Northwest **Power** and **Conservation** Council

August 6, 2024

MEMORANDUM

TO: **Council Members**

FROM: **Kevin Smit, Manager of Power Planning Resources**

SUBJECT: **Distributed Solar Primer**

BACKGROUND:

Presenters: Kevin Smit, Joe Walderman

Summary: In preparation for the Ninth Power Plan, staff are continuing to provide the Council with a series of presentations on different aspects of developing the Plan. This presentation will be on the approach for analyzing distributed solar in the Plan.

Relevance: The Northwest Power Act specially calls out "direct application renewables" as a resource to be considered in the power plan. For the upcoming Ninth Power Plan, the staff plan to expand our consideration of distributed solar relative to what we have done in the past.

Workplan: B.2.1 Prepare for the ninth power plan, developing a draft scope, preparing models and inputs, and developing environmental methodology.

Background: The primary way that we have considered distributed solar (aka Direct Application Renewables) in past power plans is to include them as a decrement to load in our load forecast. In several of the recent plans, residential rooftop solar supply curves were developed in a similar way as energy efficiency and included in the energy efficiency supply curves. However, because of the historically high cost of these resources, the

851 S.W. Sixth Avenue, Suite 1100
Portland, Oregon 97204-1348
www.nwcouncil.org

Bill Edmonds
Executive Director

503-222-5161
800-452-5161

rooftop, or distributed solar did not end up in the resource strategy as a cost-effective resource.

In recent years, the overall cost of solar has decreased significantly and there have been increases in the installation of rooftop solar systems on northwest homes. Therefore, the staff are planning to include three types of distributed solar in the analysis for the plan: 1) residential rooftop solar, 2) commercial rooftop solar, and 3) community solar. The quantities and costs of these resources will be identified so that they can be treated alongside other generating resources and conservation resources in our optimization models.

The presentation will describe the approach for defining these resources, along with some background on the current market for distributed solar.

Distributed Solar in the Pacific Northwest
Approach for the Ninth Power Plan

August 14, 2024

Kevin Smit and Joe Walderman

Northwest Power and Conservation Council

1

Agenda

- Context & Background
  - Definitions
  - Market
  - 2021 Plan
- Distributed Solar System Characteristics
  - Panel
  - Inverter
- Distributed Solar Costs
- Community Solar
- Distributed Solar Potential
  - Methodology
  - Amount
  - Cost
  - Shape
- Questions

2

Distributed Energy Resources (DERs)

For the Ninth Plan, a goal is to expand our consideration of distributed energy resources (DERs)

Reviewed regional and national definitions of DERs as a starting point for the Ninth Plan

Distributed solar (including solar plus battery storage) will be the primary new DER resource in the Ninth Plan

Past plans have primarily included DERs in the load forecast but not as a resource that competes with other generating resources

Distributed Energy Resources (DERs) are typically small, decentralized electric resources that are connected to the distribution system and are located close to customer load (e.g., behind the customer meter or sited close to the customer), that enable the utility and the grid to manage the level or timing of consumption.

For the Council's Ninth Plan, the following DERs will be included: distributed solar (e.g., commercial solar, community solar, rooftop solar), energy storage, demand response, and electric vehicles.

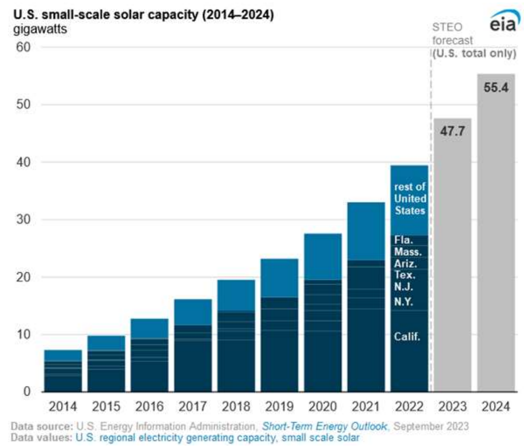
What is Distributed Solar?

- We are using this term to describe PV solar applications that are not "utility scale"
- Most distributed solar is located "behind the meter"
- Dispatchable solar (solar plus storage) will also be included
- Distributed Solar Segments
  - Rooftop residential solar for single family (and small multifamily)
  - Rooftop commercial solar
  - Community solar; included as a small reference plant

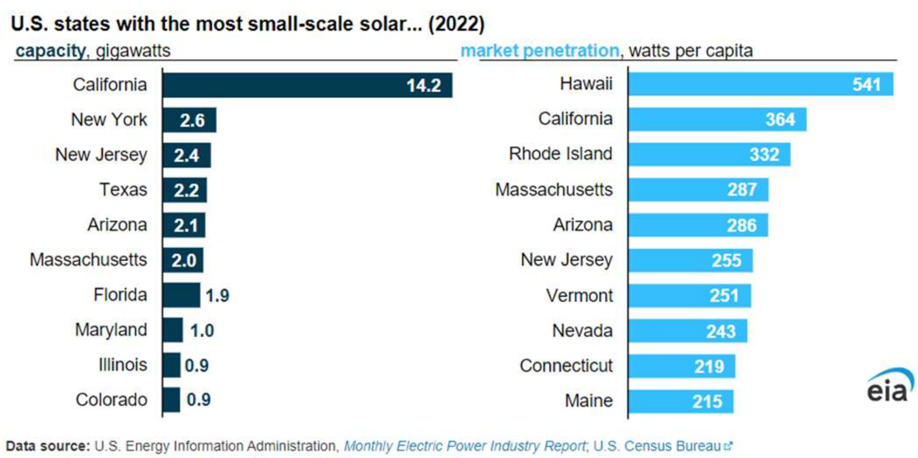
Source: Energy Trust's townhome project built by Habitat for Humanity in Bend

National Distributed Solar Installations

- More than one-third of U.S. solar power capacity is small-scale solar
- Small-scale solar is expected to generate 83 billion kWh of electricity in 2024
- The residential sector currently accounts for 67% of small-scale solar capacity among end-use sectors
- In some states, small-scale solar capacity is growing faster than the U.S. average in response to local incentives for rooftop solar installations



Distributed Solar by State

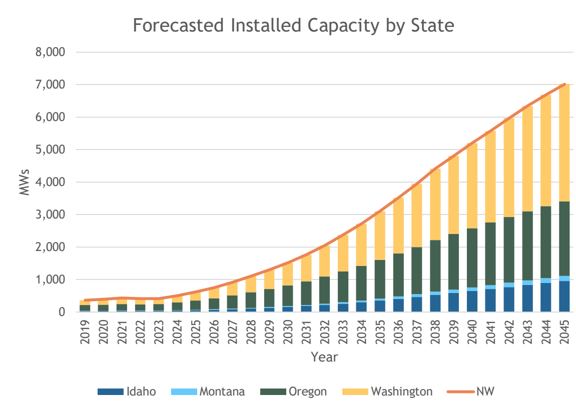


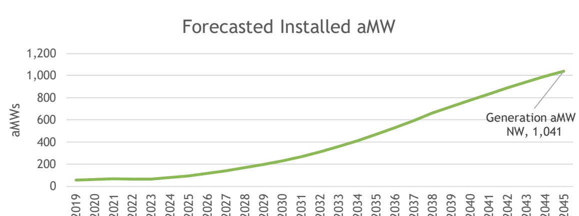
Distributed Solar in the NW Power Act

- Distributed solar is referred to in the NW Power Act as a “direct application renewable energy resource”
- 839a(19). "Resource" means–
  - 839a(19)(A). electric power, including the actual or planned electric power capability of generating facilities, or [Northwest Power Act, §3(19)(A), 94 Stat. 2700.]
  - 839a(19)(B). actual or planned load reduction resulting from direct application of a renewable energy resource by a consumer, or from a conservation measure. [Northwest Power Act, §3(19)(B), 94 Stat. 2700.
- 839d(a)(1). The Administrator shall acquire such resources through conservation, implement all such conservation measures, and acquire such renewable resources which are installed by a residential or small commercial consumer to reduce load…

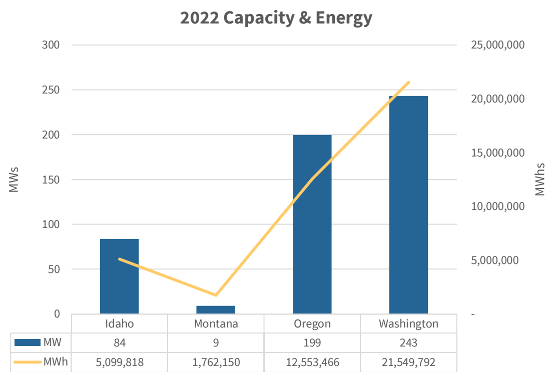
2021 Plan

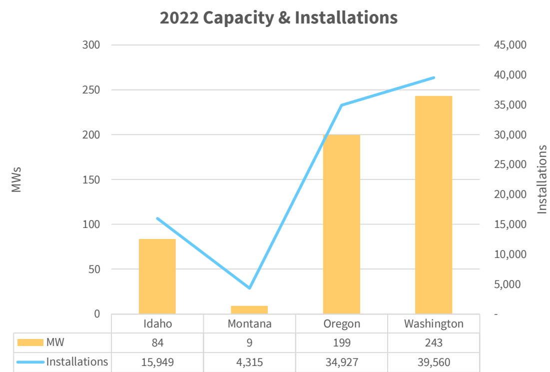
- Solar was included as a baseline load in the load forecast (decremented from load)
- Utilized EIA 861 historical net-metering data and forecasted out the loads through the planning period
- The 2021 Plan for BTM Solar consisted of two primary components: Profiles and Resource Assumptions
- Developed solar generation profiles with hourly capacity factors for a single year





Distributed Solar Installations in the NW





Northwest Power and Conservation Council

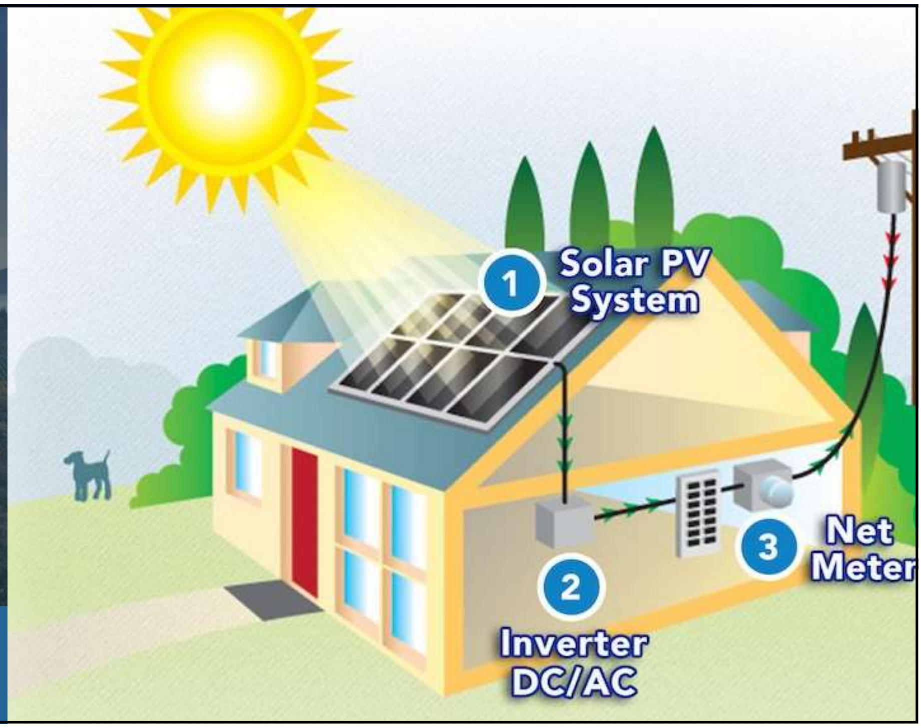
9

9

Distributed Solar System Characteristics

10

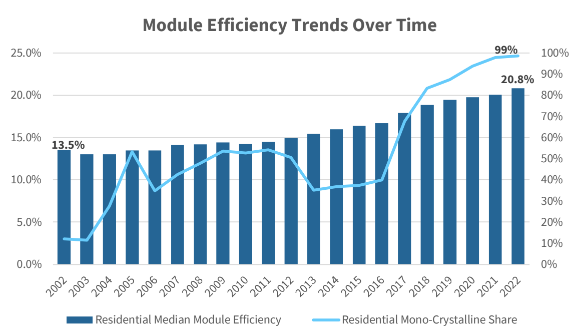
Rooftop System Components



11

Panel Characteristics

- Average panel size panel installed in the US is ~9 kW
- Efficiency of panels has increased from 13.5% in 2002 to 20.8% efficiency in 2022
- Majority share (99%) of panels are mono-crystalline
  - Created from pure silicon and formed into bars and cut into wafers
  - Identified by their uniform dark appearance and the rounded edges squares with small spaces between each cell.
- **Fun fact:** In 2019, the National Renewable Energy Laboratory managed to develop a six-junction solar cell with an efficiency of 47.1% setting 2 new world records



Northwest Power and Conservation Council

12

12

Inverter Considerations

- Inverters convert solar energy from DC Power into AC power. There are 2 main types:
  - "String" inverters, which are the lowest cost option, monitor and control the system
    - Insolates a system from the power grid
    - Most common type for small-scale solar
  - Smart inverters (aka "Microinverter") that can feed power to the grid
    - Responds to changes in frequency and other disruptions that occur during grid operations
    - Helps stabilize the grid against disruptions
- Inverter lifespan is 5-10 years versus the 25 year lifespan of solar panels
- Cost to replace inverter is between $1,000-$3,000
  - Size of the inverter is dependent on solar panels and household consumption
    - Usually sized to have more capacity than solar system because of efficiency losses

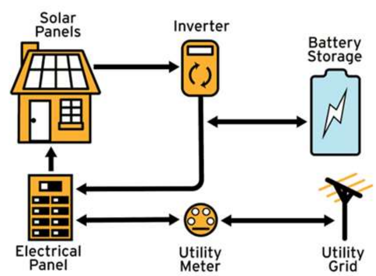
Northwest Power and Conservation Council

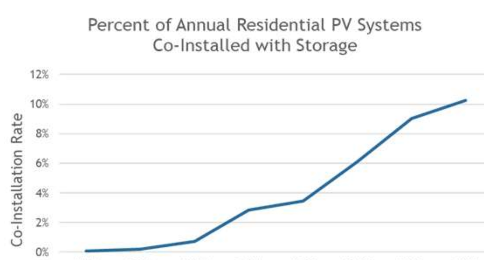
13

13

Solar Plus Battery

- Rooftop solar PV systems can include battery storage
- Batteries can store some of the energy from the daylight hours to help ride through the evening after the sun sets
- In 2022 there were 7.2 MW of co-installed storage capacity in the region
- Staff plan to develop a distributed solar plus battery application for residential
- May also be considered a demand response product





Northwest Power and Conservation Council

14

14

Community Solar

15

Community Solar

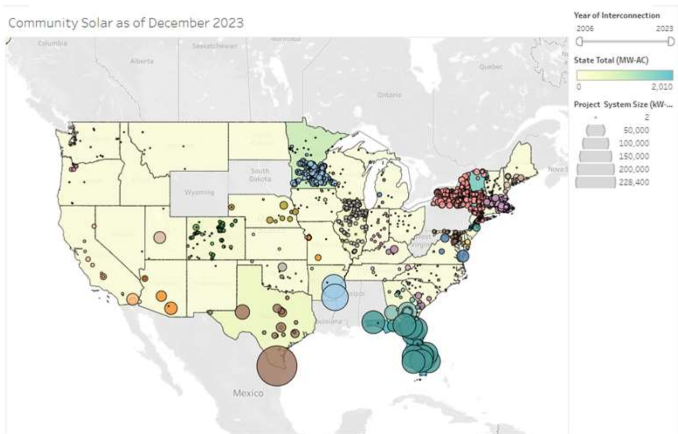
- Community solar refers to local solar facilities shared by multiple community subscribers who receive credit on their electricity bills for their share of the power produced.
- It provides homeowners, renters, and businesses equal access to the economic and environmental benefits of solar energy generation regardless of the physical attributes or ownership of their home or business.
- Community solar facilities are usually less than five megawatts (MW) of electrical capacity and vary in the number of acres affected.
- Unlike residential housing and commercial development on a sold-off farm parcel, community solar installations are generally on leased land.
- For the power plan, it will be modeled as a small reference plant

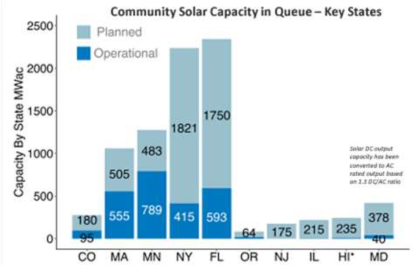
Northwest Power and Conservation Council 16

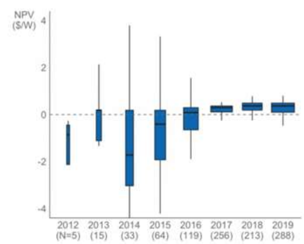
16

National Trends in Community Solar

6.5 gigawatts of community solar have been installed in the US through Q1 2024







NPV: net present value. +NPV means subscribers are saving money over the life of their subscription, as compared to not subscribing.

Northwest Power and Conservation Council

https://www.energy.gov/communitysolar/community-solar-market-trends

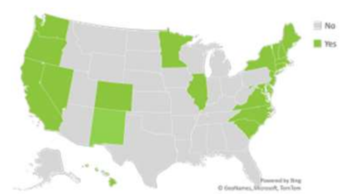
https://www.energy.gov/sites/default/files/2021-11/Sharing%20the%20Sun_FY21_Final.pdf

17

17

In-Region State Policies

- Two states in the region have passed community solar enabling legislation:
  - *Washington Community Solar Program (Community Renewables Enabling Act)*
    - *5MW limit*
    - *Direct payments to project owners starting at $0.30/kwh*
  - *Oregon Community Solar Program (SB 1547 Section 22)*
    - *3MW limit w/ subscription minimum of 5 persons*
    - *No one participant may hold more than 40% of a project's subscriptions, 50% of a project's subscriptions must be set aside for residential and small commercial customers. 10% of the total generating capacity be made available for low-income subscribers.*



State-level community solar enabling legislation*

* Legislation applies to at least one utility in the state

21 states & DC have passed some form of legislation enabling community solar. There is variation in what this legislation entails but generally they allow for some form of virtual metering to allow for subscribers to benefit from their community solar subscriptions

https://www.energy.gov/sites/default/files/2021-11/Sharing%20the%20Sun_FY21_Final.pdf

Northwest Power and Conservation Council

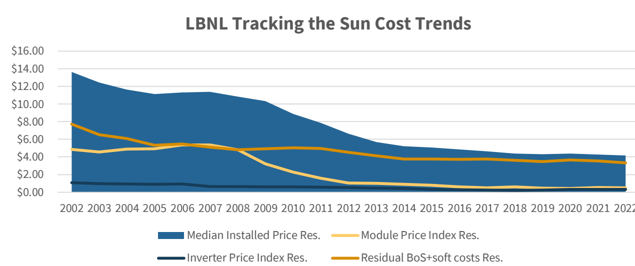
18

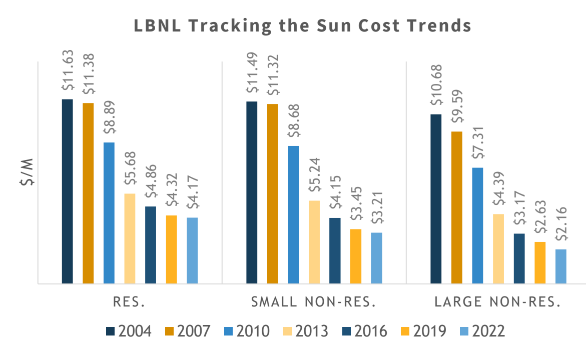
18

Distributed Solar Costs

Distributed Solar Cost Considerations

- Average installed cost per watt in 2022 was ~$4.2, down from ~$14 per watt in 2000
- Costs of installing solar varies based on many factors; including
  - Base costs include panels, inverter, wiring, racking equipment, labor, taxes, permitting and interconnection
  - Upgrades may be needed
    - Electric panel ($5k or more)
    - Bi-directional meter for net-metering (can be at no cost to the customer)
    - Roof replacement (average $7 per square foot)
  - O&M: Inverter replacement costs
  - Federal tax credits and State-specific incentives





Northwest Power and Conservation Council

20

Cost & System Size Data
(Source: LBNL Tracking the Sun)

Residential Rooftop Solar

State	$/watt	System Size (kW)	Total Cost
ID	$4.3	8.4	$35,956
MT	$4.3	10.8	$46,010
OR	$4.3	8.9	$37,793
WA	$4.3	9.5	$40,345

Commercial and Industrial Rooftop Solar

State	$/watt	System Size (kW)	Total Cost
ID	$2.2	30.3	$65,632
MT	$2.2	34.1	$73,697
OR	$2.2	42.5	$92,007
WA	$2.2	28.0	$60,519

Residential Incentives In the Region and National

Oregon
- Energy Trust of Oregon
  - PGE: $1k per for solar and up to $6k for energy storage
  - PAC: $1.2k per for solar and up to $6k per battery
- Oregon Solar plus Storage Rebate Program
  - Up to $5k for solars and up to $2.5k for energy storage, with incentives for LMI
  - Oregon-based organizations that provide services to LMI Oregonians can receive a rebate of up to $30k for solar and up to $15k for energy storages

Washington
- Washington Solar Sales Tax Incentive
- 100% exemption for solar photovoltaic systems 10 kilowatts or less, and solar thermal systems

Idaho
- Idaho Residential Alternative Energy Tax Deduction
- Income tax deduction of 40% of the cost of a solar

Montana
- Property Tax Exemption: up to $20k
- Alternative Energy Revolving Loan Program

Federal
- Solar for All in OR, WA, ID (awarded in April. Program details pending)
- Federal Tax Credit

Distributed Solar Potential

Northwest Power and Conservation Council

23

High-level Process

Units: Number of Homes or Buildings

- Develop a baseline load forecast for distributed solar by state and location
- Determine number of buildings per year, by building type, and by location
- Determine roof orientation
- Develop building distribution based on roof orientation

Measures: Capacity, Energy, Cost

- Determine average system capacity in kW by state
- Determine panel efficiency
- Calculate "derated" system capacity based on orientation and panel efficiency.
- Develop system energy in kWh using the derated system capacity and annual sunlight hours
- Develop system installed cost

Distributed Solar Potential

- Develop future technical potential for distributed solar by state and location
- Develop locational solar profiles and state-specific costs
- Develop supply curves using ProCost and a forecast of homes and commercial buildings

Northwest Power and Conservation Council

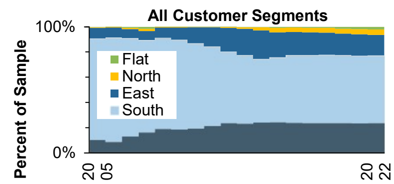
24

24

Building Stock Distribution & Roof Orientation

- Load Forecast building stock
- LBNL's Tracking the Sun data on Roof Orientation
  - Panel orientation was more varied during earlier years of solar adoption; however, panel orientation hasn't changed much in recent years
  - A greater share of non-residential systems faces exactly due-south, likely due to greater prevalence of ground-mounting and flat rooftops than in the residential sector
- Forecast of homes by region, state and BA
- Forecast of commercial buildings by region, state, and BA

Panel Orientation	2022
North	4%
East	16%
South	54%
West	24%
Flat	2%



System Capacity and Energy

- LBNL's Tracking the Sun to determine the system capacity (kW) and energy (kWh) per state
- Collaborated with ETO on findings
- Energy and Capacity Factors include
  - Annual sunlight hours
  - Panel efficiency
  - Average capacity and energy by state
- Derated capacity to account for efficiency losses and calculated energy based off the derated capacity
  - Cell type and color, interconnection of the cell, shade, orientation, location, tilt
  - Time of year (e.g., weather conditions and position of the sun)
  - Contamination (e.g., dust, dirt, bird droppings, debris

State	Average kW	Average Derated kW
Idaho	8.44	5.45
Oregon	8.87	5.72
Washington	9.47	6.11
Montana	10.80	6.97

State	Average kWh
Idaho	8,150
Oregon	6,700
Washington	6,630
Montana	10,707

Calculate Levelized Cost

- For distributed solar, like energy-efficiency, we develop a levelized cost for each measure
- The cost and benefit streams are levelized over the lifetime of the plan
- The final measure is defined by its:
  - Electricity generation (kWh)
  - Levelized cost ($/kWh)
  - Capacity impact (kW)
- Formula

Costs Included	Benefits Netted Out
Capital & Labor	Deferred T & D Expansion
Annual O&M	~~Regional Act Credit~~
Program Administration	Avoided Periodic Replacement
Periodic Replacement[1]	~~Other Fuel Benefits~~
~~Other Fuel Costs~~	Non-Energy Impacts
Non-Energy Impacts	

[1] Inverter replacement after 10 years

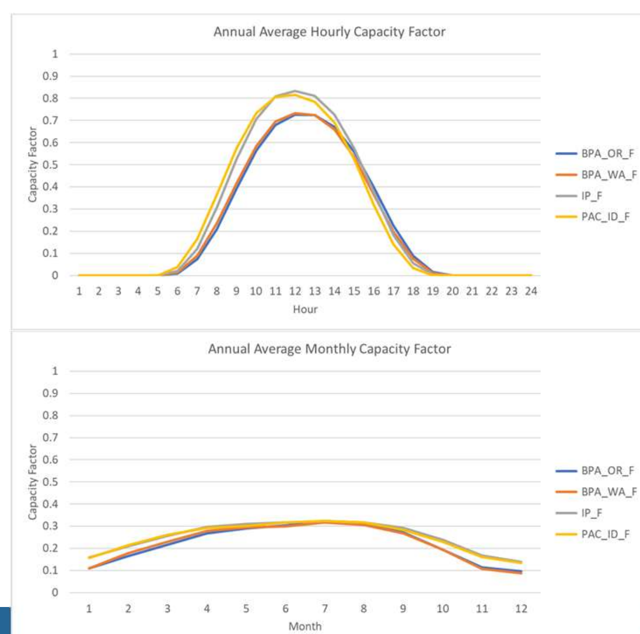
$$\text{NRC Net Levelized Cost} = \frac{NPV(cap\ cost * (1 + admin) + ann\ O\&M + \text{PerRep} + NEI - Def\ T\&D)}{Solar\ Measure\ kWh\ Site\ Generation}$$

27

Solar Shapes

- The solar shape defines when the panels are generating, and will be used to define the peak, or net load impacts
- Develop a capacity profile for all 17 balancing authorities (BAs) using latitude and longitude coordinates

Example Solar Capacity Profile from Time Series Lab



28

Residential Rooftop Solar Achievable Potential

Basic formula:

- Potential (aMW)= [kWh per home * Number of Homes * Applicability]

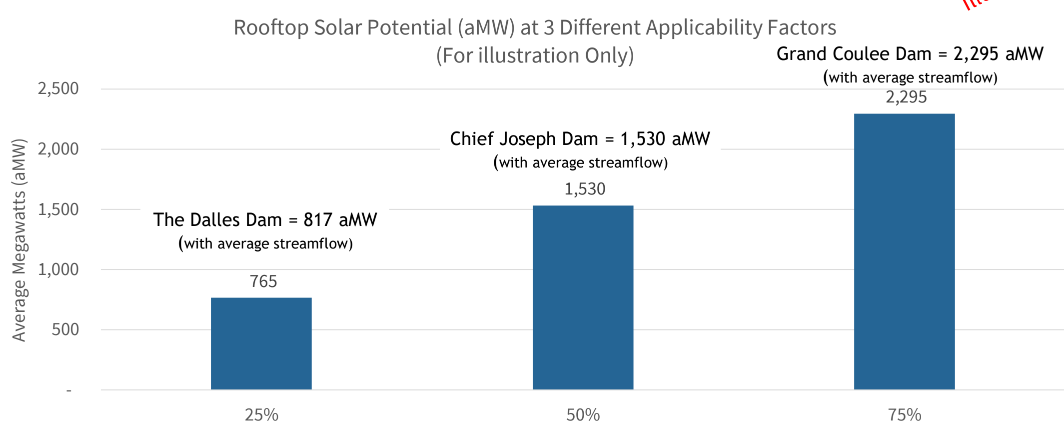
The Applicability factors include:

- Orientation of the panels
- Structural integrity (roof)
- Solar intensity
- Ramp(adoption) rates
- Physical limitations

29

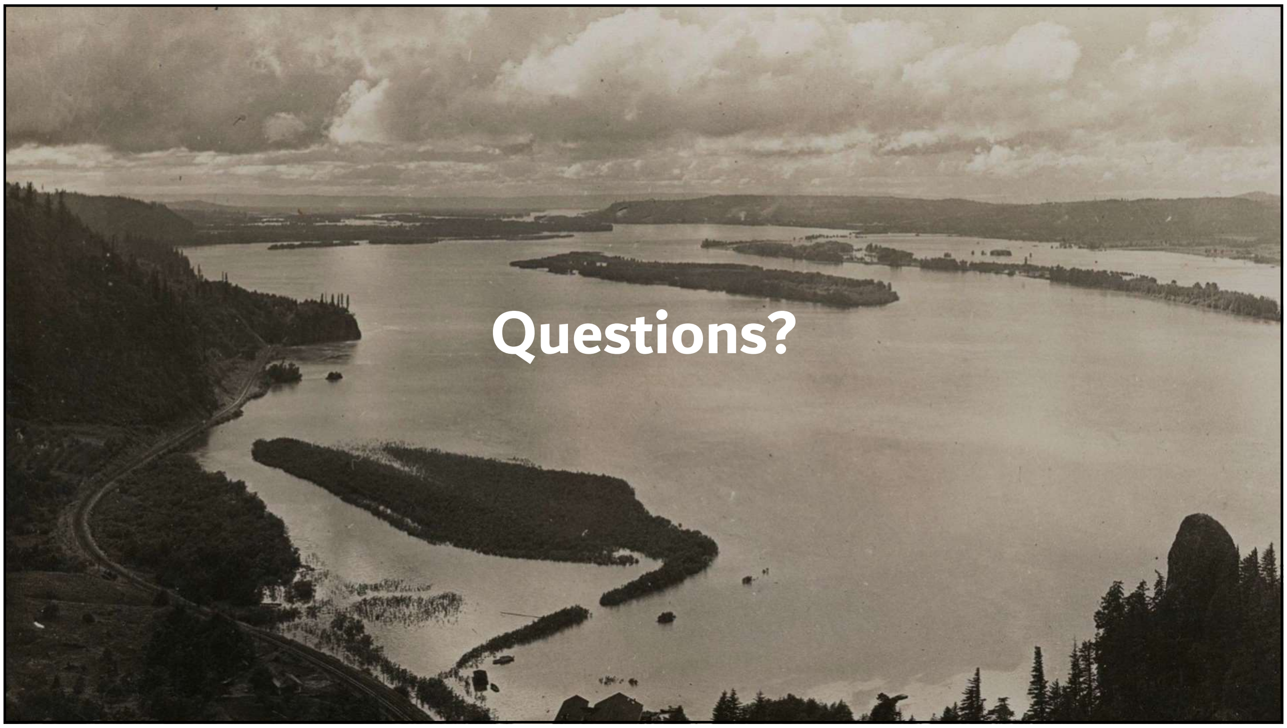
Potential Estimates – Back of Envelope

Illustration only



Note: Do not use these values. Staff are in the process of carefully defining the applicability factors. The chart should be read like: "If the applicability factor ends up being 25%, then the rooftop solar resource will be approximately 765 aMW, which is approximately the annual aMW of the Dalles dam. (Source of dam production: BPA 2022 PNW Loads and Resources Study, July 2022). Assumed 6,700 kWh per home and 4 million homes in the region

30



31

Northwest **Power** and
Conservation Council

32