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March 3, 2015

MEMORANDUM

TO: Council Members

**FROM: Gillian Charles, Energy Policy Analyst
Steve Simmons, Sr. Economic Analyst**

**SUBJECT: Council guidance on Generating Resource Characteristics
Assumptions for use in Regional Portfolio Model**

BACKGROUND:

Presenter: Gillian Charles, Steve Simmons

Summary: Staff will present a high level summary of the proposed draft Seventh Plan generating resource characteristics that will be inputs to the modeling analysis performed in the Regional Portfolio Model (RPM). These resources include: natural gas combined cycle combustion turbines, natural gas single cycle combustion turbines, reciprocating engines, utility-scale solar photovoltaic, and utility-scale on-shore wind. In addition to presenting the resource reference plants and cost estimates, staff will also compare the draft assumptions with the final assumptions used in the Sixth Power Plan.

Staff is looking to the Council for guidance and acceptance to use these characteristics as the generating resource assumptions in the RPM analysis for the Draft Seventh Plan.

Relevance: Staff is working on transferring the draft generating resource characteristics into the data input template for the RPM. Staff will be using

this data to test the functioning of the model, as well as to begin scenario analysis for the draft Seventh Power Plan.

Workplan: 1.D. Prepare for Seventh Power Plan and maintain analytical capability – generating resource characterization

Background: Staff presented these draft generating resources characterizations at the February Power Committee. Staff also previously presented generating resource characteristics information during detailed Power Committee webinars on November 18th and January 29. In addition, the Council's Generating Resources Advisory Committee (GRAC) has reviewed and vetted over multiple meetings the assumptions being proposed.

More Info: For detailed information on the work that has been presented to the GRAC, see the GRAC past meetings webpage - <http://www.nwcouncil.org/energy/grac/meetings/>. In addition, the presentation materials from the previous Power Committee webinars are available on the Council website - <http://www.nwcouncil.org/news/meetings/>.

Draft Seventh Plan Generating Resource Characteristics for use in Regional Portfolio Model

Gillian Charles, Steve Simmons

3/11/15

Council Meeting



Purpose of Today's Presentation

- **High level summary of proposed draft Seventh Plan generating resource characteristics***
 - Technology overviews
 - Reference plants and cost assumptions
 - Comparison to final Sixth Plan assumptions – what changed and why?
 - Renewable Portfolio Standard assumptions
- **Looking for Council guidance for staff to input assumptions to RPM for draft plan analysis**

*These characteristics were previously presented at the February Power Committee, Power Committee webinars, and reviewed at multiple Generating Resource Advisory Committee (GRAC) meetings.



Reviewed with P4 for Input in RPM for Draft 7th Plan

November 18, 2014 - P4 Webinar

- ✓ Utility-scale Solar PV
- ✓ Natural Gas - Combined Cycle Combustion Turbines

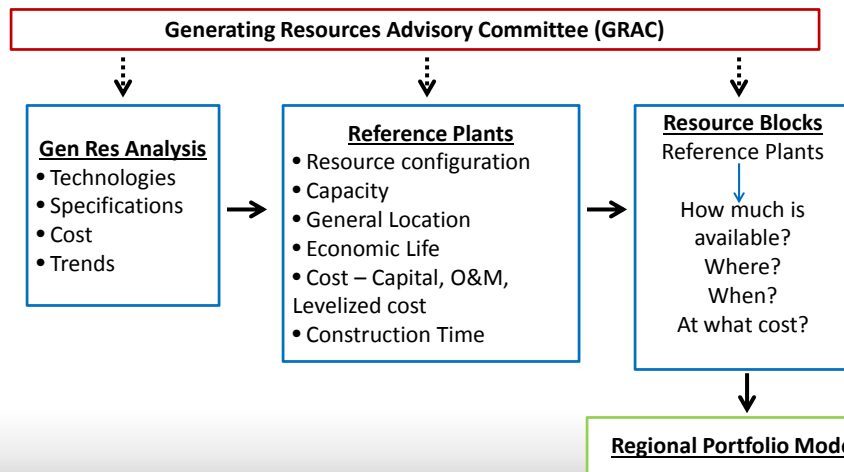
January 29, 2015 – P4 Webinar

- ✓ Utility-scale Wind
- ✓ Natural Gas – Peakers (Single Cycle Turbines and Reciprocating Engines)

February 10, 2015 – P4

- ✓ Draft Gen Resource Characteristics for use in RPM

Generating Resources Analysis in the Seventh Power Plan



GRAC Meetings To Date

GRAC Meeting	Solar PV	CCCT	Gas Peakers	Wind	Hydro Scoping	Offshore Wind	Storage	SMR	EGS	RPS
1) Jun 20 2013	1									
2) Oct 16 2013	2	1			1					
3) Feb 27 2014		2	1							
4) May 28 2014	3	3	2	1	2	1				
5) Oct 2 2014			3	2	3					
6) Nov 7 2014	4									
7) Nov 21 2014					4					
8) Dec 18 2014			4	3			1			
9) Jan 27 2015							2	1	1	
10) Feb 26 2015										1

SMR = Small Modular Reactors, EGS = Enhanced Geothermal (as opposed to conventional geothermal), RPS = Renewable Portfolio Standards

Categorization of Resources for the Draft Seventh Power Plan (1)

Prioritization based on a resource’s commercial availability, constructability, cost-effectiveness, and quantity of developable resource.

Primary; Significant: Resources that 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 don’t have a lot of developmental potential in the PNW

Assessment : Quantitative characterization sufficient to estimate levelized costs. Will not be modeled in RPM.

Long-term Potential: Resources that have long term potential in the PNW but may not be commercially available yet

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

Categorization of Resources for the Draft Seventh Power Plan (2)

Primary; Significant	Secondary; Commercial w/ Limited Availability	Long-Term Potential
Natural Gas Combined Cycle	Biogas Technologies (landfill, wastewater treatment, animal waste, etc.)	Engineered Geothermal Power Plan Narratives
Wind	Biomass - Woody residues	Offshore Wind
Solar PV	Conventional hydrothermal Geothermal	Modular Nuclear Units
Natural Gas Simple Cycle, Reciprocating Engine	New Hydropower	Wave Energy
	Hydropower Upgrades	Tidal Energy
	Waste heat recovery and CHP	Coal Technologies w/ CO ₂ Separation
RPM Input Resources	Storage Technologies* Power Plan Narratives	CO ₂ Sequestration
		Storage Technologies*

* Various storage technologies may fall under different categories

Langley Gulch, 300 MW, Idaho, 2012



Photo credit: Kiewit



Reference Plant

COMBINED CYCLE COMBUSTION TURBINE

Reference Plant(s)

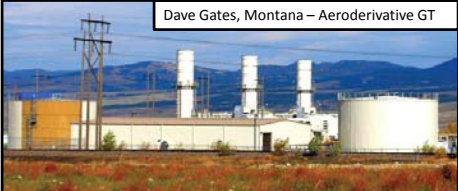
	CCCT 1	CCCT 2
Location	PNW East	PNW East
Capacity (MW)	370 (390)	425
Economic Life (years)	30	30
Earliest In –Service	2018	2020
Development time (years)	5	5
Capital Cost (\$/kW) In-service year 2016	1,147 (1,046)	1,287
Fuel	Natural Gas – East	Natural Gas – East
Heat Rate (btu/kWh)	6,770 (6,930)	6,704
Capacity Factor % (for presentation purposes)	60	60
Inv. /Prod. Tax Credit	-	-
O&M Fixed (\$/kW-yr), Variable (\$/MWh)	\$15.37, \$3.27 \$14.00, \$1.70	15.37/3.27



All costs represented in 2012 \$ 9


Black = Draft 7th Plan Assumption
Red = Final 6th Plan Assumption






Dave Gates, Montana – Aero-derivative GT

Photo credit: PowerMag.com




Danskin, Idaho – Frame GT

Photo credit: Tim Bondy



Port Westward II – Recip

Photo credit: PGE flickr




Port Westward II – Recip


Photo credit: PGE flickr

Reference Plants

GAS PEAKERS – SINGLE CYCLE AND RECIPROCATING ENGINES



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Reference Plant(s)

	Frame GE 7F 5-Series 1 X 216 MW	Aero GE LM6000 PF 4 X 47 MW	Intercooled GE LMS 100 PB 2 X 100 MW	Reciprocating Engine Wärtsilä 12 X 18 MW
Location	PNW West	PNW West	PNW West	PNW West
Capacity (MW)	216 (85)	190 (92)	200 (100)	220
Economic Life (years)	30	30	30	30
Earliest In-Service	2018	2018	2018	2018
Development time (years)	2.75	2.75	2.75	2.75
Capital Cost (\$/kW) In-service year 2016	\$800 (\$561)	\$1,100 (\$980)	\$1,000 (\$1,052)	\$1,300 (\$1,082)
Fuel	Natural gas	Natural gas	Natural gas	Natural gas
Heat Rate (btu/kWh)	9801 (11960)	9048 (9370)	8541 (8870)	8370 (8850)
Capacity Factor % (for presentation purposes)	25%	25%	25%	25%
Inv. Tax Credit	--	--	--	--
O&M Fixed (\$/kW-yr), Variable (\$/MWh)	\$7.00, \$10.00 (\$12.30, \$1.20)	\$25.00, \$5.00 (\$14.50, \$4.50)	\$11.00, \$7.00 (\$9.00, \$5.60)	\$10.00, \$9.00 (\$14.50, \$11.20)


Recommendation

- Power Committee agreed with staff and GRAC recommendation to use one gas peaker in the RPM as a proxy for all
 - Purpose/use of gas peakers trumps economics
 - P4 recommended selection of the **reciprocating engine** as the primary peaking reference plant for the draft Seventh Plan
 - Ability to add other reference plants at a later date




Outback Solar PV Plant, 5 MW, Oregon

Photo credit: Obsidian Renewables



Copper Mountain Solar facility, 48 MW, Arizona

Photo credit: Sempra Energy




Sandhill Solar Farm, 19 MW, Colorado


Photo credit: Solar Professional

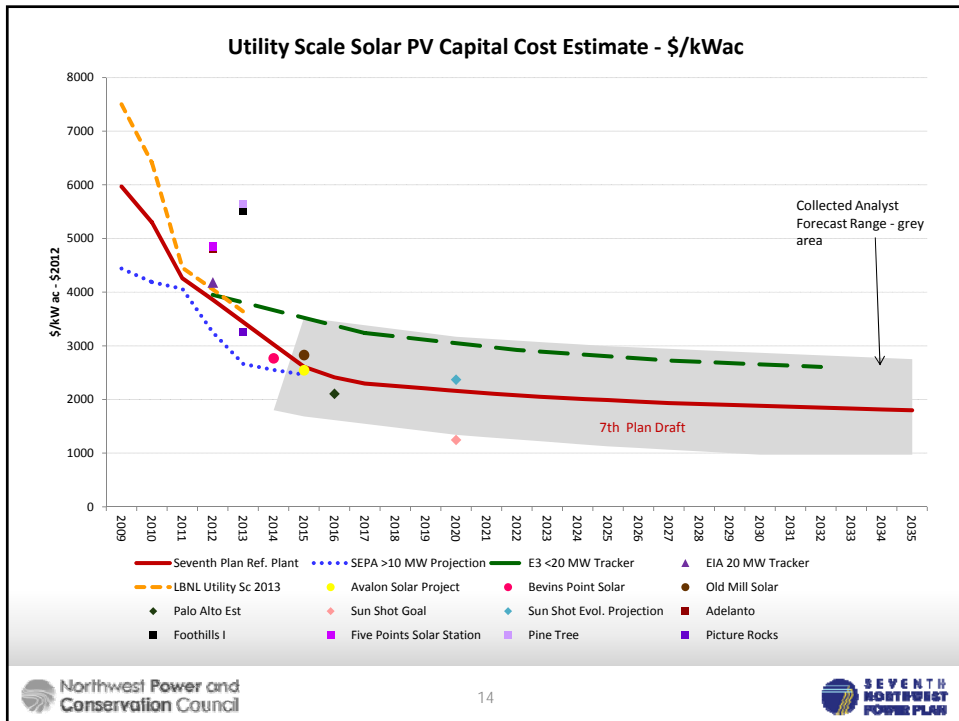
Reference Plants

UTILITY-SCALE SOLAR PV



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Reference Plant(s)

	Solar PV Utility Scale
Location	S. ID
Capacity (MW)	20 (20)
Economic Life (years)	30
Earliest In –Service	2016
Development time (years)	3
Capital Cost (\$/kWac) In-service year 2016	2,413 (5,919)
Fuel	-
Heat Rate (btu/kWh)	-
Capacity Factor % (for presentation purposes)	26.2
Inv. /Prod. Tax Credit	ITC 30%/10%
O&M Fixed (\$/kW-yr), Variable (\$/MWh)	\$16.63 (\$36.00)

Utility Scale Solar PV Modeling Blocks

1. Solar PV from Southern Idaho serving local load
2. Solar PV from Southern Idaho serving regional load via potential new transmission B2H (Boardman – Hemingway Project)



Tucannon River Wind Farm, 267 MW, 2014

Photo credit: PGE flickr

Reference Plant
ONSHORE-WIND

Reference Plant(s)

	On-Shore Wind 40 X 2.5MW	On-Shore Wind 40 X 2.5MW
Location	Columbia Basin	Central Montana, delivered to BPA system
Capacity (MW)	100	100
Economic Life (years)	25 (20)	25 (20)
Earliest In -Service	2019	2019
Development time (years)	4 (4.5)	4 (4.5)
Capital Cost (\$/kW) In-service year 2016	\$2,240 (\$1,850)	\$2,240 (\$1,850)
Fuel	--	--
Heat Rate (btu/kWh)	--	--
Capacity Factor % (for presentation purposes)	32%	40% (38%)
Inv. /Prod. Tax Credit	--	--
O&M Fixed (\$/kW-yr), Variable (\$/MWh)	\$35.00, \$2.00 (\$44.70, \$2.20)	\$35.00, \$2.00 (\$44.70, \$2.20)

Wind Modeling Blocks

1. Wind from Columbia Basin serving NW load
2. Wind from Montana serving NW load
 - a) with existing transmission
 - b) new 230kV transmission line
 - c) upgrade to the Path8/CTS transmission
 - d) Colstrip Transmission with units 1 & 2 retired

Fixed (\$/kW-yr) and full (\$/MWh)– annualized cost of capital and operation across the lifecycle

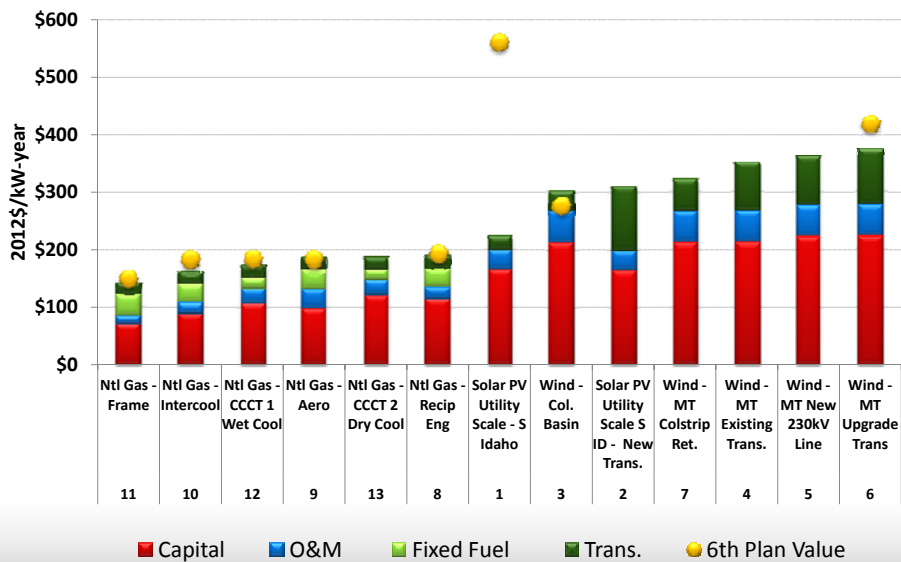
LEVELIZED COST OF ENERGY

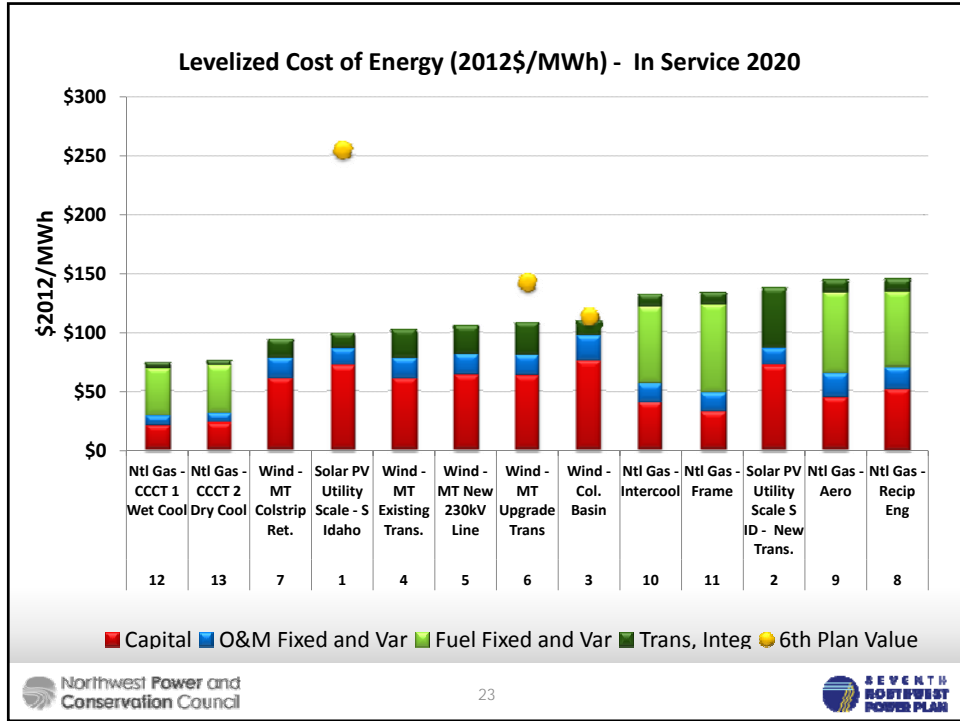
Levelized Cost

MicroFin - revenue requirements financial model is used to

1. Calculate Fixed Levelized Cost for each resource: \$/kW-yr
2. Calculate full Levelized Cost of Energy (LCOE) for each resource: \$/MWh

Levelized Fixed Cost (\$/kW-yr) - In Service 2020





Input to RPM

RENEWABLE PORTFOLIO STANDARDS

Northwest Power and Conservation Council 24 SEVENTH NORTHWEST POWER PLAN

The Standards: Overview*

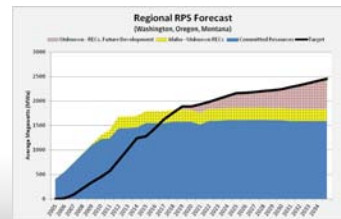
	Montana	Oregon	Washington
Standard	5% in 2008 10% in 2010 15% in 2015	5% in 2011 15% in 2015 20% in 2020 25% in 2025	3% in 2012 9% in 2016 15% in 2020
Date of Adoption	2005 Montana Renewable Power Production and Rural Economic Act	2007 Oregon Renewable Energy Act	2006 Ballot Initiative-937
Sourcing Limits	Located in MT; or deliverable to MT	Located in WECC	Located in PNW; or delivering electricity into WA
Technology Minimums	--	20 MW-AC Solar PV by 2020	--
Banking	2 years	Unlimited	1 year
Credit Trading	Allowed	Allowed	Allowed
Multipliers	--	Solar PV x 2 (if developed by 2016)	DG x 2; Union apprenticed labor x 1.2

* This table consolidates and simplifies at a high level many of the details, nuances, and unique qualities that make up each state's RPS

Purpose/Objective of Council RPS Analysis

Provide a high level analysis of state RPS standards, progress to-date, and remaining future procurement

- **Regional Portfolio Model (RPM)**
- **AURORA – WECC-wide**
- **Individual state analysis**



RPS Analysis → RPM Inputs

Inputs to RPM:

- Committed resources serving RPS for MT, WA, OR
- Banked renewable energy credits (RECs)
- Annual standards, obligated % load, banking criteria

Output from RPM:

- Run with 800 different futures (load, gas price, electricity forecasts) that determine RPS build in each future
 - Future build is forced into the model as must-run

In addition...

- Staff collecting information for narrative
 - Historical achievements
 - Prospective legislation in progress
 - Utility plans for future compliance
 - Utility challenges, successes

QUESTIONS?