Generating Resources Assessment Methodology

Power Committee

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Outline

- Generating Resources Assessment Methodology
  - Analysis
  - Models
  - Generating Resources Advisory Committee
- Categorization of Resources for the Draft Seventh Power Plan
- Where we are at, what is coming next

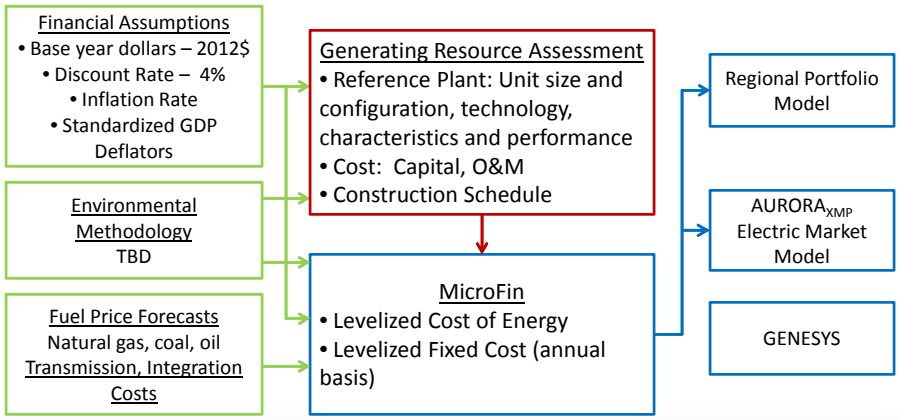
Purpose

- Council's mission – assure the region of an **A**dequate, **E**fficient, **E**conomical, and **R**eliable **P**ower **S**upply (**AEERPS**) by selecting the least cost, least risk resource strategy over the 20 year planning horizon
- Generating resource assessment informs the resource strategy
  - Resource types and technologies
  - Assumptions – Cost, Construction Schedule, Operating Characteristics and Performance, Developable Potential

Generating Resource Assessment Process

- Staff develops preliminary resource assumptions
- Review preliminary resource assumptions with the Generating Resources Advisory Committee (GRAC)
  - Incorporate feedback and information
- Review draft plan resource assumptions with the Power Committee/Council for approval to use in draft Seventh Plan analysis

Generating Resources Assessment Methodology



Reference Plant Key Attributes (1)

Reference Plant – a representative resource with a plausible configuration for development in the PNW; used in the Power Plan as possible new resource options

Configuration – Technology, number of units, air emission controls, cooling (wet vs. dry), specifications

Price Year – The vintage of the technology, overnight capital cost, and operating cost

Year Dollars – Reference year for setting dollar value; used consistently throughout power plan assumptions

Capacity (MW) - The maximum power that a machine or system can produce continuously under specified conditions

- International Standards Organization (ISO) – rating at 59°F, 1 atmosphere air pressure, 60% relative humidity; way of setting a standard condition for performance comparison
- Site – adjusts for elevation at specific sites (which effects atmospheric pressure)
- **Lifecycle** – adjusts for effects of wear and tear on the equipment and restorative maintenance

Availability – the maximum expected potential resource operation; expressed as a percentage of full capacity.

Capacity Factor – the ratio of actual/expected output over a period of time, to potential output if operating at full capacity; expressed as a percentage of full capacity. Capped by availability.

- Dispatchable resources (combined cycle, single cycle, coal) – determined by economics
- Non-dispatchable resources (wind, solar PV, landfill gas) – determined by environmental conditions, supply of primary energy resource

Reference Plant Key Attributes (2)

Heat Rate (Btu/kWh) – the amount of fuel required to produce 1 kilowatt hour of electrical output; denotes fuel conversion efficiency. Can be expressed as heat rate (energy input vs kilowatt hour out) or as conversion efficiency (percentage)
Example: GE LMS 100 intercooled single cycle turbine
- The heat rate is 8540 Btu/kWh
- The fuel conversion efficiency is 40%

The lower the heat rate, the more efficient the plant is at converting fuel to electricity

Construction Lead Time (months) - amount of time it takes from conception to commissioning; Two phases for purposes of current Regional Portfolio Model (RPM):
- Planning and Development – Identification of need (e.g. IRP) to establishment of EPC contract (includes all siting and licensing, environmental assessments, preliminary engineering)
- Construction – From Notice to Proceed to complete construction and commissioning

Economic Life – assumed useful operating life (in years)

• Btu – British Thermal Unit – standard measure of energy content; 3413 Btu per kilowatt hour.
• EPC – Engineering, Procurement, and Construction contractor (final engineering, procurement of materials and equipment, and construction and commissioning)

Draft 7th Plan Example: Aeroderivative Gas Turbine Reference Plant (1)

Year Dollars	2012 $
Price Year	2015
Technology & Configuration base	**(4) GE LM6000 PF SPRINT**
Capacity Plant Total (MW)	180 MW lifecycle capacity
Fuel	Natural Gas
Heat Rate (btu/kWh)	9050
Availability (annual)	91%
Economic Life (Years)	30
Construction Lead Time (Months)	18 planning & development 15 construction (33 total)

Reference Plant Key Cost Estimates

Overnight Capital Cost ($/kW) – Sum of engineering, procurement, and construction (EPC) costs plus owner's cost (costs incurred by the project developer – permits, licenses, land, project development costs, infrastructure, taxes, regulatory compliance costs, etc.)

- Will include a high/low cost band to capture uncertainty around estimates

Fixed Operation and Maintenance (O&M) - Costs that include operating and maintenance, labor and materials, and administrative overhead. For purposes of the Council's modeling, major maintenance, capital replacement, and decommissioning costs are also included. Expressed in $/kW-Yr.

Variable O&M – Costs that are a function of the amount of power produced; Includes consumables such as water, chemicals, lubricants, and catalysts, waste disposal, regulatory compliance costs (emission allowances/offsets, CO2 costs); expressed in $/MWh.

Levelized Cost of Energy – the estimated cost of energy for a specific resource over it's productive life, expressed in $/MWh

Estimating Capital Cost Assumptions and Normalizations

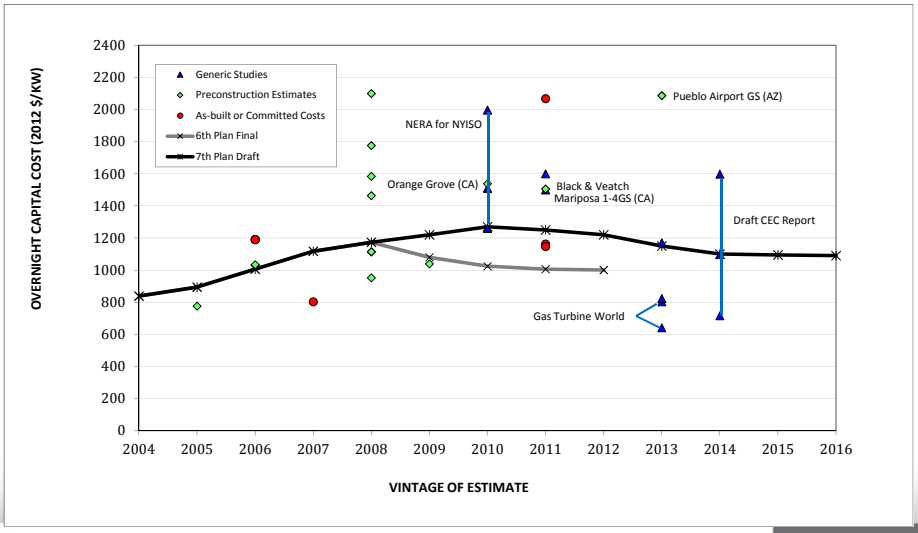
Normalization – Establishing comparable estimates by adjusting source data to common year dollars, vintage/price years, plant configuration, etc.

1. Reference sources – reported plant data, generic reports
2. Objective - normalize to draft Seventh Plan reference plant design
   - Overnight capital costs in $2012
   - Site-specific adjustments to capacity and heat rate
   - Site-specific labor costs
   - Typical configuration for PNW
3. Look for outliers, trends; forecast future 20 year trend line

List of Reference Sources

- Project-specific publically available reported info
- Technical data from manufacturer
- Regional utility IRPs
- Gas Turbine World (2013 Handbook)
- Black & Veatch analysis
- NERA analysis for NYISO
- EIA Capital Cost, EIA Annual Energy Outlook
- National Energy Technology Laboratory (NETL)
- National Renewable Energy Laboratory (NREL)
- California Energy Commission
- Generating Resources Advisory Committee (GRAC)
- Department of Energy annual market reports, technology-specific reports

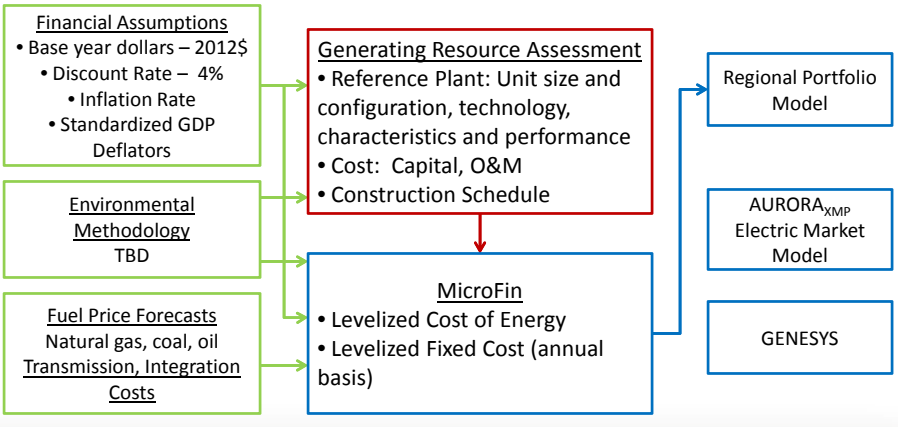
Preliminary Draft 7th Plan Capital Cost Estimate for Aeroderivative



Draft 7th Plan Example: Aeroderivative Gas Turbine Reference Plant (2)

Year Dollars	2012 $
Price Year	2015
Overnight Capital Cost ($/kW)	$1,095
Capital Cost Band (Hi/Low %)	TBD
Fixed O&M ($/kW-Yr)	$12.00
Variable O&M ($/MWh)	$4.50
Levelized Cost of Energy	TBD

Generating Resources Assessment Methodology



MicroFin – How it Works

Excel-based, revenue requirements financial model

1. Calculates annual cash flows over the plant lifetime that satisfy revenue requirements
2. Annual cash flows are compressed into a single year dollar value – Net Present Value (NPV)
3. NPV is converted into an even, annualized payment (like a mortgage payment) – Levelized Cost. When divided by annual energy production – it becomes the Levelized Cost of Energy $/MWh
4. Levelized Cost of Energy can be used to compare the average lifecycle costs of different types of resources

Three financial sponsor options
1. Muni/PUD
2. IOU
3. IPP

Key assumption differences among the sponsor types
1. Tax rates
2. Debt rates and service periods
3. Equity return rates and service periods

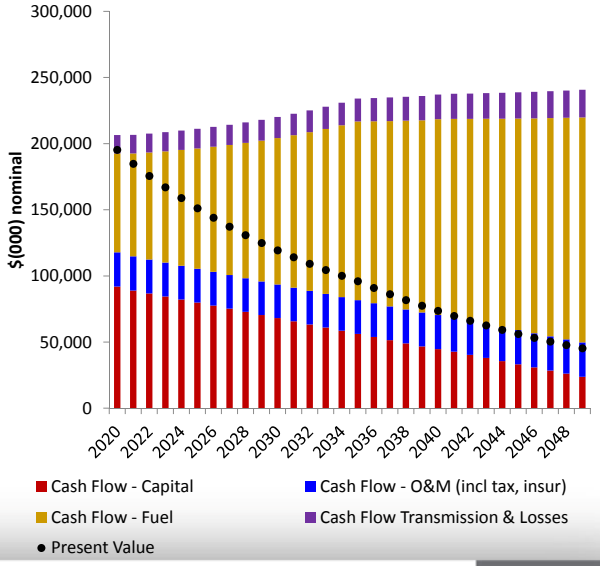
MicroFin Financials Key Assumptions	Municipal/PUD	Investor Owned Utility	Indep. Power Producer
Federal Tax - %	0	35	35
State Tax - %	0	5	5
Fed Tax Inv Credit - %	0	30/10[1]	30/10[1]
Property Tax - %	0	1.4	1.4
Insurance - %	0.25	0.25	0.25
Debt Fraction - %	100	50	60
Debt Interest Rate (not tax adjusted)	5.24	6.69	6.69
Debt payment Period	25[2]	25[2]	20[2]
Return on Equity	0	10	13.7
Equity Payment Period	25[2]	25[2]	20[2]
Discount Rate	4	4	4
Inflation Rate	1.64	1.64	1.64

[1]Solar only – Fed ITC 30% thru 2016, 10% following
[2] Gas 30/30/15

LCOE Example – Combined Cycle Combustion Turbine

ADV CCCT 2
Input
Capacity 425 MW
Capital Cost $1,217/kW
Capacity factor 0.6

ADV CCCT 2
Output
NPV $3.1 billion
Level. Cost of Energy
$71/MWh



Northwest Power and Conservation Council

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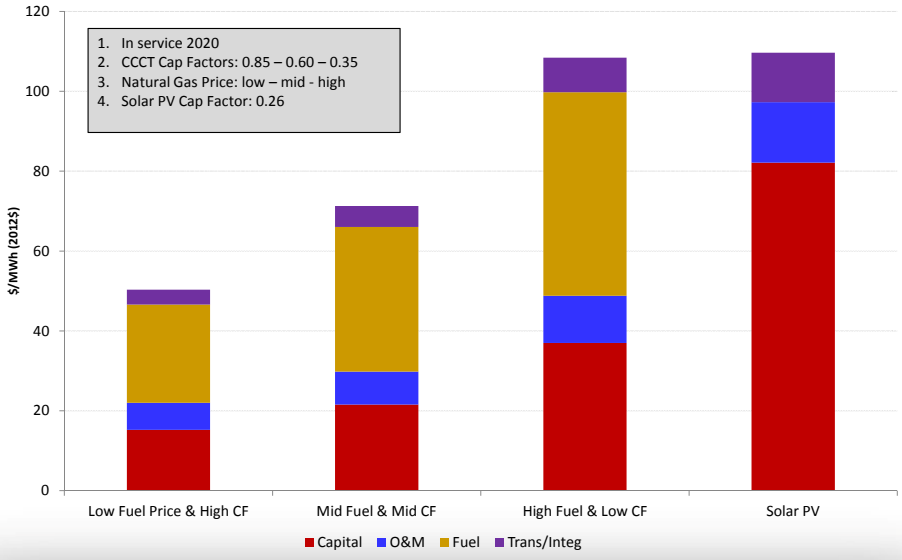
Levelized Cost of Energy Example
Advanced Combined Cycle Combustion Turbine & Utility Scale Solar PV



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In Addition to Resource Assessment…

- Wholesale Electric Price Forecast
- Renewable Portfolio Standards – WECC-wide forecast of future need
- Generating Resources Database – existing and planned projects in the PNW

Generating Resources Advisory Committee (GRAC)

- One of several advisory committees to the Council to assist in the development of the power plan
- Serves in advisory capacity only
  - No votes are taken
  - Role is to review information, vet assumptions, provide feedback
- Members from IOUs, public utilities, BPA, state commissions, public interest groups, national labs, independent contractors

Progress so far…

- Staff has reviewed the following preliminary resource assumptions with the GRAC:
  - Utility-scale Solar PV
  - Combined Cycle Combustion Turbine technologies
  - Single Cycle Combustion Turbine Technologies (gas peakers)
  - Reciprocating Engine Technologies (gas peaker)
  - Utility-scale Wind
- Staff is supervising the Council's Regional Hydropower Potential Scoping Study

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
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*	Waste heat recovery and CHP	Tidal Energy
	Hydropower Upgrades*	Coal Technologies w/ CO_2 Separation
	Storage Technologies**	CO_2 Sequestration
		Storage Technologies**

* Depending on results from hydropower potential assessment, hydropower upgrades to existing facilities may change categories
** Various storage technologies may fall under different categories

Tentative Schedule

- Now → February: Finalize draft resource assessments on primary resources for input into the RPM
  - Presentations to GRAC, Power Committee
- March → July: Perform resource assessment for secondary resources for inclusion in the draft Power Plan
  - Presentations to GRAC, Power Committee
- July → September: Discuss long-term potential resources for inclusion in draft Power Plan, Action Plan

What's coming to you over the next few months?*

November

- Rooftop Solar, Utility-scale Solar PV – draft 7P resource assessments
- Combined Cycle Combustion Turbine – draft 7P resource assessment
- Hydropower potential scoping study – results, analysis, next steps
- Wholesale Electricity Price Forecast

December

- Environmental Methodology

January

- Single Cycle and Reciprocating Engine Technologies, Utility-scale Wind – draft 7P resource assessment

* Schedule is tentative and subject to change

Questions?

Photo Credits: Slide 1. Bonneville Dam (NWPCC), Langley Gulch (NWPCC), Outback Solar (Obsidian Renewables), Lower Snake River Wind Farm (Puget Sound Energy), Boardman (OPB), Reciprocating Engines (Wärtsilä)
Slide 26: Lower Granite (NWPCC)