NorthWestern Resource Plan Update

Electric Technical Advisory Committee
2018
## Agenda

<table>
<thead>
<tr>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Themes for Resource Planning in 2018</td>
</tr>
<tr>
<td>Capacity Expansion Planning</td>
</tr>
<tr>
<td>Flexibility Requirements/Ancillary Services</td>
</tr>
<tr>
<td>Appendix</td>
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</tbody>
</table>
Key Themes for Resource Planning in 2018

Continued deployment of variable renewable resources in the WECC is fundamentally changing market dynamics.

Weather is the new fundamental driver of WECC market dynamics. Resource planning now requires incorporation of uncertainty in weather, load, generation, and prices.

Need to adjust our understanding of resource adequacy in an era of high renewables.

Characterizing sub-hourly market conditions is becoming more critical for valuation of flexible resources.
The Energy Imbalance Market (EIM)

- NWE will likely participate in the EIM in the next 5 years
- EIM provides non-CAISO balancing authorities (BAs) the opportunity to participate in CAISO’s real-time energy markets. CAISO is now studying allowing BAs to participate in Day-Ahead Market as well (“EIM +”)
- EIM is one tool to integrate high renewables
  - Leverage greater geographical diversity and more resource options for flexibility
  - Reduces need for curtailment and storage
  - BA’s get an efficient and low-cost option to solve imbalances
- Stated benefits for participants:
  - Less need for costly reserves, and better planning and efficient use of the regional high-voltage transmission system.
  - Reduced carbon emissions and more efficient use and integration of renewable energy.
  - Enhanced reliability by increasing visibility across electricity grids, improving transmission planning, and enhancing management of congestion across a wider expanse of the high-voltage transmission system.
CAISO Resource Adequacy Requirements

• **Resource adequacy for California entities**
  - Monthly and annual compliance filings showing Load Serving Entities have enough owned and contracted resources to meet at least peak demand plus a 15% reserve margin.
  - Renewables get an administratively determined Effective Load Carrying Capacity (ELCC) credit.
  - California has been very long on capacity, but the margin is shrinking quickly as thermal resources exit.

• **Requirements for non-California balancing authorities (BA) to join EIM**
  - The participating BA is required to maintain sufficient reserves (both energy and ancillaries) to meet their normal requirements under NERC standards.
  - Must go into the hour with sufficient resources to meet forecasted load. **NWE must demonstrate that it has enough contracted and owned resources to cover load forecast. Failure to schedule sufficient resources results in EIM financial penalties. Failure to schedule sufficient resources locks the entire NWE BA out of the EIM market for that hour.**
  - Must go into the hour with sufficient ramping capability to meet potential up and down ramps. **NWE must demonstrate that it has enough contracted and owned resources to cover the potential ramp. Failure to demonstrate sufficient ramping capability locks the entire NWE BA out of the EIM market for that hour.**

• **Basic operations of the EIM**
  - NWE would submit system information to ISO 75 minutes before the operating RT interval
    - Outages
    - Base schedules of resources and loads
    - Bids (buy and/or sell)
  - NWE units responsible for responding to ISO instructions after market clearing
CAISO Resource Adequacy Requirements (continued)

- Basic operations of the EIM
  - NWE would submit system information to ISO 75 minutes before the operating RT interval
    - Outages
    - Base schedules of resources and loads
    - Bids (buy and/or sell)
  - NWE units responsible for responding to ISO instructions after market clearing
Capacity Need in Greater WECC

- NorthWestern is currently operating under ~28% Reserve Margin and thus highly exposed to market risk.
- Tightening market supply and increasing demand in the region will increase NorthWestern’s risk of failing to procure sufficient supply.
- Ascend surveyed several recent IRPs to understand projected capacity shortfalls:
  - Portland General expects about 1 GW of capacity deficit by 2035 due to load growth, coal retirements, decreasing availability of hydro resources (see right).
  - Idaho Power will face capacity deficits of 1 GW between 2026 and 2036
  - Public Service of New Mexico (PNM) will retire ~1.1 GW of coal plants by 2036
  - Arizona Public Service (APS) expects load growth of ~5 GW by 2031. Similar capacity expansion is required to meet this new demand.
- To mitigate this increasing market risk, and to participate in the EIM, NorthWestern will need to build or procure additional capacity.
- To close this gap, NorthWestern will conduct a resource selection analysis through a request for offer process evaluating a wide range of resource options to meet peak demand.

*Example of Portland General’s capacity gap to meet load. This is consistent of resource needs of most utilities in the WECC
Capacity Expansion Planning

Optimized Capacity Planning with PowerSimm Planner
Incorporating Uncertainty: Deterministic vs. Stochastic Models

• Deterministic models can bias results
  • Limited view of possible futures
  • Misses critical scenarios
  • Produces inconsistent values
  • The likelihood of the simulated result actually occurring is not known
• What’s the impact of unused information?
  • Inaccurate forecasting
  • Assessing risk becomes difficult
• Stochastics capture uncertain future
  • Simulated weather captures accurate variation of renewables and load
  • Variation in thermal generation, timing of forced outages, and market prices also accurately captured
Optimized Resource Selection with PowerSimm Planner

• Uses algorithms to minimize net present value of system costs, including production cost and capital investment, across 100s of simulated futures for weather, load, renewables, and prices.

• Stochastic mixed-integer linear program finds the optimal retirement, conversion, and deployment of new resources across the planning horizon.

• Solves for expansion requirements while maintaining system-wide constraints:
  • Reserve margins
  • Renewable portfolio standards
  • Ancillary and capacity requirements
  • Transmission limits
  • Physical generation limits for new and existing resources
Features of Automated Resource Selection

- Stochastic model simulates 100s of possible scenarios and solutions
- Detailed financial calculations
- Variety of project options
  - New resource
  - Retirement
  - Repowering
- Accounts for contributions from existing resources
  - Can model changing parameters as assets degrade over time
- Constraint-driven planning
- Various optimization objectives

<table>
<thead>
<tr>
<th>Model Characteristic</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment timestep</td>
<td>1 year</td>
</tr>
<tr>
<td>Planning horizon</td>
<td>20-30 years</td>
</tr>
<tr>
<td>Model time step</td>
<td>Monthly</td>
</tr>
<tr>
<td>Dispatch Paradigm</td>
<td>Economic dispatch</td>
</tr>
<tr>
<td>Use case</td>
<td>Highly interconnected systems where market prices rather than expansion decisions and other plants drive dispatch</td>
</tr>
<tr>
<td>Advantages</td>
<td>Uses PowerSimm’s detailed dispatch results that are run over the entire planning horizon. PowerSimm is the only dispatch model that uses stochastic simulations to quantify risk in planning decisions.</td>
</tr>
</tbody>
</table>
Capacity Expansion Planning in PowerSimm Planner

Inputs
- Market Prices
- Economic Assumptions

Candidate Portfolios

Constraints
- RPS
- Reserve Margin
- Energy Constraint

NPV Costs
- $$$

Optimal Decision
- $
PowerSimm Planner Capacity Expansion
Parameter Inputs: Global and Project-Specific

- **Economic considerations**
  - WACC
  - Tax rates
  - Inflation

- **Project-specific details**
  - Flexible/Fixed implementation dates
  - Capital expenditure
    - Escalation rate (optional)
  - Reserve margin contribution
# Relative resource value for 2025 and beyond

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Relative Energy Value</th>
<th>Flexibility Value</th>
<th>Capacity Value</th>
<th>Avoided Transmission Value</th>
<th>Why for 2025?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combine Cycle</td>
<td>+++</td>
<td>+</td>
<td>+++++</td>
<td>N/A</td>
<td>High start-up cost and min run times of 4+ hours.</td>
</tr>
<tr>
<td>Combustion Turbine</td>
<td>+</td>
<td>++</td>
<td>+++++</td>
<td>N/A</td>
<td>High start-up cost. Ramps to full load in 15 min.</td>
</tr>
<tr>
<td>ICE</td>
<td>++</td>
<td>+++++</td>
<td>+++++</td>
<td>N/A</td>
<td>No start-up costs. Ramps to full load in 5 minutes.</td>
</tr>
<tr>
<td>Battery Storage</td>
<td>++</td>
<td>+++++</td>
<td>+++</td>
<td>+++++</td>
<td>Flexible and responds to 5 min prices. Rapidly declining costs till 2025.</td>
</tr>
<tr>
<td>Solar</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+++</td>
<td>Regional excess of solar generation in 2025. Limited dependable capacity.</td>
</tr>
<tr>
<td>Wind</td>
<td>+++++</td>
<td>+</td>
<td>+</td>
<td>N/A</td>
<td>Off-setting production to solar. Greater dependable capacity.</td>
</tr>
<tr>
<td>Energy Eff</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>+++++</td>
<td>Declining cost effectiveness for new programs. Relative cost to declining value of energy.</td>
</tr>
<tr>
<td>Demand Response</td>
<td>+</td>
<td>+++++</td>
<td>+++++</td>
<td>+++++</td>
<td>High need for flexibility.</td>
</tr>
<tr>
<td>Capacity Market</td>
<td>+</td>
<td>+++</td>
<td>+++++</td>
<td>N/A</td>
<td>Market opportunity</td>
</tr>
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</table>
# Generation Unit Characteristics and Operating Costs

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal Capacity (MW)</strong></td>
<td>26</td>
<td>43</td>
<td>44</td>
<td>123</td>
<td>18.5</td>
<td>20</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>Heat Rate (Btu/kWh)</strong></td>
<td>10,100</td>
<td>9,500</td>
<td>10,020</td>
<td>7,190</td>
<td>8,350</td>
<td>1000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Cold Startup Time (hr)</strong></td>
<td>0.167</td>
<td>0.083</td>
<td>0.167</td>
<td>4</td>
<td>0.083</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Ramp Rate (MW/hr)</strong></td>
<td>1800</td>
<td>3000</td>
<td>720</td>
<td>720</td>
<td>948</td>
<td>240</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Min. Down Time (hr)</strong></td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fixed O&amp;M ($/kW*yr)</strong></td>
<td>21.6</td>
<td>14.4</td>
<td>13.7</td>
<td>26.7</td>
<td>24</td>
<td>124</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td><strong>Cold Startup Cost ($)</strong></td>
<td>0</td>
<td>0</td>
<td>4,748</td>
<td>3,000</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>FOM ($/hr)</strong></td>
<td>125</td>
<td>170</td>
<td>-</td>
<td>165</td>
<td>80</td>
<td>166</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Variable O&amp;M ($/MWh)</strong></td>
<td>0.6</td>
<td>0.27</td>
<td>0.10</td>
<td>0.60</td>
<td>0.35</td>
<td>1.6</td>
<td>-</td>
<td>-</td>
</tr>
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</table>
# Storage Unit Characteristics and Operating Costs

<table>
<thead>
<tr>
<th></th>
<th>CAES</th>
<th>Li-Ion</th>
<th>Flow Battery</th>
<th>Pumped Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (MW)</td>
<td>100</td>
<td>25</td>
<td>25</td>
<td>400</td>
</tr>
<tr>
<td>Max Storage (MWh)</td>
<td>600</td>
<td>100</td>
<td>100</td>
<td>3600</td>
</tr>
<tr>
<td>Heat Rate (btu/kWh)</td>
<td>4500 (heat)</td>
<td>0.05 (leak)</td>
<td>0.002 (leak)</td>
<td>-</td>
</tr>
<tr>
<td>/ Leakage Rate (%/hr)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charge/Discharge VOM ($/MWh)</td>
<td>18 / 21</td>
<td>18 / 7</td>
<td>18 / 0</td>
<td>18/0.56</td>
</tr>
<tr>
<td>Charge Efficiency (%)</td>
<td>190</td>
<td>85</td>
<td>73</td>
<td>80</td>
</tr>
<tr>
<td>Charge Rate (MWh/hr)</td>
<td>100</td>
<td>25</td>
<td>15.4</td>
<td>100</td>
</tr>
<tr>
<td>Allowed Ancillary Contribution (MW)</td>
<td>100</td>
<td>25</td>
<td>25</td>
<td>400</td>
</tr>
</tbody>
</table>
Capacity Expansion Planning in PowerSimm Planner

**Inputs**
- Market Prices
- Economic Assumptions

**Candidate Portfolios**
- Candidate Assets
  - CT
  - Battery
  - Solar
  - CC
  - Wind
  - ICE

**Constraints**
- RPS
- Reserve Margin
- Energy Constraint

**NPV Costs**
- $$
- $

**Optimal Decision**
- GO
What is Resource Adequacy with High Renewables?

• Planners historically viewed resource adequacy as simply making sure to have enough supply to meet peak demand.
  ▪ This was straightforward when all capacity was dispatchable

• What does resource adequacy mean in a high renewables system?

  1. We need to understand how much renewables can be relied on under real-world operating conditions.

  2. We need to understand how batteries enhance capacity by both freeing up thermal gen from regulation duty and providing 4-hour duration energy on peak.

  3. We need to understand the need for **flexible** resource adequacy and plan for adding flexible resources to integrate renewables.

  4. Thermal begins to play the “back-up” role when the sun doesn’t shine and wind doesn’t blow. Thus we need to be careful to properly characterize forced outages.
Questions Addressed

- How does PowerSimm identify capacity and capacity attribute needs for an individual utility and for the region? How does it differ from how other modeling tools identify needs?

- How does your modeling tool characterize the capabilities of resources to provide capacity and capacity attributes? How does it differ from other tools?

- How does your modeling approach address the opportunity for regional resource sharing?
Capacity Needs Assessment

1) Capacity to Meet Peak Demand
   • **Requirement**: Procure adequate supply to serve peak demand given potential for generation outages and intermittency of renewable supply
   • **Measurement**: Traditionally *reserve margin* = firm capacity in excess of peak load
   • **Assessment of need**: Best modeled by simulating available capacity and load over a large variety of future conditions for meteorology and generation outages

2) Flexibility Resource Needs
   • Required by regional balancing authorities to keep system at 60 Hz
   • Ascend’s *PowerFlex* determines the flexible resource requirements as a function of renewable generation
     • Regulation ~ 1 minute ramp
     • INC ~ 15 minute ramp up
Capacity Expansion Planning in PowerSimm Planner

**Inputs**
- Market Prices
- Economic Assumptions

**Candidate Portfolios**
- Candidates: CT, Battery, Solar, CC, ICE, Wind

**Constraints**
- RPS
- Reserve Margin
- Energy Constraint

**NPV Costs**
- $$$

**Optimal Decision**
- $
Solving Optimal Capacity Expansion Plan: Objective Function

Minimize net present value of expected total cost

\[
E[\text{NPV of Total Costs}] = E \left[ \frac{1}{N} \sum_{t=1}^{T} \sum_{i=1}^{N} \sum_{u} (\text{Cost}_{\text{build/retire}} + \text{Cost}_{\text{fixed}} + \text{Cost}_{\text{var}} - \text{Revenue})_{tlu} \cdot \frac{1}{(1 + \text{WACC})^t} \right]
\]

- Capital Expenditure (\(\text{Cost}_{\text{build/retire}}\)) is the overnight cost of building (or retiring) the candidate project
- Fixed Costs (\(\text{Cost}_{\text{fixed}}\)) follow revenue requirements:
  - Depreciation, amortization, current taxes, deferred taxes, insurance, property taxes, on-going capital improvements, return on equity and debt
- Variable Operating Costs (\(\text{Cost}_{\text{var}}\)) are derived from PowerSimm hourly dispatch simulations:
  - Startup costs, minimum uptime/downtime constraints, emissions, variable heat rates

Subject to system-level constraints:

**Reserve Margin Constraints**
\[
\sum_{u} \text{Capacity}_{it} \geq \gamma \cdot \text{Load}_t \quad (\gamma = \text{reserve margin})
\]

**Energy Market Constraint**
\[
\sum_{u} \text{Energy}_{it} \geq \delta_{-} \cdot \text{Load}_t \quad \& \quad \sum_{u} \text{Energy}_{it} \leq \delta_{+} \cdot \text{Load}_t
\]
(Where \(\delta_{-}(+)\) is the minimum (maximum) fraction of load that must be met by native generation.)

**RPS Constraint**
\[
\sum_{u} \text{Renewables}_{it} \geq \epsilon \cdot \text{Load}_t \quad (\epsilon = \text{RPS target percentage})
\]

**Capacity Market Constraint**
\[
\sum_{u} \text{CapacityPurchases}_{it} \leq \text{CapLimit}_t
\]

**Ancillary Service Constraint**
\[
\sum_{u} \text{Reg}_{it} \geq \text{RegLimit}_t
\]
\[
\sum_{u} \text{Ramp}_{it} \geq \text{RampReq}_t
\]
Planning Constraints

- Constraint types:
  - Renewable portfolio standards (RPS)
  - Reserve margin
  - Loss of load (hours)
  - Energy market sales/purchase
  - Ancillary requirements
Capacity Expansion Planning in PowerSimm Planner

Inputs
- Market Prices
- Economic Assumptions

Candidate Assets
- CT
- Battery
- Solar
- CC
- Wind
- ICE

Candidate Portfolios

Constraints
- RPS
- Reserve Margin
- Energy Constraint

NPV Costs
- $$$

Optimal Decision
- $
Output Results from ARS: Capacity Expansion Plan

- Optimized implementation schedule for all projects
- Co-optimized capacity requirement between flexible generation requirements and energy needs
- Grid characteristics both with and without candidate projects
  - Generation, costs, risk, purchases/sales, loss of load probability, etc.
- NPV of all capital, fixed, and variable costs for optimal capacity plan

HECO’s 2017 Power Supply Integration Plan

Oahu Post April PSIP Plan vs Ascend Battery and Renewable Optimized Capacity Expansion

NorthWestern Energy
FLEXIBLE REQUIREMENTS

Determining ancillary requirements with high renewable penetration
The renewable integration challenge: staying in balance

Customers demand energy
Variability primarily driven by weather.
Hot weather drives A/C load and cold weather drives heating load.

Generators supply energy in real-time
Renewable supply is driven by weather
Remaining fleet has to adjust to "Integrate" renewables
Area Control Error (ACE)

- ACE is the difference between scheduled and actual electrical generation.
- Load volatility and intermittent renewable generation can have a significant impact on ACE.
- BalancingAuthorities have ACE limits which the utility is required to stay within for reliability.
- Higher ACE values require more fast-ramping, flexible generation assets in order to meet load demand on a minutely basis.

Sudden changes in wind generation result in a shift in net-load. ACE jumps as actual net load deviates from projected.
Reg/INC Optimization

- Regulation (Reg) is available capacity that is able to be dispatched in \(~1\) minute.
  - Reg is optimized for each month. Reg is increased until system is always balanced within 25 minutes using just Reg and a 10 minute response.
- INC is available capacity that is able to be dispatched within 10-15 minutes. INC is assumed to be a cheaper resource than Reg.
  - After 15 minutes outside Balancing Authority ACE Limit (BAAL), INC assets dispatch to set current ACE to 0 after 10 minutes (not counting Reg units), and readjusts after 5 minutes. If after 25 minutes system is not balanced, with Reg and INC units combined, regulation increases, and scenario is rerun.
- Optimal solution is balance between Reg and INC requirements that allows system to always meet ACE limit
- Ancillary requirements were calculated for all future years through PowerFlex given the current portfolio and scheduled projects/retirements
- Baseline Reg and INC are consistent with Navigant study on ancillaries—models align.
Ancillary Requirements in Base Portfolio

Forecasted Load and Capacity

<table>
<thead>
<tr>
<th>Year</th>
<th>Reg</th>
<th>INC</th>
<th>Total Ramping</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>36</td>
<td>131</td>
<td>167</td>
</tr>
<tr>
<td>2020</td>
<td>38</td>
<td>159</td>
<td>197</td>
</tr>
<tr>
<td>2025</td>
<td>39</td>
<td>163</td>
<td>202</td>
</tr>
</tbody>
</table>

Flexible generation requirements increase as renewable capacity increases through time.
Forecast Error with Load and Renewables

• Forecast error in renewables is key driver for INC and reg
• Each hour’s net load requirement is forecasted as the mean position for the hour.
• Random Normal Error is introduced to the forecasts for Load, Solar, Wind, Distributed generation PV (DGPV) forecasts.
• Standard Deviation of forecast error is calculated as a percentage of capacity for renewables, and average demand for load, for each hour.

<table>
<thead>
<tr>
<th>Item Type</th>
<th>Forecast Error 66th percentile</th>
<th>Forecast Error 99th percentile</th>
<th>Forecast Error 99.9th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Hours</td>
<td>2978</td>
<td>88</td>
<td>2</td>
</tr>
<tr>
<td>Load</td>
<td>2%</td>
<td>9%</td>
<td>13%</td>
</tr>
<tr>
<td>Solar</td>
<td>3%</td>
<td>15%</td>
<td>23%</td>
</tr>
<tr>
<td>Wind</td>
<td>4%</td>
<td>20%</td>
<td>39%</td>
</tr>
<tr>
<td>DGPV</td>
<td>2%</td>
<td>9%</td>
<td>23%</td>
</tr>
</tbody>
</table>
Hourly Dispatch Supply Stack 2020

High non-dispatchable resources contribute to off-peak sales

Inflexible generation operates in shoulder hours

NWE relies on market purchases during on-peak hours
Hourly Ramps and Gradient Changes

Base Case

- Hourly ramp rates drive INC requirements
- Hourly ramps broken down by resource type show gradient changes in net load for 2020 forecast, using Oct-16-2016 data

<table>
<thead>
<tr>
<th>Year</th>
<th>Reg</th>
<th>INC</th>
<th>Total Ramping</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>38</td>
<td>159</td>
<td>197</td>
</tr>
</tbody>
</table>

NorthWestern Energy
Hourly Ramps and Gradient Changes

Base Case + 200MW Solar

- Consistent morning solar ramps dampen morning load ramps
- Compliments wind variability
- Minimal effect on flexible requirements in wind dominant system

<table>
<thead>
<tr>
<th>Year</th>
<th>Reg</th>
<th>INC</th>
<th>Total Ramping</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>38</td>
<td>160</td>
<td>198</td>
</tr>
</tbody>
</table>

NorthWestern Energy
Hourly Ramps and Gradient Changes

Base Case + 200MW Wind

- Wind comes during all hours of the day, and is less predictable
- Causes more gradient changes
- Since system has so much wind already, increased wind adds more to worst case scenarios for reg and INC.

<table>
<thead>
<tr>
<th>Year</th>
<th>Reg</th>
<th>INC</th>
<th>Total Ramping</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>38</td>
<td>232</td>
<td>270</td>
</tr>
</tbody>
</table>
Hourly Ramps and Gradient Changes

Base Case + 100MW Solar + 100MW Wind

Solar complements wind causing lower flexible generation requirements than wind alone

<table>
<thead>
<tr>
<th>Year</th>
<th>Reg</th>
<th>INC</th>
<th>Total Ramping</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>38</td>
<td>175</td>
<td>213</td>
</tr>
</tbody>
</table>
### Forecast in 2020- with Adders

<table>
<thead>
<tr>
<th>Year</th>
<th>Solar Adder</th>
<th>Wind Adder</th>
<th>Reg</th>
<th>INC</th>
<th>Total Ramping</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>0</td>
<td>0</td>
<td>38</td>
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- Wind and solar balance each other out for reg and INC.
- Solar has a negligible effect on ancillary requirements because Montana is a heavy-wind region. Flexible resources added to compensate wind can also provide for solar variability because the time of need does not directly overlap.
- Because the system is already highly dependent on wind generation, additional capacity has a increased effect on INC requirements.
Next Steps