" version of NREL's forecast is used based on alignment with current trends

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[32] Energy and gas price forecasts used here are from Avista. Although PSE wholesale prices were used in other parts of the analysis, only Avista provided both a wholesale price forecast and natural gas price forecast, enabling the modeling of implied heat rates.

[33] RMI, Utility-Scale wind and Natural Gas Volatility. https://rmi.org/wp-content/uploads/2017/05/RMI_Document_Repository_Public-Reprts_2012-07_WindNaturalGasVolatility.pdf

[34] Utility-specific solar profiles used in this calculation are the same as those used in calculation of wholesale energy avoided costs and described in the **Bill Savings (Solar Customer Compensation)** section.

[35] NREL 2023 Annual Technology Baseline, https://atb.nrel.gov/electricity/2023/2023/data

and E3's expectation of near-term trends in solar pricing. The Conservative forecast provides a higher avoided cost value, which reflects greater benefits from NEM solar.

Clean Energy Transmission Avoided Costs

Based on feedback from the TAG, the costs of transmission network upgrades for delivering utility-scale solar are included as an avoided cost category. This category reflects the costs of interconnecting utility-scale clean energy resources to the transmission system and any associated transmission upgrades required. Like the clean energy avoided costs, avoided costs of clean energy transmission are applied to the share of a utility's energy mix that comes from clean resources.

To calculate the avoided clean energy transmission costs, E3 relies on an estimate of transmission and interconnection costs for utility-scale renewables provided by PSE in their 2023 Electric Progress Report.[36] These costs add an additional $156/kW to capital costs for utility-scale renewables. This value is escalated at 4% nominally based on BPA transmission rate escalation provided by SCL,[37] and is then input into the 2023 NREL ATB model as an incremental Grid Connection Cost. The change in the output solar LCOE values that can be attributed to this Grid Connection Cost is the value of the avoided clean energy transmission costs.

BPA Tier 1 Rate Avoided Costs

As described previously, the BPA Tier 1 rate is the marginal energy and capacity cost when a BPA customer's Net Requirement is less than their Rate Period High Water Mark (RHWM). When this is the case, changes in net load due to customer solar will decrease the total amount of energy that the utility can purchase at Tier 1 rates.[38] Utility RHWMs are assumed to decrease in 2029 due to decreases in BPA system size and increases in demand for BPA resources. This assumption comes from Snohomish PUD's IRP.

Snohomish PUD and Seattle City Light currently have a Net Requirement less than their RHWM. This is expected to continue until 2028 and 2029 respectively, at which point increases in load and decreases in RHWM cause the Net Requirement to exceed the RHWM. This is shown in Figure 14. The other two public utilities have a Net Requirement greater than their RHWM for the duration of the study period.

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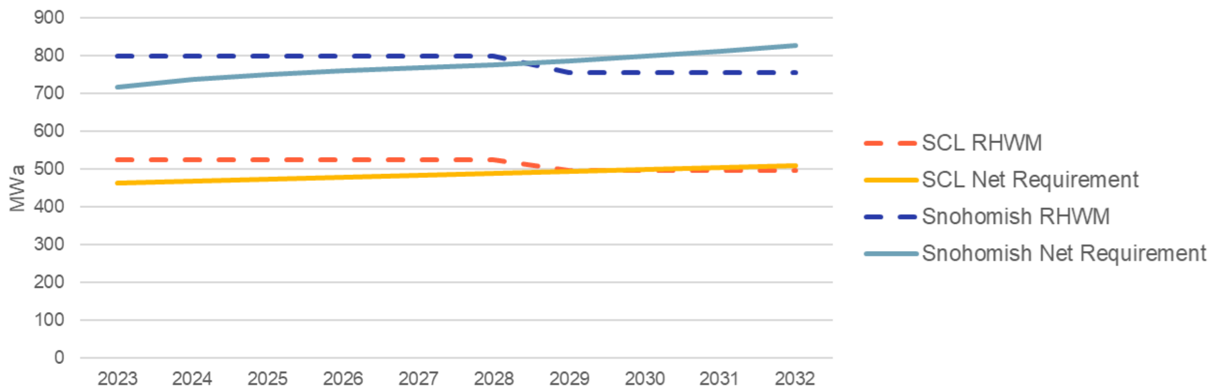
[36] PSE 2023 Electric Progress Report, Chapter Five: Key Analytical Assumptions. https://www.pse.com/en/IRP/Past-IRPs/2023-IRP

[37] Seattle City Light 2022 IRP, Appendix 3. https://www.seattle.gov/documents/Departments/CityLight/2022IntegratedResourcePlan.pdf

[38] Tier 1 rates cover the costs of Tier 1 System Resources, primarily the federal hydropower system operated by BPA.

Figure 14: SCL and Snohomish PUD Net Requirement vs. RHWM



The BPA Tier 1 rate is comprised of three components:

1. **Customer Charge:** assigns a percentage of Tier 1 system costs to each utility based on their Tier 1 Cost Allocator (TOCA) and slice percentage. The TOCA is equal to the lesser of the utility's RHWM and Net Requirement divided by the sum of RHWMs. The customer charge is applicable to all BPA customers.[39]
2. **Demand Charge:** a $/kW-month rate, differentiated by month. The demand charge is applicable to Load Following and Block with Shaping Capacity customers only.
3. **Load Shaping Charge:** a $/MWh charge reflecting the difference between the customer's load shape and the BPA system shape considering HLH (High-Load Hours) and LLH (Low-Load Hours) of each month.[40] Load shaping charges are applicable to Load Following, Block, and the Block portion of Block/Slice. For Block and Block/Slice customers, the customer's load shape is the shape of the contracted block which is fixed for the duration of the contract term.

The breakdown of the Tier 1 rate for SCL and Snohomish PUD is shown in Table 10.

[39] There are three broad types of BPA customers: Block, Block/Slice, and Load Following. Block and Block/Slice customers are considered Partial Requirements customers because they only purchase Tier 1 energy through BPA Regional Dialogue contracts and must procure additional energy by other means. Block customers purchase Tier 1 energy in a block which has a shape that was defined at the beginning of the contract period. The block can be flat or vary by month and Heavy and Light Load Hours. Block/Slice customers purchase a block (similar to Block customers, but all blocks are flat across each month) as well as a Slice which entitles them to a specified percentage of the Tier 1 system output, provided in the same shape as the Tier 1 system shape. Load Following customers are considered Full Requirements customers because they purchase all of their energy and capacity from BPA. This includes a block of Tier 1 energy (similar to Block customers), as well as additional energy at a Tier 2 rate. The Tier 2 rate is similar to a wholesale market rate.

[40] HLH are Monday to Saturday, hour ending 7am to 10pm; LLH are all other hours.

Table 10: Summary of BPA Tier 1 Rate for SCL and Snohomish PUD

Utility	Customer Type	Customer Charge ($/MWh)			Load Shaping Charge ($/MWh)		Total ($/MWh)
		Composite	Non-Slice	Slice	HLH	LLH	
SCL	Block Only	$40.26	$(7.08)	$0	$1.91	$2.14	$37.23
Snohomish	Block/Slice	$40.26	$(3.48)	$0	$(1.02)	$1.07	$36.83

The total BPA Tier 1 rates are modeled as remaining unchanged going forward in nominal dollars. This is based on historical values of the Customer Charge, which collects the majority of Tier 1 costs and has changed little (on average) since 2014. The BPA Tier 1 system size decrease modeled in 2029 is assumed to have little impact on total costs and therefore increases the total effective rate in proportion to the system size decrease.

Energy Balancing for BPA Tier 1 Rates

For SCL and Snohomish PUD, when their Net Requirements are less than their RHWM, the reduction in Tier 1 energy from BPA due to NEM solar is shaped to their block shape. Thus, when a customer installs NEM solar, these utilities gain generation with a solar profile but lose generation with the shape of their block. These utilities will therefore need to buy and sell energy at wholesale prices to make up the difference between their NEM solar load shape and their block shape. This energy balancing effect could be either a net cost or a net benefit depending on the relative wholesale electricity prices during the hours with NEM solar generation and the hourly profile of the BPA block. Based on hourly wholesale prices, the need to procure energy balancing is a net cost for these utilities, *i.e.*, it is a negative avoided cost.

Generation Capacity Shortfall for BPA Tier 1 Rates

Similar to the energy balancing that SCL and Snohomish PUD need to procure when their Net Requirement is less than their RHWM, these utilities also need to procure additional generation capacity to make up the difference between the reduction in capacity for their BPA Tier 1 block and the gain in capacity due to NEM solar. This generation capacity shortfall is calculated based on the difference between the utilities' NEM solar shape and their block shape, and the Peak Capacity Allocation Factors (PCAFs) as outlined in the **Transmission and Distribution Avoided Costs** section. Where applicable, the generation capacity shortfall is included in the generation capacity avoided cost category. This category also results in a negative avoided cost for these utilities because of the low capacity value of NEM solar relative to the BPA Tier 1 Block.

Transmission and Distribution Avoided Costs

Avoided costs for transmission and distribution are combined in this analysis based on the level of detail in the data provided by the detailed study utilities. These costs, which are avoided by deferring or reducing the need for investments in transmission and distribution capacity, are calculated by scaling each utility's total system transmission and distribution unit costs by the overlap between system peak loads and a customer solar production profile in a typical meteorological year. E3 uses a PCAF method incorporating the top 500 load hours in the historical 2022 year to perform this scaling. Hourly load data for the balancing area relevant to each utility were obtained from the U.S. Energy Information Administration

(EIA) Electric Grid Monitor.[41] Customer solar production profiles are the same profiles used in the wholesale energy calculation and sourced from NREL's PVWatts tool,[42] though for this calculation the month-hour averages of the profiles are used for matching with the historical load data.[43]

The calculated overlap between peak loads and solar profiles ranges from 7-20% for the detailed study utilities, meaning that 7-20% of the system's marginal T&D costs are avoidable by NEM solar. Figure 15 provides an illustration of this limited overlap for PSE's customer solar production profile and distribution of peak loads. For PSE, the overlap between the solar generation profile and the PCAF peak load distribution is 7%, meaning that 1 kW-AC of NEM solar would only avoid 0.07 kW of T&D capacity need.

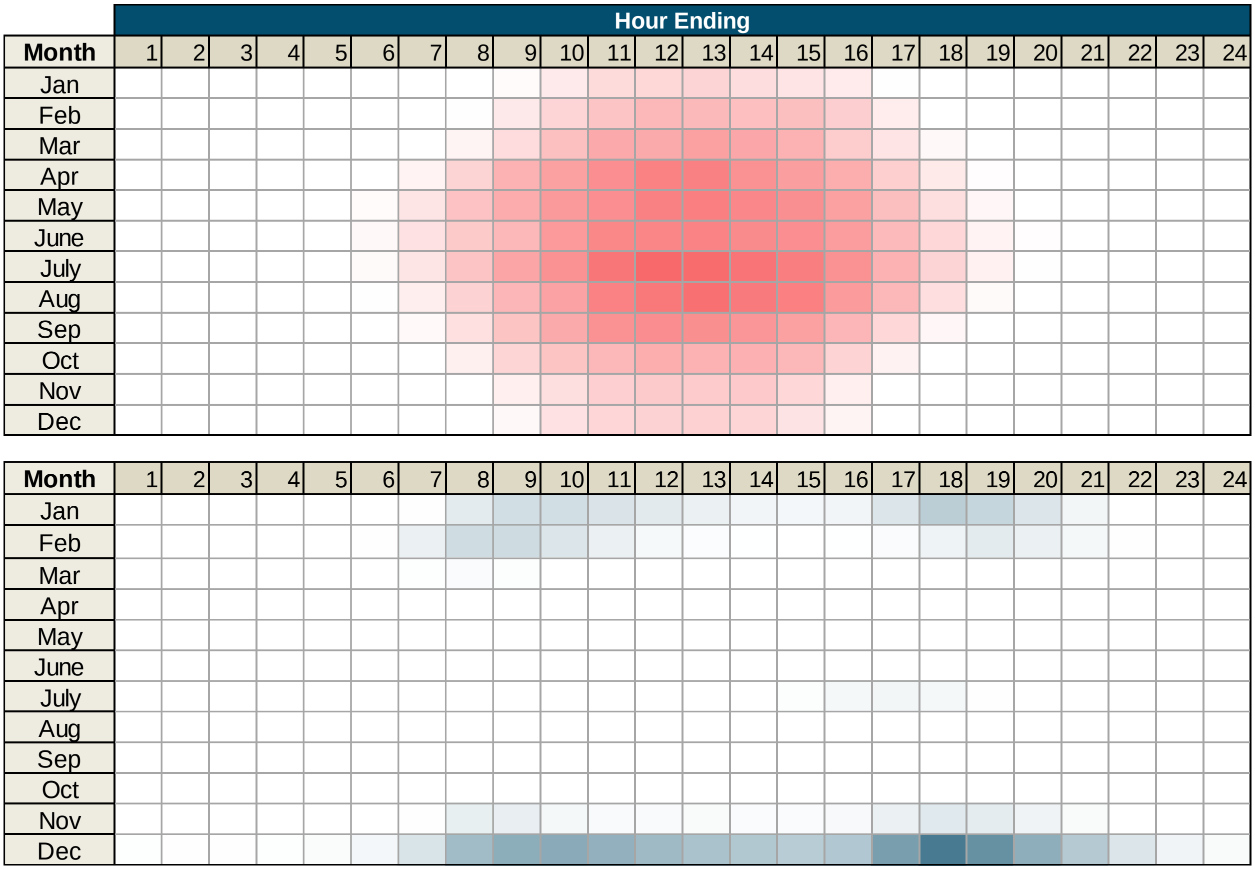
The resulting avoidable T&D costs are escalated at 4% nominally, based on the historical rate of escalation for BPA transmission provided by SCL.

[41] https://www.eia.gov/electricity/gridmonitor/dashboard/electric_overview/US48/US48

[42] https://pvwatts.nrel.gov/

[43] Month-hour averages were used as a means of normalizing the solar profiles, because solar profiles were not available specific to the 2022 year of the load data

Figure 15. PSE Customer Solar Generation Profile (Top) and Distribution of Peak Loads (Bottom)



Ratepayer Impact Metrics

The Ratepayer Impact Measure (RIM) test compares ratepayer benefits (utility avoided costs) to ratepayer costs (solar customer compensation) over an assumed 25-year lifetime of the solar system.

Figure 16. Benefits and Costs Included in the Ratepayer Impact Measure (RIM) Test

	Ratepayer Impact Measure (RIM)	
	Benefits	Costs
Bill Savings / Solar Customer Compensation		X
Upfront Cost		
Inverter Replacement Cost		
Interconnection Fee		
Federal Incentives		
Utility Avoided Costs	X	
Other Societal Benefits		

The methodology and assumptions used for each of the benefits and costs are as follows:

- **Bill savings/solar customer compensation:** Compensation to solar customers for customer solar generation is equal to the average customer bill savings; see the **Bill Savings (Solar Customer Compensation)** section for additional information.
- **Utility avoided costs:** Reductions in utility costs due to customer solar adoption (described in detail in the **Utility Avoided Cost Framework** section)

In addition to the RIM test, E3 evaluated several other ratepayer metrics:

- **Residential cost shift forecast**: Total annual residential NEM cost shift accounting for all interconnected NEM systems based on three solar adoption forecasts:

  1. No changes to the legislative NEM minimum, linear kW/year growth per utility based on 2018-2022 data
  2. Legislative NEM minimum removed, linear kW/year growth per utility based on 2018-2022 data
  3. Legislative NEM minimum removed, compound annual growth per utility based on 2018-2022 data

  For each of the three adoption forecasts, utilities outside of the detailed study utilities are calculated using the average growth rate of the detailed study utilities. NEM minimums, where applicable, are applied to each utility individually to create the "Rest of State" forecast.

- **Average electric residential rate impact in 2024 and 2030:** ¢/kWh rate increase for all residential ratepayers due to compensation to NEM solar customers. The rate impact is calculated based on the difference between an estimated rate with and without NEM. The 2024 rate with NEM is calculated as the 2024 revenue requirement (2022 residential retail revenue escalated to 2024 by the assumed rate escalation factor of 3% per year, nominal) and dividing by 2022 residential retail sales.[44] The 2024 rate without NEM is estimated by adding total avoided costs (from residential solar adoption) to the revenue requirement, and by adding modeled solar generation to residential sales. To estimate 2030 rate impacts, for each of the three NEM solar adoption forecasts, sales are assumed to remain constant, and the revenue requirement is assumed to grow at the rate escalation factor.
- **Average low-income customer bill impact in 2024 and 2030:** Monthly bill increase for an average low-income customer due to compensation to NEM solar customers. This bill increase is calculated by multiplying the residential rate impact from NEM by monthly average consumption for representative low-income customers, which was provided by the detailed study utilities.

E3 also conducted a qualitative evaluation for benefits and costs that were not included quantitatively in the ratepayer analysis. Benefits include secondary effects of NEM solar systems, driver for new technology (virtual power plants), frequency regulation, voltage support, and diversity of resources. Costs include solar integration, grid modernization, and utility program administration costs. The qualitative impact of these benefits and costs are discussed in the **Qualitative Evaluation** section.

[44] 2022 residential retail revenue and sales are from EIA 861 data

Ratepayer Results

Avoided Costs Results

Figure 17 shows the total avoided costs for the six detailed study utilities over the period 2023-2050. Utility avoided costs vary significantly among utilities, with the largest difference stemming from whether the utility's marginal energy and generation capacity are purchased under the BPA Tier 1 rates. Because Seattle City Light and Snohomish PUD remain within their Tier 1 allocation, with Net Requirements below their RHWMs for the first several years, their total avoided costs are each less than 2.5 cents/kWh until 2030 and 2029, respectively. Avoided costs for the other utilities are in the 4-6 cents/kWh range during that same period. Once SCL and Snohomish PUD exceed their Tier 1 allocation, their avoided costs rise by 2-3 cents/kWh to align with the other utilities.

Figure 17. Utility Total Avoided Costs by Utility (Nominal cents/kWh)

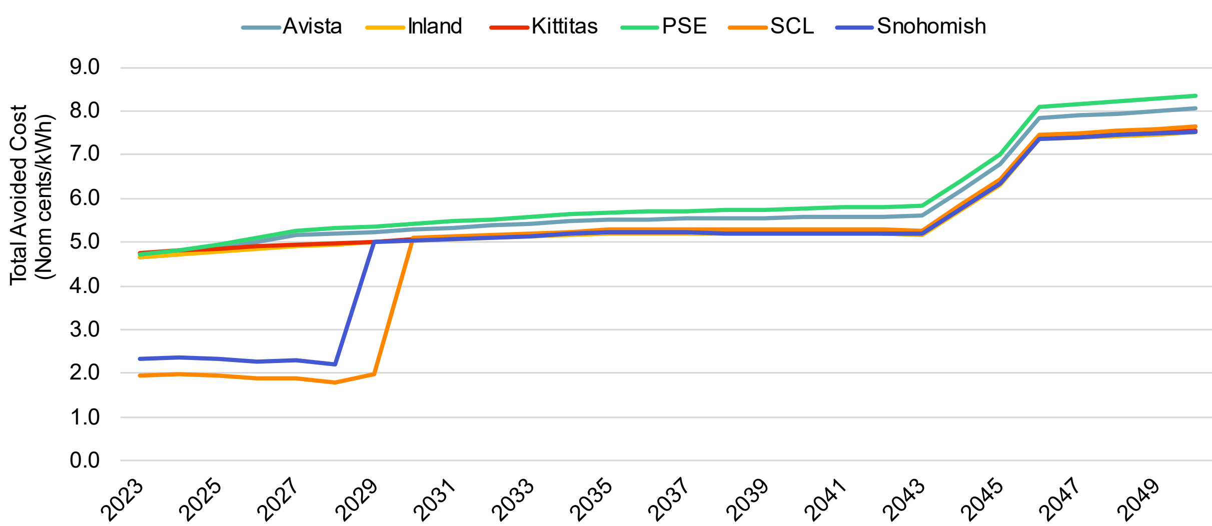
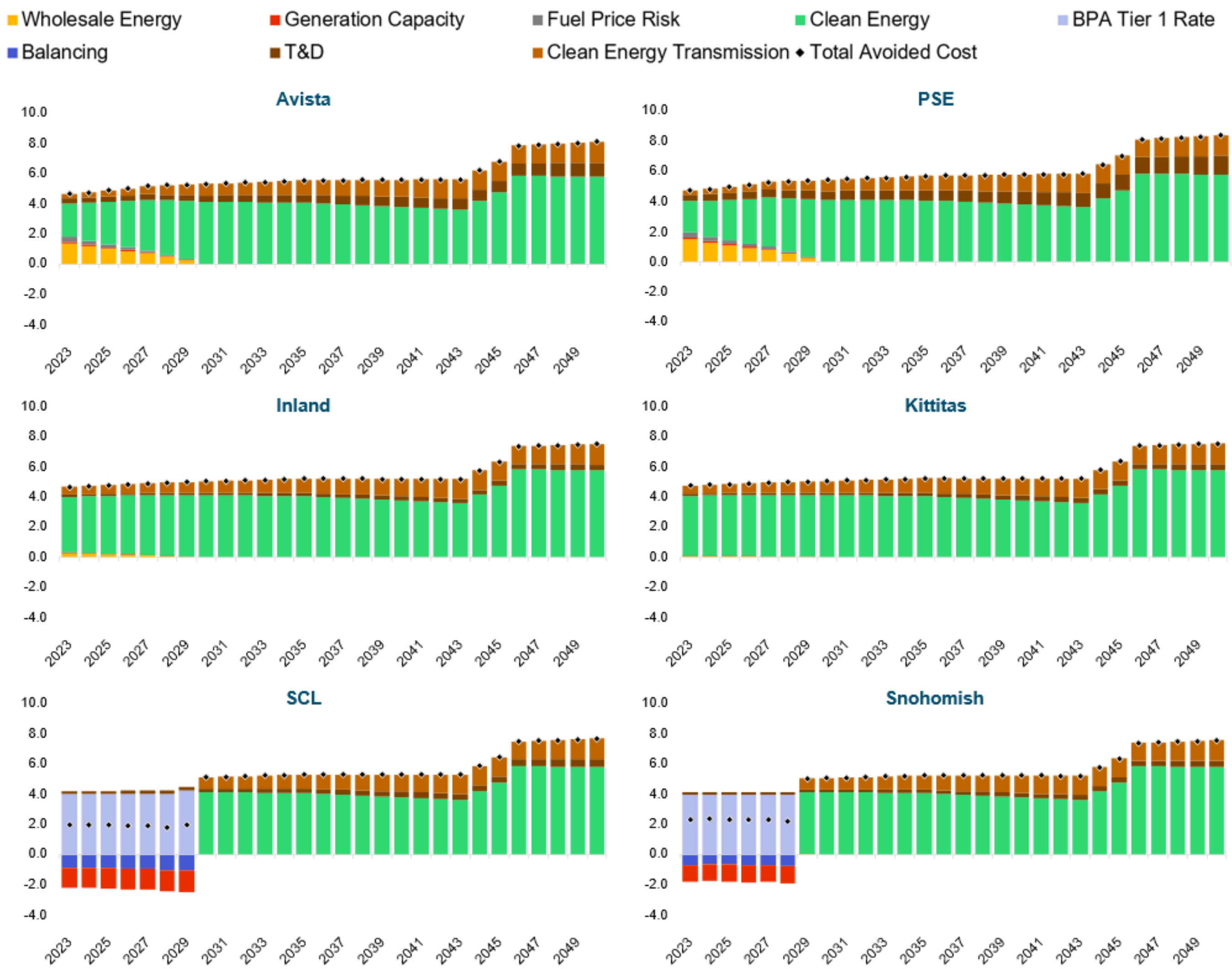


Figure 18 shows the breakdown of utility avoided costs by component for each utility. Avoided wholesale energy (including GHGs) and the avoided cost of clean energy make up the largest share of each utility's avoided costs. Both of these components are relatively flat over time in nominal dollars, slightly declining in real dollar value. The exception to this is in the mid-2040's, when the avoided cost of clean energy rises rapidly due to the forecasted phase-out of the production tax credit (PTC). Once this phase-out is complete, avoided costs will have risen by about 3 cents/kWh and then remain relatively flat.

Figure 18. Utility Avoided Cost Components by Utility (Nominal cents/kWh)



When examining results in terms of cents per kWh, the trends in avoided costs can roughly be grouped by pairs of utilities. Avista and Puget Sound Energy have similar avoided cost results, with the same component structure and similar mixes of conventional fossil fuel and clean resources in early years. As both utilities grow from around 55% to 100% renewable energy from 2023 to 2030, the weighting of the wholesale energy, generation capacity, and fuel price risk components decreases, while the weighting of the clean energy avoided costs increases. There is a gradual decrease in the cost of utility-scale solar until the production tax credit is phased out. Both utilities have T&D costs and clean energy transmission costs avoidable by NEM solar each starting below 0.5 cents/kWh. These start as relatively small components and grow as both are modeled to increase by 4% nominally. Clean energy transmission scales up with the share of energy from clean resources over time. These components account for a significant share of avoided costs by the end of the analysis period.

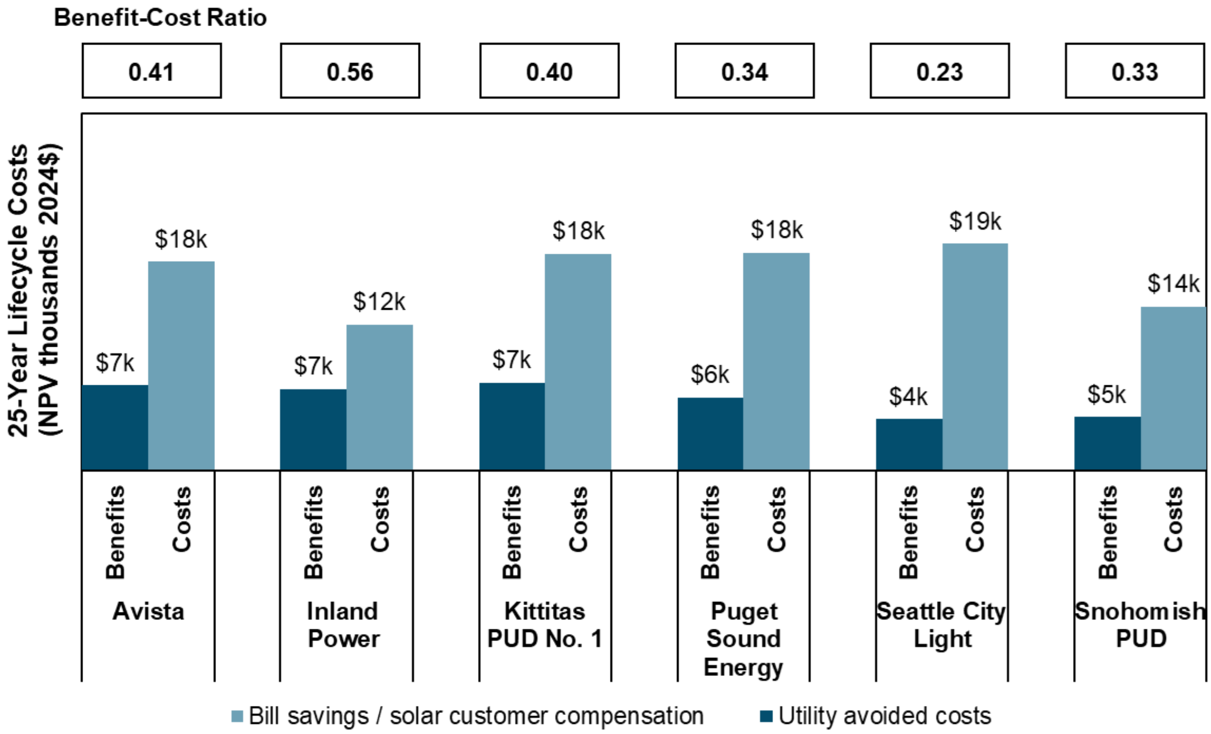
Inland Power and Light and Kittitas PUD are both BPA-reliant utilities that have demand exceeding their BPA Tier 1 rate allocation. Because the utilities have indicated that Tier 2 rates trend toward wholesale pricing, avoided costs for these utilities are modeled similarly as for Avista and PSE, although with a much larger share of energy coming from GHG-free sources in 2024. T&D avoided costs for both Inland Power and Light and Kittitas PUD are based on the same BPA rates and load profile. Because the utilities also receive very similar amounts of energy from clean resources (approximately 90% for Inland and 96% for Kittitas), this means that the avoided cost results are very similar on a cents/kWh basis. Their total avoided costs begin around 4.7 cents/kWh and rise to around 7.5 cents/kWh over time. Avoided clean energy procurement makes up 70-80% of avoided costs throughout the entire analysis period.

Seattle City Light and Snohomish PUD are the final pair of utilities with similar trends in avoided costs. Both utilities begin with the BPA Tier 1 rate reflecting their avoided cost for marginal energy, GHG, and generation capacity, and then have Net Requirements exceeding their RHWM around 2030. After this point, avoided clean energy procurement represents the majority of their avoided costs, which are similar to those described for Inland and Kittitas. Due to the energy balancing and generation capacity shortfall when the BPA Tier 1 Rate is on the margin, the utilities' avoided costs in early years are significantly lower than those for the other utilities. One way to understand this result is that Tier 1 pricing reflects a relatively low cost for a block of power shaped to the utility's loads. As a result, when NEM solar avoids Tier 1 energy, the avoided costs are relatively low. Snohomish PUD exceeds the Tier 1 allocation in 2029, and SCL follows suit in 2030. In these years, the utility total avoided costs approximately double and then flatten out again until the production tax credit phase-out.

Ratepayer Impact Measure Results

Figure 19 shows the Ratepayer Impact Measure (RIM) results based on an example residential 7 kW-AC system. Benefits and costs are lifecycle net present value (NPV) $/system values over the assumed 25-year lifetime of the solar system. Ratepayer benefits include utility avoided costs, while ratepayer costs include solar customer compensation. The benefit-cost ratio ranges from 0.23 (Seattle City Light) to 0.56 (Inland Power), indicating that, from the ratepayer perspective, the lifetime benefits from NEM solar adoption are less than the lifetime costs. This outcome indicates that retail rate compensation under NEM is higher than cost savings for the electricity system.

Figure 19. Ratepayer Impact Measure (RIM) by Utility for an Example 7 kW-AC System



Cost Shift Results

This section focuses on the cost shift for the residential customer class. The residential class reflects 85% of NEM solar capacity installed for the six detailed study utilities. Furthermore, E3's expectation is that cost shifting predominantly affects customers within a given customer class. In other words, impacts on residential rates and residential bills due to NEM would be predominantly driven by the cost shift from residential NEM solar. For these reasons, this section is focused on forecasting the residential cost shift, which enables calculating the corresponding impacts on rates and bills for residential customers.

Non-residential customers are likely to have a lower $/kWh cost shift due to retail rates for non-residential customers having larger fixed and/or demand charges and lower volumetric charges. Thus, E3 expects that the residential NEM cost shift forecast developed in this section reflects 85% or more of the total statewide cost shift for all customer classes.

Table 11 shows the 2024 residential cost shift ($/year) for an example residential 7 kW-AC system for each of the detailed study utilities.

Table 11: 2024 Residential Cost Shift ($/year) by Utility for an Example 7 kW-AC System

	Avista	Inland Power	Kittitas PUD	Puget Sound Energy	Seattle City Light	Snohomish PUD
2024 Cost Shift ($/year) Example 7-kW System	$570	$240	$560	$690	$990	$640

As described in the section **Introduction**, Washington State Law RCW 80.60 requires electric utilities to offer NEM to eligible customer-generators until they have reached their "legislative minimum" for NEM capacity, equal to four percent of each utility's peak demand during 1996.

Figure 20 shows a forecast of the total residential cost shift from 2024 to 2030 assuming linear growth in customer solar, with no changes to the legislative NEM minimum and with the legislative NEM minimum removed. In the near term, the cost shift is similar across the two adoption forecasts but begins to diverge in the mid-2020s as utilities reach their NEM minimums. By 2030, the total residential cost shift with no change to the legislative NEM minimum is $49 million, while the cost shift with the legislative NEM minimum removed is $67 million.

For the scenario with no changes to the legislative NEM minimum, three of the detailed study utilities reach their NEM minimum before 2030. Kittitas PUD has already reached the NEM minimum, PSE is modeled to reach it in 2026, and SCL is modeled to reach it in 2028.

Figure 20. Total Residential Cost Shift Forecast Under Linear Growth Rate, With No Changes to NEM Minimum and With Legislative NEM Minimum Removed

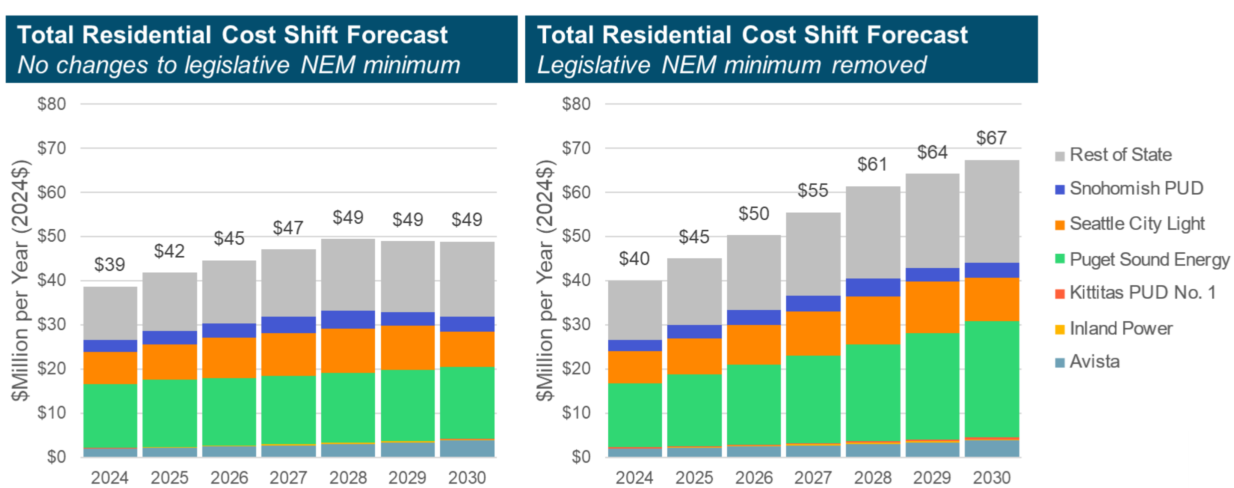
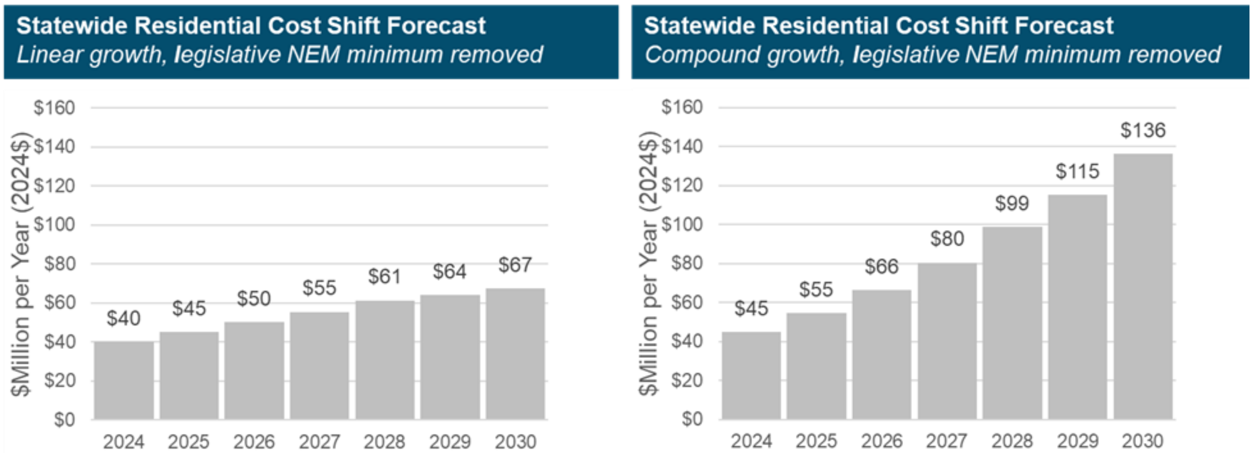


Figure 21 shows a forecast of the total statewide residential cost shift from 2024 to 2030 for solar adoption forecasts with the legislative NEM minimum removed under a linear growth rate and under a compound annual growth rate. The linear growth rate is the same analysis as shown in Figure 20, and reflects 2030 adoption of 678 MW-AC, leading to a $67 million/year cost shift by 2030. Under a compound annual growth rate assumption, NEM solar capacity reaches 1,375 MW-AC by 2030, leading to a cost shift of $136 million/year by 2030.

Figure 21. Total Residential Cost Shift Forecast with Legislative NEM Minimum Removed Under Linear Growth Rate and Compound Annual Growth Rate



Residential Rate and Low-Income Bill Impacts

E3 also calculated the residential rate impacts due to the NEM solar cost shift, as well as representative bill impacts for a low-income customer in each utility service territory. These impacts are calculated for 2024 and for 2030 under the same three scenarios described above. These scenarios are:

1. No changes to the legislative NEM minimum, linear kW/year growth per utility based on 2018-2022 data
2. Legislative NEM minimum removed, linear kW/year growth per utility based on 2018-2022 data
3. Legislative NEM minimum removed, compound annual growth per utility based on 2018-2022 data

Figure 22 shows the estimated monthly bill impact due to NEM solar for an average residential low-income customer. These bill impacts are estimated by multiplying the calculated rate impacts by representative monthly low-income customer usage provided by each utility. Note that these bill impacts do not include low-income bill discount programs; the bill impacts would be lower for customers who are enrolled in bill discount programs. See **Appendix A.2.** for more information on residential NEM customers enrolled in bill discount programs.

The 2030 bill impacts show a range for the three different scenarios described above. Kittitas PUD has the highest average bill impacts due to very high modeled NEM solar adoption as a share of residential load. Kittitas has already significantly exceeded the NEM minimum and this modeling assumes that, if the NEM minimums were removed, Kittitas would offer NEM to all existing solar customers as well as to future adopters.

Figure 22. 2024 and 2030 Estimated Residential Low-Income Bill Impact due to NEM Solar ($/month, 2024$)

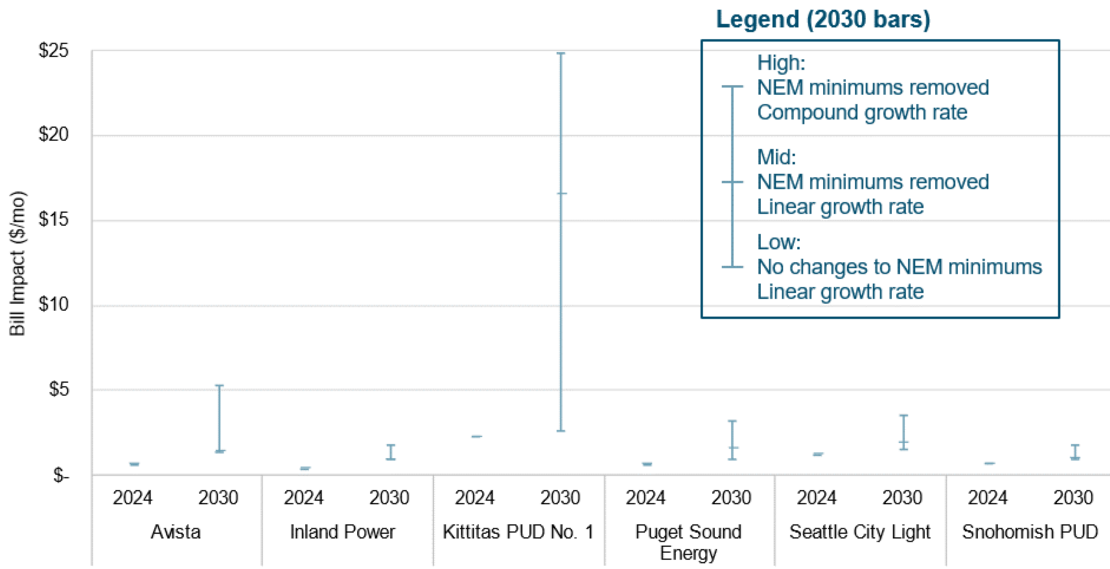


Table 12 shows the residential rate impact and low-income bill impact in 2024 as well as in 2030 for the three solar adoption forecasts described above. The bill impacts in this table are the same as what is shown above in Figure 22. Higher levels of NEM solar adoption by 2030 lead to higher rate and bill impacts by 2030.

Table 12. NEM Solar Capacity, Residential Rate Impact, and Representative Low-income Bill Impact in 2024 and 2030 under Different NEM Solar Adoption Forecasts (All Monetary Values in 2024$)

	Avista	Inland Power	Kittitas PUD No. 1	Puget Sound Energy	Seattle City Light	Snohomish PUD
2024						
Total Residential NEM Solar Capacity (kW-AC)	21,240	3,408	723	115,946	44,452	26,130
Residential Rate Impact (c/kWh)	0.0655	0.0244	0.1309	0.0911	0.1726	0.0686
Percentage Increase Due to NEM (%)	+0.6%	+0.3%	+1.0%	+0.8%	+1.4%	+0.6%
Low-Income Bill Impact ($/month)	$0.63	$0.39	$2.27	$0.65	$1.22	$0.66
2030 Adoption Forecast: No Changes to NEM Minimum, Linear Growth Rate						
Total Residential NEM Solar Capacity (kW-AC)	41,331	6,780	723	151,981	65,617	46,366
Residential Rate Impact (c/kWh)	0.1449	0.0593	0.1490	0.1320	0.2148	0.1017
Percentage Increase Due to NEM (%)	+1.3%	+0.7%	+1.1%	+1.0%	+1.6%	+0.9%
Low-Income Bill Impact ($/month)	$1.39	$0.95	$2.59	$0.95	$1.51	$0.98
2030 Adoption Forecast: NEM Minimum Removed, Linear Growth Rate						
Total Residential NEM Solar Capacity (kW-AC)	41,331	6,780	4,093	243,491	82,313	46,366
Residential Rate Impact (c/kWh)	0.1449	0.0593	0.9524	0.2148	0.2720	0.1017
Percentage Increase Due to NEM (%)	+1.3%	+0.7%	+7.0%	+1.7%	+2.0%	+0.9%
Low-Income Bill Impact ($/month)	$1.39	$0.95	$16.52	$1.54	$1.91	$0.98
2030 Adoption Forecast: NEM Minimum Removed, Compound Growth Rate						
Total Residential NEM Solar Capacity (kW-AC)	143,283	12,360	5,772	482,636	148,249	81,733
Residential Rate Impact (c/kWh)	0.5540	0.1105	1.4299	0.4436	0.5085	0.1825
Percentage Increase Due to NEM (%)	+4.9%	+1.2%	+10.4%	+3.4%	+3.8%	+1.6%
Low-Income Bill Impact ($/month)	$5.32	$1.77	$24.80	$3.19	$3.58	$1.76

Under the 2030 adoption forecast with no changes to the NEM minimum and a linear growth rate, the rate impact sees a range of 0.7% (Inland Power) to 1.6% (Seattle City Light) relative to a rate without NEM. Utilities that are at or close to their NEM minimum in 2024 experience less solar adoption from 2024-2030, resulting in less upward pressure on rates.

Under the 2030 adoption forecast with the NEM minimum removed and a linear growth rate, the rate impact sees a range of 0.7% (Inland Power) to 7.0% (Kittitas PUD) relative to a rate without NEM. Under this scenario, the rate impact is higher for Kittitas PUD, Puget Sound Energy, and Seattle City Light since these utilities reach their NEM minimum by 2030 and therefore would experience higher solar adoption in a scenario with the NEM minimum removed. Avista, Inland Power, and Snohomish PUD do not reach their NEM minimum by 2030 and therefore have the same rate impact under this scenario.

Under the 2030 adoption forecast with the NEM minimum removed and a compound growth rate, the rate impact sees a range of 1.2% (Inland Power) to 10.4% (Kittitas PUD) relative to a rate without NEM. The rate impacts are higher under this scenario due to higher solar adoption forecasts.

Qualitative Evaluation

Secondary Effects of NEM Solar Systems

The TAG requested that E3 evaluate the benefit to ratepayers from NEM solar inducing participants to use more electricity at optimal times for the grid. This benefit is not quantified within this study because this is not a benefit provided by solar on a flat or tiered rate structure, which are the existing rate structures offered by the utilities evaluated in this study. This benefit could be provided either by a time-of-use (TOU) rate structure on its own, or if NEM solar were paired with a battery and implemented on a TOU rate structure that incentivizes customers to use their electricity at optimal times.

The TAG also requested that E3 evaluate any benefit to ratepayers from NEM solar inducing participant participation in energy efficiency or electrification programs. Customer solar adoption may correlate with or result in customer education and broader engagement with energy issues, leading to the adoption of energy efficiency or electrification measures. However, the opposite may also be true, as reductions in customer bills tied to NEM solar may reduce a customer's concern with conserving energy by decreasing their perceived average cost of electricity. Separating out and attributing specific causation for these behaviors to NEM solar would require surveys and other customer facing research, which is beyond the scope of this study.

Driver for New Technology

The TAG requested that E3 evaluate the benefits of NEM solar to ratepayers as a driver for new technology, specifically the enablement of virtual power plants (VPPs). This benefit is not quantified within this study because standalone NEM solar is unlikely to enable VPPs. Customer energy exports will not necessarily occur at optimal times for the grid and therefore cannot be relied upon as a generation capacity source at a level beyond the ELCC values modeled here. If NEM solar is paired with a battery and also implemented alongside programs that enable utility dispatch or coordination, this could enable VPPs. However, the role of NEM solar in encouraging or enabling VPPs is speculative at this time given the relatively small number of VPPs that exist.

Frequency Regulation

The TAG requested that E3 evaluate the impacts of NEM solar for ratepayers in serving as a resource for frequency regulation. This benefit is not quantified within the study because the relevant "smart" inverters which can support frequency regulation are not yet widely available or in use for small-scale solar installations. Initial deployment for these benefits has been focused on utility-scale plants rather than NEM customer solar. However, any future requirements for and deployment of smart inverters when paired with NEM solar could support frequency regulation.

Voltage Support

The TAG requested that E3 evaluate the impacts of NEM solar for ratepayers in serving as a resource for voltage support, including inverter "ride through" ability. Like frequency regulation, this benefit is not quantified within this study because it would rely primarily on "smart" inverters to provide voltage support and "ride through" capability. Smart inverters are not yet widely available or in use, particularly with NEM solar. Increased deployment of these inverters may eventually provide voltage support and accompanying ratepayer benefits.

Diversity of Resources

The TAG requested that E3 consider a benefit to ratepayers of having a diverse resource portfolio. Increasing the breadth of a utility's portfolio can reduce the reliance on any single power plant or resource type. However, NEM solar does not appreciably increase diversity in a utility's portfolio if the resource that is displaced is utility-scale solar. Some benefits of diversity such as the capacity credit are already included in the quantitative results.

Solar Integration Costs

The TAG requested that E3 evaluate the impacts of NEM solar on ratepayers through solar integration costs. Customer solar can result in increases in utility and ratepayer costs by increasing the need for intra-hour flexibility of resources and raising costs for power plant standby/station power as well as operations and maintenance due to cycling. These costs are not quantified in this study as they are expected to be minor relative to other cost components.

Grid Modernization

The TAG requested that E3 evaluate the impacts of NEM solar on ratepayers through accompanying requirements for grid modernization. Grid modernization investments are not generally associated with a specific increment of distributed energy resources (DERs) such as NEM solar and are instead made strategically to enable the utility to better manage both existing and anticipated DERs. As such, these costs may be incurred largely on behalf of programs such as NEM but are typically recovered from all customers, thus resulting in a net cost to ratepayers. These investments can include advanced metering infrastructure to more accurately track and monitor DERs, advanced distribution management systems or distributed energy resource management systems (DERMS) tools to coordinate various interconnected resources at the distribution level, as well as other communication and monitoring and control systems. However, because these investments are made based on assumptions for the grouped needs of DERs, they are difficult to assign to a specific subset such as NEM solar and are therefore not quantified in this study.

Utility Program Administration Costs

The TAG requested that E3 evaluate the impacts of program administration costs associated with NEM solar on ratepayers, including costs associated with marketing, administration, evaluation, and incentives. Some of these costs are accounted for in this study via incentives (*i.e.*, NEM customer compensation) and interconnection fees. Other administrative expenses such as customer education efforts and NEM solar program administration are not quantified in this study.

Societal Benefits and Costs

Methodology

The societal perspective captures benefits that accrue to society at large. This category includes NEM participant benefits that are not costs to ratepayers, ratepayer benefits, and additional societal benefits that do not accrue directly to participants nor ratepayers. This methodology section focuses on the last category, which has not been discussed previously.

The key metric for societal benefits and costs is the Societal Cost Test (SCT), which compares societal benefits (federal incentives, utility avoided costs, and other societal benefits that can be quantified) to societal costs (upfront system costs and inverter replacement costs) over the assumed 25-year lifetime of the solar system.

Figure 23. Benefits and Costs Included in the Societal Cost Test (SCT)

	Societal Cost Test (SCT)	
	Benefits	Costs
Bill Savings / Solar Customer Compensation		
Upfront Cost		X
Inverter Replacement Cost		X
Interconnection Fee		
Federal Incentives	X	
Utility Avoided Costs	X	
Other Societal Benefits	X	

The methodology and assumptions used for each of the benefits and costs are described in the list below. Some of these components were described in previous sections but are repeated here for clarity.

- **Federal incentives:** Assumes all customers who install solar in 2024 receive a 30% ITC,[45] equivalent to $1,068/kW-AC based on assumed upfront cost. Note that it may be optimistic to assume that all customers receive the federal Investment Tax Credit (ITC) because customers without tax liability may not qualify for the full tax credit.

[45] https://www.energy.gov/eere/solar/homeowners-guide-federal-tax-credit-solar-photovoltaics

- **Upfront cost:** Assumes customers who install solar in 2024 pay $3,558/kW-AC before incentives for the system upfront cost, based on average residential installed cost data for Washington from EnergySage[46]
- **Inverter replacement cost**: Assumes customers who install solar in 2024 pay a $463/kW inverter replacement cost after 12 years (i.e., inverter replacement in 2036 for a 2024 adopter)[47]
- **Utility avoided costs:** Avoided energy, GHG, generation capacity, transmission capacity, and distribution capacity costs due to customer solar generation. Detailed methodology is provided in the **Utility Avoided Cost Framework** section.
- **Other societal benefits:** Societal benefits that can be quantified and are not included in other categories. For this study, quantified societal benefits include reduced criteria pollutants, GHG emissions, and land use. The detailed methodology for each quantified societal benefit is discussed in the following subsections.

E3 also conducted a qualitative evaluation for other societal benefits that could not be monetized in this study. A detailed discussion of qualitative societal benefits is provided in the **Qualitative Evaluation** section.

Reduced Criteria Pollutant Emissions

Increasing distributed renewable energy generation by installing more NEM solar may reduce the amount of air pollution from fossil fuel generators. The AVERT tool (AVoided Emissions and geneRation Tool) from the Environmental Protection Agency (EPA) models the criteria pollutant emissions reductions from energy efficiency, renewable energy, and electric vehicles.[48] Results from AVERT can be fed into another EPA tool, COBRA (CO-Benefits Risk Assessment.[49] COBRA is a model that uses changes in air quality to calculate an economic value of the corresponding benefits to benefits to human health.

To estimate criteria pollutant emissions reductions, E3 ran the AVERT model with 100 MW of utility-scale solar in the Northwest region to model the extent to which criteria pollutants could be avoided with additional renewable resources. About 21% of the reduced need for generation occurs within Washington. Next, the Washington share of the Northwest region AVERT emissions reduction and change in generation outputs were input into COBRA across all Washington counties. COBRA results were exported with a 3% real discount rate, which is aligned with the 5% nominal discount rate used in the SCT in this analysis. The results only consider criteria pollutant emissions reductions and corresponding health impacts that occur within Washington. Reducing gas generation in Washington would also have spillover emissions reduction impacts in other states that are not accounted for in this study. The COBRA results include both “high” and “low” scenario estimates. The “high” scenario estimates from COBRA were used in this study, reflecting greater air quality benefits for NEM solar.

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[46] https://www.energysage.com/local-data/solar-panel-cost/
[47] https://www.nrel.gov/docs/fy23osti/87303.pdf
[48] AVoided Emissions and geneRation Tool (AVERT), Environmental Protection Agency, https://www.epa.gov/avert
[49] CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA), Environmental Protection Agency, https://www.epa.gov/cobra

Criteria pollutant emissions and health benefit results are averaged across the state. While this accounts for the total emissions and health benefits seen within the state, it does not account for distributional differences. Communities with high levels of criteria pollutants from existing thermal generation sources will see a greater health impact than those without. This distributional impact is not linked to where the customer solar is installed, but rather the location of the resource it is displacing, which changes hourly with grid conditions and might not be located in Washington state.

The health benefits from COBRA are applied to each utility in each year with a multiplier that represents their share of non-CETA-eligible renewable resources (*i.e.*, fossil fuel resources). Since CETA mandates a carbon-neutral electricity supply by 2030, the avoided health benefits from distributed solar are modeled to be zero by 2030.

Reduced Greenhouse Gas Emissions

Beyond the monetized carbon price included in the hourly electricity market price forecast, E3 estimated an incremental societal value for the avoided carbon emissions attributable to NEM solar systems. E3 assessed this benefit using the social cost of carbon (SCC), which estimates the net present value of lifetime societal damages tied to each tonne of carbon emissions. For this analysis, E3 used the proposed SCC from the US EPA *Report on the Social Cost of Greenhouse Gases* with a 2% discount rate.[50] This value begins at $190 per metric tonne of carbon dioxide for 2020 emissions and rises for carbon dioxide emitted in later years. To avoid double counting, the monetized cap-and-invest carbon price that is already incorporated in the wholesale market price forecast is subtracted from the SCC.

To assign a dollar value to the incremental reduction in emissions, it is necessary to determine the hourly marginal emissions rate for the electric grid. The hourly implied heat rates for wholesale energy were calculated as described in the section **Fuel Price Risk Avoided Costs**. Multiplying the hourly implied heat rate by the carbon content of natural gas results in the hourly marginal emissions rate for wholesale electricity from conventional fossil resources.[51] This marginal emissions rate is then multiplied by each utility's share of generation sourced from conventional fossil fuel resources in each year, by the customer solar profile, and by the SCC (less the cap-and-invest carbon price) to achieve a final dollar value.[52]

NEM solar does not provide incremental reductions in carbon emissions for energy that would otherwise be coming from renewable sources. The incremental benefit of avoided fossil fuel combustion reduces to zero by 2030 when CETA mandates a carbon-neutral electricity supply by 2030.

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[50] https://www.epa.gov/system/files/documents/2022-11/epa_scghg_report_draft_0.pdf (Table 4.1.1)

[51] Carbon content of natural gas at 0.053 tonnes of CO2 per MMBtu per the EPA Greenhouse Gas Equivalencies Calculator https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[52] Utility-specific customer solar profiles obtained from NREL's PVWatts tool (https://pvwatts.nrel.gov/); utility shares of conventional and renewable generation obtained from disclosures to the WA Department of Commerce (https://www.commerce.wa.gov/wp-content/uploads/2023/08/2022-FMD-Report.pdf) and scaled linearly to 100% by 2030

Reduced Land Use Impacts

Reduced land use impacts reflect the value of putting NEM solar in the built environment, preserving land for agriculture, commercial and housing needs, and natural habitats. To quantify this value, E3 estimated the value of avoided land use corresponding to utility-scale solar. First, E3 reviewed literature estimates for the societal or environmental value of different types of land. Estimates of this value vary broadly. Costanza et al. provide a useful review of estimated ecosystem services values and how they have changed over time.[53] The values used in E3's analysis are based on the estimates included in the Costanza et al. paper and include the environmental, recreational, and cultural value for global ecosystem types. The Washington State University Least Conflict Solar Siting Report[54] states that shrubsteppe is the most common ecosystem for solar siting in the Columbia River Basin. Since Costanza et al. did not include shrubsteppe as an ecosystem type, the grassland value of utility-scale solar is used as a proxy.

To convert the value per acre into a value per kW, E3 used an estimate from work completed by NREL, which found that single axis utility-scale solar has a land use intensity of approximately eight acres per MW.[55] This aligns with estimates from the Solar Energy Industries Association, which reports a range of five to ten acres per MW for utility-scale solar.[56]

The $/kW land benefits are applied to each utility in each year with a multiplier that represents their share of CETA-eligible renewable resources, which is a proxy for new utility-scale solar investments to maintain CETA compliance. The value of avoided land use increases over time as utilities that currently have thermal marginal resources shift to utility-scale solar as the marginal resource.

Ecosystem services are not the only benefit that natural lands in Washington could provide. Utility-scale solar could also be built on land with alternative uses for agricultural or ranching purposes. Farms or ranches that would be converted to utility-scale solar would have the value of the land included in the cost to acquire the land and build the resource, which is why it is not included in this analysis.

Furthermore, utility-scale solar may not always be built on ecologically valuable land. Washington State University's Least-Conflict Solar Siting study analyzed the Columbia River Basin and applied geospatial filters for solar suitability, environmental conservation, farmland, and ranchland.[57] Results of that study show that not all land should be valued equally; there are least-conflict locations that have less value compared to natural or working lands. Since least-conflict sites may be the lowest cost to develop, utility-scale solar is likely to be prioritized on these sites. Thus, the reduced land impacts calculated in this evaluation are upper limits of the potential value of land impacts.

The value of preserved viewscapes is not included in this analysis. Utility-scale solar is one of least visible types of generation.[58] There is increasing pressure on developers to decrease the visual impacts of their

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[53] Changes in the global value of ecosystem services, Costanza et al., https://www.robertcostanza.com/wp-content/uploads/2017/02/2014_J_Costanza_GlobalValueUpdate.pdf
[54] Least-Conflict Solar Siting on the Columbia Plateau, WSU Energy Program, https://www.energy.wsu.edu/documents/Least-Conflict_Solar_Siting_Report-WSUEP23-04--6-29.pdf
[55] https://www.nrel.gov/docs/fy13osti/56290.pdf
[56] https://www.seia.org/initiatives/siting-permitting-land-use-utility-scale-solar
[57] https://www.energy.wsu.edu/documents/Least-Conflict_Solar_Siting_Report-WSUEP23-04--6-29.pdf
[58] https://www.bia.gov/sites/default/files/dup/assets/as-ia/ieed/ieed/pdf/idc1-021617.pdf

energy projects by avoiding certain areas, minimizing their impact, rehabilitating local surroundings, and compensating nearby stakeholders.[59] There is also precedent for energy projects, usually located near urban areas, to compensate communities, neighborhoods, or non-profits for disturbing viewscapes. This payment is generally intended to offset the impacts of the project by investing in other community aesthetic enhancements, especially in the form of trails, parks, plantings, or interactive exhibits.[60] These values are location-specific and depend on both the type of viewscape disturbance and the impact on the surrounding environment. Since these values are inherently site-specific, E3 did not quantify these impacts to be included in the benefit-cost analysis.

Societal Results

Societal Cost Test Results

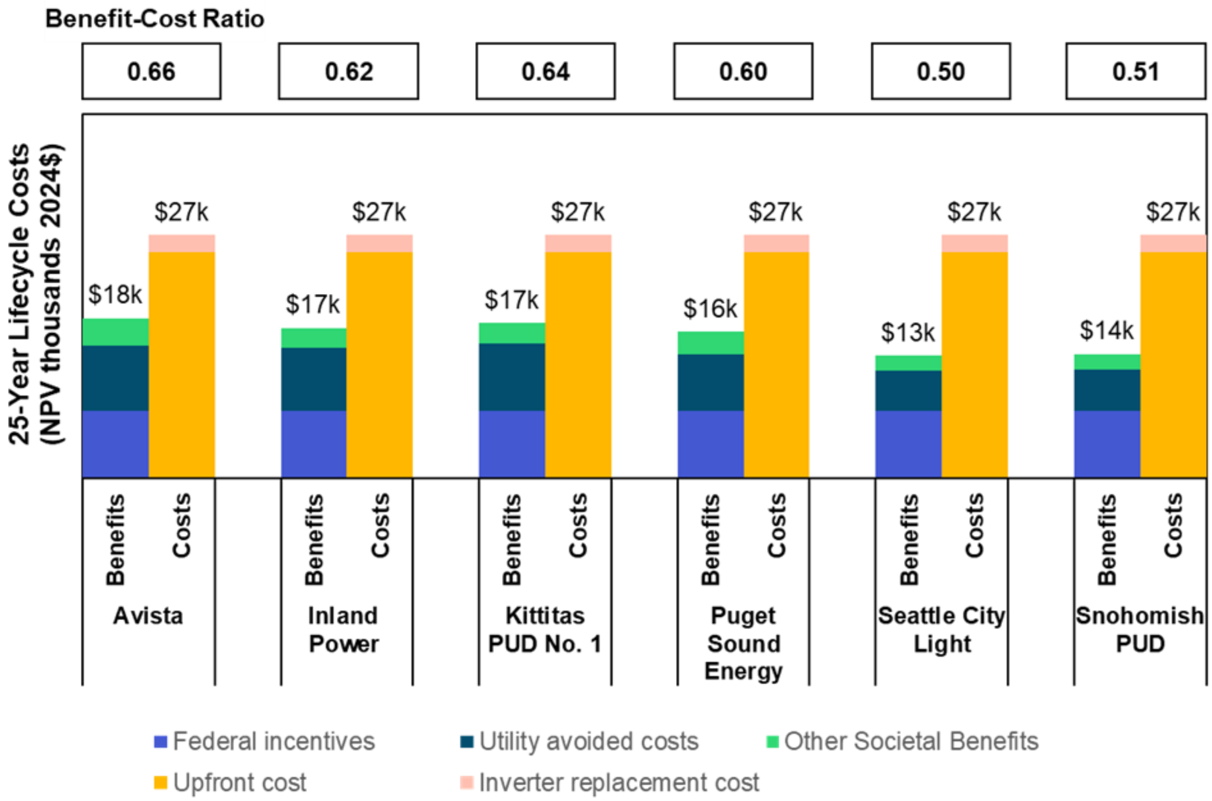
Figure 24 shows the Societal Cost Test (SCT) results based on an example residential 7 kW-AC system. Benefits and costs are lifecycle net present value (NPV) $/system values over the assumed 25-year lifetime of the solar system. Societal benefits include federal incentives, utility avoided costs, and other societal benefits that can be quantified, while societal costs include upfront system costs and inverter replacement costs.

The federal investment tax credit is included as a benefit because, if more NEM solar is developed in Washington State, that would bring a greater amount of federal tax credits to residents of Washington State without appreciably increasing the tax burden for other taxpayers in the state. Note that it may be optimistic to assume that all customers receive the federal ITC because customers without tax liability may not qualify for the full tax credit.

Federal incentives, upfront costs, and inverter replacement costs do not vary by utility, while utility avoided costs and other societal benefits do vary, with utility avoided costs primarily driving the differences in results by utility. The benefit-cost ratio ranges from 0.50 (Seattle City Light) to 0.66 (Avista), indicating that on average, lifetime benefits are less than the lifetime costs for society.

[59] https://www.fs.usda.gov/nrs/pubs/gtr/gtr-nrs-p-183papers/23-donaldson-VRS-gtr-p-183.pdf
[60] https://www.fs.usda.gov/nrs/pubs/gtr/gtr-nrs-p-183papers/23-donaldson-VRS-gtr-p-183.pdf

Figure 24. Societal Cost Test (SCT) by Utility for an Example 7 kW-AC System



Societal Benefits

Societal benefit values vary across both utilities and time. Some societal benefits such as criteria pollutant and GHG emissions reductions are a product of avoided fossil fuel generation, while other benefits such as avoided land use are benefits of avoided utility-scale solar. Emissions benefits will decrease as utility-scale renewables become the replacement resource. By 2030, all utilities will be procuring 100% clean resources to comply with CETA, at which point there is no avoided fossil generation and therefore no emissions reduction benefits. Conversely, land use benefits increase as utility-scale renewables increasingly become the replacement resource. For more information about the methodology for each quantified societal benefit, see the **Methodology** section of the **Societal Benefits and Costs** chapter. Table 13 shows the values for each societal benefit in 2024.

Table 13. Physical Units and Monetized Values of Societal Benefits in 2024

Utility	Physical Units per kW-year			Societal Value (¢2024/kWh)		
	Avoided Land Use (acres)	Criteria Pollutant Emissions Reduction (lbs)	GHG Emissions Reduction (tCO_2e)	Avoided Land Use	Criteria Pollutant Emissions Reduction	GHG Emissions Reduction
Avista	0.004	0.94	0.19	0.63	0.47	2.39
Inland Power and Light	0.006	0.20	0.04	0.95	0.10	0.49
Kittitas PUD	0.006	0.08	0.02	1.01	0.04	0.19
Puget Sound Energy	0.003	0.84	0.17	0.60	0.51	2.53
Seattle City Light	0.005	0.05	0.01	1.01	0.03	0.15
Snohomish PUD	0.005	0.06	0.01	1.01	0.04	0.18

Qualitative Evaluation

Reduced Water Consumption – Fossil Fuel Cooling

The TAG requested that E3 evaluate the benefit to society from NEM solar reducing water consumption for fossil fuel cooling. Water use in electricity generation varies widely across generators depending on their characteristics. According to 2021 EIA data, Washington has five power plants with recirculated cooling, one with hybrid cooling, and one with dry cooling.[61] Recirculated cooling plants use the most water at 467 gallons of water per MWh, followed by the hybrid system at 8.5 gallons per MWh. The dry cooling system does not use any water for cooling. The eight plants use an average of 343 gallons of water per MWh.

The direct cost of water saved from reduced thermal power generation would be included in plant operation and maintenance costs, and thus is already included in the utility avoided costs through the avoided wholesale energy component. The societal value of water is not well defined. One way of calculating the implied societal cost of water is to look at how much public agencies and water utilities value water conservation. Many large water utilities in Washington have a $100 rebate for a low-flush toilet.[62,63,64] Over a 10-year lifetime with a 5% discount rate, these toilets save about 100,000 gallons of

[61] Thermoelectric cooling water data, Energy Information Administration, https://www.eia.gov/electricity/data/water/
[62] Toilet Replacement Rebate, Saving Water Partnership, https://www.savingwater.org/toilet-replacement-rebate/
[63] Water Conservation, City of Olympia, https://www.olympiawa.gov/services/water_resources/drinking_water/water_conservation/index.php
[64] Water Wise Rebate, Spokane City, https://static.spokanecity.org/documents/publicworks/water/water-wise-spokane/rebates/2022/2022-water-wise-rebate-toilets-info.pdf

water.[65,66] This yields an implied social cost of water of $0.001/gallon. Since this value is very small, it was not included in the benefit-cost analysis for this study.

Reduced Water Consumption – Irrigation Canal Coverage

The TAG requested that E3 evaluate the benefit to society from NEM solar reducing water consumption when solar panels shade irrigation canals and reduce evaporation and water loss. The total share of distributed generation that could be deployed in the form of irrigation canal coverage is extremely small. E3 is not aware of any operational solar sited on irrigation canals in the United States. Two projects are under development, one in California and one in Arizona.[67,68] Both of these projects are utility-scale projects, and as such, would not be eligible for NEM. Until irrigation canal-sited solar becomes widespread and less novel, it is unlikely that individual customer-generators would be willing to install similar projects due to uncertainties about cost and ease of maintenance. Due to limited installation of canal-sited solar and an uncertain magnitude of impacts, this value was not quantified in this study.

Preserve Tribal Lands and Resources and Increase Tribal Sovereignty

The TAG requested that E3 evaluate the benefit to society from NEM solar preserving Tribal lands and resources and increasing Tribal sovereignty due to less solar being sited on Tribal lands. Tribal sovereignty refers to the status of Tribes as sovereign governments within the United States. Within that context, energy sovereignty describes Tribes having the ability to determine what types of resources their energy is derived from and to what extent they are dependent on external resources. Opinions on how best to work towards Tribal energy sovereignty differ among Tribes and among individuals within Tribes. Historically, many types of development projects, including energy projects, have been sited on Tribal lands at the expense of the communities and ecosystems.[69] One example of this in Washington is the Hanford Nuclear Site, which is sited on land that was designated by the Yakama Nation Treaty of 1855 to be used for hunting and fishing by Tribal nations.[70]

While acknowledging these historical harms, there are many remaining questions about how Tribes that are interested in renewable energy can implement Native-led renewables. According to a National Renewable Energy Laboratory study, there is over $75 billion worth of potential wind and solar investment on Tribal lands in the United States.[71] This potential provides an opportunity for Tribes that are interested in pursuing development. Since Tribal nations are recognized as sovereign entities by the US government, they are not eligible for many incentives that other entities are and must engage in a more complicated permitting and approval process.[72] According to the 2021 Status of Tribes and Climate Change Report, "Tribal nations are also increasingly pursuing green enterprises to enhance their climate resiliency,

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[65] Residential Toilets, Environmental Protection Agency, https://www.epa.gov/watersense/residential-toilets
[66] Toilet Installation, Home Guide, https://homeguide.com/costs/toilet-installation-cost
[67] Project Nexus, Turlock Irrigation District, https://www.tid.org/about-tid/current-projects/project-nexus/
[68] Arizona utilities have long rejected covering canals with solar panels. Here's why that may change, Ryan Randazzo, https://www.azcentral.com/story/money/business/energy/2023/03/21/should-solar-panels-cover-arizona-canals-srp-asu-looking-at-effects/70022804007/
[69] https://www.sciencedirect.com/science/article/abs/pii/S2214629623003031#preview-section-references
[70] http://nau.edu/stacc2021
[71] https://www.nrel.gov/docs/fy18osti/70807.pdf
[72] http://nau.edu/stacc2021

including renewable energy, carbon offsets, and subsistence-based trade... marking a rediscovery and resurgence of Indigenous heritages, philosophies, sciences, and knowledges."[73] The report goes on to recommend ways in which Tribes can access federal funds and resources to pursue renewable energy, particularly pointing out barriers such as a lack of financing, access to career training, and a lack of support for Tribal leadership. One of the final recommendations of the report is to "remove barriers to renewable energy development, while supporting Indigenous people in a just transition, to reduce reliance on and negative impacts from fossil fuels and nuclear energy." More work is being done on the Federal level to engage in conversations about Tribal sovereignty and renewable energy, for example the 2022 Tribal Clean Energy Summit.[74]

To mitigate and avoid possible harms of utility-scale solar being sited on land with Tribal importance, the Washington State University Least-Conflict Solar Siting Report compiled concerns and suggestions on solar siting from Tribal members.[75] One highlighted concern is the least-conflict maps "would be misunderstood and give false assurance that Tribes sanction the least-conflict areas," since the maps do not include sensitive or non-public cultural resource sites. The report goes on to stress the importance of government engagement with local Tribes before siting for energy resources can begin, and at the same time, recognizing that Tribes may be overburdened with these proposals, and may not have the time, funding, or staff to respond to them in full. Renewable energy, including utility-scale solar, has the potential to provide a wide array of benefits and harm to Tribal nations. Since there are both benefits and harms involved in these projects, the net benefits or costs cannot be determined without in-depth conversations with Tribes that are affected by these developments. For these reasons, E3 is unable to quantify this benefit within the benefit-cost analysis framework.

Reduced Wildfire Risk

The TAG requested that E3 evaluate the benefit to society from NEM solar reducing wildfire risk. Specifically, the TAG noted that NEM solar reduces urban loads, allows for deenergizing transmission and distribution lines, and allows for islanding remote rural customers. This benefit is not quantified in this study because standalone NEM solar is unlikely to result in reduced wildfire risk. When paired with energy storage, customer solar could potentially support other benefits including resiliency values for outages, the ability to "island" during public safety power shutoff events, and/or could allow utilities to preemptively deenergize transmission and distribution lines during high-risk weather events.

Increased Public Awareness for Energy Issues

The TAG requested that E3 evaluate the benefit to society from NEM solar resulting in increased public awareness for energy issues. Specifically, the TAG suggested that onsite generation might encourage residential storage, be a driver for electrification, and reduce the need for demand reduction. Increased adoption of customer solar systems may increase interest, engagement, and understanding of important energy issues for participating customers and their neighbors. The process of installing solar could also be

[73] http://nau.edu/stacc2021
[74] https://www.energy.gov/indianenergy/tribal-clean-energy-summit-2022
[75] Least-Conflict Solar Siting, WSU Energy Program, https://www.energy.wsu.edu/RenewableEnergy/LeastConflictSolarSiting.aspx

used as a tool to educate these customers about their utility's resource mix, decarbonization plans, or overarching energy policy within the state. Similarly, non-participating customers seeing solar panels in their neighborhood may increase their interest in renewable energy, possibly even prompting them to adopt solar.[76] Additionally, thinking more about energy usage may lead participating customers to pay greater attention to conservation through behavioral changes, purchase energy efficient appliances, or engage in further conversations about clean energy. E3 recognizes the value that this type of increased engagement can provide to customers and, by extension, the local community or society more broadly. However, E3 is not aware of any methods to quantify a dollar amount on such values.

Economic Development

The TAG requested that E3 evaluate the benefit to society from NEM solar resulting in economic development. Specifically, the TAG noted that NEM solar attracts federal funds to Washington State, particularly the Local Solar for All grant program that will support low- and moderate-income households. Additionally, the TAG noted that the tax credits and rebates from the Inflation Reduction Act will help to grow the Washington economy.

Federal tax credits are included as a benefit in this NEM evaluation. However, a full evaluation of the potential macroeconomic benefits and costs of customer solar is not within the scope of this study. Relevant inputs to such a study, which would use a regional macroeconomic model, could include (1): changes to upfront investments over time with increased investment in customer solar, but lower investment in shared energy system resources such as utility-scale solar and transmission and distribution facilities, when compared to a base case scenario without customer solar; and (2): changes in electricity rates paid by utility customers over time, relative to a base case scenario without customer solar, that would impact consumer spending and the broader economy.

The total impact of these changes depends on the magnitude of each component over time. Based on E3's experience with similar customer solar studies, there are both short-term and long-term economic impacts to consider. In the short term, increased customer solar would likely result in higher economic activity in Washington because customer solar is more costly than the resources it replaces. In the long term, customer solar may result in lower economic activity in Washington, as increasing the number of customer solar systems leads to bill increases for non-solar customers due to the NEM cost shift. As energy burden increases, non-solar customers have less income to spend on both essential and non-essential non-energy goods and services. Additionally, local businesses' ability to sustain local jobs and create economic growth may be reduced due to electricity rate increases. The net effect of the short-term and long-term impacts depends on the size of each impact and the amount of solar adoption.

Local Employment

The TAG requested that E3 evaluate the benefit to society from NEM solar resulting in local employment benefits including green jobs, apprenticeship opportunities, local living wage employment, and training in the electrical field. Studies show that the solar industry employs a large number of workers across the

[76] Spatial patterns of solar photovoltaic system adoption: The influence of neighbors and the built environment, Marcello Graziano and Kenneth Gillingham, https://academic.oup.com/joeg/article/15/4/815/2412599#40643064

United States with about 260,000 solar workers as of December 2022.[77] Similar data shows that policy choices that affect either utility-scale or customer solar can have an impact on jobs; for example, the Inflation Reduction Act is expected to increase solar jobs in 2024 and threats of panel and cell tariffs led to the loss of 6,000 utility-scale solar jobs in 2022.[78]

The price per kW of customer solar is more than three times the price per kW of utility-scale solar, in large part because of labor.[79,80] Between 12% and 14% of capital costs for both customer and utility-scale solar are for installation labor or permitting, interconnection, and inspection labor.[81,82] Using the 2024 values from the avoided cost modeling done for this study, this is a total of $58/kW for customer solar and $21/kW for utility-scale solar. However, E3 is unable to isolate the marginal economic benefits of this labor that would not be captured through employment in other industries without a macroeconomic model, which is beyond the scope of this study.

Leveraging Private Capital

The TAG requested that E3 evaluate the benefit to society from NEM solar leveraging private capital to support clean energy development. Initially, the upfront costs for both utility-scale and customer solar may be paid for by private capital. However, both types of solar are ultimately paid for by ratepayers. Customer solar is initially financed by individual customers or third-party developers but these costs are ultimately paid off with ratepayer funds through NEM compensation (*i.e.*, over the "payback period"). Utility-scale solar is similarly funded with upfront private investments, but paid off by ratepayers whether through a power purchase agreement or through the utility rate base. E3 is unable to isolate a significant difference between leveraging private capital for customer- vs. utility-scale renewable resources.

Investment in Disadvantaged Communities

The TAG requested that E3 evaluate the benefit to society from NEM solar resulting in investments in disadvantaged communities, including jobs and local spending in these communities. This benefit is not quantified in this study because disadvantaged communities do not currently see significant net benefits from participating in NEM due to low solar adoption in these communities. Additionally, as described in the

Cost Shift Results section, NEM solar results in a cost shift from participants to non-participants. If new programs incentivized significant NEM investment in low- and middle-income communities, there may be

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77 National Solar Jobs Census 2022, Interstate Renewable Energy Council (IREC), https://irecusa.org/census-executive-summary/

78 National Solar Jobs Census 2022, Interstate Renewable Energy Council (IREC), https://irecusa.org/census-executive-summary/

79 Solar Panel Cost in 20203, EnergySage, https://www.energysage.com/local-data/solar-panel-cost/

80 Electricity Annual Technology Baseline, National Renewable Energy Laboratory, https://atb.nrel.gov/electricity/2023/2023/data

81 Why Are Residential PV Prices in Germany So Much Lower Than in the United States?, Seel et al., https://eta-publications.lbl.gov/sites/default/files/german-us-pv-price-ppt.pdf

82 Benchmarking Non-Hardware Balance-of-System (Soft) Costs for U.S. Photovoltaic Systems, Friedman et al., https://www.nrel.gov/docs/fy14osti/60412.pdf

additional benefits to disadvantaged communities, but current adoption patterns show that NEM solar systems are predominantly installed in wealthier communities.

Equity-driven organizations, ratepayer advocates, and utilities have expressed concern about the NEM cost shift, particularly in states with high retail rates. They argue that NEM programs tend to shift utility costs to lower income customers. Across the country, customers who install solar systems tend to have a higher income due to the high upfront costs of these systems. As of 2022, a study by the Lawrence Berkley National Laboratory found that 81% of solar adopters in Washington have an income of more than 300% of the federal poverty level, and 60% of solar adopters are above 120% of the area median income.[83] This is aligned with data received from the detailed study utilities, which shows that while about 20% of the general population falls into communities that are designated as "highly impacted" based on the Washington Health Disparities Map, only 7% of existing NEM customers live in those areas. Additionally, homeowners are more likely to have solar than renters. As of 2020, 4.3% of homeowners in the United States have installed solar, but only 0.8% of renters.[84]

Since low- and middle-income customers often lack the upfront capital to install solar systems, they may be excluded from the benefits that solar can provide without significant rebate or discount programs. Existing federal benefits, such as tax credits from the Inflation Reduction Act, might not be able to be used by low-income households if they do not have enough tax burden to receive a tax credit. Since low-income communities are currently more likely to be non-participating customers and see impacts of the cost shift rather than the benefits of installing solar, E3 did not consider economic benefits to disadvantaged communities in this study.

Reduced Energy Burden for Low-Income Customers

The TAG requested that E3 evaluate the benefit to society from NEM solar resulting in a reduced energy burden for low-income customers. Low-income customers who participate in NEM programs, like all participants, will see a bill decrease and therefore a decrease in energy burden. More information on participant benefits can be found in the **Participant Results** section. At the same time, bills will increase for non-participating customers, as described in the **Ratepayer Results** section, which includes bill impacts for non-participating low-income customers. E3 is not aware of any robust methods to further quantify a dollar amount for additional societal benefits of bill reductions or bill increases for low-income customers.

[83] Solar Demographics Tool, Lawrence Berkeley National Lab, https://emp.lbl.gov/solar-demographics-tool
[84] Energy Information Administration, https://www.eia.gov/todayinenergy/detail.php?id=54379

Review of Customer Generation Tariff Design in Other U.S. Jurisdictions

Retail Electric Rates May be Misaligned with Avoidable Utility Costs

Across the United States, volumetric charges are generally the core component of retail rates for residential and small commercial customers. However, fixed costs related to the recovery of capital investments represent an increasing share of electric utility costs. A shift in electricity generation from fuel combustion to renewable resources such as wind and solar is exacerbating this trend. This has led to a misalignment between retail electric rates and the share of utility costs that can be avoided through a reduction in electricity sales.

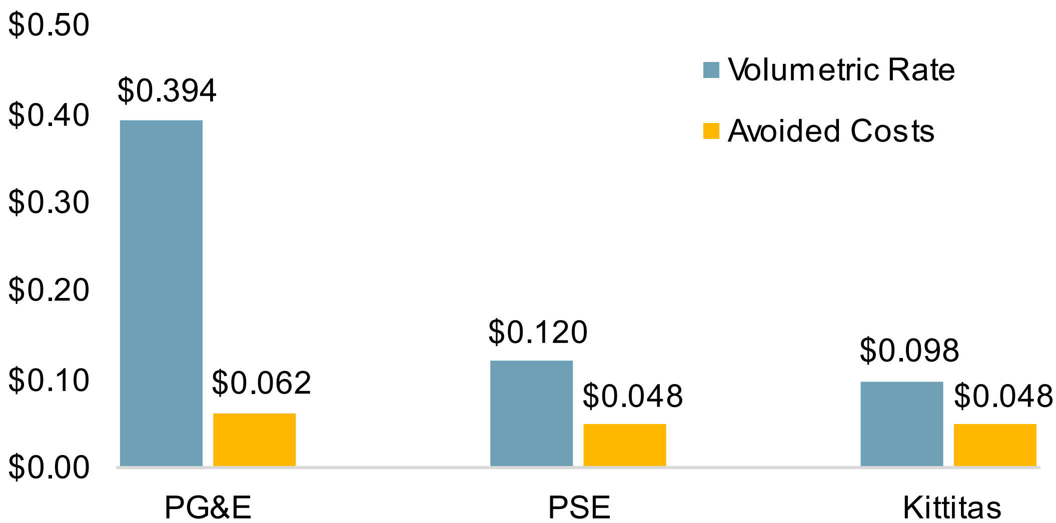
Figure 25 compares the average residential volumetric electricity rate to the solar-average utility avoided cost across three utilities in Washington and California. Avoided costs reflect the sum of short- and long-run marginal costs that may be avoided through a reduction in customer load. California avoided costs are from the California Public Utility Commission's Avoided Cost Calculator,[85] and Washington avoided costs were calculated by E3 in this study.

For Pacific Gas & Electric (PG&E), the investor-owned utility in Northern California, there is a dramatic difference between the marginal cost of electricity to the customer versus to the utility. This difference can also be seen in Washington, both for investor-owned utilities such as Puget Sound Energy and publicly owned utilities such as Kittitas PUD. The Washington utilities have lower overall rates than PG&E, plus their rates include customer charges that reduce the volumetric component of the rate. For all three utilities shown, the gap between the retail volumetric rates and utility avoided costs reflects the share of utility costs that *are not* driven by marginal changes in load, but that *are* collected through volumetric rates.

The misalignment between electric retail rates and grid costs is most prevalent within the residential customer class. While rates for small commercial customers may have similar issues, rates for large commercial customers generally have a lower volumetric component, plus demand and customer charges that make them more reflective of grid costs.

[85] CPUC Avoided Cost Calculator, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/energy-efficiency/idsm

Figure 25. Residential Volumetric Electricity Rates vs. 2024 Solar-Average Utility Avoided Costs ($/kWh) [86]



Under the standard cost-of-service ratemaking model, utilities set rates to recover their revenue requirement, which is based on the costs of building and operating the electric grid. This is true for both investor-owned utilities and publicly owned utilities, although the revenue requirement for investor-owned utilities will also include equity returns and corporate income taxes.

Because retail rates are misaligned with utility costs, changes in customer usage will lead to a change in utility revenue that differs from the change in utility costs. Figure 26 illustrates this effect.

Over time, utilities will need to make changes to their rates in order to recover their full revenue requirement. This effect is called a "cost shift," as the under- or over-collection of revenues results in a shift of utility costs among customer groups. Some national studies, such as the National Academies' "The Role of Net Metering in the Evolving Electricity System," call for a revisiting of traditional NEM policies as technology costs and market maturity have increased the scale of deployment of customer solar, and therefore the cost shift.[87]

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[86] California avoided costs represent solar-weighted 2022 ACC values from Figure 4 of the ACC Documentation. California Avoided Cost Calculator, California Public Utility Commission, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-side-management/acc-models-latest-version/2022-acc-documentation-v1b.pdf

Washington avoided costs represent solar-weighted 2024 values as calculated by E3 using utility-provided data.

PG&E's volumetric rate is calculated without the conservation incentive adjustment, representing the load-weighted average rate that customers pay between tiers. Residential Rate, Pacific Gas & Electric, https://www.pge.com/tariffs/electric.shtml

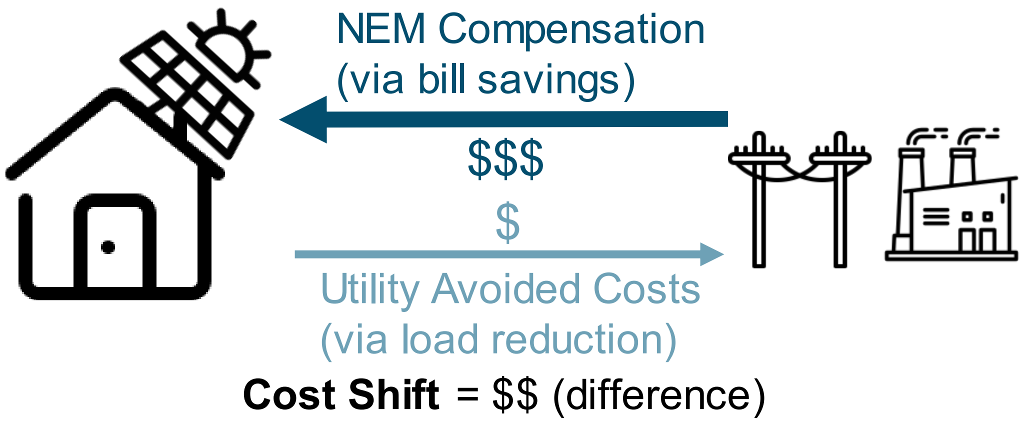
PSE's volumetric rate component is a simple average between tier 1 and tier 2 rates. Residential Rates, Puget Sound Electric: https://www.pse.com/en/pages/rates/electric-tariffs-and-rules#sort=%40documentdate%20descending

Kittitas has a simple volumetric rate component. Residential Rates, Kittitas PUD, https://www.kittitaspud.com/DocumentCenter/View/1559/Residential-Rate-Schedule---2023pdf

[87] The Role of Net Metering in the Evolving Electricity System, National Academies, https://nap.nationalacademies.org/resource/26704/Net-Metering-Briefing-Slides.pdf

Figure 26. NEM Cost Shift

When customer usage changes, a cost shift will occur if retail rates do not reflect underlying utility costs



Net Energy Metering

Net energy metering (NEM), also referred to as net metering, is a specific tariff design for customer generation. While NEM can be used for multiple types of customer generation, it is most commonly used for customer-sited photovoltaic (solar) generation. NEM specifically refers to a policy where customers are billed on their "net" consumption, *i.e.*, imports from the grid minus exports to the grid. In practice, this means that all customer generation under NEM, including both electricity that is self-consumed on-site and energy that is exported to the grid, is compensated at the customer's import rate, *i.e.*, the utility's retail rate.

Colloquially, the terms "NEM" and "net metering" are sometimes used to describe all types of tariff designs for compensation of customer generators. However, in this memo, references to NEM refer strictly to the NEM compensation structure.

Washington State's NEM program was created in 1998 under Washington Substitute House Bill 2773, "Net-metering for certain renewable energy systems."[88] The original program was capped at 0.1% of a utility's 1996 peak demand. Amendments to the law in 2000, 2006, 2007, and 2019 have expanded the program. Washington's current NEM program is set to expire when the program total reaches 4% of a utility's 1996 peak demand or in 2029, whichever comes first.[89] Any utility that reaches their NEM generating capacity minimum before 2029 may develop or propose a new successor tariff. Investor-owned utilities can submit a new tariff to the Utilities and Transportation Commission (UTC) for approval, while consumer-owned utilities can develop a new tariff without submitting a filing to the UTC. As of June 2023, Washington's NEM program is 59% subscribed across all utilities in the state with about 50,000

[88] Substitute House Bill 2773, https://lawfilesext.leg.wa.gov/biennium/1997-98/Pdf/Bills/Session%20Laws/House/2773-S.SL.pdf
[89] Net Metering, Washington State Department of Commerce, https://www.utc.wa.gov/regulated-industries/utilities/energy/net-metering

customers having installed solar. Five utilities have exceeded their NEM generating capacity minimum,[90] and additional utilities may exceed their minimum in the next few years.

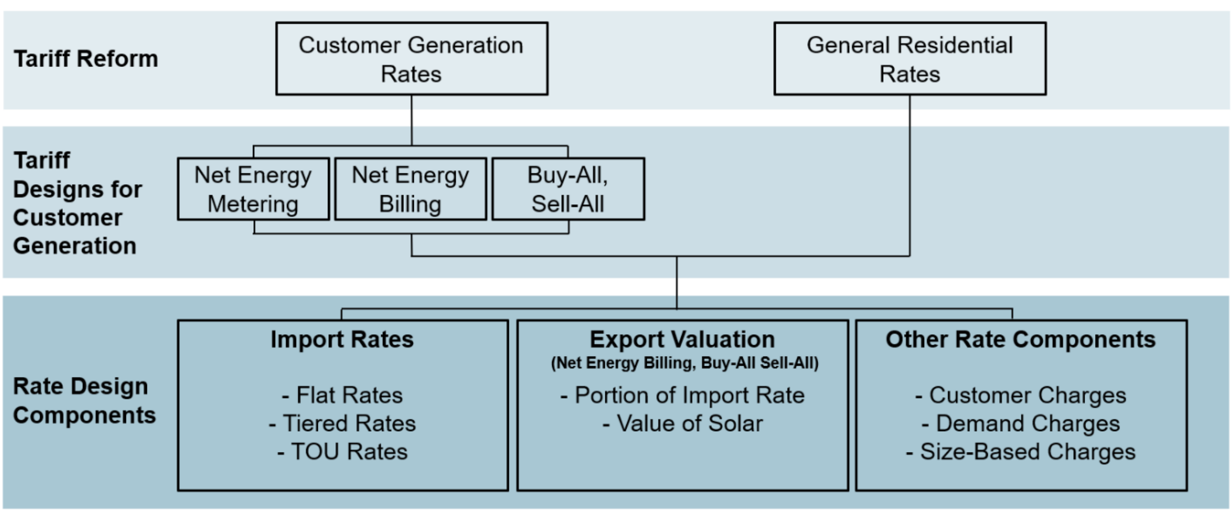
As of 2022, 47 states plus Washington, DC have adopted statewide customer generation compensation programs. Thirty-five of those use a NEM tariff: Alaska, Arkansas, Colorado, Connecticut, Delaware, Florida, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Minnesota, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, Washington, Washington, D.C., West Virginia, Wisconsin, and Wyoming.[91]

This memo focuses on tariff design examples from the states of California, Hawaiʻi, and New York. More information on customer generation tariffs across all 50 states can be found in the Database of State Incentives for Renewables & Efficiency.[91]

Alternative Tariff Options

There are two different approaches to updating tariffs for customer generation. One approach is to change the compensation structure for customer generation, moving to a tariff design that provides compensation at levels closer to avoided utility costs. Within this approach, there are different fundamental design options for customer generation tariffs as well as additional rate design considerations. An alternative approach would be to update general retail rates for both customer-generators as well as traditional utility customers. Figure 27 provides an illustration of these options.

Figure 27. Overview of Tariff Reform Options



[90] WSU Energy Program Net Metering Reporting, https://www.energy.wsu.edu/documents/Net%20Metering%20Reporting_20230630.pdf

[91] DSIRE, NC Clean Energy Technology Center, https://www.dsireusa.org/

Tariff Designs for Customer Generation

There are three main tariff designs for customer generation that are used in the United States: net energy metering (NEM), net energy billing (NEB), and buy-all, sell-all. These compensation structures are summarized in Figure 28.

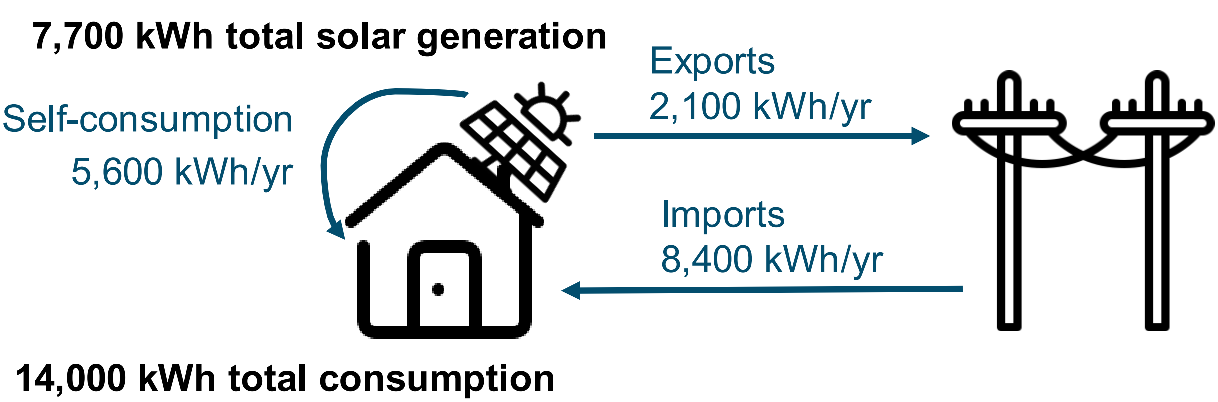
Figure 28. Tariff Designs for Customer Generation

Tariff	Self-Consumption	Exports	Metering Requirements
Net Energy Metering	All generation (both self-consumption and exports) credited at the customer's **import rate**		
Net Energy Billing	Self-consumption credited at the **import rate**	Exports credited at the **export rate**	Requires 2-channel meters that differentiates imports and exports
Buy-all, Sell-all	All generation (both self-consumption and exports) credited at the **export rate**		Requires independent metering of customer generation

Note: "Net Metering / NEM" is often used erroneously to describe all tariffs for crediting exports from customer-generators

These tariff designs differ in how they treat self-consumption versus exports. To illustrate what these terms mean, Figure 29 shows an example customer-generator with a solar system that produces 7,700 kWh/year of generation. Of that total, 5,600 kWh/year overlaps with customer load and is consumed on-site, and the remaining 2,100 kWh/year is exported to the grid. The customer imports 8,400 kWh/year of power from the grid to meet their remaining electricity needs.

Figure 29. Example Customer-generator



Net Energy Metering (NEM)

Overview of Net Energy Metering

Under the Net Energy Metering (NEM) tariff design, customers are billed based on their net consumption over the billing period (imports minus exports). Effectively, this means that all customer generation is compensated at the customer's import rate.

NEM can be implemented with a single bidirectional meter: when electricity is drawn from the grid, the meter reading increases, and when electricity is exported to the grid, the meter reading decreases. NEM can also be implemented on a two-channel meter, in which case customers are billed based on net consumption over the billing period (imports minus exports). NEM is currently the most widely used form of compensation for customer generation in the U.S.

Challenges with Net Energy Metering

NEM generally provides significant bill savings to participating customers, but it may also create a cost shift for non-participating customers. Because NEM compensates all solar generation at the import rate, NEM tariffs will generally provide more bill savings than net energy billing or buy-all, sell-all tariffs, but would also generate greater cost shifts than those tariff designs.

Net Energy Billing (NEB)

Overview of Net Energy Billing

Under a Net Energy Billing (NEB, or "net billing") tariff design, the share of customer generation that is self-consumed on site can be used to reduce imports from the grid. However, exports to the grid are credited based on a distinct export rate, which is generally lower than the import rate and may be developed to reflect the value of solar to the electric grid or to society. Under this design, self-consumption is effectively credited at the import rate, while exports generate bill credits at the export rate. Net billing has been implemented in states including California, New York, and Hawaiʻi.

California introduced the Net Billing Tariff in 2022, colloquially referred to as "NEM 3.0."[92] Under California's Net Billing Tariff, California's investor-owned utilities compensate grid exports from customer generation based on the utility's hourly avoided costs plus a near-term incentive to support market transition.

In New York, some customer generation is compensated with the "Value Stack" tariff, also known as the Value of Distributed Energy Resources (VDER).[93] Like in California, the VDER tariff varies by hour to reflect the changing value of grid exports during different times.

Hawaiian Electric has separate compensation rates for customers with and without energy storage. Their Customer Grid-Supply Plus rate, for customers without energy storage, credits exports at a fixed value across all hours.[94] Hawaiian Electric's Smart Export rate, for customers with dispatchable energy storage, offers no credit for exports from 9:00 am to 4:00 pm, and a fixed value in all other hours.[95]

Challenges with Net Energy Billing

Net billing designs have been politically popular in some jurisdictions because they set compensation for grid exports based on the value of solar to the grid, while leaving in place the customer's ability to reduce

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[92] Net Billing Tariff, California Public Utilities Commission, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/customer-generation/nem-revisit/net-billing-tariff

[93] The Value Stack, New York State Energy Research and Development Authority, https://www.nyserda.ny.gov/All-Programs/NY-Sun/Contractors/Value-of-Distributed-Energy-Resources

[94] Customer Grid-Supply Plus, Hawaiian Electric, https://www.hawaiianelectric.com/products-and-services/customer-renewable-programs/rooftop-solar/net-energy-metering-plus/customer-grid-supply-plus

[95] Smart Export, Hawaiian Electric, https://www.hawaiianelectric.com/products-and-services/customer-renewable-programs/rooftop-solar/smart-export

their bills through self-consumption that occurs behind the meter. However, there are a number of potential challenges with net billing designs.

Due to the reduction in export compensation, participating customers will generally see smaller bill savings than under NEM tariffs. This will result in longer payback periods for customer solar systems.

Although net billing designs will generally reduce the cost shift relative to NEM, in jurisdictions with high import rates, net billing tariffs may still result in a cost shift from on-site self-consumption, especially for customers who pair a small battery in order to self-consume the majority of their solar generation and limit grid exports. Analysis of California's Net Billing Tariff has indicated that a solar+storage customer will still generate a significant cost shift of $1,100-$1,800 per year on average due to California's very high volumetric rates.[96]

A final challenge is that net billing tariffs provide "asymmetric" pricing for imports vs. exports, which does not facilitate optimal dispatch of demand-side resources. For example, under a net billing design, customers may be incentivized to dispatch a battery to maximize on-site self-consumption of solar energy. However, greater system benefits could potentially be achieved by discharging the battery during hours of greatest system need, even if that generates some amount of exports. Research has indicated that optimizing dispatch of distributed energy resources to generate the greatest system value may require "symmetric" rates that reflect time-differentiated system value for both imports and exports.[97]

Buy-All, Sell-All

Overview of Buy-All, Sell-All

"Buy-all, sell-all" is a tariff design where a customer-generator "buys" 100% of the electricity to serve their loads from the utility and sells 100% of their generation to the utility. The customer's import rate is used to price all electricity consumption, and a distinct export rate is used to price all electricity generation. Under a buy-all sell-all tariff, customers cannot self-consume generation on-site to reduce their electricity purchases from the utility. This tariff design requires independent metering of customer load and generation.

Buy-all, sell-all tariffs are uncommon for residential solar and have predominantly been used for distributed generation that is physically located front-of-meter rather, such as in programs like "virtual net metering" and community solar. In August 2023, the California Public Utilities Commission proposed a new buy-all sell-all tariff for multi-meter properties under the virtual net metering program. Under this program, a property owner installs solar behind the service point at a multifamily or multi-tenant commercial property and bill credits are allocated to the tenants.[98] Many community solar tariffs and other distributed generation projects are structured around tariffs under which the site owner sells all of

[96] CPUC Decision on the Net Billing Tariff, https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M500/K043/500043682.PDF

[97] CPUC CalFUSE proposal, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-response/demand-response-workshops/advanced-der---demand-flexibility-management/ed-white-paper---advanced-strategies-for-demand-flexibility-management.pdf

[98] Virtual Net Billing Tariff Proposed Decision, California Public Utilities Commission, https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M515/K973/515973905.PDF

the generation to a load-serving entity at a set pricing structure, without any assumed self-consumption or offsetting against customer load. For example, under New York's Value of Distributed Energy Resources (VDER) tariff, credits for community solar projects are calculated based on the solar "value stack" tariff for all generation.[99]

Although this report is not focused on community solar or virtual net metering, these examples were used because buy-all sell-all tariffs are uncommon for single-owner properties. This report does not intend to provide an overview of community solar tariffs.

Where buy-all, sell-all tariffs are designed with a rate based on the utility avoided costs for distributed solar, then solar compensation is equal to utility avoided costs and there is zero cost shift as defined here.

Challenges with Buy-All, Sell-All

Buy-all, sell-all tariffs have historically been limited to customer generation that is installed front-of-meter, such as in multi-unit buildings or in community solar installations. This may reflect regulators' hesitancy to restrict a customer's ability to offset their loads behind the meter in order to reduce their bills.

There are two additional customer-side challenges of buy-all, sell-all tariff designs for retail customers. First, buy-all, sell-all tariffs require customers to have a dedicated meter for the generation resource. Second, buy-all sell-all tariffs are likely to result in the lowest bill savings among NEM, NEB, and buy-all sell-all tariffs, as they do not enable any generation to be consumed on-site and compensated at the customer's import rate. This could significantly increase the payback period of solar installations relative to the other two tariff designs.

Transition to New Tariffs

In general, when jurisdictions introduce new tariffs for customer generation, these tariffs are applied to new customer-generators, *i.e.*, new customer solar adopters. Customer rates and rate designs are generally not guaranteed: rates will vary over time, and utilities may transition customers to new rate designs. However, existing customer-generators will generally be allowed to retain the legacy tariff structure, either indefinitely or for a period of time that would enable them to make back their upfront investment. As an example, if a jurisdiction transitions from NEM to Net Billing, existing customer generators may be allowed to retain the NEM structure for some period of time, although the specific rates they are on may change as rate levels increase over time and/or as the utility considers new rate options for different customer groups.

In addition, income-qualified groups may not be required to transition to new rate options at all. For example, the proposed virtual net billing tariff in California would retain the former NEM-like tariff design for the income-qualified program "Solar on Multifamily Affordable Housing."[100]

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[99] NYSERDA NY-Sun, "The Value Stack," https://www.nyserda.ny.gov/All-Programs/NY-Sun/Contractors/Value-of-Distributed-Energy-Resources

[100] Proposed Decision on Consumer Protections for Solar Customers, Multitenant and Multi-Property Solar Programs, and Implementation of Greenhouse Gas Standards for Fuel Cells, California Public Utilities Commission, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/net-energy-metering-nem/nemrevisit/vnem-pd-fact-sheet-update-111323.pdf

To support market transition, new tariffs may offer additional incentives or credits in initial years to ease the transition to the new design. These incentives or credits may be offered to all customers or may be differentiated for income-qualified customers. For example, California's Net Billing Tariff offers a transition credit to all customers, with a higher credit amount provided to low-income customers.[101]

Rate Design Components

Within the different tariff design structures, there are important considerations regarding the specific rate design components. These include considerations around the import rate, export rate, and other rate components.

Import Rates

Many utilities offer multiple rate options for residential customers. As new rates are introduced, utilities may offer customers the option to "opt out" and retain their old rates. Changing to a new rate option may result in some customers seeing bill decreases and others seeing bill increases. Although new rates will generally better reflect policy objectives, the option to opt out may help protect customers from adverse bill impacts, which is especially important for low-income customers.

Customer generation programs may require participants to adopt a specific rate in order to enroll. Regulators may expect that any adverse bill impacts due to a rate change would be more than offset by the bill savings from their new solar system. In this way, jurisdictions may see new customer generation tariffs as an opportunity to encourage or require new customer-generators to take service on import rates that are better aligned with policy goals. Requiring a specific import rate may be done as part of any of the three tariff designs: net metering, net billing, or buy-all sell-all.

As an example, California's investor-owned utilities have offered time-of-use rate options for nearly a decade. However, not all customers have been transitioned to these rates and customers may opt out of time-of-use rates to a traditional tiered rate option. When California enacted the NEM 2.0 tariff in 2016, the tariff required that participants be on time-of-use rates. Subsequently, when California enacted the Net Billing Tariff in 2023, participants were required to be on "electrification rates" with increased customer charges and larger peak/off-peak price differentials.

Export Rates

Net energy billing and buy-all sell-all tariffs both require the development of an export rate. Under net energy billing, this sets the price at which grid exports are credited. Under buy-all sell-all, this sets the price under which all solar generation is credited.

There are two basic approaches to developing export rates.

[101] Modernizing NEM to Meet California's Reliability and Climate Goals, California Public Utilities Commission, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/net-energy-metering-nem/nemrevisit/final-fact-sheet-nem.pdf

Export Rate as a Portion of the Import Rate

Export rates may be developed to reflect a portion of the import rate, *i.e.*, less than 100% of the import rate. This design is intended to reflect that exports offset only a share of the electric grid costs reflected in the retail rate.

One example is provided by California's "NEM 2.0" tariff, which, despite the name, was a net billing tariff. NEM 2.0 set the export rate as the import rate minus a set of "non-bypassable charges." The non-bypassable charges included public purpose program funding, securitization of costs from the 2001 energy crisis, and other line items. Because regulators recognized that these costs could not be avoided or reduced via customer solar generation, export compensation excluded these components of the retail rate.

Another example is California's local government self-generation bill credit program, which is a buy-all sell-all program for distributed generation owned by local governments.[102] Under this program, solar generation is credited based on the *generation* component of the retail rate, with no credits for the distribution or transmission components, nor for other line items.

It should be noted that, under a net billing design, excluding certain charges from the export rate would mean that customers could not bypass these charges via grid exports, but they *could* bypass these charges for solar generation consumed on-site, which is valued at the customer's import rate.

Export Rate Designed to Reflect Value of Solar

Alternatively, a new export rate can be designed to reflect the value of solar, either to the utility or to society. Some jurisdictions may choose to use a constant export rate across all hours of the year, reflecting the average value of solar. This approach may be easier for customers to understand though it does not provide time-varying price signals for customer battery dispatch. As an example, Sacramento Municipal Utility District (SMUD) in California has implemented a constant value of solar-based export rate of 7.4 cents per kWh, compared to volumetric import rates of roughly 15c/kWh.[103]

Alternatively, export rates can be time-varying in order to value grid exports differently at different times of day or in different seasons. For two examples, New York's Value of Distributed Energy Resources (VDER) tariff is a time-varying rate for grid exports, and California's Net Billing Tariff uses month-hour average values from the CA Avoided Cost Calculator (ACC) to set export rates. Both of these export rates vary across the hours of the year.[104] These rates aim to compensate projects for the benefits they provide to the grid, including utility cost components such as energy, capacity, and environmental values.

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[102] Pacific Gas and Electric, Local Government RES-BCT program, https://www.pge.com/en_US/for-our-business-partners/interconnection-renewables/export-power/distributed-generation-handbook/net-energy-metering/res-bct-program.page

[103] Solar and Storage Rate, Sacramento Municipal Utility District, https://www.smud.org/en/Rate-Information/Solar-and-Storage-Rate

[104] The Value Stack, New York State Energy Research and Development Authority, https://www.nyserda.ny.gov/All-Programs/NY-Sun/Contractors/Value-of-Distributed-Energy-Resources

California Avoided Cost Calculator, California Public Utility Commission, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/energy-efficiency/idsm

Not all time-varying rates change their compensation in each hour of the year. Hawaiian Electric's Smart Export rate, for customers with solar and energy storage, offers no credit for exports during solar hours when grid costs are low (from 9:00 am to 4:00 pm) and a fixed value in all other hours.[105] Other states such as South Carolina, North Carolina, and Michigan, have other examples of time-varying compensation that have recently been proposed or implemented.[106]

Some export rates include values for societal benefits that go beyond utility avoided costs. New York's VDER Tariff and California's Net Billing Tariff both include environmental benefits for greenhouse gas reductions that exceed regulatory costs for carbon emissions.

Finally, export rates may reflect other values to the grid or society. For example, VDER includes "Locational System Relief Value," which is a value added in certain utility-designated resource-constrained areas, and a "Community Credit," which is given to community customer generation projects.[107]

Other Rate Components

In addition to $/kWh import and export pricing, retail rates may include a number of rate components such as customer charges ($/month), demand charges ($/kW demand), grid participation charges ($/kW solar capacity), and other charges.

Customer charges ($/month), also called basic service charges, are generally included as part of the import rate. Customer charges reflect that a portion of utility costs do not vary based on changes in customer usage or demand. Larger customer charges recover a greater share of the revenue requirement, resulting in a smaller volumetric component of the rate. Historically, stakeholders have expressed concerns that higher customer charges may have adverse impacts on low-income customers, who may be smaller electricity users. A new proceeding in California is developing income-graduated fixed charges that would be smaller for lower-income customers.[108]

Demand charges are based on a customer's maximum usage over some time period, generally assessed based on the customer's highest-usage hour over the billing period, though there are many alternatives for how to assess customer demand. Historically, regulators have been hesitant to include demand charges in residential rates due to concerns that residential customers may not have a sophisticated understanding of their electricity usage and may be unable to manage their demand. However, some jurisdictions are considering introducing demand charges in residential retail rates. For example, the Hawaiʻi Public Utilities Commission is considering introducing demand charges into residential rates. Stakeholders in Hawaiʻi have also suggested that these demand charges could be "bi-directional," *i.e.*,

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[105] Smart Export, Hawaiian Electric, https://www.hawaiianelectric.com/products-and-services/customer-renewable-programs/rooftop-solar/smart-export

[106] 50 States of Solar (2021), NC Clean Energy Technology Center, https://nccleantech.ncsu.edu/the-50-states-reports/

[107] The Value Stack, New York State Energy Research and Development Authority, https://www.nyserda.ny.gov/All-Programs/NY-Sun/Contractors/Value-of-Distributed-Energy-Resources

California Avoided Cost Calculator, California Public Utility Commission, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/energy-efficiency/idsm

[108] CPUC Advanced Rate Design and Demand Flexibility Rulemaking, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-flexibility-rulemaking

assessed based on the customer's maximum demand in either direction (imported or exported).[109] Implementing demand charges requires customers to have interval or demand meters. Demand charges generally provide more benefit to customers who are better able to shift their electric usage into different hours. Customers with newer and more efficient devices, in particular smart devices programmed to reduce demand, are better prepared to benefit from demand-based rate designs. This customer segment is more likely to be high income.

Another rate component that may be included in customer generation tariffs is a grid participation charge, which is assessed based on the size of the customer's solar system and is meant to recover costs that are otherwise bypassed by customer solar owners. For example, NEM customers in New York State are subject to a Customer Benefit Contribution (CBC) charge to recover costs of public benefit programs, with the charge ranging from $0.59 to $1.33/kW-DC per month.[110] In California, an initial proposal for the Net Billing Tariff included a Grid Participation Charge of $8/kW-AC based on the size of the customer's solar system, though this charge was removed from the final Net Billing Tariff.

Recent Tariff Updates in Other Jurisdictions

The North Carolina Clean Energy Technology Center maintains a list of net metering successor tariffs across the United States, as documented in their regular reports[111] and in the Database of State Incentives for Renewables & Efficiency (DSIRE).[112] This section provides examples from additional jurisdictions that have updated their customer generation tariffs in the last couple of years.

- **Georgia (Georgia Power)**: Georgia Power offers a net billing tariff. Exports are compensated based on a solar avoided cost rate, currently 2.90 c/kWh, plus an additional 4 c/kWh for exports that was approved in the 2022 rate case.
- **Indiana**: In 2022, the large investor-owned utilities transitioned to a net billing tariff. Exports are compensated at 125% of average wholesale electricity prices from the prior year.
- **North Carolina (Duke Energy Carolinas, Duke Energy Progress)**: The North Caroliana Utilities Commission approved a new customer generation tariff for Duke Energy customers. Under this tariff, customers will be required to switch to time-of-use rates with monthly minimum bills. Customers will be able to net imports and exports based on the time-of-use valuation, and export credits may roll over to later months. This rate design would be classified as net billing with export credits based on the customer's TOU rate.
- **Florida**: In 2022, lawmakers passed legislation that would have established a net billing tariff, with export credits phasing down to an avoided cost rate over time. However, the governor vetoed the bill after its passage.

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[109] Hawai'i PUC, Decision and Order No. 38680, https://dms.puc.hawaii.gov/dms/DocumentViewer?pid=A1001001A22K01B04701A00323

[110] New York State NY-Sun Customer Benefit Contribution, https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Programs/NY-Sun/2023-Utility-Published-Customer-Benefit-Contribution-Rates.pdf

[111] 50 States of Solar (2022), NC Clean Energy Technology Center, https://nccleantech.ncsu.edu/the-50-states-reports/

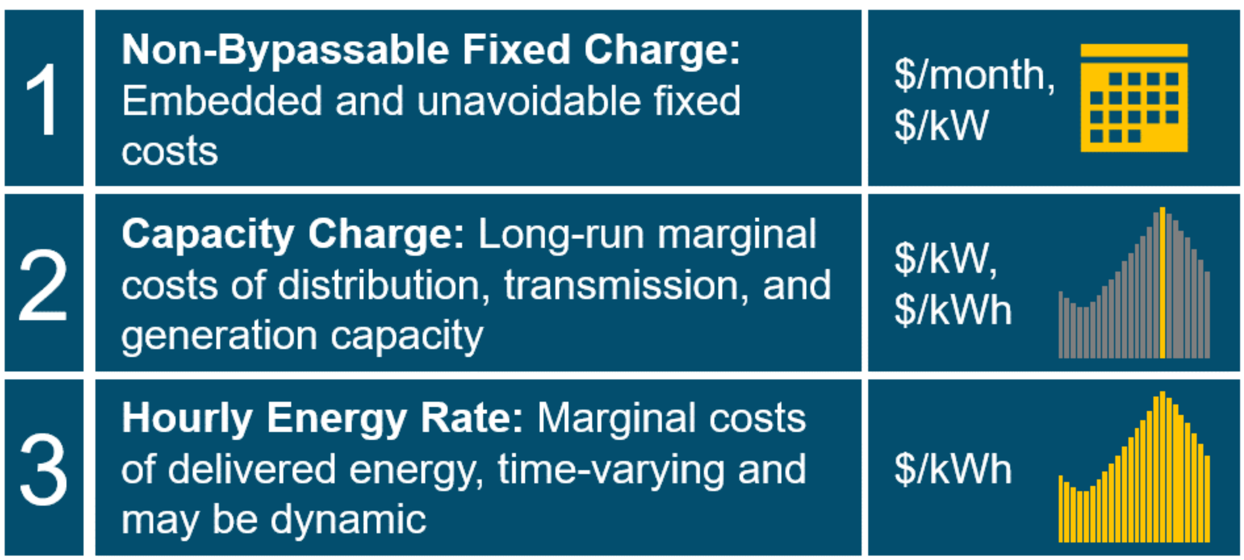
[112] Database of State Incentives for Renewables & Efficiency, NC Clean Energy Technology Center, https://www.dsireusa.org/

General Retail Rate Reform

The NEM cost shift arises because electric rates are misaligned with utility costs. Thus, an alternative approach to reducing the cost shift is to update general retail rates to better align with system costs.

As a conceptual bookend, a cost-based rate design, with volumetric prices based on utility short-run marginal costs, would result in no cost shift. Cost-based rates are often referred to as “three-part rates.” The first component is a non-bypassable fixed charge designed to recover utility embedded and unavoidable fixed costs. This charge may be assessed as a customer charge, size-based charge, demand-based charge, income-based charge, or other options. The second component is a set of charges to recover long-run marginal distribution, transmission, and generation capacity costs. These capacity charges could be assessed as demand charges ($/kW) or expressed as per-kWh adders during critical hours. The final part is an hourly energy rate ($/kWh) reflective of the marginal costs of delivered energy. The energy rate would be time-varying and may be dynamic, *i.e.*, based on actual wholesale pricing. Figure 30 provides a description of cost-based rate design.

Figure 30. Cost-based Rate Design Aligns Rates with Utility Costs



Many economists argue that a shift toward cost-based rates, with greater recovery of fixed and long-run marginal costs outside of volumetric charges, can enable more equitable and efficient customer adoption and dispatch of distributed resources.[113,114,115,116,117,118,119,120] These rates could also promote affordability by offering significant discounts on fixed charge components to low-income customers while still providing efficient price signals for distributed resource adoption and dispatch decisions.

There are important concerns with cost-based rates. They can be complicated for customers to understand, they may increase bills for small users depending on the size of fixed charges, and they would reduce incentives for conservation outside of critical hours. In addition, rates with dynamic pricing would likely increase bill volatility, and would require planning and oversight to provide adequate customer protections.

Cost-based rates have not historically been used in the residential sector, but large commercial customers are more likely to see rates with considerable customer and demand charges and with volumetric charges much closer to the marginal price of delivered energy. For example, Puget Sound Energy's Large Demand General Service rate has a monthly customer charge, a per-kW demand charge, and a per-kWh energy charge.

While utilities are unlikely to move immediately to fully cost-based rates, near-term rate changes may include increases in fixed and/or demand-based charges to reflect the embedded and long-run marginal costs of the grid. Although not without challenges, these changes would reduce the volumetric rate, better align with system costs, and ultimately reduce the cost shift. This approach could be taken while retaining NEM or could be coupled with a transition in tariff design (*e.g.*, to net billing).

Next Steps for Tariff Options

As policy goals shift, some jurisdictions have re-evaluated their tariffs for compensation of customer generation. Misalignment between retail electric rates and utility costs leads to a cost shift. Some jurisdictions are considering tariff options that can maintain a sustainable solar market while reducing the cost shift.

Different tariff design options may be considered for customer generation. There are three broad categories of tariffs for customer generation: net energy metering, net energy billing, and buy-all, sell-all.

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[113] Rate Design for a DER Future, AEE (Advanced Energy Economy), https://info.aee.net/hubfs/PDF/Rate-Design.pdf

[114] Full Value Tariff Design and Retail Rate Choices, Energy and Environmental Economics, https://www.ethree.com/wp-content/uploads/2016/12/Full-Value-Tariff-Design-and-Retail-Rate-Choices.pdf

[115] "Optimizing Prices for Small-Scale Distributed Generation Resources: A Review of Principles and Design Elements, Amparo Nieto, https://doi.org/10.1016/j.tej.2016.03.004

[116] CPUC CalFUSE Proposal, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/demand-response/demand-response-workshops/advanced-der---demand-flexibility-management/ed-white-paper---advanced-strategies-for-demand-flexibility-management.pdf

[117] Rate Design for the Energy Transition, Olson et al., https://www.esig.energy/wp-content/uploads/2023/04/ESIG-Retail-Pricing-dynamic-rates-E3-wp-2023.pdf

[118] Smart Electric Power Alliance, 2019. Residential Electric Vehicle Time-Varying Rates That Work: Attributes That Increase Enrollment, https://sepapower.org/resource/residentialelectric-vehicle-time-varying-rates-that-work-attributes-that-increase-enrollment/

[119] Zinaman, Bowen, and Aznar, 2020, An Overview of Behind-the-Meter Solar-Plus-Storage Regulatory Design, https://www.nrel.gov/docs/

[120] Borenstein, Fowlie, and Sallee, 2021, Designing Electricity Rates for An Equitable Energy Transition, https://haas.berkeley.edu/wp-content/uploads/WP314.pdf

Under net energy billing and buy-all, sell-all, export rates can be designed to remove non-bypassable costs from export compensation, or novel export rates can be developed to reflect the value of solar to the electric grid or to society.

Shifting to more cost-reflective retail rates would reduce cost shifting under net energy metering. As an alternative approach or in parallel, changes can be made to default retail rates to better align with system costs. Cost-based rates would have lower volumetric charges aligned with the marginal cost of delivered energy, and greater fixed and capacity-based components to reflect fixed and long-run marginal costs. A shift toward cost-based rates would reduce the NEM cost shift.

Washington State legislators have different options. If the state maintains current policies, then as utilities reach their net metering capacity minimum, they may develop their own successor tariffs, with investor-owned utilities filing the new tariffs with the Utilities and Transportation Commission for approval. Alternatively, Washington could choose to expand the current NEM program, requiring utilities to offer NEM to a greater number of customers. Finally, Washington could choose a new tariff design that would apply statewide as the successor to NEM.

Conclusions

This study provides an evaluation of NEM solar in Washington State with the goal of informing future policy proposals regarding customer solar in Washington. To prepare this analysis, E3 worked with Gridworks and the Technical Advisory Group to develop a robust catalog of benefits and costs of customer solar. Next, E3 worked with a group of utilities to assemble key data on NEM solar systems in Washington. E3 developed a model to evaluate NEM solar from different perspectives including the NEM customer (participant) perspective, the utility ratepayer perspective, and the societal perspective. E3 also reviewed customer generation tariff design in other U.S. jurisdictions to provide examples of how other states are approaching compensation for customer-generators.

The key findings of this study are:

+ **Customer solar systems interconnected under Washington's current NEM programs can provide significant benefits to participants through bill savings.** This study estimates first-year bill savings ranging from about $750 to nearly $1,200 per year among the utilities studied, based on a representative residential 7 kW-AC system. **Participant Cost Test (PCT) results for a representative residential 7 kW-AC system range from 0.72 to 0.99 among the utilities studied, indicating that, assuming a 7% nominal discount rate and 25-year lifetime, lifecycle benefits are less than or nearly equal to the lifecycle costs for a customer solar adopter across the six detailed study utilities.** While at face value, this metric would indicate it is not cost-effective for customers to adopt solar under NEM in Washington, participants may also see additional non-monetary benefits that are not captured quantitatively in this study, and these may influence solar adoption decisions. Additionally, customer discount rates and financial opportunity costs may be different from the 7% discount rate assumed for this study.
+ **Ratepayer Impact Measure (RIM) results for a representative residential 7 kW-AC system range from 0.23 to 0.56, indicating that, from the ratepayer perspective, the lifetime benefits from NEM solar adoption are less than the lifetime costs.** This outcome is expected because retail rate compensation under NEM is higher than cost savings for the electricity system.
+ Solar customer compensation through NEM significantly exceeds the value of customer solar to the system, resulting in a cost shift from solar to non-solar customers. **The total residential cost shift is forecast to be $39M/year by the end of 2024, and estimated to grow to $49M/year by 2030 under a linear growth rate and assuming the current legislative NEM minimum remains in place. If the legislative NEM minimum were removed, the cost shift is forecast to grow to $67M/year by 2030 under a linear growth rate, or to $136M/year by 2030 under a compound growth rate.** Bill impacts for representative low-income customers are forecast to be $0.39-$2.27/month in 2024 and grow to $0.95-$2.59/month by 2030 if the legislative NEM minimum remains in place. If the legislative NEM minimum were removed, 2030 bill impacts would be $0.95-$16.52/month assuming linear growth of NEM solar or $1.76-$24.80/month assuming compound annual growth.
+ NEM solar provides additional societal value beyond that which accrues directly to ratepayers. **Additional societal benefits quantified in this study include reduced criteria pollutant emissions, reduced greenhouse gas emissions, and reduced land use impacts. The Societal**

Cost Test (SCT) results for a representative 7 kW-AC system range from 0.50 to 0.64, indicating that on average, lifetime benefits are less than the lifetime costs for society. There are a variety of means to achieve the utility avoided costs and other societal benefits quantified in this study, including NEM solar, utility-scale solar and other renewables, energy efficiency, demand response, and others. Note that utility-scale resources would not achieve avoided land use or avoided T&D benefits.

+ **Washington State legislators have different options for NEM solar.** If the state maintains current policies, then as utilities reach their net metering capacity minimum, they may develop their own successor tariffs, with investor-owned utilities filing the new tariffs with the Utilities and Transportation Commission for approval. If legislators instead opt to pursue a new tariff design that would apply statewide, this report includes examples of how some other U.S. jurisdictions have approached tariff design for customer generation.

Table 14 shows the 2024 residential cost shift ($/year) for an example residential 7 kW-AC system for each of the detailed study utilities.

Table 14: 2024 Residential Cost Shift ($/year) by Utility for an Example 7 kW-AC System

	Avista	Inland Power	Kittitas PUD	Puget Sound Energy	Seattle City Light	Snohomish PUD
2024 Cost Shift ($/year) Example 7-kW System	$570	$240	$560	$690	$990	$640

Table 15 shows a comparison of the utility avoided costs, societal benefits, and NEM compensation in 2024. NEM solar generates benefits for the utility and its ratepayers (*i.e.*, utility avoided costs) of about 2.0-4.8 cents/kWh. In addition, NEM solar generates societal benefits of about 1.2-3.6 cents/kWh. Under NEM, residential participants are compensated at 7.0-13.5 cents/kWh.

Table 15. 2024 Utility Avoided Costs, Societal Benefits, and NEM Compensation (2024 cents/kWh)

(2024 c/kWh)	Category	Utility: Avista	Utility: Inland Power	Utility: Kittitas PUD	Utility: Puget Sound Energy	Utility: Seattle City Light	Utility: Snohomish PUD
Utility Avoided Costs	Wholesale Energy Market Purchases	1.18	0.24	0.09	1.27	0.00	0.00
	Generation Capacity	0.10	0.02	0.01	0.10	0.00	0.00
	Clean Energy Purchases	2.50	3.78	3.99	2.39	0.00	0.00
	Fuel Price Risk	0.25	0.00	0.00	0.27	0.00	0.00
	BPA Tier 1	0.00	0.00	0.00	0.00	4.00	3.96
	BPA Energy Balancing Adjustment	0.00	0.00	0.00	0.00	-0.87	-0.65
	BPA Generation Capacity Adjustment	0.00	0.00	0.00	0.00	-1.34	-1.09
	Transmission and Distribution	0.34	0.14	0.15	0.45	0.19	0.15
	Clean Energy Transmission	0.36	0.54	0.57	0.34	0.00	0.00
	Total: Utility Avoided Costs	**4.73**	**4.72**	**4.81**	**4.81**	**1.98**	**2.35**
Societal Benefits	Reduced Criteria Pollutant Emissions	0.47	0.10	0.04	0.51	0.03	0.04
	Reduced Land Impacts	0.63	0.95	1.01	0.60	1.01	1.01
	GHG Savings (Societal)	2.39	0.49	0.19	2.53	0.15	0.18
	Total: Additional Societal Benefits	**3.49**	**1.55**	**1.24**	**3.64**	**1.19**	**1.22**
Compensation Under NEM	**NEM Customer Bill Savings**	**10.13**	**7.00**	**9.78**	**12.63**	**13.46**	**9.95**

Appendix A.

A.1. Total Resource Cost Test Results

The Total Resource Cost (TRC) Test evaluates the benefits and costs to all utility ratepayers, including participants and nonparticipants, over the lifetime of the solar system installation (modeled to be 25 years, spanning 2024-2048). The TRC is similar to the Societal Cost Test (SCT) but does not consider quantified environmental or health benefits that do not accrue as monetized value to utility ratepayers. Figure 31 below depicts the benefits and costs included in the TRC. The benefits in the TRC are federal incentives and utility avoided costs. The costs in the TRC are the upfront costs of solar systems and inverter replacement costs.

Figure 31. Benefits and Costs Included in the Total Resource Cost (TRC) Test

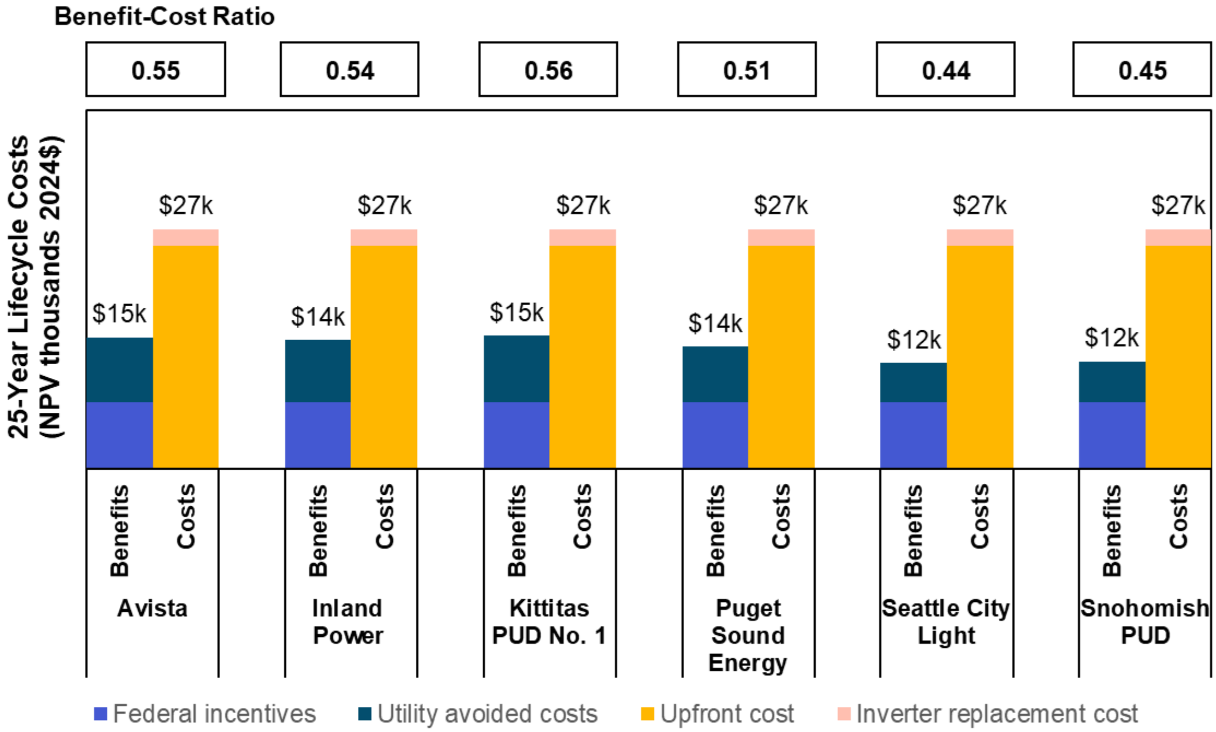
	Total Resource Cost (TRC)	
	Benefits	Costs
Bill Savings / Solar Customer Compensation		
Upfront Cost		X
Inverter Replacement Cost		X
Interconnection Fee		
Federal Incentives	X	
Utility Avoided Costs	X	
Other Societal Benefits		

Figure 32 shows the TRC results based on an example residential 7 kW-AC system, which was approximately the average system size for residential customers across the six detailed study utilities. Benefits and costs are lifecycle net present value (NPV) $/system values over the assumed 25-year lifetime of the solar system.

Similar to the SCT, the TRC includes the federal investment tax credit as a benefit because more NEM solar development in Washington State would bring a greater amount of federal tax credits to residents of Washington State without appreciably increasing the tax burden for taxpayers in the state. Note that it may be optimistic to assume that all customers receive the federal ITC because customers without tax liability may not qualify for the full tax credit.

Federal incentives, upfront costs, and inverter replacement costs do not vary by utility, while utility avoided costs do vary by utility. The benefit-cost ratio ranges from 0.44 (Seattle City Light) to 0.56 (Kittitas PUD), indicating that on average, lifetime benefits are less than the lifetime costs for the full class of utility ratepayers.

Figure 32. Total Resource Cost (TRC) Test by Utility for an Example 7 kW-AC System



A.2. Low-Income Program Participation

Table 16 summarizes the share of residential NEM customers and the share of total residential customers that are enrolled in low-income bill assistance programs provided by three of the detailed study utilities. The bill assistance programs of focus here include: Puget Sound Energy's Home Energy Lifetime Program (HELP),[121] which offers qualifying customers a bill credit of up to $1,000 depending on income level; Seattle City Light's Utility Discount Program (UDP),[122] which offers qualifying customers a 60% monthly bill discount; and Snohomish PUD's Income Qualified Assistance Rate Discount,[123] which offers qualifying customers bill discounts of 25% or 50% depending on income level. Based on the customer level data provided the utilities, 0.5% of PSE's residential NEM customers are enrolled in HELP, around 1.2% of SCL's residential NEM customers are enrolled in UDP, and 0.3% of Snohomish PUD's residential NEM customers are enrolled in the Income Qualified Assistance Rate Discount. The shares are similar when reporting by share of capacity.

For additional context, comparing 2020 total low-income program participation reported by the Washington State Department of Commerce[124] to the 2020 total residential retail utility customers reported in EIA Form 861[125]: 1.9% of Puget Sound Energy's residential customers were enrolled in HELP; 11.0% of Seattle City Light residential customers were enrolled in UDP, and 4.7% of Snohomish PUD's residential customers were enrolled in the Income Qualified Assistance Rate Discount program.

Table 16. Residential NEM Customers and Total Residential Customers Enrolled in Low-Income Bill Assistance Programs

	# of Residential NEM Customers (2023)			# of Total Residential Customers (2020)		
Utility	Enrolled	Total Residential NEM	Share of Total Residential NEM	Enrolled	Total Residential	Share of Total Residential
Puget Sound Energy	81	15,216	0.5%	19,670	1,039,596	1.9%
Seattle City Light	85	6,977	1.2%	46,974	426,359	11.0%
Snohomish PUD	12	3,750	0.3%	15,418	327,512	4.7%

Note: Utility-specific low-income programs included here are Puget Sound Energy's Home Energy Lifetime Program (HELP), Seattle City Light's Utility Discount Program (UDP), and Snohomish PUD's Income Qualified Assistance Rate Discount. Residential NEM Customers data provided by detailed study utilities; total residential customer data publically available from the Washington State Department of Commerce and the U.S. Energy Information Administration.

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121 https://www.pse.com/en/account-and-billing/assistance-programs/HELP
122 https://www.seattle.gov/utilities/your-services/discounts-and-incentives/utility-discount-program
123 https://www.snopud.com/account/financial-assistance/bill-assistance/
124 https://www.commerce.wa.gov/growing-the-economy/energy/ceta/ceta-energy-assistance/
125 https://www.eia.gov/electricity/data/eia861/

A.3. Technical Advisory Group Comments

Washington Department of Commerce

1. *I saw that you included the % of installs that are in highly impacted census tracts for the detailed study utilities. Is it possible to provide the % of NEM customers who are low-income or are participating in utility discount programs? I know the report must avoid disclosing any sensitive customer information but if it is possible to provide that figure across all 6 detailed study utilities, it would be helpful.*

   Response: While E3 does not have data for the percentage of NEM customers who are low-income, three of the detailed study utilities provided data for NEM customers participating in utility bill discount programs. Please see **Appendix A.2.** for a summary of this information.

2. *I wanted to flag the statement that, "from a utility avoided cost perspective, there is little difference in benefits and costs to the utility for energy consumed behind the meter vs. energy that is exported". As we heard during the last discussion, there is a tendency to assume real time, onsite consumption of generated electricity is more beneficial than exports. Is the impact on the distribution system from BTM solar consumed onsite versus exported negligible? Does this account for any feeder capacity constraints?*

   Response: Whether solar generation is consumed behind the meter or is exported to the grid, the effect is the same. The impact to the utility avoided costs occurs because customer generation reduces the need for the utility to procure energy and other grid services. Hour-by-hour changes in whether solar generation is consumed on-site versus exported to the grid should not affect the distribution grid: as part of the interconnection process for a customer solar system, a utility will ensure that the distribution system can handle the full export from the solar system. This report includes these points in the **Ratepayer Benefits and Costs Methodology** section.

3. *We noted the weighting for conventional energy (1 - % clean) but lack of weighting for BPA Tier 1. As you will see in Washington's fuel mix report, some of BPA customer utilities electricity comes from "unspecified" sources. For example, Inland Power, is 12.28% unspecified power in 2021. Since the generation facility and fuel source information is not known, we can't assume those resources are 100% renewable so the statement that "All BPA-reliant utilities have 100% renewable generation as of 2021 per their Washington Department of Commerce disclosures" should be amended.*

   Response: E3 appreciates this feedback and revised the final analysis such that the "unspecified" sources are treated as fossil fuel resources. Please see the **Utility Avoided Cost Framework** section of this report for a detailed description of the methodology.

4. *Can you clarify how you are treating utilities that aren't served 100% by BPA Tier 1 rates? For example, Snohomish PUD and Seattle City Light. Does the utility avoided cost framework account for utilities using Tier 1 BPA and conventional resources?*

   Response: For Snohomish PUD and Seattle City Light specifically, BPA Tier 1 rates are used to represent the marginal resource until they have exceeded their Tier 1 allocation. NEM solar will change these utilities' Net Requirements, which will change their allocation of Tier 1 energy. Thus, Tier 1 energy is the marginal energy resource for these utilities. When they exceed their Tier 1 allocation (and similarly for Inland Power and Light and Kittitas PUD who use Tier 1 but already exceed the allocation), BPA Tier 2 energy is the resource on the margin and the methodology for this calculation is based on the percent of energy from renewable or conventional fossil fuel resources. The **Utility Avoided Cost Framework** section of this report describes the methodology in more detail.

5. *Does the estimated low-income bill impact reflect bill discounts that utilities are provided? Since for the IOUs, the percentage of discount provided increases for lower levels of income, are the impacts shown for a median income qualified customer post-discount?*

   Response: The low-income bill impact shown in this study does not reflect bill discounts. The **Residential Rate and Low-Income Bill Impacts** section of the report notes that the analysis does not include these discounts, and the bill impacts would be lower for customers who are enrolled in bill discount programs.

6. *As I shared previously, Commerce's most recent fuel mix disclosure and GHG content report clarifies that "Unspecified power purchase" refers to power purchases where the generation facility and fuel source information is not known. The "Initial Percent Clean Energy" on the Avoided Cost Calculator and any related statements need to be updated. It currently indicates that SCL, SnoPUD, Inland, and Kittitas are all 100% clean energy. Per the report for calendar year 2021, each utility's share of unspecified power is as follows: SCL: 3.55%, SnoPUD: 4.41%, Inland 12.28%, and Kittitas: 4.75%.*

   Response: E3 appreciates this feedback and revised the final analysis such that the "unspecified" sources are treated as fossil fuel resources. Please see the **Utility Avoided Cost Framework** section of this report for a detailed description of the methodology.

7. *The following statement needs to be edited: Any utility that reaches their NEM generating capacity minimum before 2029 may propose a new successor tariff to file with the Utilities and Transportation Commission for approval. Per RCW 80.60.020, IOUs must file with the UTC but COUs can separately develop a standard rate or tariff (not subject to UTC approval).*

   Response: E3 appreciates this feedback. The **Review of Customer Generation Tariff Design in Other U.S. Jurisdictions** section of this report is revised to reflect this comment.

8. *Why is the LCOE for utility scale solar for Inland and Kittitas ~2X the LCOE for utility scale solar for Avista and PSE? The methodology seems to indicate this would be a set number for utility scale solar in Eastern WA which would make more sense to me.*

   Response: The base LCOE for utility-scale solar applied to both Inland Power and Light and Kittitas PUD is the same; however, the LCOE is scaled by the share of energy coming from clean energy resources. For Avista and PSE, that share is only about half of that of Inland and Kittitas in early years, though for all utilities this share scales up to 100% by 2030. The **Utility Avoided Cost Framework** section of this report describes this methodology in more detail.

9. *Why is the avoided costs NPV (2024 $/kW) in the RIM test and in the Excel model lower for PSE than for Kittitas whereas the simple average avoided costs is higher for PSE than Kittitas?*

   Response: The avoided costs are presented in cents per kWh of energy produced. In this framing, PSE has slightly higher avoided costs than Kittitas PUD. However, to achieve values in $/kW-year applicable to a NEM solar system, these values are adjusted based on the capacity factor of NEM solar. Because a NEM solar system of the same kW size would be expected to produce more energy if cited in Kittitas territory compared to PSE territory, the $/kW-year avoided cost is higher for Kittitas than PSE. This final report presents avoided cost results in cents/kWh to reduce potential confusion in displaying results with different units.

10. *Relatedly, I'm trying to understand why the trends for the avoided costs by utility NOM $/kW-yr versus the avoided costs by utility NOM $/MWh are so different. In the first, Kittitas has the highest avoided costs while in the second, PSE has the highest avoided costs.*

    Response: This is due to the $/kW-yr avoided costs accounting for the capacity factor and differences in expected solar production of NEM solar sited in each utility's service area. Because the capacity factor for NEM solar is highest if sited in Kittitas territory, the scalar applied to get from $/MWh to $/kW-yr is higher and increases its avoided costs relative to the other utilities. This final report presents avoided cost results in cents/kWh to reduce potential confusion in displaying results with different units.

11. *Can you also help me understand why the RIM results are shown in $/kW? I had assumed everything would be based on energy since NEM provides credits on a kWh basis.*

    Response: E3 acknowledges that the cost test results are more easily understood with a different unit basis. The final cost test results in this report are reported on a $/system basis, based on a representative 7 kW-AC average system size for the detailed study utilities.

Natural Resources Defense Council

1. *Consider referring to the NAS study in the review of tariff options. The study recommendations and the memo are aligned and that reference may make the memo stronger. Check out the link*

to the NAS study, and look at the public briefing slides for a quick overview: https://nap.nationalacademies.org/resource/26704/Net-Metering-Briefing-Slides.pdf

Response: E3 appreciates this recommendation from NRDC and added a reference to this study to the **Review of Customer Generation Tariff Design in Other U.S. Jurisdictions**.

Spark Northwest and Northwest Energy Coalition

1. *Abbreviated study timeline: House Bill ("HB") 1427 was introduced but did not pass during the 2023 legislative session. Among several proposals to address the future of NEM in Washington, HB 1427 would have required that a value of solar and cost shift study be conducted by the Department of Commerce, in consultation with the UTC and a workgroup of interested parties. Requirements of this study, similar to those in the utility-funded NEM evaluation conducted by E3, were described in HB 1427. However, HB 1427 required that the study be completed by July 1, 2025 and that a report be delivered to the Legislature by December 31, 2025. From the end the 2023 legislative session in April 2023, HB 1427's study would have offered a timeline of about two-and-a-half years. This is approximately four times the duration of the E3 study. From the onset we were concerned that the E3 study's relatively short timeline could lead to methodological issues, incomplete data collection, limited literature review, and insufficient stakeholder engagement. Please see below for further explanation as to how we believe the brief timeline of this study has impacted the final outcome.*
2. *Incomplete TAG Recruitment: We recognize and truly appreciate that the TAG was created separately and not convened by E3 or the study utilities. Our initial concern with the creation of the TAG coincides with the brevity of the study. The TAG for such a critical solar study should represent a broad group of interested parties— including but not limited to the rooftop solar industry, agricultural farms, environmental justice advocates, labor unions, consumer advocates, the department of labor and industries, rural communities, and tribes. However, each of these groups, particularly the voices of tribes, were missing from the TAG. This is likely due to how quickly the group was put together. A quickly formed and convened advisory group does not provide adequate time for engaging with all interested parties, incorporating their perspectives, and ensuring that the study addresses key concerns and considerations from various perspectives.*
3. *Lack of Community Perspective: Our final concern is for the lack of community perspective included in the final result, particularly the lack of input from environmental justice and low-income communities and Tribes, all of whom are in the very early stages of accessing net metered solar.*

Response to Comments 1-3: E3 appreciates the feedback on the study timeline, TAG recruitment, and community perspective. E3 recognizes that the study timeline was shorter than some stakeholders may have preferred, but the timeline was sufficient to develop a robust analysis of the costs and benefits of NEM solar in Washington. Despite the timeline, Gridworks succeeded in hosting three productive TAG meetings with a diverse group of stakeholders and perspectives, as well as offering other venues for feedback such as office hours and feedback via email.

4. *Concerns on Lack of Benefits: This study has made clear that NEM solar can create costs to consumers and society. The study does not capture the myriad of consumer, societal, and environmental benefits associated with NEM solar. The TAG was asked to provide a list of benefits associated with NEM solar, but the benefits listed by the TAG are not included in the draft report. The exclusion of benefits, including the following priority benefits, may cause policymakers who do not have specific expertise in distributed energy resources to assume that NEM solar creates societal and consumer costs without providing critical benefits.*

   Response: E3 acknowledges that there are numerous consumer, societal, and environmental benefits associated with NEM solar. This study considers *all* participant, ratepayer, and societal benefits and costs suggested by the TAG, which are summarized in Table 5 and Table 6 in the **Evaluation of NEM Solar Benefits and Costs** section of this report. E3 quantified benefits and costs where possible and provided a qualitative evaluation of the remaining benefits and costs.

5. *Net metered solar preserves tribal land and resources – less solar being forced onto tribal lands. Self-generation can preserve tribal resources and increase tribal sovereignty.*

   We are very disappointed that this benefit was not included in this NEM evaluation study. In Washington State, tribal sovereignty, collaboration, and approval are paramount to the advancement of an equitable and just clean energy transition. In its draft results, E3 said that "[n]et benefits or costs cannot be determined without in-depth conversation with tribes that are affected by these developments." We wholeheartedly agree and emphasize that the necessary in-depth conversations and collaboration with willing tribes would have been feasible and advantageous given a longer study duration.

   Furthermore, E3 stated that it can't "quantify a dollar amount and instead recognizes the further potential benefit provided by NEM solar". This statement makes it clear that, while it wasn't included in this study, the perspective of tribes and the value that NEM solar provides to tribes is essential to a comprehensive statewide NEM evaluation.

   Response: E3 acknowledges this as a potential benefit of NEM solar and included it as a qualitative benefit, which is described in the following section of this report: **Preserve Tribal Lands and Resources and Increase Tribal Sovereignty**. E3 recognizes that renewable energy has the potential to provide a wide array of benefits and harms to Tribal nations. Since there are both benefits and harms involved in these projects, the net benefits or costs cannot be determined without in-depth conversations with Tribes that are affected by these developments. For these reasons, E3 was not able to quantify this benefit within the benefit-cost analysis framework but agrees that it is an important topic for future research.

6. *Net metered solar increases awareness around clean energy, because it is tangible and visible to neighbors and the public. It raises public awareness for energy issues; onsite generation might encourage residential storage; it can be a driver for electrification; and it can reduce the need for demand reduction. The study excluded this benefit because E3 is unaware of methods to quantify and monetize this benefit. This is another benefit that could have potentially been quantified or assessed further with additional time. Alternatively, closer collaboration with the TAG could have resulted in a different metric that could have been used to assess this benefit or an adder that could have been included to give weight to the "hard-to-quantify" benefits.*

   Response: E3 acknowledges increased public awareness as a benefit of NEM solar and included it as a qualitative benefit, which is described in the following section of this report: **Increased Public Awareness for Energy Issues**. E3 recognizes the value that this type of increased engagement can provide to customers and, by extension, the local community or society more broadly. However, E3 is not aware of any methods to quantify a dollar amount on such values and no such methods or prior studies in other jurisdictions were provided by stakeholders.

7. *Net metering incentivizes small-scale projects that create local green jobs, apprenticeship opportunities, local living wage employment, and training in the electrical field.*
   Living wage green jobs and apprenticeships are essential to enabling a just clean energy transition that NEM and solar are a part of.

   In its reasoning for excluding the local employment benefit, E3 said it is "unable to isolate the marginal economic impacts of an increase in customer solar without a larger macroeconomic model". Once again, we believe that additional time would have resulted in a method to quantify the benefits of living wage green jobs and apprenticeships for Washington communities. As referenced by E3, a larger macroeconomic model could have been explored with more time.

   A tool that we offer for this work is the Interstate Renewable Energy Council's ("IREC") annual "National Solar Jobs Census". In its 2022 report, IREC found that "residential solar jobs [in the United States] grew by 11%, or about 9,500 jobs" and that over 70 percent of these jobs were at installation and project development firms and in operations and maintenance (https://irecusa.org/census-executive-summary/). All of which offer local employment opportunities. In Washington, solar jobs grew nearly 20% since 2017 (https://irecusa.org/census-solar-jobs-by-state/). Resources like this IREC report should be used to estimate local employment benefits from residential solar as opposed to leaving this benefit out entirely.

   Response: E3 acknowledges local employment benefits as a benefit of NEM solar and included it as a qualitative benefit, which is described in the **Local Employment** section of this report. E3 is unable to isolate the marginal economic benefits of labor that would not be captured through employment in other industries without a macroeconomic model such as REMI or IMPLAN, which is beyond the scope of this study. E3 appreciates Spark Northwest and the Northwest Energy Coalition pointing out the IREC annual "National Solar Jobs Census" resource, and included this resource as part of the qualitative discussion in this report. However, it is important for macroeconomic studies to consider both the *direct* impacts of a particular measure (e.g., solar installer jobs) and the *indirect* impacts (loss of jobs elsewhere in the economy due to higher electric rates, which requires in-depth macroeconomic analysis beyond simply estimating the direct employment impact.

8. *Investment in disadvantaged communities – jobs and local spending in disadvantaged communities. While it is true that some historically excluded communities "don't currently see significant benefits from participating in NEM due to low adoption in these communities," it is important to consider the broader and long-term advantages that can arise from increased participation. The exclusion of this benefit showcases the dire need to hear from historically excluded communities about their experiences and ideas for quantifying or developing a proxy to represent this benefit. At the very least, E3's NEM evaluation should do more to acknowledge the lack of significant measurement and representation of the benefits that NEM directs towards Washington's named communities.*

   Response: E3 acknowledges investment in disadvantaged communities as an important benefit that can arise from increased participation in these communities. However, since low-income and disadvantaged communities are currently more likely to be non-participating customers and see impacts of the cost shift rather than the benefits of installing solar, Washington's current NEM program is unlikely to provide net economic benefits to disadvantaged communities. Additional details are included in the section **Investment in Disadvantaged Communities**.

Washington Solar Energy Industries Association

Comments on the Review of Tariff Options in Other U.S. Jurisdictions

1. *Figure 25: For California, the report shows the results from the Avoided Cost Calculator. However, the results from this calculator are disputed by many parties. The ACC was adopted in a separate proceeding where it was not identified as being a key component of the upcoming reform to the California's net energy metering (NEM) tariff.*

   In the next round of ACC updates, significant revisions are expected. The ACC arrives at avoided cost values that are only about half of what the utilities themselves calculate in their rate case filings. This large discrepancy further undermines the validity of these findings.

   Avoided costs calculated for the Washington utilities using a similar methodology (as E3 prepared California's ACC model) will likely have significant issues as well.

   Response: The California Avoided Cost Calculator is developed as part of a public proceeding at the California Public Utilities Commission and reflects feedback from numerous stakeholder groups. The Washington avoided costs were developed as part of this study.

2. *Figure 29: The diagram is too simplistic in showing the power flow. The imports first come from remote generation, then through the transmission system, then the local distribution network*

which should be shown with multiple customers. The exports then flow from the customer generator's rooftop to neighbors on the local circuit. None of that power flows back up to the transmission system which is not used at all by the customer-generator when exporting electricity.

NEM customers should be paying nothing for the transmission system for their power exported. The combination of self-consumption and exports represents transmission capacity freed for generation to be sent to other customers.

Response: Figure 29 is not meant to reflect power flow and is instead a simplification to illustrate self-consumption, imports, and exports.

3. *The* ***Overview of Net Energy Billing*** *section lists three specific states with non-NEM tariffs, yet the* ***Net Energy Metering (NEM)*** *section states "NEM is currently the most widely used form of compensation for customer generation in the U.S." The section fails to 1) list all of the states with NEM tariffs, 2) identify where states have reviewed those NEM tariffs and made minimal or no changes (e.g., Kentucky) and 3) describe what if any revisions have been made to those tariffs. The* ***Recent Tariff Updates in Other Jurisdictions*** *section does list three more states where NEM tariffs have been revised, including two to net billing tariffs. Only four states total currently have a net billing structure.*

   The fact is that a preponderance of states, especially those with low adoption rates similar to Washington's, have not acted to revise their NEM tariffs.

   Further, the report states "NEM generally provides significant bill savings to participating customers, but it may also create a large cost shift for non-participating customers." The report fails to define what "large" means. Is 0.3% "large"? Is 1.4% "large"? Is 44 cents per month "large"? Is even $2.43 per month "large"? Most people lose that much money in pocket change each month. Those are the values shown for 2024 estimated residential rate impacts in Washington Utilities NEM Evaluation, Draft Results*. The fact is that for most states, the purported "cost shift" is similarly small. Without a definitive threshold for "large" this statement is meaningless to the reader, and even deceptive given the context in Washington.*

   In addition, the same can be said of energy conservation and efficiency which reduces utilities' loads and shifts costs from participating customers to nonparticipating customers, at least in the short term, even when it provides overall savings. That the customers that invest in energy savings receive the lion's share of financial gains is consistent with incentivizing these investments.

   Response: This report notes that most states have NEM tariffs. Based on this feedback from WASEIA, E3 added a list of all states with NEM tariffs. With that said, the focus of the review of tariff options is to provide examples of non-NEM tariffs in other U.S. jurisdictions. E3 appreciates WASEIA raising the point about the use of "large" and revised the text to remove words like "large" and "small" that do not provide context for the magnitude of the value.

4. *The report states without supporting evidence "(m)any community solar tariffs and other distributed generation projects are structured around tariffs under which the site owner sells all of the generation to a load-serving entity at a set pricing structure, without any assumed self-consumption or offsetting against customer load." Again, the definition of "many" is lacking. There are many states with community solar tariffs that successfully encourage much more development than states like California where residential solar has been the focus. This report should review the tariffs being offered in those states.[126] Many of the states are also in the northern tier with solar insolation similar to Washington.*

   A notable observation is that California's adoption of the buy-all/sell-all tariff for virtual NEM and aggregated NEM projects is likely to kill any further interest in those projects as currently structured.[127] The consequence of this approach cannot be underestimated.

   Response: This section of the report intends to provide examples of buy-all, sell-all, rather than a summary of community solar tariffs. E3 added additional context to this section to note that this study is not focused on community solar, but includes this as an example of where buy-all, sell-all tariffs have been implemented.

5. *The report asserts "(m)any economists argue that a shift toward cost-based rates, with greater recovery of fixed and long-run marginal costs outside of volumetric charges, can enable more equitable and efficient customer adoption and dispatch of distributed resources." That statement then lists five citations, of which at least two are self-references to E3 documents. The fact is that many economists dispute the need for large capacity charges beyond the direct service connection (which costs $10-$20 per month) and relying on hourly energy market rates as "cost based." The Regulatory Assistance Project is one such organization that has published reports contradicting this assertion.[128] This statement should be deleted from the report as biased and unsubstantiated.*

   Response: E3 appreciates this feedback. The final report adds other citations to this statement. This section of the report is not meant to argue that large capacity charges are needed, but instead to note that cost-based rates with a reduced volumetric component are one type of alternative tariff design that would reduce the cost shift from NEM.

6. *While about a half dozen states have modified their NEM tariffs, many more have either left those tariffs untouched or made minor tweaks. Unfortunately, this report emphasizes those*

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[126] See for more information: https://www.energysage.com/community-solar/comparing-top-community-solar-states/ and https://ilsr.org/nationalcommunity-solar-programs-tracker/

[127] Jeff St. John, "California's rooftop solar policy is killing its rooftop solar industry," Canary Media, California's rooftop solar policy is killing its rooftop solar industry, December 1, 2023

[128] See https://www.raponline.org/

small number that have acted rather than the large number that have remained with the existing business-as-usual approach.

There is no justification provided for including a statement about shifting to "cost-reflective" retail rates. Beyond a small number of citations, several being self-referential, E3 has not presented any supporting analysis to come to that conclusion. This paragraph should be deleted.

Response: This report notes that most states have NEM tariffs. Based on this feedback from WASEIA, E3 added a list of all states with NEM tariffs to the text of the **Net Energy Metering** section. With that said, the focus of the review of tariff options section is to provide examples of non-NEM tariffs in other U.S. jurisdictions. E3 appreciates WASEIA raising the point about the citations and has included additional references. This section of the report is not meant to argue that large capacity charges are needed, but instead to note that cost-based rates with a reduced volumetric component are one type of alternative tariff option that would reduce the cost shift from NEM.

Comments on Draft Results

1. *Questions about the study framing: The study's first issue is its framing. It was initially put forward as a cost-shift analysis, but then the authors began to bolt onto their work elements of a value of distributed solar study. The mix of different perspectives used in the analysis reflects this confusion. The split focus of the authors between cost shift, and value of distributed solar, results in three possible frames—they should choose one:*
   i. *A classic cost of service study that takes the current system and revenue requirements as static, assumes that it has been built out optimally, and applies standard cost allocation factors to determine customer revenue responsibility. This type of study ignores the past benefits created through displaced infrastructure investment and lower energy consumption so it overestimates the actual cost shift that has occurred.*
   ii. *An assessment of future costs and benefits, with changes in resources and investments, and projected customer usage and resource options. This framing is implied by the use of forecasted 2030 prices in the study. Unfortunately, the report's approach fails to acknowledge that the current investments by customers are sunk costs based on expectations about utility rates at the time the solar was installed.*
   iii. *An assessment of historic costs and benefits using contemporaneous market values and avoided investments as well as changes in customer usage and resources. This framing is implied in the report by the use of historic customer and DER installation data such as costs. To execute this framing completely the authors would have needed to use historic forecasts and costs. This latter element is missing from this study.*

The study's methodology uses forecasted 2030 generation market prices, current rooftop solar costs with no accounting for projected cost reductions, which are then applied to increasing solar installations. There is no accounting for displaced infrastructure, resources (e.g., energy efficiency spending) and greenhouse gas (GHG) emissions in the past. Mix and matching as the *authors have, leads the study to an overestimation of the cost-shift, and wide misses of the other elements of the value of distributed solar.*

An important missing element includes changes in the electricity market environments, e.g., increased addition of batteries and rate designs that better address time and location costs/benefits. The value of distributed solar in the past when these installation decisions were made is not the same as the value going forward. We encourage the authors to make that distinction.

Response: The scope of this study was shared with TAG members at the first TAG meeting. As described in the **Introduction** section, this study aims to evaluate the benefits and costs of a solar system interconnected today under NEM, and to understand how the benefits and costs for NEM solar, as well as the cost shift, would evolve over time as more customers adopt NEM solar. E3 believes that the methodology used in this study is appropriate for addressing these questions and disputes the assertion that the study "mixes and matches" among a set of valid but mutually exclusive potential framings for such a study. E3 agrees that the value of distributed solar will change with changes in electricity market environments. Since this evaluation is focused on Washington's current NEM programs, the study does not consider existing or future non-NEM tariffs, time-of-use (TOU) rates, or solar paired with battery storage.

2. *A cost-shift study is not a value of distributed solar study: A cost-shift study is a ratepayer-impact measure (RIM) or a "no loser" test. This perspective is clearly the motivation and emphasis of this study. Ironically RIM tests are no longer used for energy conservation or efficiency measures in Washington. Instead, Washington uses the total resource cost test (which is defined to match a societal cost test) as a primary assessment, and utility cost as a secondary test.[129] Importantly, distributed solar generation is defined as energy conservation in Washington State law for public buildings.[130] Given these legal specifications, this study does not conform with the standard for evidentiary analysis in this state. The report at a minimum should acknowledge upfront its failure to follow the specifications required.*

   Response: To provide results for different perspectives, this evaluation used four Standard Practice Manual (SPM) cost tests including the PCT, RIM, TRC, and SCT. The cost shift metric is one of several metrics produced for this evaluation, which are described in the **NEM Evaluation Model** section of this report. E3 appreciates WASEIA raising the point about Washington's use of the TRC and has added this point to the **NEM Evaluation Model** section of

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[129] See ACEEE, "State and Local Policy Database: Evaluation, Measurement & Verification," https://database.aceee.org/state/evaluation-measurement-verification

[130] RCW 43.19.670 - Energy conservation—Definitions (3) "Energy conservation measure" means an installation or modification of an installation in a facility which is primarily intended to reduce energy consumption or allow the use of an alternative energy source, including: (e) Solar space heating or cooling systems, solar electric generating systems, or any combination thereof; (f) Solar water heating systems; https://app.leg.wa.gov/rcw/default.aspx?cite=43.19.670

this report. This study provides the TRC among many other metrics, and E3 disputes the claim that the report "does not conform with the standard for evidentiary analysis."

3. *The State's energy efficiency programs would fail the ratepayer impact test using this methodology: We might for example apply this cost-shift perspective to energy efficiency program spending by the three investor-owned utilities (IOUs) in the state. Because the benefiting customers are a small portion of the total customer base, there is a cost shift from those customers through the utility rebates to other non-participating customers. Avista, Pacific Power and Puget Sound Energy (PSE) collectively are spending $175 million to reduce energy loads by 379,000 megawatt-hours (MWH).[131] Using an expected average life of 10 years[132] and PSE's cost of capital,[133] the average utility contribution is $66.23 per MWH. The NEM Avoided Costs Model developed for the report shows an avoided cost value for 2023 of $40.56 per MWH. That gives a net cost to ratepayers of $25.67 per MWH in direct payments, resulting in direct payment from non-participants to participants of these energy efficiency programs of $9.7 million per year.*

   Additionally, then there are the lost sales revenues that are foregone contributions to the "fixed" transmission and distribution costs. Again, other customers would have to pick up those cost obligations using the rationale in the study. Applying PSE's average rate and subtracting the avoided costs, the avoided bill payments amount to $31.5 million. All of that spending from energy efficiency programs are in fact a "cost shift" from all ratepayers to a small group of ratepayers who benefit through reduced bills.

   In total the apparent cost shift is $41.2 million in 2023 for just the three IOUs' ratepayers. That would easily exceed the $43 million purportedly, as per the study, shifted from customer-generators to noncustomer-generators. Why do the authors of this study not push for a significant revision of the state's energy efficiency programs due to the apparent inequity? Because increasing energy efficiency investment is one of the cornerstones of the State's climate action policies.

   This study purports to assess cost shifts from net metered solar, but, as illustrated by using energy efficiency programs, it does not actually do that at all. The study conflates the concepts of cost shift and revenue shift. A cost shift is when one set of ratepayers pays more to benefit another set of ratepayers. Most utility conservation programs include both cost shift and revenue shift. The cost shift is in the form of fees assessed to all ratepayers to subsidize conservation measures for some ratepayers. This is considered acceptable in order to accomplish the social good of reducing energy consumption. The reduced energy consumption results in reduced energy sales and thus revenue for the utility, which is the revenue shift.

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131 See https://www.utc.wa.gov/consumers/energy/company-conservation-programs

132 Rachel Gold and Seth Nowak, "Energy Efficiency over Time: Measuring and Valuing Lifetime Energy Savings in Policy and Planning," American Council for an Energy-Efficient Economy, Report U1902, https://www.aceee.org/sites/default/files/publications/researchreports/u1902.pdf, February 2019

133 PSE 2023 10Q, https://fintel.io/doc/sec-puget-energy-inc-wa-81100-10q-2023-may-11-19488-2216

As a form of conservation, net metered solar reduces energy consumption from the grid and thus utility revenue. This should be considered a benefit as it is with other conservation measures, not a cost. Additionally, unlike other conservation methods, net metered solar provides this benefit with no fees assessed to other ratepayers. This study calculates the magnitude of the conservation benefit of net metered solar, but then asserts that it is not a benefit, but a cost shift. An honest assessment of any ratepayer costs from NEM systems would include actual utility costs, not reduced sales from unsubsidized conservation.

The underlying premise of this study revives the opposition raised by utilities in the 1970s opposing conservation efforts because of high fixed costs and the supposed immutability of the grid. As Washington has demonstrated by maintaining rates below the national average, while implementing one of the most aggressive energy-efficiency efforts, the utility system is actually quite malleable over the long run. Virtually all system costs can be displaced through reduced energy use, and this study must acknowledge this fundamental lesson from the last 40 years.

Response: These comments argue that NEM solar is a form of conservation and should be viewed equivalently. As noted here and in the section **NEM Evaluation Model**, load reduction measures generally lead to net costs under a ratepayer impact measure (RIM) perspective, and this holds for conservation measures as well as customer solar. WASEIA noted above that the total cost perspective is generally used to evaluate such measures, using tests like the Total Resource Cost Test (TRC) or Societal Cost Test (SCT). Conservation measures may show net benefits under these perspectives, indicating that the total benefits to all utility customers exceed the costs of these measures. However, in this evaluation, NEM solar is found to have net costs under both the TRC and SCT, indicating that the costs to all utility customers exceed the benefits. E3 disputes the claim that "virtually all system costs can be displaced through reduced energy use" for two reasons:

1. A significant share of utility costs can only be avoided if load reduction (or customer generation) occurs during high-load hours for the system. While some conservation measures may reduce load in these hours, this study finds that NEM solar provides relatively little generation during high-load hours, leading to low avoided costs for distribution and transmission capacity and for generation capacity, as described in the section **Utility Avoided Cost Components**.
2. Under CETA, Washington State must equitably decarbonize energy use in the state by 2045. Over the next 22 years, a significant amount of utility costs will reflect the recovery of costs for assets that have already been built, such as the costs for existing transmission and distribution infrastructure. These "sunk" costs are not avoidable for the utility and its ratepayers and cannot be displaced through reduced energy use. Both conservation measures and NEM solar may affect who pays for these investments, but will not be able to avoid the recovery of "sunk" costs for existing infrastructure.

4. *A value of solar study requires a much more deliberative approach: Going beyond the question of whether a cost-shift/ratepayer impact study is a valid evaluation tool, this study is not structured as a value of distributed solar study, but it really wants to be. The initial study format did not include many acknowledged benefits of either distributed or grid-scale solar, even going so far as to assume that the entire state's utility grid would be entirely GHG-free by 2030 and that the hydropower system has no significant environmental impacts. This ignores the facts. The rest of the Western Interconnect, including California, is relying on Pacific Northwest (PNW) generation to reduce its GHG emissions after 2030, and that the Columbia River system is the focus of fisheries restoration efforts including the potential decommissioning of the Snake River dams.*

   This oversight arises from two factors. First the Technical Advisory Group (TAG) was given a few weeks to gather a list of possible benefits, without sufficient time or resources to document those benefits. Second, the E3 authors appear to give only cursory consideration to the TAG's list, often rejecting them simply because they would be too difficult to quantify in the short time given for the study. The TAG suggested many sources for the E3 team to research, but none of that information appears to have been used.

   E3's failing to use benefits of distributed solar and storage highlights why this cannot be considered a full value of distributed solar study. This process was not provided the necessary time and resources. Other value of solar studies in Oregon and Minnesota have been multi-year efforts. The utility consortium, in their commissioning of this study, allowed only four months.

   Conclusions about which resources are preferred cannot be drawn from an incomplete cost-shift study that does not meet the requirements of a value of distributed solar study. Washington State statute requires that the type of conclusions put forward in this report be supported by a full integrated resource plan (IRP), not a "back of envelope" study that focuses on a single resource.[134]

   Response: E3 recognizes that the study timeline was shorter than some stakeholders may have preferred, but the timeline was sufficient to develop a robust analysis of the costs and benefits of NEM solar in Washington. Despite the timeline, Gridworks succeeded in hosting three productive TAG meetings with a diverse group of stakeholders and perspectives, as well as offering other venues for feedback such as office hours and feedback via email. E3 has worked to be responsive to TAG feedback, and this study includes the quantification of two benefit categories based on feedback from WASEIA. For more details, see the sections **Clean Energy Transmission** and **Fuel Price Risk Avoided Costs**.

5. *The study asserts that NEM customers have acted irrationally: Equally problematic is the study's finding that customer-generators (or prosumers) are not making rational decisions by*

[134] See RCW 19.280.030: Development of a resource plan—Requirements of a resource plan—Clean energy action plan. http://app.leg.wa.gov/RCW/default.aspx?cite=19.280.030.12

choosing to install rooftop solar because it is a money loser for them under E3's analysis. The Participant Cost Test (PCT) Results shows that for every example utility, customer generators would have been better off to avoid becoming a customer-generator. Clearly the authors are missing the broader motives of NEM customers which might be to reduce environmental impacts, or the comfort of future bill stability. E3 is missing these customers' expectations, and asserting that customers' choices are not a valid basis for assessing the benefits that accrue to participants. This is an analyst who puts themselves in the place of a consumer, and declares that the consumer is consistently making a bad choice. A more likely conclusion would be that the analyst does not have the full picture of the choices being made.

Response: E3 agrees that NEM customers may have multiple motives that influence their decision to adopt solar. Assuming a 7% nominal discount rate and 25-year lifetime, this evaluation finds that lifecycle financial benefits are less than or nearly equal to the lifecycle costs for a customer solar adopter across the six detailed study utilities. However, participants may also see additional non-monetary benefits that are not captured in the PCT, and these may influence solar adoption decisions. Additionally, their economic opportunity costs may be different than the 7% discount rate used here. These points are mentioned in the **Participant Cost Test Results** section of this report.

6. *Missing risk hedging values, and overlooked hydropower flexibility improvements: The study uses forecasted 2030 Mid-Columbia market hub prices to determine avoided costs. But those prices can be quite volatile, both within the year and across years. Distributed solar allows customer-generators and utilities to limit exposure to that volatility which hedges their risk. How to value this risk hedging is well understood in financial economics and is the basis for a large segment of the financial markets in options and futures. Despite being provided with references on the topic by the TAG, the study's authors have ignored this benefit.*[135]

   A study from Rocky Mountain Institute (2012) sets out one method for calculating the volatility cost of natural gas-powered electricity, which is the primary source for energy setting the market clearing price in the Mid-Columbia market. That study found the hidden cost of market volatility in market gas price appears to be $1.50 to $2.50 per MMBtu. Assuming a thermal efficiency or "heat rate" for the marginal use of gas in the electricity market of 7,500 British thermal units per kilowatt-hour (BTU per kWh), that translates to an additional 1.125 to 1.875 cents per kWh or $11.25 to $18.75 per megawatt-hour (MWH) provided by distributed solar.

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[135] These references were provided but not included or expanded on in the study: https://rmi.org/wp-content/uploads/2017/05/RMI_Document_Repository_Public-Reprts_2012-07_WindNaturalGasVolatility.pdf; https://rmi.org/hot-air-cheapnatural-gas/; https://rmi.org/blog_managing_natural_gas_volatility_the_answer_is_blowin_in_the_wind/. In fact, E3 personnel published a study on the risk premium embedded in forward prices in the Mid-Columbia hub in 2011: Andrew DeBenedictis et al, "How Big Is the Risk Premium in an Electricity Forward Price? Evidence from the Pacific Northwest," The Electricity Journal, 24:3, pp. 72-6, https://www.sciencedirect.com/science/article/abs/pii/S1040619011000601, April 2011. The TAG expected E3 to conduct further research on its own and expand this analysis since it should have all of the expertise and data required to calculate this hedging value.

Other customers on a customer-generator's respective utility benefit from this load reduction. That in turn reduces the prices in the Mid-Columbia market paid on all load served from that market, in turn reducing their exposure to market volatility. The E3 study is therefore failing to account for what is called a "pecuniary externality" where a reduction in overall market prices is created by the investments made by customer-generators. Quantifying that added value requires more complete system modeling than was conducted in this study.

Customers relying on full-requirement deliveries by the Bonneville Power Administration (BPA) could possibly assert that they are not exposed to this volatility because they have a fixed price contract. This unfortunately ignores the effects of climate change and drought in the Pacific Northwest. Volatility coming from the variability in hydro availability is substantial and needs to be accounted for in the same manner as gas price volatility. Northwest utilities' witnesses asserted in proceedings at the Federal Energy Regulatory Commission in 2002 that the Western energy crisis of 2000-2001 was triggered by the BPA declaring a shortfall of firm energy in May 2000.[136] The run on those markets illustrates the volatility that all customers face.

The prosumer's "assist" to this dilemma is ignored in the study. While a portion of the state's hydro plants are run of river, the largest plants such as Grand Coulee and BC Hydro's Revelstoke and Mica Dams[137] are managed to provide both summer exports to the rest of the Western Interconnect and irrigation to Columbia Basin farmers.[138] Increased solar generation from customer-generators reduces Pacific Northwest loads, improves flexibility, and also allows those plants to either export more power to California, thus reducing customer rates, or release more water at times that can enhance fisheries. As drafted, this study ignores the market reality that the state, and the region as a whole, is interacting with the Western Interconnect as a whole. Prosumers have a role to play in this future. Studying the prosumer's value will take significant time and resources, and the authors are encouraged to acknowledge this massive oversight in their work.

Response: E3 appreciates this feedback**.** Based on the resources provided by WASEIA, this study includes an avoided cost component corresponding to reduced fuel price risk. Details are available in the section **Fuel Price Risk Avoided Costs**. With respect to market price effects, most Washington utilities are net sellers of power on wholesale electricity markets, hence lower wholesale electricity prices lead to higher retail electricity rates. All utilities are required under CETA to achieve a greenhouse gas neutral electricity supply, which will largely eliminate any benefit or cost associated with lower wholesale electricity market prices. The purported impacts on hydropower operations are speculative, and in any event are not materially different from the impact of utility scale solar.

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[136] M.Cubed partner Richard McCann testified on behalf of the California Parties, including on the issue of hydropower availability

[137] The BC Hydro complex is operated in coordination with the U.S. hydro fleet under the Columbia River Treaty and must be considered as a single system

[138] https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/community/columbia-river-operations-summary-fall-2020.pdf

7. *The forward-looking perspective overlooks the shifting of loads to summer peaks and the benefits of reducing those peaks afforded by distributed solar: The heat dome of 2021 highlighted an important trend—that the PNW utility system is becoming dual winter/summer peaking. Average summertime highs in Seattle and Portland have risen substantially over the last 40 years*[139] *with the number of days over 70 degrees increasing 50% and 90 degree days doubling during the 2010s compared to previous decades.*[140] *More households are installing air conditioning as a result.*[141] *Winter temperatures have risen commensurately which leads to reduced heating loads. Average highs have risen 1.8 degrees since the 1970s and the average lows have risen 1.7 degrees over the same period.*[142] *The number of days below 32 degrees has fallen by a third in the last decade.*[143] *It is getting hotter in the PNW. This trend is not reflected in the modeling conducted for this study. That leads to a substantial undervaluation of distributed solar generation by E3.*

   Transmission and Distribution shows the solar generation profile (which is the same for rooftop and grid-scale solar) and compares it to grid peak load cost allocation factors. Those allocators may be valid for the distribution system based on historic data, but as discussed above, the region is now going beyond historic conditions and peak loads will rise in July and August.[144] *Rooftop solar can defer when circuits become summer peaking through local supplies. That value is not reflected in the study.*

   Figure 29 can be corrected to show how the power flow from rooftop solar is isolated to the local distribution circuit and avoids using transmission. The imports first come from remote generation, then through the transmission system, then the local distribution network which should be shown with multiple customers. Most of the solar output is used to meet household loads and never leaves the customer site. The remainder is exported, flowing from the customer-generator to neighboring local circuit. None of that power flows back up to the transmission network which is not used at being used at that time by the exporting customer-generator. NEM customers should be paying nothing for the transmission system as it relates to their exported power. The combination of self-consumption and exports represents transmission capacity freed for generation to be sent to other customers. This value is completely ignored in the E3 study.

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[139] In the last 10 years, eight rank among the top 10 with number of days over 80 degrees. https://www.extremeweatherwatch.com/cities/seattle/yearly-days-of-80-degrees. Number of days over 90 degrees exceeded eight before 2015 only once but has been eight or higher in five years since 2015. https://www.extremeweatherwatch.com/cities/seattle/yearly-days-of-90degrees

[140] https://www.currentresults.com/Weather-Decades/USA/WA/Seattle/temperature-average-by-decade-seattle.php

[141] "The rise in Seattle's 90-degree days, charted all the way back to 1945," Seattle Times, https://www.seattletimes.com/seattle-news/data/the-rise-in-seattles-90-degree-days-charted-all-the-way-back-to-1945/, July 27, 2022

[142] https://www.currentresults.com/Weather-Decades/USA/WA/Seattle/temperature-average-by-decade-seattle.php

[143] https://www.currentresults.com/Weather-Decades/USA/WA/Seattle/temperature-average-by-decade-seattle.php

[144] As an important note, San Diego Gas and Electric went from being a winter peaking utility as late as the early 1980s to a summer peaking utility within 20 years

Response: E3 appreciates this feedback. While air conditioning usage and climate impacts may drive greater summer loads, it is also true that widespread building electrification to support decarbonization goals would lead to significant growth in winter loads. PSE and Avista have forecasted seasonal loads in their IRPs. Both IRPs show significant growth in both summer and winter peak loads, although both IRPs show a winter peak load greater than the summer peak load throughout the entire period through 2045.[145,146] In addition, summer-peaking jurisdictions like California find that the gross peak occurs around 5:00 PM, by which time solar energy is generating at relatively low levels, and that the net peak may occur later still. For these reasons, NEM solar is unlikely to contribute significantly to system capacity needs during peak load hours.

8. *California's experience shows the value of distributed solar: Distributed solar generation installed under California's net energy metering (NEM/NEMA) programs has mitigated and even eliminated load and demand growth in areas with established customers. This benefit supports protecting the investments that have been made by existing customer-generators. Similarly, prosumers can displace investment in distribution assets. That distribution planners are not considering this impact appropriately is not an excuse for failing to value this benefit for the purposes of this study. For example, Pacific Gas and Electric's sales fell by 5% from 2010 to 2018 and other utilities had similar declines. Peak loads in the CAISO balancing authority reach their highest point in 2006, and the peak in August 2020 under exceptional conditions was 6% below that level.*[147]

   A closer look at California illustrates that much of that decrease appears to have been driven by the installation of rooftop solar. The figure below illustrates the trends in CAISO peak loads in the set of top lines and the relationship to added NEM/NEMA installations in the lower corner. It also shows the CEC's forecast from its 2005 Integrated Energy Policy Report as the top line. Prior to 2006, the CAISO peak was growing at annual rate of 0.97%; after 2006, peak loads have declined at a 0.28% trend. Over the same period, solar NEM capacity grew by over 9,200 megawatts. The correlation factor or "R-squared" between the decline in peak load after 2006 and the incremental NEM additions is 0.93, with 1.0 being perfect correlation. Based on these calculations, NEM capacity has deferred 6,500 megawatts of capacity additions over this period. Comparing the "extreme" 2020 peak to the average conditions load forecast from 2005, the load reduction is over 11,500 megawatts. The obvious conclusion is that these investments by Californian NEM customers have saved all ratepayers both reliability and

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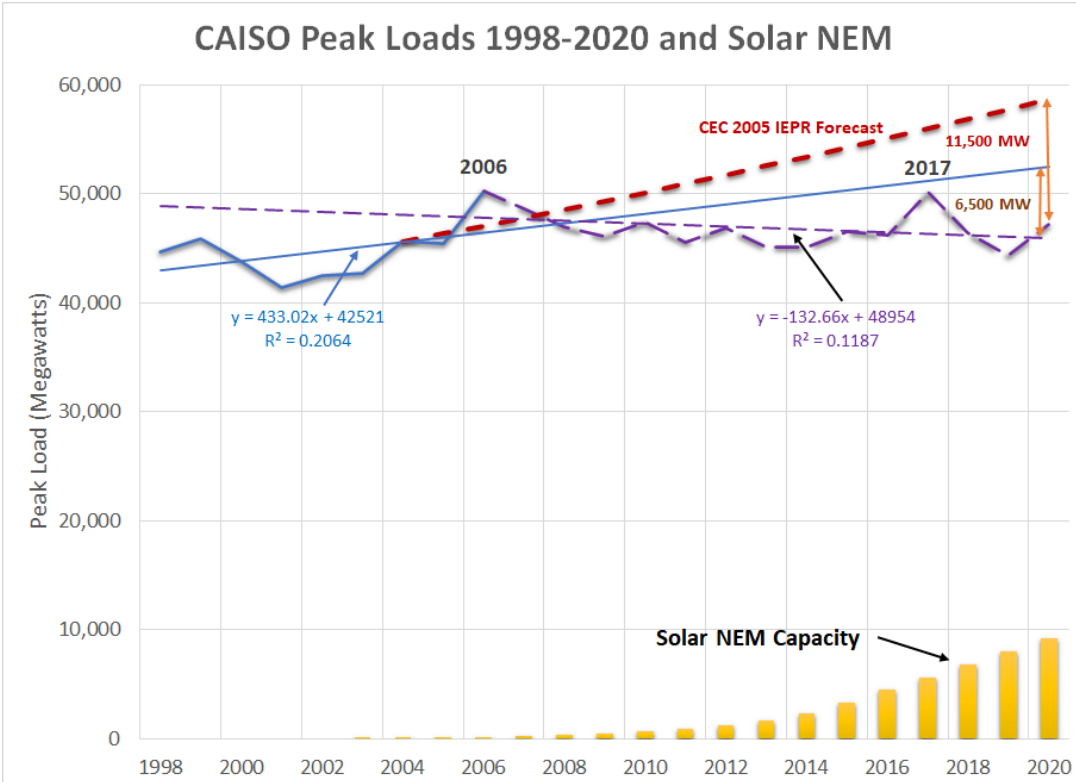
[145] PSE 2023 Electric Progress Report, Chapter Six: Demand Forecast. https://www.pse.com/-/media/PDFs/IRP/2023/electric/chapters/06_EPR23_Ch6_Final.pdf?sc_lang=en&modified=20230331182920&hash=52BD0586A96719FE92757E21A6719734

[146] Avista 2023 Electric IRP. https://www.myavista.com/-/media/myavista/content-documents/about-us/our-company/irp-documents/2023/2023-electric-irp-final-w-cover.pdf

[147] The peak in September 2022 that falls outside of the analysis period was created by exceptional one-in-35 year weather conditions and still less than 4% above the previous record

energy costs while delivering zero-carbon energy. Washington can expect similar benefits if rooftop solar is allowed to flourish.



Response: E3 agrees that very high levels of NEM solar adoption in California have led to lower electricity sales. This study evaluates the extent to which NEM solar adoption in Washington would lead to avoided capacity costs, both for generation capacity and T&D capacity. Because NEM solar output is not correlated with peak generation or distribution loads in Washington, the generation capacity and T&D capacity savings from NEM solar adoption are relatively small.

9. *Avoidable transmission costs are underestimated: The "heat map" misrepresents the loads on Washington's transmission system. Distribution is installed to meet increases in customer connections and loads, and those circuits are connected via feeders to substations. Those increased loads are often offset by decreased loads on other circuits so that system loads do not increase. In the PNW, peak and energy loads have been flat since 2000, reflecting this geographic shifting.*[148]

On the utility's end, if needed, generation is added to meet increased loads, and then transmission is added to convey that generation to substations. Added transmission is rarely motivated by increased loads without associated incremental generation capacity. The

[148] See NPPC: https://www.nwcouncil.org/2021powerplan_historic-trends-energy-use/

incremental cost of new transmission is determined by the installation of new generation capacity as transmission delivers power to substations before it is then distributed to customers. For this reason, marginal transmission costs must be attributed to generation.

The report's heat map chart does not include perhaps the largest single load on the transmission system-the export of hydropower during the summer peak down the Pacific Intertie. That is because the chart relies entirely on local loads and ignores the larger wholesale market. Focusing on generation instead would show a different focus for transmission versus distribution.

The cost of transmission for new generation has become a more salient issue.[149] *The appropriate metric for distributed solar is therefore the long-term value of displaced transmission. Using similar methodologies for calculating this cost in the CAISO and PJM balancing authorities, the incremental cost in both independent system operators is $37 per megawatt-hour or 3.7 cents per kilowatt-hour.*[150] *This added cost about doubles the cost of utility-scale renewables compared to distributed resources. The rapid rise in transmission rates over the last decade are consistent with these findings. If economies of scale did hold for the transmission network, those rates should be stable or falling. This amount should be used to calculate the net benefits for the prosumer avoiding the need for additional transmission investment by providing local resources rather than remote bulk generation.*

E3 asserts without evidence that it had not seen large transmission costs associated with renewables in Washington. The reason is understandable—the state has added only about 700 MW of grid scale wind and solar power since 2014. In comparison, California has added more than 20,000 MW of solar alone over the same period.[151] *To meets its ambitious GHG reduction targets, Washington will have to install a commensurate amount of renewables, distributed and/or grid scale.*

Response: E3 appreciates this feedback**.** E3 continues to believe that bulk transmission needs for utility scale solar will be relatively modest in the Pacific Northwest because solar energy production does not occur during the peak demand periods for which the transmission system is sized, meaning that capacity will be available during the hours when solar is generating. However, based on this feedback, the final analysis incorporates an avoided cost component for "clean energy transmission" in addition to the load-driven avoided transmission costs that

[149] Doug Karpa, "Exploding transmission costs are the missing story in California's regionalization debate," Utility Dive, https://www.utilitydive.com/news/exploding-transmission-costs-are-the-missing-story-in-californias-regional/526894/, July 5, 2018

[150] "Testimony of Richard McCann, Ph.D. on Behalf of the Agricultural Energy Consumers Association and the California Farm Bureau Federation," CPUC Rulemaking 20-08-020, June 18, 2021, pp. 15-16; and "Prepared Supplemental Testimony Of Richard McCann, Ph.D on Behalf of the Kentucky Solar Energy Industry Association," before the Public Service Commission of the Commonwealth of Kentucky, Kentucky Power Company Case No. 2020-00174, February 25, 2021, pp. 9-10

[151] https://www.seia.org/state-solar-policy/california-solar

were already included in the draft results. More details are available in the section **Clean Energy Transmission**.

10. *Greenhouse gas reductions are likely underestimated: Long term emission reductions, not hourly market emission rates, must be used to calculate GHG savings from DERs. A recent study mistakenly used hourly power GHG emissions as "marginal" which were higher than the average emissions, yet average rates were falling.*[152] *This is not mathematically possible—when average rates are falling, incremental emission reductions must be above average reductions. Relying on emissions at the Mid-Columbia market hub therefore underestimates the reductions created by reducing metered loads by the prosumer.*

    Response: E3 agrees that "incremental emissions reductions" are generally "above average [emissions] reductions" in a given hour. The calculation of avoided GHG emissions for this study relies on marginal hourly electric sector emissions rates. This approach reflects higher avoided emissions, and thus greater modeled benefits for NEM solar, than an approach that reflects average emissions. E3 notes that it is indeed mathematically possible for the marginal emissions rate to be lower than the average emissions rate in a given hour. For example, this would occur if most of the generation were provided by coal plants, but the marginal unit is a natural gas plant. Details are available in the section **Reduced Greenhouse Gas Emissions**.

11. *Installing customer-owned distributed energy resources is more likely to increase, not stymie, conservation investment: The study makes the assertion that energy conservation is likely to decrease for customers who install rooftop solar. The conservation incentive for customers is upfront when installing customer-owned generation. A customer immediately avoids, with little uncertainty, expensive solar investment by reducing on-site load. The incentive to reduce energy use cost effectively may be even more obvious when installing solar panels than for customers who remain on utility service and see their savings trickle in small amounts over a period of years instead of immediately.*

    Response: As described in the section **Secondary Effects of NEM Solar Systems**, it is difficult to know whether NEM solar would lead customers to pursue conservation measures with greater interest or reduced interested. Customer solar adoption may correlate with or result in customer education and broader engagement with energy issues, leading to the adoption of energy efficiency or electrification measures. However, the opposite may also be true, as reductions in customer bills tied to NEM solar may reduce a customer's concern with conserving energy by decreasing their perceived average cost of electricity. Separating out and attributing specific causation for these behaviors to NEM solar would require surveys and other customer facing research, which is beyond the scope of this study.

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[152] Holland et al (2022), "Why marginal CO2 emissions are not decreasing for US electricity: Estimates and implications for climate policy," https://resources.environment.yale.edu/kotchen/pubs/margemit.pdf

Overall Comments

1. *We appreciate the hard work and attention of all involved. However, as was stated several times throughout the process, we wish to respectfully note for the official record concerns about the speed of the process and how the meetings were organized and conducted. The items outlined below are a few of the major issues we found with this process which may be largely the result of the compressed timetable to conduct the study. These were concerns raised at the time that this utility-funded study was announced, and the TAG was convened last summer, that this schedule was too short, which is further evidenced by the far longer timelines taken to do similar studies in several other states.*
2. *TAG Recruitment. This TAG was hastily convened over a month in the Summer which resulted in non-participation by parties who should have been at the table, particularly voices of tribes and named communities. Throughout the process TAG members exhibited a lack of attendance, and a lack of response to surveys and questions circulated during meetings.*
3. *Timeliness. Datasets and other meeting materials were repeatedly not delivered to TAG members on a consistent and timely basis, making it difficult for participants to adequately prepare for the three TAG sessions. In the case of the third and final TAG meeting, some information, including a crucial data model, was not provided until after the meeting.*
4. *Meeting Standardization. Meetings were not conducted via Roberts Rule of Order or a similar, standard regimen to formally structure meetings. This lack of structure allowed discussion to be shaped and often dominated by meeting participants that were not actual members of the TAG.*
5. *Lack of Benefits. A thoughtful and lengthy list of the benefits of distributed generation were identified by TAG participants in Meeting No. 1, but virtually none of those benefits were included by E3 in the preliminary cost shift calculations. E3 cited time constraints and lack of resources as the reason these important points were left unaddressed.*
6. *A Distant TAG. TAG members with specific professional expertise were not consulted on the proper sources of much of the data used in the preliminary cost shift calculations. Examples include: the state's distributed solar production metric, UL 1741-SB smart inverters, and contemporary price-per- watt cost figures.*
7. *Conclusion. A properly planned and executed process must be undertaken to ensure that unvetted and inaccurate assumptions, regardless of the party's position, are not used to influence policy in Washington State. When a single party is allowed to dominate the outcome of the process by controlling what gets evaluated, how it is evaluated, and how it is presented to the public, as happened in this study, it will inevitably end with a significantly biased view rather than a consensus view. This flawed and incomplete study could result in a major disruption in the current acceleration of deployment of valuable distributed energy resources needed to meet Washington's clean energy goals and energy building code requirements.*

Response to Comments 1-7: E3 appreciates the feedback on TAG recruitment, timeliness, meeting standardization, lack of benefits, and a distant TAG. E3 recognizes that the study timeline was shorter than some stakeholders may have preferred, but the timeline was sufficient to develop a robust analysis of the costs and benefits of NEM solar in Washington. Despite the short, Gridworks succeeded in hosting three productive TAG meetings with a diverse group of stakeholders and perspectives, as well as offering other venues for feedback such as office hours and feedback via email. This study considers all participant, ratepayer, and societal benefits and costs suggested by the TAG, which are summarized in Table 5 and Table 6 in the **Evaluation of NEM Solar Benefits and Costs** section of this report. E3 quantified benefits and costs where possible and provided a qualitative evaluation of the remaining benefits and costs.

Washington Rural Electric Cooperative Association

Comments on Draft Results

1. *What percentage of all WA energy production in 2030 will come from new rooftop solar (2024 - 2030) versus other resources, based on E3 growth and model assumptions?*

   Response: While this study used wholesale energy price forecasts from PSE to understand marginal wholesale energy prices, it did not model the future resource mix for Washington.

2. *E3 Objective: "Help inform future policy proposals for NEM in Washington." Solar in Washington can't be boiled down to a few simple talking points. How will E3 communicate the nuance and critical details Legislators will need to make informed policy decisions? Many legislators have been lead to believe that rooftop solar is a feel-good "silver bullet" solution to solving all reliability, carbon reduction, electrification, and CETA mandates. In reality, rooftop solar barely moves the kWh needle. It reduces equity. It removes capital from more efficient, effective renewable projects.*

   Response: This report is intended to provide an evaluation of Washington's NEM solar programs to support future policymaking regarding customer solar.

3. *The benefit-cost analysis methodology seems very biased in favor of rooftop solar as every "utility avoided cost" benefit listed is a subsidized cost paid for by ratepayers. We would appreciate an opening bullet that helps the novice reader understand the important underlying implications. In comparison to other renewable generation projects (especially utility-scale solar) in the PNW, rooftop solar is twice as expensive, 1/2 as efficient, and technically inferior in our region.*

   Response: The solar cost assumptions are described in the section **Participant Benefits and Costs**.

4. *Northwest utilities typically buy power from BPA for ~3.5¢/kWh and sell it for about ~11.5¢/kWh. The ~7¢ difference is what utilities need financially to fund the operations of the grid. Every solar rooftop kWh reduces that operations cost funding source.*

   Response: This study carefully evaluated the benefits and costs of NEM to utility ratepayers. Across the detailed study utilities, the study finds 2024 utility avoided costs ranging from 2.0-4.8 c/kWh, and NEM customer compensation ranging from 7.0-13.5 c/kWh.

5. *The cross subsidy information contained in your report isn't as clear as it should be. Rooftop solar customers use the grid constantly (night versus day) but pay less in grid costs. NEM customers (who are more financially well off) force non-solar customers to pay a subsidy to help rooftop solar customers pay back faster. This leads to rooftop solar members underpaying for the fixed cost of the grid, a portion of which is typically paid through kWh sales. We would appreciate an opening bullet that helps the novice reader understand the important underlying simple math.*

   Response: The section

   Cost Shift Results describes the impact of cross-subsidization on utility ratepayers.

6. *Clearly, Legislators should be made aware that lower-income customers are subsidizing wealthier NEM customers. Any new NEM legislation should require that rooftop solar members pay their fair share of the grid cost. Having NEM customers pay their fair share of the grid will eliminate cost shifting. That is financially equitable and consistent with the CETA and CCA financial equity mandates.*

   Response: The section

   Cost Shift Results describes the impact of cross-subsidization on utility ratepayers.

7. *Excess summer solar kWh generation has historically been "banked" and used when the sun isn't shining and when the cost of power is more costly. This cost-shifting from summer to night/winter is inequitable and discourages efficient use of energy. In winter, the load doubles, but solar is minimal. Solar credits should be at the time of generation, at applicable and equitable rates for that hour.*

   Response: This report discusses alternative tariff designs in the section **Review of Customer Generation Tariff Design in Other U.S. Jurisdictions**. The cost shift calculations in the report include the timing of solar production relative to wholesale energy prices.

8. *Ratepayer Impact: "Utility avoided cost" is not a "green colored X" benefit. It's a pass-through cost and turns further into the cost category as it fails to collect grid, operating, and other power-related costs.*

   Response: In this study, "utility avoided costs" describe the benefits from customer solar to the utility grid. This is different from NEM customer compensation, which is captured in a separate benefit/cost category called "bill savings / solar customer compensation."

9. *The participant results are further misleading. Every benefit to the Participant is subsidized by Rate Payers who, in most cases, are less well off financially.*

   Response: The primary benefit to participants is "bill savings / solar customer compensation." This component appears as a cost to ratepayers in the ratepayer perspective, as described in the section **Ratepayer Benefits and Costs**.

10. *In no case will ratepayers benefit from "utility avoided costs" associated with solar production until the solar cross-subsidization is fixed. Further, there are no reductions in system costs that*

can be passed to customers via rate reductions. Also, we totally disagree with the Note regarding energy consumed behind the meter vs. exported to the grid. Northwest utilities typically buy power from BPA for ~3.5¢/kWh and sell it for about ~11.5¢/kWh. The ~7¢ difference is what utilities need financially to fund the operations of the grid. E3 should use this example to calculate the actual cost shift.

Response: This study carefully evaluated the benefits and costs of NEM to utility ratepayers. Across the detailed study utilities, the study finds 2024 utility avoided costs ranging from 2.0-4.8 c/kWh, and NEM customer compensation ranging from 7.0-13.5 c/kWh.

11. In comparing the full lifestyle GHG reduction of hydro versus solar, solar is higher in GHG emissions. BPA has TIER 2 headroom that is also 100% hydro and lower in GHG emissions.[153]

Response: *E3 appreciates this feedback. While lifecycle emissions may be an important area for future study, this report has treated NEM solar, as well as utility-scale renewables, as being zero-GHG resources.*

12. LCoE is based on the eastern side of State. However, you should use metrics from the whole state or create rates that are based on local LCoE. Further, the localization of NEM rates should reflect the fixed cost versus kWh cost unbalance that leads to cost shifting. Each utility situation is unique. One size doesn't fit all.

Response: As discussed in the section **Clean Energy Avoided Costs**, this study used eastern Washington utility-scale solar as the representative clean resource that is avoided by NEM solar. This approach overestimates the avoided cost value because an optimal portfolio with a blend of different clean energy resources would cost less, or at least no more, than a portfolio of 100% utility-scale solar. Locally appropriate solar capacity factor values are used for NEM solar.

13. The avoided costs methodology erroneously concludes that NEM solar is firm power and fails to consider battery and other costs of firming.

Response: E3 appreciates this feedback. This study does consider the avoided costs or net costs associated with generation capacity, as described in the sections **Generation Capacity Avoided Costs** and **Generation Capacity Shortfall for BPA Tier 1 Rates**.

14. Solar is likely to be over-generated in the summer (lower market value) and less in winter (not available). Averaging solar generation for the year is misleading and exacerbates cost shifts.

Response: All model results reflect the hourly profile of NEM solar, which incorporates seasonal impacts.

15. For T&D avoided costs, E3 should use average solar figures. At night, solar participants still require power and should be paying for the T&D costs to receive it. If utilities allow the banking of kWh, these figures are less than accurate.

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[153] NREL; Life Cycle Greenhouse Gas Emissions from Electricity Generation, 2021

Response: As described in the section **Transmission and Distribution Avoided Costs**, this study reflects that NEM solar can only avoid T&D costs to the extent that the solar profile overlaps with high-load hours for each utility.

16. *For the RIM results, once again, over-selling solar production as a benefit is misleading. Power cost avoidance is a pass-through cost and turns further into the cost category as it fails to collect grid, operating, and other power-related costs. Northwest utilities typically buy power from BPA for ~3.5¢/kWh and sell it for about ~11.5¢/kWh. The ~7¢ difference is what utilities need financially to fund the operations of the grid.*

    Response: This study carefully evaluated the benefits and costs of NEM to utility ratepayers. Across the detailed study utilities, the study finds 2024 utility avoided costs ranging from 2.0-4.8 c/kWh, and NEM customer compensation ranging from 7.0-13.5 c/kWh.

17. *For the cost shift results, what is "NEM minimum?" What is 2030 contribution to total WA generation? What percentage of customers have rooftop solar in 2030? Cost shift should be expressed in $ per non-solar customer per month. Every solar kWh has a cost shift of ~7 cents. E3's cost shift calculation is misleading and inaccurate.*

    Response: E3 appreciates this feedback. The "legislative NEM minimum" reflects the capacity of solar that must be enrolled under NEM per Washington State Law RCW 80.60, as described in the **Introduction** section. Table 12 includes the modeled solar capacity in 2030, as well as modeled bill impacts due to NEM solar.

18. *Qualitative evaluation of ratepayer benefits and costs - Many of those benefits are theoretical and are actually costs, with conventional inverters. Local generation requires millions in grid modernization to support, but those costs aren't shown. We just don't want to assume the costs go away since the grid is being magically modernized (unfunded mandate).*

    Response: The qualitative evaluation of benefits and costs is focused on the benefit and cost components identified by the TAG.

19. *Only a small percentage of all WA energy production in 2030 will come from new rooftop solar (2024 - 2030) versus other resources. Rooftop solar barely moves the kWh needle. If you really wish to help inform legislators of future policy proposals for NEM in Washington, clearly communicate that rooftop solar is not a land use "silver bullet" solution to solving all reliability, carbon reduction, electrification, and CETA mandates.*

    Response: The section **Societal Benefits and Costs** includes a quantification of the land use and GHG benefits associated with NEM solar, as well as the societal costs of NEM solar.

20. *We generally agree with the headline conclusions. You confirm that rooftop solar has lousy payback and is cost-shifting. It is an expensive, inequitable use of precious capital that could be put to better, more effective use. Why subsidize rooftop solar, given its minimal contribution to the regional generation mix? Better payback is afforded by going large utility-scale. The cost shift with compound growth triples. At that rate, what percentage of customers have solar, and what is total contribution to the state generation mix? E3's $5-27/year cost shift seems low, and is this for linear or compound? It suggests not many people are getting solar in their*

model, or they have failed to account for what percentage of the cost comes from kWh sales. Rural co-ops, with their enormous fixed operating costs funded by kWh sales, should be more deeply evaluated as an example to help make the case for NEM rate equitability in rural areas.

Response: As described in the section **Residential Rate and Low-Income Bill Impacts**, $5-$27/year reflects 2024 annual bill impacts on low-income non-participating customers due to NEM.

Comments on the Review of Tariff Options in Other U.S. Jurisdictions

1. *The document is an excellent primer on approaches to solar generation incentives and their pros and cons. Well done!*
2. *The document is very detailed and not designed for the "average" reader. Including an Executive Briefing at the beginning would be helpful. We offer an example below.*
    a. *Washington state's 2021 Energy Strategy projects that the state's load will nearly double by 2050. There is no new hydro. New generation resources will need to be developed. Solar and wind potential is lacking, and the state plans to import as much as possible (e.g., solar from the southwest and wind from Idaho and Montana. What solar energy there is in Washington is most cost-effectively harnessed through massive utility-scale solar projects east of the Cascades.*
    b. *States that wish to incentivize rooftop solar have created a variety of net energy metering (NEM) rates to accelerate payback by helping the customer save money on their electric bills.*
    c. *But those savings result in a cost shift to customers who don't have or can't afford rooftop solar. The larger the rooftop solar customer savings, the greater the cost shift. There is no "free lunch."*
    d. *That cost shift makes NEM rates inherently regressive, violating Washington CETA and CCA financial equity mandates.*
    e. *California, an early leader in NEM rates, recognized the inequity of NEM rates and recently issued a new, more equitable NEM 3.0 rate. From a recent LA Times interview with Matt Baker of the California Public Advocates Office (an independent watchdog arm of the Public Utilities Commission): "The question is how to encourage the technology in a way that's fair to everyone. Baker said California is "addicted" to solar incentives paid for by utility customers through their electric rates. That's how net metering has always worked, and it's been easy for politicians to get behind because it doesn't require them to allocate taxpayer funds in the state budget. They can just let the Public Utilities Commission stick utility customers with the bill. In an ideal universe, Baker said, state lawmakers would approve robust upfront rebates for rooftop solar installations — with an emphasis on solar for low-income families. Then we wouldn't have to worry so much about rising electricity rates.*
    f. *We have such an "upfront" funding mechanism here in Washington. It's called The Clean Fuel Standard. It carbon-taxes GHG emitters (e.g., fuel suppliers), which generate credits to fund clean transportation (e.g., EV charging infrastructure). Similarly, it could fund renewable generation by taxing coal and natural gas power generation.*

g. *Washington's solar potential is a small fraction of California's. Annual solar production is 32% less than in California. December solar production is 72% less than in California when the winter load peaks.*
h. *In California, rooftop solar is only 4.6% of the total state energy portfolio. It is a minor contributor to the state's energy mix. In Washington, it's much less – just 0.3% – estimated to grow to about 1% by 2030. There are better uses of capital to grow clean energy capacity at utility scale.*

Response: E3 appreciates this feedback. This document is included as a section in the broader WA NEM Evaluation report. Thus, readers will have the full context from the report itself.

3. *We would like to see more data about income and property values of solar homes versus non-solar and low-income homes. This can help give context to the impact of cost-shifting.*

Response: E3 agrees that better data on income and/or wealth would be valuable. The study cites a 2022 analysis from the Lawrence Berkeley National Laboratory, which shows that 27% of solar adopters in Washington have a household income less than the area median income (AMI) and that 60% of adopters earn more than 120% of the AMI.

4. *Typo: On the bottom of page 6, it says: "... grid exports based on the value of solar the grid..." Insert "to" after "solar"*

Response: Corrected.

5. *Suggested edit: The section 3 discussion about NEM, NEB, and Buy-All, Sell-All is very helpful. In the NEM and NEB sections, you provide explicit examples of the cost-shift that results. This helps give a balanced sense of the pros and cons. But in the Buy-All, Sell-All section, there is no similar cost-shift statement. We would suggest including one in the* ***Challenges with Buy-All, Sell-All*** *section.*

Response: E3 appreciates this feedback. A sentence has been added to the section **Overview of Buy-All, Sell-All** indicating that, if buy-all sell-all is implemented with pricing based on utility avoided costs for distributed solar, there would be zero cost shift because the solar compensation would be equal to avoided costs.