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January 6, 2015

MEMORANDUM

TO: Power Committee

FROM: Tom Eckman, Gillian Charles, Steve Simmons, Charles Grist, Tina Jayaweera and Kevin Smit

SUBJECT: Assessment and treatment of emerging generating and conservation resources technologies

BACKGROUND:

Presenter: Tom Eckman, Gillian Charles, Steve Simmons, Charles Grist, Tina Jayaweera and Kevin Smit

Summary:

In prior plans the Council has generally taken a conservative approach regarding the potential for improvement in the cost or performance of existing technology or availability of new and emerging technology. This approach stemmed largely from the guidance in the Power Act that requires that a resource considered for development in the Council's Plan be forecast "*to be reliable and available within the time it is needed*"¹ Since the Council must review and consider revising its plan at five year intervals, this approach allowed for re-consideration of resource technology advancements on relatively frequent intervals without requiring undue speculation. However, in its prior plans the Council also recognized the need to develop potentially cost-effective energy efficiency and generating resource technologies. Consequently, nearly all prior plans have included Action Plan activities that would better position the region to take advantage of new and emerging resource options. For example, the Sixth Plan contained action items for both generating and conservation resources designed to

¹ Northwest Power Act, §3(4)(A)(i), 94 Stat. 2698.

expand the availability of resource options, reduce their costs or improve their performance/reliability.²

Staff is proposing a similar approach for considering emerging technology in the Seventh Plan. However, some parties have requested that the Council to investigate the implications of alternative carbon constrained scenarios. In order to test scenarios that severely or completely eliminated power system carbon emissions staff is recommending that the Council develop two blocks of both generating and conservation emerging technology options as resource alternatives. The first block would contain technologies that satisfy the Act's standard for reliability and availability within the next five years. The second block would contain those emerging technologies that may *not currently* meet the "similarly reliable and available" standard in the Act, but are likely to do so within the next 10 – 20 years when they might be required to satisfy scenarios that significantly constrained or eliminate power system carbon emissions. A description of the generating and conservation resources that might be included in these blocks follows.

Generating Resources

When identifying generating resources and technologies for the draft power plan, staff analyzes the availability of the resource in the region, their development potential, development lead time, capital and operating costs, levelized cost, and environmental effects/benefits, among many other attributes. The resources that are well understood, cost-effective and available in large quantities rise to the forefront (natural gas, wind, solar, etc.) and are assessed in greater detail and treated as resource options in the regional portfolio model (RPM), where they compete with demand-side resources. In addition, there are other resources that could be cost-effectively developed in the region, but are not directly tested in RPM. These potentially economical resources are technically available, but generally in much smaller quantities or in limited locales in the region are treated as secondary resources in the analysis. The cost and development assumptions for these smaller resources will be described in the plans narrative. But what about the emerging resources and technologies that are still in the development cycle and not yet commercially available?

Staff proposes to assess generating emerging technologies for the draft Seventh Power Plan in the following way. Working with the Generating Resources Advisory Committee (GRAC) and the Council, staff will prioritize emerging technologies with the best economic and technical characteristics and available developmental potential in the region within the next twenty years. Based on available information, staff will estimate costs and potential for these higher priority emerging technologies. These technologies may be used to supplement or complement (e.g., storage) existing renewable resources (wind, solar) in a potential low or no carbon future scenarios for the power plan.

² See Action Items, GEN-7 and CONS-20.

Analysis of emerging technologies necessarily includes uncertainty regarding their costs, potential performance and development lead times. If during the draft plan development process, it appears that reliance on specific emerging generating or storage technologies is necessary to achieve desired levels of power system carbon reductions this may point to the need for action items in the Seventh Plan.

Conservation Resources

Staff will analyze two levels of emerging technology in the energy efficiency realm: near term and long term. The first level, or near term emerging technologies, includes measures that are available and reliable now, though often at a significantly higher cost than other conventional technologies. These will be included as part of the Council's normal efficiency supply curves. Such emerging technology measures include heat pump clothes dryers, near-term solid state lighting, luminaire-level lighting controls, permanent magnet motors, and advanced heating, cooling and refrigeration controls and equipment. As many of these emerging measures have relatively high levelized costs, they may not be economic in many scenarios, except those significantly limit power system carbon emissions.

The second level of emerging technologies will include measures potentially available within five to ten years that could have significant impact on electric loads if certain technical, economic, or market barriers can be overcome. These measures do not currently meet the Regional Act standard of being "forecast to be similarly available and reliable" to generating resource options. But, promising technology advances or changes in market dynamics could improve efficiency or reduce costs significantly.

In the second tier, three or four key technologies with broad application will be analyzed. Technologies include heat pumps for water and space heating that use carbon dioxide as a refrigerant. These heat pumps can be two to three times as efficient as standard heat pumps available today. Lighting is another large use of electricity. Advancements in solid state lighting could potentially lead to performance twice that of today at a reduced cost. Photonics offers the possibility of reducing computing energy use significantly by a factor of two or more. Finally the rapid expansion of low-cost sensors, controllers and interconnectivity offers the possibility to reduce electricity use by optimizing control strategies to minimize waste in more applications and at lower cost than available today. Even small savings across a wide array of end uses could lead to a significant reduction in electricity use.

The timing of availability of the second tier of emerging technologies is a key consideration. Staff will estimate the pace at which each major technology could influence electricity loads. Changing out durable equipment, like heat pumps, will likely occur as existing equipment wears out. As such, even with a large jump in efficiency, it may take at least a decade to embed a significant amount of the equipment in homes and businesses once the technology is available. On the other hand, lighting systems are relatively inexpensive and less invasive to replace in the existing stock, so the impact of these technologies on loads may be felt sooner.

The emerging technology efficiency analysis will also include an assessment of the forecast cost and supply of distributed solar photovoltaic systems that could be installed at homes and businesses. The cost of solar is forecast to continue to fall significantly for both utility scale and distributed solar. The potential availability of distributed solar, above what is forecast to be adopted in the baseline, will be modeled in the RPM as a generating resource option instead of an efficiency resource, to better reflect its electric system resource characteristics.

Relevance: An assessment of potential generating and conservation emerging technology resources are needed to assess the feasibility and cost of resource management portfolios that produce low or no greenhouse gas emissions from the regional power system.

Workplan: I. D. Prepare for Seventh Power Plan and maintain analytical capability. Update conservation and generating resource assessments

Background: The Council has received request to analyze low or no power system carbon emissions scenarios as part of the development of the Seventh Plan. This will likely require assumptions regarding the cost, availability and performance of both conservation and generating technologies typically not considered in the Council's planning process.

More Info: N/A

Assessment and Treatment of Emerging Generating and Conservation Resource Technologies

January 13, 2015

Why Focus On Emerging Technologies?

- Prior Plans have viewed Act's "similarly reliable and available" standard as constraint on resources considered for development
- Analysis of "low or no" carbon emission power system scenarios requires assumptions regarding emergence of technological options
- RPM Scenario Analysis May Inform
 - What technologies could be used
 - When they might be needed (when they need to be "reliable and available")
 - What there cost/performance "targets" might be

Emerging Technologies Generating Resources

Gillian Charles & Steve Simmons

Questions for Generating Resource Emerging Technology Analysis

- Low or No Carbon Future Scenarios for Seventh Plan
 - Which resources are potential candidates to fulfill this future?
 - Which emerging technologies would compliment existing non-CO₂ producing renewable technologies (wind, solar)?
- What generating resource technologies are mature enough to be developed first?
- In what time frame?
- At what lead time?
- At what cost?

Proposed Treatment of Emerging Technologies in Draft Seventh Power Plan

- **Prioritize emerging technologies based on economics, beneficial characteristics to region (e.g. renewable integration), development potential within next 20 years**
- **Provide limited cost estimates and narratives in power plan for high priority emerging technologies**
 - **Potential action items in the Action Plan – further research, hosting informational meetings**
- **Run low or no carbon emissions scenario in the RPM with “proxy” generating and storage technologies (tentative)**

Emerging Technologies Under Review (in no particular order...)

- **Storage – Batteries, Compressed Air Energy Storage, Pumped Storage*, etc.**
- **Offshore Wind**
- **Enhanced Geothermal**
- **Small Modular Reactors**
- **Carbon Capture and Storage**
- **Wave/Tidal**

* While pumped hydro storage is not by definition an emerging technology, its potential uses and benefits are changing and emerging to fit new generation challenges

GRAC Meetings Regarding Emerging Technologies

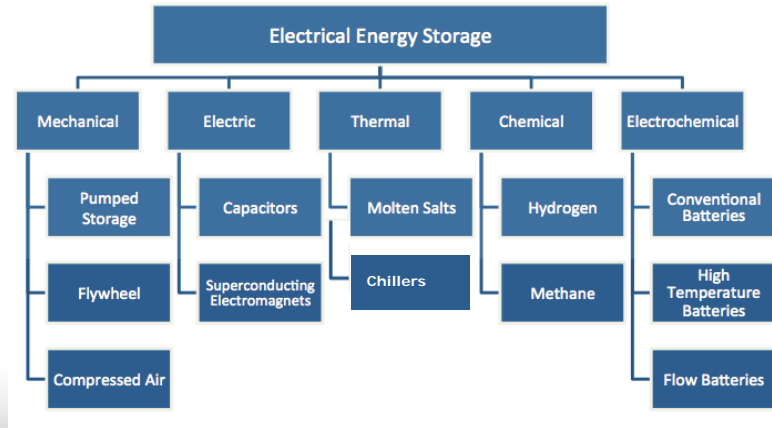
- May 2014 - Off-shore wind
- December 2014 - Overview of energy storage technologies
- Jan 27, 2015 - Pumped storage
- Jan 27, 2015 - Small Modular Reactors
- Battery storage - TBD
- Engineered (Enhanced) Geothermal – TBD

Back-Up

- Not sure if we need...

Technologies

- There is a full taxonomy of storage technologies, many of them developing rapidly, but also including some old standards.



Emerging Technology Conservation for Low Carbon Futures

Charlie Grist
Kevin Smit
Tina Jayaweera
January 13, 2015

Conservation Emerging Tech

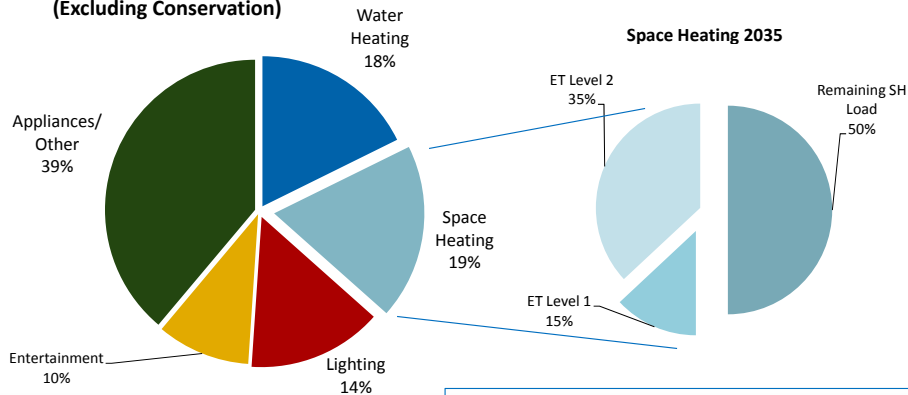
- Consider two levels of Emerging Tech
- ET Level 1: Available in the next 5 years
 - Already built into the 7P supply curves
 - May be higher cost than most measures
 - **Also includes forecast of distributed solar PV (10-years)**
- ET Level 2: Potentially available after 5 years
 - Technologies on the horizon which could have major impacts if advancements occur
 - Not “reliable and available” now, but may warrant near-term actions to develop into “reliable” future resources
 - Compete with other non-carbon resources in low-carbon RPM scenarios

ET Level 2 Measures

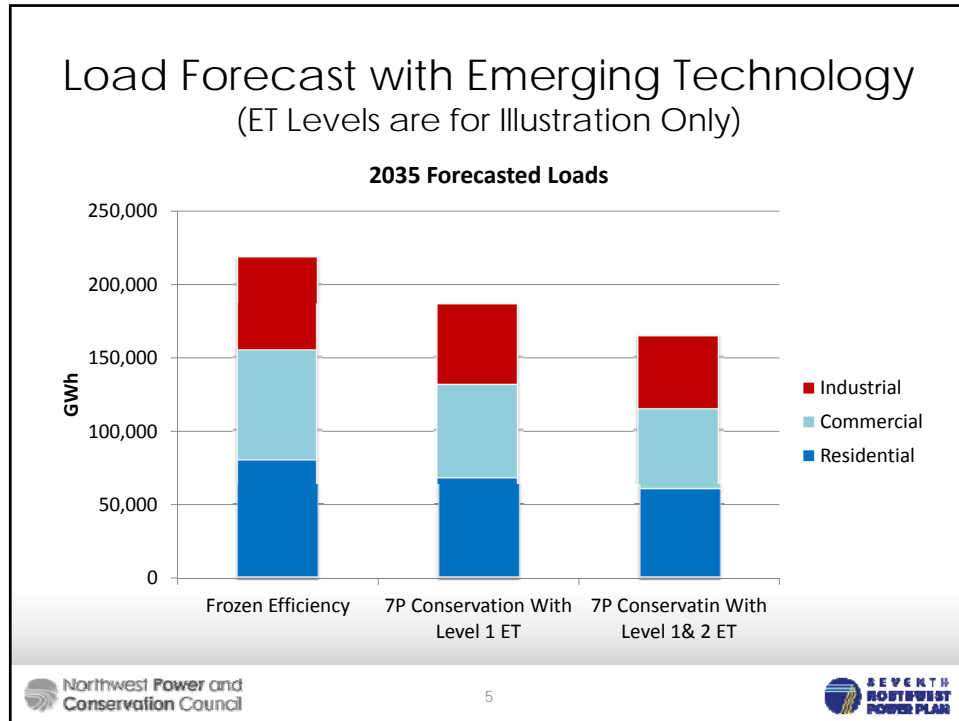
- **Solid State Lighting**
 - Quantum dots
 - Could cut lighting power in half
- **CO2 Heat Pumps Space Heating**
 - Could double heating efficiency
- **CO2 Heat Pump Water Heaters**
 - Could double efficiency
- **Next advance in silicon wafer technology**
 - Photonics
- **Highly Insulated Dynamic Windows**

Illustration of Impacts

Residential End-Use Forecast (2035)
(Excluding Conservation)



The End-Use Forecast Shares are from current load forecast
The Space Heating Shares are broad-brush preliminary estimates for illustration purposes only



Next Steps

- **Finish supply curves with ET Level 1**
 - CRAC review
 - Solid cost and savings definitions
- **Further develop ET Level 2 estimates**
 - Cost and savings estimates – will likely be at the high end of the supply curve costs
 - Availability estimates – cost declines and performance increases based on secondary research
 - Pace – most based on equipment turnover rates - Not available instantly, but accumulates over time