Changing the Energy Mix in a Remote Microgrid
An Impact Assessment for Nome, Alaska

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- Remote
  - security of fuel access
  - high transport costs
  - $0.37/kWh before subsidy

- Cold
  - high energy consumption
Wind-Diesel Grid

- **Diesel Generators**
  - 2x 5.2 MW
  - 0.4, 1.9 and 3.6 MW
  - Added soon

- **Wind Power**
  - 18x 50kW turbines
  - 2x 900kW turbines

- **Load**
  - 4MW average

Image Sources: alaskarenewableenergy.org
Pilgrim Hot Springs

- 90°C 20m below surface, est. reservoir temp is ~150°C
- 37 miles from Nome
- Strong local interest in development of site
- Appears to be economical to develop at 2MW+
Grid Integration Assessment

Does it make sense?
- 2MW geothermal
- 2.7MW wind
- 2.5MW base load, 4MW average

Simulation objectives
- Reduction in diesel generator output
- Increase in wind diversion
- Change in diesel generator operation
Simulation Overview

- 0-5.5MW geothermal
- Different available diesels

<table>
<thead>
<tr>
<th>Case #</th>
<th>Available Diesels</th>
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<tbody>
<tr>
<td>1</td>
<td>1.9 MW, 3.7 MW, 5.2 MW (2)</td>
</tr>
<tr>
<td>2</td>
<td>0.4 MW, 1.9 MW, 3.7 MW, 5.2 MW (2)</td>
</tr>
<tr>
<td>3</td>
<td>1.0 MW, 1.9 MW, 3.7 MW, 5.2 MW (2)</td>
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<tr>
<td>4</td>
<td>All Gensets</td>
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</tbody>
</table>
Diesel Generators

Operating bounds
- Spinning Reserve Capacity (SRC)
- Minimum Optimal Loading (MOL)
- Minimum Operating Time (MOT)
- Warm up/cool off

Scheduling
- Minimize MOL
- Maximize RE import
Results - Diverted RE

- Critical level of geothermal
- More diverse diesel fleet = less RE diversion
Diverted RE vs. Displaced Diesel
Impact on Diesels - Loading
Impact on Diesels - Switching
## Energy mix at 2 MW Geothermal

<table>
<thead>
<tr>
<th>Total Annual Demand</th>
<th>35,300 MWh</th>
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<tbody>
<tr>
<td>Total Wind Energy</td>
<td>4,110 MWh</td>
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<table>
<thead>
<tr>
<th>Scenario 1</th>
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<tbody>
<tr>
<td>Diesel displaced</td>
<td>15,300 MWh</td>
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<tr>
<td>Wind diverted</td>
<td>1,252 MWh</td>
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<tr>
<td>Geothermal diverted</td>
<td>1.42 MWh</td>
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<thead>
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<th>Scenario 2</th>
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<tbody>
<tr>
<td>Diesel displaced</td>
<td>15,500 MWh</td>
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<tr>
<td>Wind diverted</td>
<td>1,017 MWh</td>
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<td>Geothermal diverted</td>
<td>1.36 MWh</td>
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<th>Scenario 3</th>
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<tbody>
<tr>
<td>Diesel displaced</td>
<td>15,800 MWh</td>
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<td>Wind diverted</td>
<td>691 MWh</td>
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<td>Geothermal diverted</td>
<td>1.29 MWh</td>
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<tbody>
<tr>
<td>Diesel displaced</td>
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<td>Wind diverted</td>
<td>575 MWh</td>
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<td>Geothermal diverted</td>
<td>1.21 MWh</td>
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Conclusions

- Adding geothermal:
  - displaces diesel output (linear)
  - increases RE diversion (quadratic)
  - increases diesel switching
  - reduces diesel loading

- Adding diesel generators:
  - reduces RE diversion
  - displaces diesel output
  - increases loading
  - increases switching

At geothermal outputs above the base load, an engineering solution allowing load following is desirable.