MEMORANDUM

TO: Power Committee Members

FROM: Kevin Smit, Tina Jayaweera, Charlie Grist

SUBJECT: Draft Energy Efficiency Curves for 2021 Plan

BACKGROUND:

Presenter: Charlie Grist, Tina Jayaweera, Kevin Smit

Summary: As part of development of the 2021 Plan, staff is developing energy efficiency (EE) supply curves that provide levelized cost (dollar per megawatt-hour) and savings (average megawatts) for each energy efficiency measure. These will be used as an input for the Regional Portfolio Model for doing scenario analysis. These supply curves will be finalized by March 31, 2020.

In developing the EE supply curves, staff has been working closely with the conservation resources advisory committee (CRAC) for advice regarding key underlying assumptions and direction regarding specific measures or categories of measures. Staff has also sought technical input from the Regional Technical Forum (RTF) as well as utilized the support of the RTF contract analysts. In addition, Bonneville has hired multiple consultants to conduct significant detailed review of each of our measure workbooks. The EE staff have also convened smaller groups of subject matter experts where additional technical expertise and advice are needed.

To date, the EE staff have developed over 90 individual measure workbooks containing thousands of individual energy efficiency measures.
The presentation will show preliminary aggregated results. The presentation will summarize EE achievable potential by sector (Residential, Commercial, Industrial, Agriculture, and Distribution System) and will highlight new EE potential relative to the Seventh Power Plan. The supply curve details will continue to be revised through the end of March as the EE team addresses reviewer comments.

Relevance: Development of inputs for the 2021 Power Plan

Workplan: Power Division A.1: Develop the 2021 Power Plan: Conservation

More Info:

EE Supply Curve Workbooks Undergoing Public Review: 
https://www.nwcouncil.org/energy/energy-advisory-committees/conservation-resources-advisory-committee

Summary of CRAC Decisions as of December 2019: 
https://nwcouncil.box.com/s/rqr7defydc5684q1jkhonc3gvdc57xqq
Draft Conservation Supply Curves for the 2021 Power Plan

Power Committee Meeting
March 17-18, 2020
Charlie Grist, Tina Jayaweera, Kevin Smit
Agenda

• Background
• Approach
• Process – Review and Collaboration
  • CRAC Meeting Key Issues summary
• Results by Sector
• Overall Supply Curve

NOTE: All values presented are DRAFT. The review and revision process will continue through the end of March 2020.
Context:
Energy Efficiency as a Resource

Need to Assess:
Amount Energy & Capacity, Cost, Pace
The Basic Formula for Savings Potential

Achievable Savings Potential =
Number Units * kWh savings per Unit * Achievable Penetration

Examples:
• Number Homes
• Floor Area of Retail
• Number of Refrigerators
• Acres Irrigated
• Number transformers

(kWh/Unit at Baseline Efficiency – kWh/Unit at Improved Efficiency)

Fraction of available or remaining stock that is realistically achievable over time
How do we develop energy efficiency supply curves?

1. Baseline
   - Identify measures that save electricity
   - Establish the measure’s “baseline” consumption (i.e., what the measure is compared against)

2. Cost & Savings Per Unit
   - Estimate incremental electricity & capacity savings per unit
   - Estimate incremental costs & benefits per unit
   - Estimate measure life

3. Technical Potential
   - Calculate cost per kWh saved
   - Calculate number of units available
   - Multiply unit savings and cost by the number of units

4. Technical Achievable Potential
   - Apply achievability limits
   - Ramp rates
Identify Measures for Supply Curves

• Residential, Commercial, Industrial, Agriculture, Utility
• Nearly 100 Measure Workbooks
  • Buildings
  • Appliances & Equipment
  • Processes
  • Behavior
• Over 2400 measure permutations
  • By climate zone, vintage, heating system type
  • Items that change incremental cost or savings
Develop Cost & Savings per Unit

**Energy Savings (kWh)**
- kWh per unit at the site (annual)
- Line losses site to source
- Seasonal & daily shape of savings
- Measure interactions
- Measure “Take Back”

**Costs**
- Capital & Financing
- Labor
- Program Administration
- Operations & Maintenance
- Reinstallation Cost

**Capacity Benefits (kW)**
- Deferred distribution and transmission line expansion cost ($/kW-yr) where coincident with system peak
- System peak impact

**Non-Electric Impacts**
- Water use changes
- Gas use changes
- Operations & maintenance
- Lamp replacements
- Quantifiable Environmental Impacts

**Measure Life**
- Expected lifetime of the measure

**Measure Interaction & Overlap**
- Savings in one measure impact another
- No double counting

**ProCost**
Convert annual cash flow of costs & benefits to discounted constant cost per unit of savings (levelized cost in $/MWh)

And other metrics - winter & summer capacity (kW)
Estimate Annual Availability & Pace of Acquisition

Depends on Ramp Rates & Turnover

[Graph showing annual availability and pace of acquisition over program years, with lines representing different ramp rates and turnovers.]

Program Year

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Data Sources

• Residential Building Stock Assessment
• Commercial Building Stock Assessment
• Industrial Segment Research
• Regional Organizations
  • Regional Technical Forum
  • Northwest Energy Efficiency Alliance
  • Bonneville Power Administration
  • Energy Trust of Oregon
  • Regional Utilities
  • US Department of Energy
  • US EPA (ENERGY STAR)
  • Pacific Northwest National Labs
  • State Energy Offices
• Contractors and Consultants
  • Consulting firms, trade allies, program delivery contractors
## Decisions Reviewed with the CRAC

<table>
<thead>
<tr>
<th>Subject</th>
<th>Summary Decision</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource Cost Framework</td>
<td>Living matrix of rationale and approach to incorporate quantifiable costs for 28 cost categories including NEIs</td>
<td>QRC Memo, QRC Matrix</td>
</tr>
<tr>
<td>Environmental Methodology</td>
<td>Use cost of regulatory compliance. Use qualitative approaches for residuals, unregulated impacts, &amp; most benefits. (eg: water quantified—wood smoke not)</td>
<td>EM Memo</td>
</tr>
<tr>
<td></td>
<td><strong>(Applies to new resources)</strong></td>
<td></td>
</tr>
<tr>
<td>Climate Change</td>
<td>Incorporate impacts as baseline conditions—both direct (temperature &amp; precipitation) and indirect (population &amp; industry shift)</td>
<td>CC Memo, CC &amp; Load Pres</td>
</tr>
<tr>
<td>Discount Rate</td>
<td>Blended WACC of resource decision makers (3.75% real)</td>
<td>Disc Rate, DR Workbook</td>
</tr>
<tr>
<td>T&amp;D Deferral</td>
<td>Revised method &amp; updated source data—Values significantly lower</td>
<td>T&amp;D Deferral</td>
</tr>
<tr>
<td>Admin Cost Percentage</td>
<td>Retain previous—use single estimate for all measures set at 20% of measure incremental cost</td>
<td>Admin &amp; Max</td>
</tr>
<tr>
<td>Maximum Achievable EE</td>
<td>Do on measure-by-measure basis. Can exceed 85% used previously.</td>
<td>Admin &amp; Max</td>
</tr>
</tbody>
</table>
Specific Issues Reviewed with the CRAC

• Modeling Approaches
  • RPM modeling; Development logic, bundling, kW impact
  • Impact of state and federal legislation, codes, standards
  • Incrementalism

• Measure-specific (selected)
  • Commercial and Industrial Fans and Pumps
  • Strategic Energy Management
  • Conservation Voltage Reduction; CVR/DVR
  • Lighting Methodology & Approach
  • Behavioral Measures
  • Ductless Heat-Pump Controls Optimization
Development and Review Process

EE Staff Develop Measures:
- savings, cost, life
- Units, applicability, turnover, achievability, ramp rates

Public Review of Workbooks

RTF

Jennifer and Annika help coordinate with RTF and RTF Analysts

START WITH ALL RTF MEASURES

EEA, DOE, BPA, TRMs, Universities

BLA, PNNL, ETO, NEEA, BPA, EPA-ENERGY STAR, TRMs, Universities

Consultants

Advisory Committees and Ad Hoc Expert Groups

BPA & Consultants

Photo of Charlie, Tina, and Kevin circa summer 2019
Highlights of EE Supply Curves for 2021 Plan

- *Following Charts are DRAFT results
- **Still developing workbooks
- ***Still getting outside review
- ****Some climate change incorporated
# Summary Results

<table>
<thead>
<tr>
<th>Sector</th>
<th>20-Year Achievable Potential (aMW) (all cost bins)</th>
<th>Winter Peak MW</th>
<th>Summer Peak MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector</td>
<td>7th Plan</td>
<td>2021 Plan PRELIMINARY</td>
<td>2021 Plan PRELIMINARY</td>
</tr>
<tr>
<td>Residential</td>
<td>2,328</td>
<td>2,444</td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>1,871</td>
<td>1,255</td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>580</td>
<td>871</td>
<td></td>
</tr>
<tr>
<td>Utility</td>
<td>218</td>
<td>232</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>126</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td>5,123</td>
<td>4,872</td>
<td>8,230</td>
</tr>
</tbody>
</table>
Residential
## Key Findings - Res

<table>
<thead>
<tr>
<th>End Use</th>
<th>Achievable Potential 2041 (aMW) All Cost Bins</th>
<th>Drivers of Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>123</td>
<td>LEDs market share, Washington standard, new fixture measures</td>
</tr>
<tr>
<td>HVAC (weatherization &amp; equipment)</td>
<td>1292</td>
<td>Additional measures (e.g. central AC) and updated analysis. Many are high cost</td>
</tr>
<tr>
<td>Water Heating</td>
<td>455</td>
<td>Savings decrease across most measures, Washington standard for showerheads, aerators</td>
</tr>
<tr>
<td>Dryers</td>
<td>295</td>
<td>Lots more work on heat pump dryers (though slow ramp rate)</td>
</tr>
<tr>
<td>Electronics, Cooking, Behavior</td>
<td>278</td>
<td>Few new measures, updated savings</td>
</tr>
<tr>
<td>Total</td>
<td>2,444</td>
<td>New Residential Building Stock Assessment</td>
</tr>
</tbody>
</table>
Commercial
## Commercial Potential by Category

<table>
<thead>
<tr>
<th>Commercial Measure Categories</th>
<th>Achievable Potential 2041 (aMW) - All Cost Bins</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting</td>
<td>389</td>
<td>LED lighting &amp; controls for indoor, exterior, street &amp; roadway applications</td>
</tr>
<tr>
<td>HVAC</td>
<td>378</td>
<td>Efficient Fans and Variable Speed Drives, VHE-DOAS (NEEA Research), Strategic Energy Management, Ductless Heat Pumps, and Variable Refrigerant Flow</td>
</tr>
<tr>
<td>Refrigeration</td>
<td>226</td>
<td>Grocery Refrigeration (BPA Emerging Tech Research), Water Coolers, Icemakers, Vending</td>
</tr>
<tr>
<td>Motors/Drives</td>
<td>100</td>
<td>Pumps (VS Drives, Optimization) - data from DOE standards rulemaking</td>
</tr>
<tr>
<td>Electronics</td>
<td>70</td>
<td>Embedded data centers, primarily Servers</td>
</tr>
<tr>
<td>Other</td>
<td>91</td>
<td>Engine Block Heater Controls, Circulation Pumps, Heat Pump Water Heaters</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1255</strong></td>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

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**Notes:**

- **Lighting:** LED lighting & controls for indoor, exterior, street & roadway applications
- **HVAC:** Efficient Fans and Variable Speed Drives, VHE-DOAS (NEEA Research), Strategic Energy Management, Ductless Heat Pumps, and Variable Refrigerant Flow
- **Refrigeration:** Grocery Refrigeration (BPA Emerging Tech Research), Water Coolers, Icemakers, Vending
- **Motors/Drives:** Pumps (VS Drives, Optimization) - data from DOE standards rulemaking
- **Electronics:** Embedded data centers, primarily Servers
- **Other:** Engine Block Heater Controls, Circulation Pumps, Heat Pump Water Heaters
Commercial Lighting: Rapid LED Adoption

In 7P LED adoption was less than 5% - except for Street & Roadway
Commercial: Embedded Data Centers

• **Embedded Data Centers Only**
  • Excludes Enterprise & Cloud DC where EE is in the forecast

• Large shift towards efficiency underway since 2014
  • Virtualization, consolidation, more efficient servers

• Complete re-vamp of conservation potential
  • Focus on efficient servers (New Energy Star™ specification 3.0)
  • Efficient servers cut server power by 18% – 25%
  • Added savings from lower HVAC requirements

49 aMW savings by 2041 at $7/MWh
Industrial
Industrial Supply curve

![Bar chart showing the technical achievable potential (aMW) for different cost levels (2016$/MWh) across various industrial sectors such as Fans, Material Handling, Pumps, Lighting, Process, Refrigeration, and HVAC.]
# Industrial Potential By Category

<table>
<thead>
<tr>
<th>Industrial Measure Categories</th>
<th>Achievable Potential 2041 (aMW) All Cost Bins</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumps</td>
<td>176</td>
<td>New pump research based on NEEA and DOE Standards data – Variable speed, trim, optimization</td>
</tr>
<tr>
<td>Strategic Energy Management</td>
<td>161</td>
<td>Based on regional program evaluations</td>
</tr>
<tr>
<td>Fans and Blowers</td>
<td>137</td>
<td>Significant new research – NEEA and DOE standards</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>Refrigeration</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Water/Wastewater</td>
<td>60</td>
<td>Significant revision based on project data</td>
</tr>
<tr>
<td>Other</td>
<td>156</td>
<td></td>
</tr>
</tbody>
</table>

Other includes Material Processing and Handling, HVAC, Lighting*
Note: Average achievements 2010-2018 = 47 aMW per yr
Agricultural
Agricultural Sector

NRC Net Levelized Cost (2016$/MWh)

Technical Achievable Potential (aMW)
### Key Findings - Ag

<table>
<thead>
<tr>
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<th>Achievable Potential 2041 (aMW) All CostBins</th>
<th>Drivers of changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation Hardware/Efficiency</td>
<td>46</td>
<td>Savings analysis, additional measures including Variable Rate Irrigation</td>
</tr>
<tr>
<td>Irrigation Water Management</td>
<td>0</td>
<td>Scientific Irrigation Scheduling no longer included - found to be standard practice</td>
</tr>
<tr>
<td>Lighting</td>
<td>6.3</td>
<td>Higher LED saturation</td>
</tr>
<tr>
<td>Dairy</td>
<td>9.5</td>
<td>More measures, including fans</td>
</tr>
<tr>
<td>Stock tanks, block heaters, motor</td>
<td>8.2</td>
<td>Additional measures</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>New Census of Agriculture</td>
</tr>
</tbody>
</table>
Utility
Distribution Efficiency: Conservation Voltage Reduction (CVR)

What is CVR?

- Distribution system equipment settings and/or upgrades can save energy by reducing line voltage and balancing line loading while still maintaining adequate power quality.
- Energy savings come from reduced losses and lower consumption from some (but not all) devices.

![CVR Diagram]

CVR: Conservation Voltage Reduction
Major Changes in 2021 Plan

1. Much better estimate of substation count
2. Bottom-up cost approach
   - Seventh Plan: Cost per substation, large and small, with costs from 15-year-old study
   - 2021 Plan: Cost per asset, estimate of assets on an urban vs. rural feeders, and resistive versus inductive load
3. Applies to small amount of industrial load
4. Generalized basis voltage drop (dV) & CVR factor (CVRf)

Substantial input from distribution system engineers at Bonneville and regional utilities
Distribution Efficiency: Initial Outcomes

In simple terms, dividing total savings (MWh) by total costs ($) results in comparable findings (within ~10%) between the Seventh and 2021 Plans.

**Seventh Plan:**
- Region:
- Savings: ~2M MWh
- CapEx: ~$725M
- O&M: ~$3.75M

**2021 Plan:**
- Region:
- Savings: ~1.6M MWh
- CapEx: ~$630M
- O&M: ~$31.5M

*Savings Potential: ~230aMW by 2041 at cost of $23 to $60/MWh*
Summary
Aggregate Supply Curve

Technical Achievable Potential (aMW)

NRC Net Levelized Cost (2016$/MWh)

Utility, Residential, Industrial, Commercial, Agriculture
Cumulative Savings Potential First Six Years

Program Year

aMW

<20 $/MWh

50-80

80-110

110-140

140-170

>170
Next Steps

• Several measure estimates still under development
• Finalize workbooks based on reviewer comments & data updates
• Re-run all measure workbooks with our final assumptions
• Bundle the supply curves into cost bins for the RPM