MEMORANDUM

TO: Power Committee
FROM: Charlie Grist
SUBJECT: Primer on Energy Efficiency Assessment Methodology

Presenter: Charlie Grist

Summary: Staff will present an overview of the Council methods used to develop estimates of energy conservation potential for the Seventh Power Plan. The presentation will summarize the key steps used to estimate the amount, cost and availability of energy efficiency resource potential. The presentation will cover the process up to the point where efficiency resources are passed to the Regional Portfolio Model for evaluation compared to generation and demand response resources.

Staff will highlight analytical methods, data sources and issues related to developing an assessment of energy conservation potential. Most of the assessment is data driven. The Council primarily uses a bottom-up approach which evaluates hundreds of measures with respect to cost, savings and availability across all sectors of the economy. It relies on data from a wide range of data sources. There are a few policy choices which will need to be made over the course of Power Plan development. These will be identified for future Council discussions.
The presentation will also touch on the review process used for the conservation potential assessment. Both the Regional Technical Forum (RTF) and the Conservation Resources Advisory Committee (CRAC) are used to vet the analysis and make suggestions on improvements.

Relevance: The assessment of regional conservation potential is one of the principle components of the Council’s plan development process. This primer will provide Council members with an understanding of analytical steps used to conduct this assessment as well as the public review process used by staff.

Workplan: 1.D. Update conservation resource assessment

Background: The staff has presented previously on the calculation of the levelized cost of energy at both GRAC meetings and Council meetings.

More Info: For a primer on the LCOE calculation, see the April 2013 presentation http://www.nw council.org/media/6838753/4.pdf
Primer on Conservation Potential Assessment Methodology

October, 2014

Agenda

- Some Terms We Use
- Methodology Overview
- Step Through Methodology
- Identify Issues
Terms You’ll Hear Today

- Conservation Supply Curves
- Lost-Opportunity Conservation
- Retrofit Conservation
- Baseline
- Current Practice
- Incremental Cost or Savings
- Program Administration Cost
- Deferred Distribution Expansion
- Regional Act 10% Credit
- Non-Energy Benefit
- Total Resource Cost
- Discount Rate
- Cost of Saved Energy
- Levelized Cost

Some Terms for Today

- Mid-C Price, Market Price
- High Load Hour, Low Load Hour
- Energy
- Kilowatt-hour (kWh)
- Megawatt-hour (MWh)
- Average megawatt (aMW)
- Capacity
- Peak Demand
- Kilowatt (kW)
- Megawatt (MW)
Overview of Steps

1. Build Supply Curves
2. Schedule Availability
3. Adjust Retrofit Supply Curve for Program Deployment
4. Shape Savings by Season & Hi/Lo
5. Regional Portfolio Model
7. Conservation Build-Out over 750 futures
8. Conservation Targets & Action Plan

Features:
- Northwest Power and Conservation Council
- Over 750 futures
- Least-Cost & Least-Risk
- Regional Portfolio Model
Supply Curves Show How Much Savings Are Available At What Cost

Steps in Building Supply Curves

1. Identify Measures that Save Electricity
2. Establish the Measure’s “Baseline” Efficiency
3. Estimate Electricity & Capacity Savings per Unit
4. Estimate Costs & Benefits per Unit
5. Estimate Measure Life
6. Calculate Cost per kWh Saved
7. Calculate Number of Units Available
8. Multiply Unit Savings and Cost * Number of Units
Step 1: Identify Measures for Supply Curves

- Example - Nearly 400 measures bundles in Sixth Power Plan
  - Buildings
  - Appliances
  - Processes
  - Utility distribution system (poles, wires and transformers)
  - Across residential, commercial, industrial, agriculture, utility

- Over 1400 measure permutations
  - By climate zone, vintage, heating system type
  - Items that change incremental cost or savings

Step 2: Establish Baseline

Depends on Decision Timing

**New**
- New homes
- New buildings
- New equipment
- New additions

**Natural Replacement**
- Burn-out
- Remodel
- Market shifts

**Retrofit**
- Remove & Replace (windows)
- Add-on (insulate attic of older home)

- Decision when new item is built or purchased.
  Baseline is best of minimum code requirement, federal standard, or common practice

- Decision when burnout or obsolescence.
  Baseline is best of minimum code requirement, federal standard, or common practice

- Decision timing is discretionary.
  Baseline is as-found condition, unless subject to code or standard
### Set Baseline (Examples)

<table>
<thead>
<tr>
<th></th>
<th>New</th>
<th>Natural Replacement</th>
<th>Retrofit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attic Insulation</td>
<td>State Code sets minimum</td>
<td>N/A</td>
<td>As-found condition in stock.</td>
</tr>
<tr>
<td></td>
<td>May vary by state: WA, OR, ID, MT</td>
<td></td>
<td>Data from Residential Building Stock Assessment</td>
</tr>
<tr>
<td></td>
<td>R-49 (15 inches)</td>
<td></td>
<td>6% less than 3 inches</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20% 3 to 10 inches</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>25% 10 to 15 inches</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>49% Greater than 15 inches</td>
</tr>
<tr>
<td>High Efficiency Clothes Washer</td>
<td>Federal Standards for Energy Factor &amp; Water Factor</td>
<td>Same Federal Standards</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Four types of machines with different standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effective dates</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Sync Baseline with Electricity Load Forecast

- Forecasts of electricity demand AND conservation potential must both use same baseline efficiency
- Council Approach: Freeze the efficiency level of New and Natural Replacement purchase events
  - New and replacement products enter the stock at the market efficiency of new-products or minimum code/standard, which ever is greater
  - As a result of product turnover, the average efficiency of the stock of appliances and equipment increases over time
### Step 3: Estimate Electricity & Capacity Savings

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

#### Capacity Benefits (kW)
- IF coincident with peak:
  - kWh per unit at the site
  - Line losses from source to site
  - Seasonal & daily shape of savings
  - Measure interactions
  - Measure “Take Back”

**Data Sources:**
- Program evaluation data
- Billing history analysis
- Sub-metered data
- Engineering estimates
- DOE Rule makings
- Building simulation models
- Independent testing labs
- End use load research

---

### The Basic Formula for Savings

\[
\text{Achievable Savings Potential} = \text{Number Units} \times \text{kWh savings per Unit} \times \text{Achievable Penetration}
\]

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

**Achievable Penetration:**
- Fraction of available or remaining stock that is realistically achievable over time

\[
(\text{kWh/Unit at Baseline Efficiency} – \text{kWh/Unit at Improved Efficiency})
\]
Step 4:
Estimate All Costs & Benefits Above Baseline

Costs
- Capital & Financing
- Labor
- Program Administration
- Operations & maintenance
- Reinstallation Cost
- Quantifiable Environmental Costs

Non-Electric Benefits
- Water savings
- Gas savings
- Materials savings
- Operations & maintenance
- Lamp replacements
- Quantifiable Environmental Benefits

Data Sources:
- Program Data
- Contractor Bids
- Retail Price Surveys
- World Wide Web
- Engineering estimates
- DOE Rule makings
- Manufacturers
- Secondary Research

The Basic Formula for Cost

All Costs & Benefits Per Unit
Capital, Financing, Labor, Program Admin, O&M, Reinstallation Cost, Deferred Transmission & Distribution Line Expansion, Other Non-Electric (Gas & Water)

Cost of Saved Energy
Result: $ per MWh saved comparable to market purchase or generation cost

In the year they occur
### Step 5: Estimate Measure Life

<table>
<thead>
<tr>
<th>Measure Lifetime (Years)</th>
<th>20-Year Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Res. Halogen light bulb</td>
<td>2</td>
</tr>
<tr>
<td>Res. CFL bulb</td>
<td>8</td>
</tr>
<tr>
<td>Res. LED bulb</td>
<td>12</td>
</tr>
<tr>
<td>Insulation</td>
<td>40</td>
</tr>
<tr>
<td>Irrigation scheduling</td>
<td>1</td>
</tr>
</tbody>
</table>

- 20-Year Analysis
- Short-life measures are “re-installed”
- Reflects total cost over 20 years

**Data Sources:**
- Program evaluation data
- Engineering estimates
- DOE Rule makings
- Manufacturers data
- Census data

**Measure Life Issues:**
- Persistence of behavioral measures

### Step 6: Calculate Cost per kWh Saved

**Problem:**
- Measures have different lifetimes
- Costs & benefits occur at different times over the 20-year period
- Need to compare to costs of power purchase or cost of generation

**Solution:** Convert annual cash flow to constant annual cost per unit of savings (e.g., cents/kWh, $/MWh)
**Discounted Costs & Benefits Over 20 Years**

**Energy Efficient Clothes Washer**

![Graph showing discounted cash flow over 20 years with various cost and benefit categories indicated.](image)

---

**Step 7: Estimate Number of Units Where Measure is Applicable**

- **New**
  - New homes
  - New buildings
  - New equipment
  - New additions

- **Natural Replacement**
  - Burn-out
  - Remodel
  - Market shifts

- **Retrofit**
  - Remove & Replace
  - Add-on

Number of units driven by population or economic growth

Number of units driven by equipment life, turnover rates, consumer preference & obsolescence

Number of units driven by remaining stock not adopting measure
Estimate Number of Units

Examples of Units
- Number of replacement clothes washers per year (330,000)
- Number of new single family homes per year (84,000)
- Floor area of Mini Mart groceries (45,000,000)
- Sq.Ft. of attics with no insulation in older homes (540,000,000)

Data Sources:
- Council forecast models
- DOE Rule makings
- Manufacturers data
- Stock assessments (RBSA, CBSA, IFSA)

Annual Estimates
- Year-by-year for 20-year forecast period
- Existing stock minus demolition & conversion
- New stock added
- New appliances added
- Appliance & equipment turnover

Step 8: Add Up Each Measure Cost & Savings
Overview of Steps

1. Build Supply Curves
2. Schedule Availability
3. Adjust Retrofit Supply Curve for Program Deployment
4. Shape Savings by Season & Hi/Lo
5. Regional Pt f l i
7. Conservation Build-Out over 750 futures
8. Conservation Targets & Action Plan

Why Schedule Availability of EE?

- Need EE construction schedule for comparability to generation resources
- Not all energy efficiency can be acquired immediately
- Three key considerations
  - Maximum achievable over planning period (i.e., 20 years)
  - Maximum annual availability (i.e., MWa/year)
  - Maximum rate of change in availability (i.e., ramping/acceleration rate)
Maximum Achievable

- Achievability Assumes:
  - Utility system can pay all cost (if measure is cost-effective based on power system benefits)
  - Many efficiency requirements can be embedded in codes/standards
  - 20-year time frame
  - Less than 100% adoption generally assumed
    - Assumes not all customers will accept the efficient unit, even if offered “free-of-charge”
  - Achievable Potential is Always Less Than Technical Potential

Maximum Annual Availability

Depends on Timing of Decisions

- **New**
  - New homes
  - New buildings
  - New equipment
  - New additions

- **Natural Replacement**
  - Burn-out
  - Remodel
  - Market shifts

- **Retrofit**
  - Remove & Replace
  - Add-on

Driven by population or economic growth

Driven by equipment life, turnover rates, consumer preference & obsolescence

Existing stock has useful remaining life but could be replaced or upgraded
**Applicable Stock Estimate**

**Clothes Washer Example**

<table>
<thead>
<tr>
<th>Year</th>
<th>Replacement Washers</th>
<th>Washers for New Homes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>50,000</td>
<td>100,000</td>
</tr>
<tr>
<td>2017</td>
<td>200,000</td>
<td>200,000</td>
</tr>
<tr>
<td>2019</td>
<td>300,000</td>
<td>300,000</td>
</tr>
<tr>
<td>2021</td>
<td>400,000</td>
<td>400,000</td>
</tr>
<tr>
<td>2023</td>
<td>500,000</td>
<td>500,000</td>
</tr>
<tr>
<td>2025</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2027</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2029</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2031</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2033</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Maximum Program Ramp Rates**

Realistic Rates for Each Measure

- Mature Program
- Fast
- Medium
- Slow
- Very Slow

Data Sources that inform Ramp Rate:
- Past program performance
- Timing of new standards
- Cost of measure
- Consumer acceptance
- Non-energy benefits
- Physical availability of equipment
- Training & education requirements
Available Stock COMBINED with Ramp Rates Determines Maximum Availability Schedule

Overview of Steps

(1) Build Supply Curves
(2) Schedule Availability
(3) Adjust Cost of Retrofit Supply Curve for Program Deployment
(4) Shape Savings by Season & Hi/Lo
(5) Regional Portfolio Model
(6) Strategy for Least-Cost & Least-Risk
(7) Conservation Build-Out over 750 futures
(8) Conservation Targets & Action Plan
Adjustments to Cost of Retrofit Curve to Reflect Program Deployment

- Try to represent realistic program acquisition costs
- Portfolio Model acquires lowest-cost resources first
- But, real world programs don’t acquire only the lowest cost conservation first
- Programs buy “up to” a cost effectiveness limit
- So adjust conservation supply curve to meld in some higher cost measures with the low-cost

Overview of Steps

1. Build Supply Curves
2. Schedule Availability
3. Adjust Retrofit Supply Curve for Program Deployment
4. Shape Savings by Season & Hi/Lo
5. Regional Portfolio Model
7. Conservation Build-Out over 750 futures
8. Conservation Targets & Action Plan
Shape the Savings by Season & High/Low Load Hours

Average Seasonal Rate
High and Low Load Hour Conservation
2029 and < $100 per MWh

Reflect Time of Savings for Energy and Capacity

- Value of savings depends on when savings occur
  - Based on time-dependent market price of energy
  - Winter energy more valuable than summer
  - Daytime energy more valuable than nighttime

- Capacity value of savings depends on timing too
  - More valuable if coincident with peak system needs
  - Peak coincident savings defer need for generating capacity
  - Peak coincident savings defer need for expanding transmission and distribution systems
Review of Steps

1. Build Supply Curves
2. Schedule Availability
3. Adjust Retrofit Supply Curve for Program Deployment
4. Shape Savings by Season & Hi/Lo
5. Regional Portfolio Model
7. Conservation Build-Out over 750 futures
8. Conservation Targets & Action Plan

End
Preparing Supply Curves for the Regional Portfolio Model

- Four major steps
- Data-driven analysis
  - Costs, savings, availability
- A few areas require some judgment
  - Maximum achievable
  - Ramp rates
- Issues & analysis reviewed by advisory committees
  - Regional Technical Forum (RTF)
  - Conservation Resources Advisory Committee (CRAC)
Measure Identification Issues

- Is the technology/measure “similarly available and reliable”
- Which measures to remove?
  - What’s been done by programs?
  - What will codes and standards capture?
  - Is there remaining potential?
- Which to add?
  - What new technology is available?
  - Is the technology being adopted?

Baseline Issues

- Is Common/Standard Practice better than the applicable minimum code/standard?
  - Need reliable market data
- Is the Measure a Natural Replacement or Early Retirement?
  - Products or systems replaced before failure may have short remaining useful lives (i.e., their savings do not persist)
Savings Issues

- How to account for rapid changes in technology
- Persistence of savings for behavioral measures
- Interactions between measures over time
- Do productivity increases count as savings?
- Data on market baseline can be scarce
- Data on shape of savings is old and/or must be estimated for some measures (e.g. lighting controls)

Cost Issues

- Are “All Costs” captured?
- Treatment of tax credits for efficiency
- What non-electric benefits to include
  - YES: Direct & Quantifiable (water savings)
  - NO: Comfort, Noise reduction, Reduced absentee
  - MAYBE: Health benefit?
- Forecast cost increases or decreases?
  - Generally not
  - YES, if changing fast (Solid State Lighting)
Ramp Rate Issues

- Uncertainty predicting program uptake
- Staff & Advisory Committee input

Models Used for Estimating Conservation Resource Potential

- Measure Cost
- Measure Savings and Load Shape
- Measure Lifetime
- Forecast Model
- Regional Portfolio Model
- ProCost
- Aurora Model
- Supply Curve Models
Setting Baseline Can Be Complex: Lighting Market

- Multiple sub markets
- Multiple purchase events in each market
- Separate baselines each segment
- Need to track both efficiency and unit count for each market segment

Both Electricity Demand & Savings Potential Decrease As A Result of Normal “Stock Turnover”
Separate curves are created for lost-opportunity & retrofit measures due to differences in limits to deployment.

**Mid-C Historical Power Prices**

2013 Monthly Prices

- High Load Hours
- Low Load Hours

- $ per MWh

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>$40</td>
<td>$35</td>
<td>$30</td>
<td>$25</td>
<td>$20</td>
<td>$15</td>
<td>$10</td>
<td>$5</td>
<td>$0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>