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

June 9, 2020

MEMORANDUM

TO: **Power Committee**

FROM: **Gillian Charles**

SUBJECT: Summary of primary generating resource reference plants and emerging tech reference plant for draft 2021 Power Plan

BACKGROUND:

Presenter: Gillian Charles

Summary: At the June Power Committee meeting, staff will review the primary generating resource reference plants developed for inclusion in the draft 2021 Power Plan. All of these reference plants were previously presented in detail to the Power Committee over the past year and have been vetted by the Council's Generating Resources Advisory Committee.

In addition, staff will present the proposed emerging technology reference plant to be included as a resource option in the plan's scenario analysis.

Workplan: A.4.1 Develop generating resource reference plants for the 2021 Power Plan (incl. review w/ GRAC)

Summary of primary generating resource reference plants and emerging tech reference plant for draft 2021 Power Plan

Power Committee, June 16, 2020

Gillian Charles

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1

Power Committee & Council Meetings: New Generating Resource Reference Plants

2019	March & April	NW transmission utilization & impacts of transmission on resource planning
	May	Process Review: Developing a reference plant
	July	Categorization of new generating resource options
	August	Process review: Methodology for determining quantifiable environmental costs and benefits of new resources
	Sept/Oct (Council)	Briefing, staff proposal, and follow-up: Methodology for determining quantifiable environmental costs and benefits of new resources
	Oct	Reference Plants: Solar, Battery Storage, Solar + Battery
	Nov	Reference Plant: Onshore Wind
	Dec	Reference Plant: Pumped Storage
2020	Feb	Reference Plants: Natural Gas and Conventional Geothermal
	June	Reference Plants: Emerging tech, summary of all primary resource reference plants

Note: The work products that staff presents to the Power Committee have all been vetted with the Generating Resources Advisory Committee (GRAC) and when applicable the System Analysis Advisory Committee (SAAC).

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2

Resource Categories*

Prioritization based on a resource's commercial availability, constructability, cost, and quantity of developable resource in the region

Primary; Significant: Resources that are fully commercial and look to play a major role in the future PNW power system.

Assessment: In-depth, quantitative characterization to support system integration and risk analysis modeling. Will be modeled in RPM.

Secondary; Commercial w/ Limited Availability: Resources that are fully commercial but that have limited developmental potential in the PNW.

Assessment: Mix of qualitative and some quantitative analysis sufficient for potential modeling in the RPM.

Emerging/Long-term: Resources that have long-term potential in the PNW but that are not commercially available yet.

Assessment: Qualitative discussion of status & regional potential, quantify key numbers as available. Will not be modeled in RPM.

*Note: the categorization is a framework that helps determine the level of analysis (a work plan of sorts); however it can be revisited and revised by the Council at any point in the development of the power plan

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3

3

New Resource Options for 2021 Plan

Primary	Secondary	Emerging/Long-term
Solar PV	Conv. Geothermal	Enhanced Geothermal Systems
Onshore Wind	Offshore Wind	Small Modular Reactors
Gas CCCT	Distributed Generation	Carbon Capture & Sequestration
Gas SCCT – Frame	Biomass	Hydrogen Gas Turbine
Battery storage (Li-ion)	Hydro Upgrades	Allam Cycle Gas
Solar + Storage	Biogas	Wave, Tidal
Pumped Storage	Power-to-Gas	
Reciprocating Engine	Small Hydro	
Gas SCCT - Aeroderivative	Combined Heat and Power	

= reference plant

Omitted: Advanced nuclear, coal, large hydro

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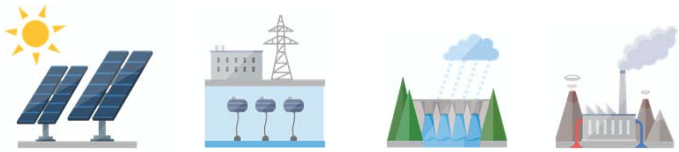
4

4

Defining a Reference Plant



A **reference plant** is a collection of characteristics that describe a resource technology and its theoretical application in the region. It includes estimates of typical costs, logistics, operating specifications, and development potential.

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5

5

Environmental effects and the Power Plan process

The Council considers **a wide array of environmental effects** related to the power system and integrates these effects into its analysis in a variety of ways

- The methodology for quantifying the environmental costs and benefits of new resources is only one "slice of the pie"
- Other examples include fish & wildlife measures on the hydro system capability and dispatch and state clean energy standards on existing system operations and future resource development

Slide copied from the September and October 2019 Council Meetings

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6

6

Summary: Proposal for methodology for quantifying the environmental costs and benefits of new resources

Reflected in the overnight capital cost and O&M costs of new resources in the reference plants

Staff Proposal for 2021 Plan:

1. Account for the financial costs of compliance with **existing regulations** in the cost of new resources.
2. Recognize that **residual and unregulated** environmental effects from resources exist but are hard or impossible to quantify in any systematic and consistent way; describe them qualitatively in the narrative of the plan and consider them when determining a resource strategy.
3. Address and consider costs of compliance with **proposed regulations** on a case-by-case basis.
4. Do not attempt to include **quantified environmental benefits** in new resource costs beyond the few historic examples, but recognize and emphasize in the resource strategy in other ways the value of certain resource choices in helping to mitigate other harmful environmental effects.

Slide copied from the September and October 2019 Council Meetings

7

The Northwest Power System utilizes long-term firm transmission contracts*

- PNW operates within a bilateral market in which the developer of a resource must (in general) hold a long-term firm transmission (LTF) contract – essentially a reservation for transmission capacity between specific points - in order to proceed with building and selling the resource
- It is entirely possible – and common – that a given transmission path could be **fully contractually encumbered** on a LTF basis, while still having **substantial available physical capacity** most or all hours of the year
  - LTF reservations are maintained regardless of whether or not the capacity is physically utilized**

*For simplification purposes in terms of long-term power planning and development; there are limited conditional firm contracts available on a short-term basis

** By FERC Order, all unused transmission capacity must be marketed on OASIS for short-term utilization. However, for practical planning and development purposes, short term transmission access may have limited value to entities seeking to develop new resources in the Northwest because of deliverability risk in financing.

8

Defining Maximum Build-out

Maximum build-out

- ✓ Upper bound limit for potential selection in a portfolio model
- ✓ It is specific to a resource *and* location
- ✓ It is the ceiling. The floor is zero. The model will optimize on cost, accounting for policy requirements and operational constraints

- In the 7th Plan, maximum build out was closely aligned with commercial transmission inventory
- 2021 Power Plan, strategy is to allow for a higher *potential* maximum build-out (capped by balancing authority load + export capability) and not give consideration to physical utilization and contractual encumberment
  - Additional limiting factors – like technical potential – applied to certain resources

Thank you to my former colleague Mike Starrett for his thorough, thoughtful, and colorful analysis on the utilization of the region's current transmission system

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9

9

Primary Resource Reference Plants: Review

10

10

Primary resource reference plants: draft 2021 Plan

Solar PV (2 reference plants)
15 MWac single-axis tracker, 100MWac single axis tracker
Location(s): W. Washington, E. of Cascades
Annual capacity factor(s): 24.7%, 32.5%
Overnight capital cost: $1,465/kW, $1,350/kW
Fixed O&M cost: $14.55/kW-yr
Economic life: 30 years

Battery Storage (1 reference plant)
100MW, 4 hour Li-ion battery
Location: n/a
Round-trip efficiency: 88%
Overnight capital cost: $1,400/kW
Fixed O&M cost: $31/kW-yr
Economic life: 15 years

Solar + Battery Storage (1 reference plant)
100MWac co-located with 100MW/400MWh battery
Location(s): n/a
Overnight capital cost: $2,568/kW
Fixed O&M cost: $31/kW-yr
Economic life: 15/30 years

* All costs in 2016$; see 2021 Plan webpage and GRAC meetings for full presentation materials

11

Primary resource reference plants: draft 2021 Plan

Onshore Wind (3 reference plants)
216 MW (60 x 3.6MW turbines, 105m hub height)
Location(s): Columbia Gorge, SE Washington, Montana
Annual capacity factor(s): 39.8%, 41.2%, 45.5%
Overnight capital cost: $1,450/kW
Fixed O&M cost: $30/kW-yr
Economic life: 25 years

Pumped Storage (1 reference plant)
400 MW, 8hr closed-loop system
Location: n/a
Round-trip efficiency: 80%
Overnight capital cost: $2,300/kW
Fixed O&M cost: $14/kW-yr
Economic life: 50 years

Conventional Geothermal (1 reference plant)
22 MW closed-loop, binary cycle
Location: Cascades
Overnight capital cost: $5,400/kW
Fixed O&M cost: $150/kW-yr
Variable O&M: $5/MWh
Economic life: 30 years

* All costs in 2016$; see 2021 Plan webpage and GRAC meetings for full presentation materials

12

Primary resource reference plants: draft 2021 Plan

Frame Gas Peaker (1 reference plant)
380 MW GE 7HA.02
Location: East side
Overnight capital cost: $550/kW
Fixed O&M cost: $5.50/kW-yr
Variable O&M cost: $6.50
Economic life: 30 years

Combined-cycle Combustion Turbine (1 reference plant)
1x1 GE 7HA.02
Location: East side
Overnight capital cost: $1,150/kW
Fixed O&M cost: $10/kW-yr
Variable O&M cost: $3/MWh
Economic life: 30 years

Note: Council staff developed and vetted reference plant parameters for natural gas reciprocating engines, aeroderivative gas peakers, and intercooled gas peakers. The frame is included as a reference plant proxy for the other gas peakers; they all have attributes that may make them optimal resource choices in different circumstances.

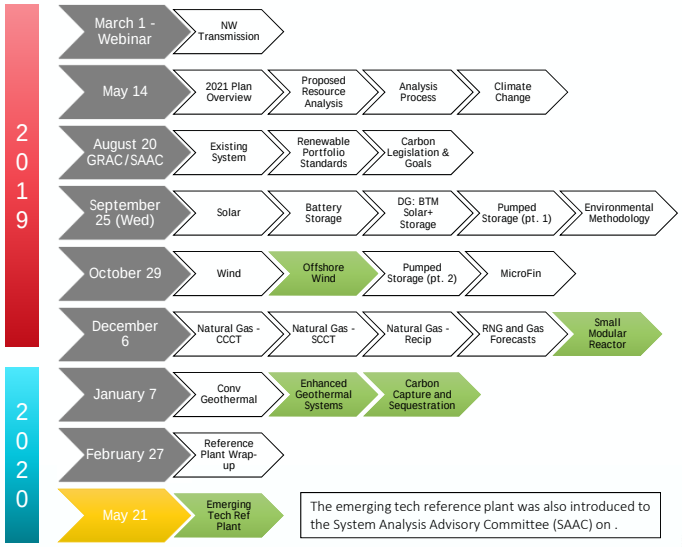
* All costs in 2016$; see 2021 Plan webpage and GRAC meetings for full presentation materials

13

Emerging Tech

14

GRAC Meetings: Focus on Emerging Tech



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15

Emerging Tech Ref Plant

Purpose: Develop an emerging tech reference plant to be added as a resource option in the Council's scenario analysis

- Ref plant will compete as an option against primary resources as well as additional EE potential

- Scenario analysis: Council planning on testing seven scenarios
  - Emerging tech ref plant will be especially useful in the "pathways to decarbonization" scenario

- Reminder: Power Plan is a 20 year plan, with focus on the initial 5 years; produce a new plan every ~5 years (action plan period)
  - Emerging tech ref plant important to inform future power system, but none of the options will be realistically available for selection in the first five years

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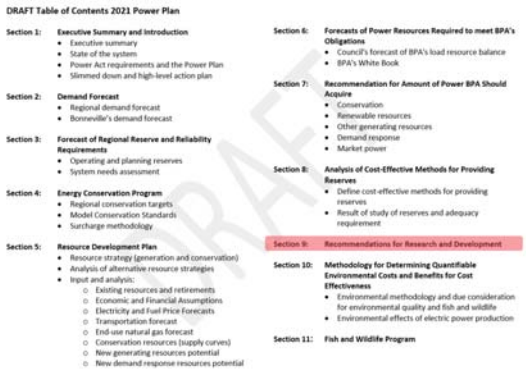
16

Further Opportunities for Emerging Tech

- Per the Power Act, the Power Plan is to include recommendations for research and development
  - Section 9 in the proposed 2021 Plan table of contents
- Opportunity to highlight promising emerging technologies with potential in the region
  - Identify gaps in R&D

Proposed 2021 Plan Table of Contents



DRAFT Table of Contents 2021 Power Plan

Section 1: Executive Summary and Introduction
- Executive summary
- State of the system
- Power Act requirements and the Power Plan
- Slimmed down and high-level action plan

Section 2: Demand Forecast
- Regional demand forecast
- Bonneville's demand forecast

Section 3: Forecast of Regional Reserve and Reliability Requirements
- Operating and planning reserves
- System needs assessment

Section 4: Energy Conservation Program
- Regional conservation targets
- Model Conservation Standards
- Surcharge methodology

Section 5: Resource Development Plan
- Resource strategy (generation and conservation)
- Analysis of alternative resource strategies
- Input and analysis:
  - Existing resources and retirements
  - Economic and Financial Assumptions
  - Electricity and Fuel Price Forecasts
  - Transportation forecast
  - End-use natural gas forecast
  - Conservation resources (supply curves)
  - New generating resources potential
  - New demand response resources potential

Section 6: Forecasts of Power Resources Required to meet BPA's Obligations
- Council's forecast of BPA's load resource balance
- BPA's White Book

Section 7: Recommendation for Amount of Power BPA Should Acquire
- Conservation
- Renewable resources
- Other generating resources
- Demand response
- Market power

Section 8: Analysis of Cost-Effective Methods for Providing Reserves
- Define cost-effective methods for providing reserves
- Result of study of reserves and adequacy requirement

Section 9: Recommendations for Research and Development

Section 10: Methodology for Determining Quantifiable Environmental Costs and Benefits for Cost Effectiveness
- Environmental methodology and due consideration for environmental quality and fish and wildlife
- Environmental effects of electric power production

Section 11: Fish and Wildlife Program

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17

Offshore Wind (Floating)
- Emerging technology - esp. compared to commercial fixed-bottom - with pilot projects in Europe
- Significant technical potential off Oregon coast
- Carbon-free, renewable
- 15MW turbines expected in 2030, COD 2032

Small Modular Reactors (SMR)
- Pre-fabricated, modular concept
- Ability to provide baseload resource and flexibility through modules
- Undergoing licensing through NRC
- Carbon-free
- First plant expected online ~2026 (UAMPS)

Enhanced Geothermal Systems
- "Conventional" EGS vs. "super-hot" EGS
- Significant technical potential
- High availability and energy density
- Still need to develop "next generation" drilling equipment capable of economically reaching new depths (10-20km)
- Carbon-free, renewable

Carbon Capture Technologies
- New carbon capture innovations in development
- Testing at Allam-cycle NET power plant; potential commercial availability in early 2020's (??)
- Carbon-free; Potential utility of captured CO_2 for enhanced oil recovery
- Risks! Kemper coal gasification

Wave, Tidal
- Diverse wave energy conversion technologies in various stages of development
- POET – local industry development efforts
- PacWave test facility off Newport
- Significant technical potential
- Winter-peaking resource
- Carbon-free, renewable

18

Staff proposal for emerging tech reference plant

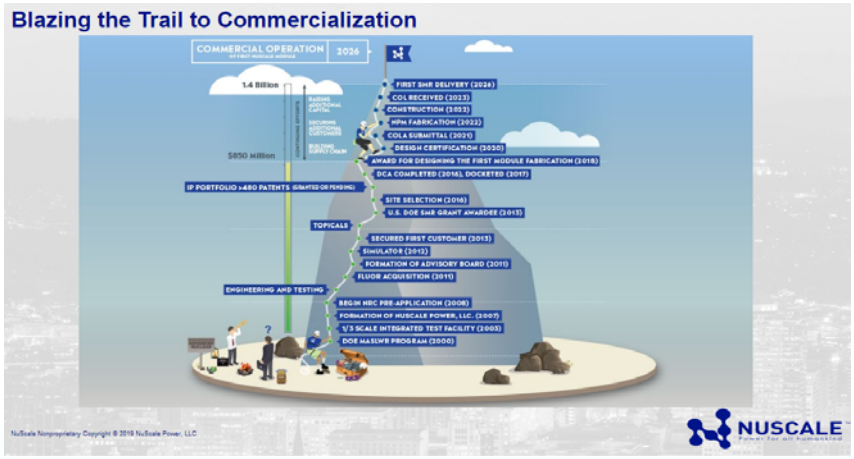
- Develop a reference plant that can serve as a **proxy*** for all of the emerging technology options
  - All emerging tech highlighted have potential to play a role in the future system
  - All are carbon free and could potentially be available to fulfill clean policy goals (depending on commercial readiness)
  - All have overnight capital costs that are currently above the "primary" resources

Proposal: **Develop SMR** as a proxy emerging tech reference plant for use in scenario analysis
✓ Considered as resource option in several regional IRPs
✓ Regional development planned – UAMPS

* Proxy won't be completely reflective of all emerging tech resource attributes; but should be treated as a representative future resource

What is SMR?

Current status of NuScale SMR



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21

UAMPS Carbon Free Power Project

- 720 MW gross/683 MW net, 12 module power plant planned – partnership between NuScale and UAMPS
- Feb 2016 US DOE issued site permit at Idaho National Lab (DOE also supporting partner of project)
- Currently 35 UAMPS members executed long-term sales agreements for 213 MW
  - ~1/3 project subscribed
- Planned COD for first module is 2026, plant completion estimated 2028

47 members in Utah, California, Idaho, Nevada, New Mexico, Oregon, and Wyoming

UAMPS Utah Associated Municipal Power Systems

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22

2021 Plan Emerging Tech Reference Plant (Proxy): SMR

	Small Modular Reactor Ref Plant
Configuration & Technology	(12) NuScale modules (incl. 12 turbine generators)
Capacity (MW)	684 MW (net); 720 MW (gross)
Heat Rate (Btu/kWh)	Confidential
Economic Life (years)	40 (licensed for 40 years; designed for 80 years)
Overnight Capital Cost ($/kW)	$5,400
Fixed O&M Cost ($/kW-yr)	Confidential
Variable O&M Cost ($/MWh)	Confidential
Development Time (years)	4 years
Construction Time (years)	4 years
Earliest Commercial Online Date	2030
Resource Maximum Build-out (potential)	3,420 MW (5 reference plants)

PTC available for 6,000 MW new nuclear; some of this already accounted for in developments, but some may be applicable for PNW developments

Discussion at the GRAC & SAAC

GRAC webinar 5/21: Reviewed emerging technology analysis and presented the staff-proposed emerging technology reference plant

- While there was some discussion about the benefits and risks of several of the emerging technologies, including SMR, there was **mostly agreement about the strategy and selection of SMR as a proxy resource**
  - Interest in action plan and monitoring of emerging technologies as potential future resources
  - Some concern about use of confidential information in analysis

SAAC webinar 6/2: Reviewed SMR as an emerging technology for use in scenario analysis and some outstanding modeling issues

Thank you advisory committee members and stakeholders!

Next Steps

- Council staff working with NuScale and Energy Northwest to refine some additional model inputs
- Some information may end up being proprietary and/or only available via non-disclosure agreement – which is unusual for Council inputs, but may be necessary in this case
  - Council staff working on alternatives… stay tuned
- Further discussion re: modeling inputs at future SAAC meeting (TBD)

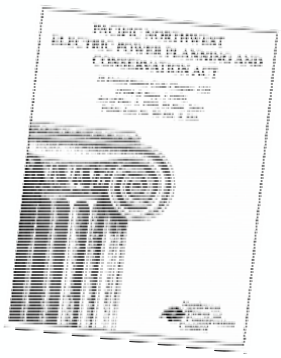
25

Background Slides

26

What is the methodology for quantifying environmental costs and benefits of new resources?

- The Northwest Power Act requires the Council (1) develop and (2) apply a "methodology for determining [the] quantifiable environmental costs and benefits" of **new** electric generating and conservation resources §4(e)(3)(C)
- The environmental methodology is to
  - Consider **costs *and* benefits** to the **environment**...
  - And, for those costs and benefits to be **quantifiable**, recognizing that not all environmental effects can be reduced to quantified costs and benefits...
  - And, the costs must be **directly attributable** to the resource, not incidental or indirect



Terms not defined in the Act; Council uses common sense understanding, as guided by context of the Act and discussions in legislative history