Eva Creek – Year One
ACEP Community Energy Lecture Series - Blue Loon

Paul Morgan
GVEA, Eva Creek Manager
February 18, 2014
Blade Repairs
Location, Location, Location...
GVEA’s first met tower
At Eva Creek, 2003

30 m tall

Later towers were
hub height
80 m / 262 ft
REpower MM92 CCV WEC

Cold Climate Version* – Wind Energy Convertor

- Installed 12 REpower CCV MM92 Turbines
- **2.05MW** rated output @ 12.5 m/s (28 mph)
- 80 m (262 ft) Hub Height
- 92.5 m (303 ft) Rotor Diameter
- 6,720 m² (72,333 ft²) Swept Rotor Area - (1.66 Acres)
- 45.2 m (148 ft) Blade Length
- 3.0 m/s Cut-in Speed (**6.7 mph**)
- 24.0 m/s Cut-out Speed (**53.7 mph**)

*Cold Climate Version – Additional Pitch Heating, the first turbine in the MM class with the NGX/CSC4/Next Generation converter including liquid cooling & heating of IGBTs, additional gearbox heating, two stage cooling fans. Ultrasonic anemometer for wind speed & direction even in icing.
REpower renamed SENVION in 2014
Costs – Eva Creek

- **Capital Costs**
  - Capital Costs: $94 million (including grants)
  - State Renewable Energy Fund: $3.6 million
  - State Grant: $10 million
  - CREB (renewable energy bonds) Financing at 1.05%

- **Operating Costs**: $1,200,000/year

- **Cost of energy**: 8.7 cents/kWh
  - Exclusive of regulation costs
Regulation Cost (Load Following)

- A **load following power plant** is one that adjusts its output as demand for electricity fluctuates throughout the day.
- With **Eva Creek** load following is more complicated. Grid demand can go up while wind energy drops, causing ramp rates which potentially exceed a plant’s capacity to respond.
Conceptual Fairbanks 24 Hour Load Curve

Grid Load

Wind Generation

Power Estimated And Purchased 24 Hours Earlier
Performance Measurements

• **Net output**
  - energy produced minus energy used at the site

• **Capacity Factor**
  - the total electricity a generator actually produces as a percentage of the maximum it could produce, for a given period

• **Availability**
  - the amount of time a plant is able to produce electricity, divided by the amount of the time in the period
Production for Jan 2014, typical month, no days at full load and no days without wind
# Eva Creek Monthly Performance 2013

<table>
<thead>
<tr>
<th>Month</th>
<th>Days</th>
<th>Output MWh</th>
<th>Capacity Factor</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-13</td>
<td>31</td>
<td>8,713</td>
<td>47.6%</td>
<td>98.31%</td>
</tr>
<tr>
<td>Feb-13</td>
<td>28</td>
<td>6,754</td>
<td>40.9%</td>
<td>98.60%</td>
</tr>
<tr>
<td>Mar-13</td>
<td>31</td>
<td>6,903</td>
<td>37.7%</td>
<td>99.71%</td>
</tr>
<tr>
<td>Apr-13</td>
<td>30</td>
<td>3,808</td>
<td>21.5%</td>
<td>99.04%</td>
</tr>
<tr>
<td>May-13</td>
<td>31</td>
<td>3,335</td>
<td>18.2%</td>
<td>99.51%</td>
</tr>
<tr>
<td>Jun-13</td>
<td>30</td>
<td>4,438</td>
<td>25.1%</td>
<td>99.78%</td>
</tr>
<tr>
<td>Jul-13</td>
<td>31</td>
<td>4,857</td>
<td>26.5%</td>
<td>98.37%</td>
</tr>
<tr>
<td>Aug-13</td>
<td>31</td>
<td>5,298</td>
<td>28.9%</td>
<td>99.74%</td>
</tr>
<tr>
<td>Sep-13</td>
<td>30</td>
<td>6,005</td>
<td>33.9%</td>
<td>99.83%</td>
</tr>
<tr>
<td>Oct-13</td>
<td>31</td>
<td>9,513</td>
<td>52.0%</td>
<td>99.12%</td>
</tr>
<tr>
<td>Nov-13</td>
<td>30</td>
<td>5,873</td>
<td>33.2%</td>
<td>99.53%</td>
</tr>
<tr>
<td>Dec-13</td>
<td>31</td>
<td>5,513</td>
<td>30.1%</td>
<td>96.01%</td>
</tr>
<tr>
<td>Year - 2013</td>
<td>365</td>
<td>71,010</td>
<td>33.0%</td>
<td>99.00%</td>
</tr>
</tbody>
</table>
Output in terms of homes powered

- Average home around Fairbanks uses 660 kWh/month
- Eva Creek supplied electricity for 8,966 homes for a whole year
Availability

Eva Creek 2013 Availability

- Chart showing monthly availability percentages for December 2013.
2013 Eva Creek Capacity Factor 33.0%
Predicted Performance

- Error only 0.1%, V-Bar Meteorologists
  Way to go V-Bar...

<table>
<thead>
<tr>
<th>Net Output*</th>
<th>Predicted</th>
<th>2013 Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>74,378 MWh</td>
<td>74,276 MWh</td>
</tr>
</tbody>
</table>

| Capacity Factor | 34.50% | 34.50% |

* Including curtailments due to GVEA’s occasional incapacity to Load Follow
Eva Creek 2013 Actual vs. Estimated Yields by Quarter (with Dispatch Curtailment)

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Output ** (MWh)</th>
<th>Dispatch Curtailed (MWh)</th>
<th>Total Output w/ Curtailed (MWh)</th>
<th>Total V-Bar Estimate (MWh)</th>
<th>Actual vs. Estimate</th>
<th>Capacity Factor %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Quarter</td>
<td>22,474</td>
<td>976</td>
<td>23,450</td>
<td>22,330</td>
<td>5.0%</td>
<td>44.1%</td>
</tr>
<tr>
<td>2nd Quarter</td>
<td>11,740</td>
<td>337</td>
<td>12,077</td>
<td>15,908</td>
<td>-24.1%</td>
<td>22.5%</td>
</tr>
<tr>
<td>3rd Quarter</td>
<td>16,262</td>
<td>732</td>
<td>16,994</td>
<td>15,583</td>
<td>9.1%</td>
<td>31.3%</td>
</tr>
<tr>
<td>4th Quarter</td>
<td>21,005</td>
<td>852</td>
<td>21,857</td>
<td>20,455</td>
<td>6.9%</td>
<td>40.2%</td>
</tr>
<tr>
<td>Total</td>
<td>71,481</td>
<td>2,897</td>
<td>74,378</td>
<td>74,276</td>
<td>0.1%</td>
<td>34.5%</td>
</tr>
</tbody>
</table>

** Notes:
- High Side T1: Actual output.
- Curtailed: Curtailment.
Icing

• Primary concern is related to impact from ice, which can be thrown over 1,000 ft
  – There are no local highway routes or buildings

• Secondary concern is exceeding design capacity due to rotor imbalance or vibration

• Thirdly is performance degradation
  – We estimate 1% to 3% reduction in capacity factor due to icing, depending on the year
Icing

• Phase 1, reduced to 1.5 MW
  – When differences detected between heated and unheated anemometers

• Phase 2, full shutdown
  – Due to deviations from anticipated power curve

• No means as yet to calculate actual verses possible production
Superhydrophobic Coatings

- Ice shedding coatings involve nanotechnologies still in their infancy
- No anti-icing technology is as yet sufficiently developed
Generation Hierarchy – Least Cost First

- Delta Plant Frame 5 Gas Turbine
- Zehnder Plant Frame 5 Gas Turbines
- North Pole Frame 7 Gas Turbines
- Eva Creek Wind (requires load following)
- North Pole Combined Cycle Plant
- Healy Coal Plant
- Purchased gas power over Intertie
- Bradley Lake Hydro
Regulation Issues - GVEA’s System

• Purchased power is scheduled a day ahead, so GVEA must have flexible generation to fill the gap

• Wind will reduce the availability of purchased energy (other utilities must load follow wind in their area)

• Coal and combined cycle plants used to load follow can trip due to low limit or sudden instability. Once off they cannot immediately start back up

• Start time and start-up costs
LM6000 (747 engine) used for load following
Combined Cycle Plant

Gas Turbine
(44% max efficiency in simple cycle)

- 100% Fuel Flow
  - 50 MW Nominal
  - Highest Efficiency
- 44% GT
- 52% With ST
- 33% GT
- 39% With ST
- 22% GT
- 24% With ST
- 11% GT
- 0% With ST
- 0% GT

Steam Turbine

- 12 MW Nominal
- 9 MW
- 6 MW
- 3 MW
- 3.2 MW steam

Cost of Operation

- 0% Fuel
- 30% Fuel
- 100% Fuel
Combined Cycle Plant

Steam Turbine
-12 MW Nominal
-9 MW
-6 MW
-3 MW

6.5 MW steam

Gas Turbine
(44% max efficiency in simple cycle)

100% Fuel Flow
-50 MW Nominal

Highest Efficiency

-40 MW

-31.5 MW, 63% load, 72% fuel

-30 MW

-20 MW

-10 MW

-0 MW – Lowest Efficiency

Cost of Operation

Eva Creek

-0 MW

-24 MW Nominal

Savings of ~18 GPM Naphtha (in this specific scenario)

NPEP Produced 54 MW on the gas turbine and 12.5 MW on the steam turbine on Nov 20, 2013. 65 GPM Naphtha, -30F ambient, >52% efficiency

0% Fuel

30% Fuel

65 GPM Naphtha, -30F ambient, >52% efficiency
Combined Cycle Plant

**Steam Turbine**

1. -12 MW Nominal
2. -9 MW
3. -6 MW
4. -3 MW

**Gas Turbine**

1. 100% Fuel Flow
2. -50 MW Nominal
   - Highest Efficiency

**Eva Creek**

-0 MW

**System Load**

Insufficient for Full Load

Minimum load Naphtha 15 MW > Operation on Jet A

- 30% Fuel
- 0% Fuel

Cost of Operation

-0 MW – Lowest Efficiency

North Pole LM6000 Gas Turbine
Low load near trip condition

-Pink- Gas Turbine MW load
-Green- Steam Turbine MW load
-Blue- HP Boiler feed water flow
-Light blue- HP steam pressure at the turbine control valve
-Red- HP steam temperature at the control valve
Conceptual Fairbanks 24 Hour Load Curve

Power Estimated And Purchased 24 Hours Earlier

Grid Load

Wind Generation

Start another gas turbine

Curtail Wind
2013 Eva Creek Capacity Factor with Curtailment 34.5%

Eva Creek Production with Curtailed Generation

Net MWh

Curtailed

Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec
SETPOINTS

POWER CURTAIL:

LESS THAN 4.8 WILL TURN some TURBINES OFF
LESS THAN 1.23 WILL TURN all TURBINES OFF
MIN CHANGE = 0.10

VOLTAGE:

PMU INPUT=11 (ANALOG) INPUT=14 (IEC)
85 % kV
100 % kV

MIN/MAX = 95/105 %
MIN CHANGE = 1 %

WIND SPEED: 28.8 MPH
WIND DIRECTION: 166.9 deg
AVAILABLE: 24.2 MW
ACTUAL: 18.5 MW
Concepts for more economical load following:

- **STORAGE:**
  - Store wind energy in a reservoir and use it later like any other dispatched resource
    - Water storage (pumped hydro)
    - Compressed air storage
    - Batteries (flow batteries)
- **LOAD MANAGEMENT:**
  - Smart Grid type control of loads
    - Electric storage heaters in homes and businesses controlled by utility SCADA system
    - Capacity to delay less critical loads for a time when generation resources can be more efficiently applied, as in, with plants fully loaded or off-line
Concepts for more economical load following:

Incremental generation

Banks of diesel engines

As the load increases, additional engines are brought on, all the engines but one are at full load and therefore at their highest efficiency.

Five 5 MW gensets, fast on, fast off, auto-synchronizing.
Maintenance – typical daily events:

DATE: 03 February 2014

CURRENT WEATHER: ESE Breeze @ 5 m/sec. Temp -2C @ Site, -18C in Ferry. Clear.

TODAY:
- 12 Turbines Online
- WEC 16 – Pitch Comm Slipring, Inspect & Swap for Clean & Lube (begin)
- WEC 16 – Cable Guide & Top Ladder Strengthening (resume)
- Sitewide – LOTO Verification & Documentation (continue)
- Sitewide – Tower Ladder Cable Guide Upgrade (continue)

FRIDAY & WEEKEND:
- 12 Turbines Online
- Sitewide – Tower Ladder Cable Guide Upgrade (continue)
- Sitewide – Converter Cabinet Inspection – Temp Sensors & Hose Fittings (completed)
- WEC 16 – Pitch Comm Errors, Slipring Faults (Sunday, Remote Reset)

Larger Maintenance Issues in 2013
1. Burned slipring (January)
2. Frequency Converter Contactor (June)
3. Frequency Converter Choke (December)
Maintenance Issues

• Road Maintenance
  – 17 miles of road
  – Snow removal
  – Visibility
  – Ice on road (chains)
Bird Mortality Study

• Only four birds (one ptarmigan and three song birds) found dead at site. No raptors or large birds of any kind

• This is less than expected, based on an earlier study performed for the Intertie in that area

• Scavenging rate is high for small birds so some birds will have been carried away, but there have been no feathers or any sign of larger bird remains

• The observers were tested and found almost all the test birds

• There is a two year third party study in progress
Related Projects at Eva Creek

• Prospective balloon mount wind generator comparative icing test
Related Projects at Eva Creek

- State of Alaska LiDAR testing
Thank you for attending
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Paul Morgan
GVEA, Eva Creek Manager
February 18, 2014