2018 ESRPP
GENERATION RESOURCE OPTIONS
GENERAL

- ESRPP supply-side alternatives
- Inputs to PowerSimm (Ascend)
- Broad set of generic resources
- HDR is advisor and owner’s engineer
HDR FAST FACTS

- Employee-owned A/E firm founded in 1917
- 10,000+ employees in 225+ offices worldwide
- Projects in 50 states and 60 countries
- 1,000+ employees devoted to energy
- Planning, development, implementation support
RESOURCES CONSIDERED

- 15+ resources considered
- Renewables: wind, solar, geothermal
- Storage: pumped hydro, batteries, CAES
- Thermal: simple and combined cycle
- Generic characteristics
**METHODOLOGY**

- Performance and operating characteristics
- Capital and operating costs
- “Inside-” versus “outside-the-fence”
- Leverage market data, supplier feedback, IRPs
- Unbiased and objective
THERMAL RESOURCES

- Simple cycle combustion turbine
- Reciprocating internal combustion engine (RICE)
- Combined cycle
- Representative site characteristics
WIND GENERATION

- 100 MW facility nameplate
- 3 proxy locations considered
- Estimated wind resource

<table>
<thead>
<tr>
<th>Estimated Wind Site Annual Net Capacity Factors</th>
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<tbody>
<tr>
<td>Anaconda, MT</td>
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<td>Billings, MT</td>
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<td>Great Falls, MT</td>
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SOLAR PV

- 100 MW facility nameplate (DC)
- 2 locations considered
- Estimated solar resource

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GEOTHERMAL

- Nominal 20 MW flash steam plant
- Assumed geothermal resource
- High capacity factor
- Permitting and integrity of resource
PUMPED HYDRO STORAGE

- 400 MW with 9 hours of storage
- Single-stage and variable speed
- Capex heavily dependent on location
- Typically longer lead time
COMPRESSED AIR ENERGY STORAGE (CAES)

- Off-peak compression
- On-peak generation
- Very few installations globally
- 100 MW, 8 hours discharge considered
25 MW BATTERY ENERGY STORAGE (BESS)

- Li-on and vanadium redox flow
- 25 MW / 100 MWh assumed
- Function critical to understand
WRAP-UP AND DISCUSSION

- Development in progress
- Market/industry fluidity
- Questions/discussion