Technical Session 3

Diesel Engine Efficiency

10:30 am, Wednesday, September 28, 2011

Centennial Hall
is the glass half full or half empty?.. 

• The optimist says the glass is half full.
• The pessimist says the glass is half empty.
• The project manager says the glass is twice as big as it needs to be.
• The first engineer says the glass is over-designed for the quantity of water.
• The second engineer says he's glad he put the other half in a redundant glass.
• The consultant says let's examine the question, prepare a strategy for an answer, and all for a daily rate of...
• The realist says the glass contains half the required amount of liquid for it to overflow.
• And the cynic... wonders who drank the other half.
• The teacher says it's not about whether the glass is half empty or half full, it's whether there is something in the glass at all.
• Anyway... Attitude is not about whether the glass is half full or half empty, it's about who is paying for the next round.
House Keeping

- Each presenter has about 15-20 minutes.
- Please ask questions during each of the presentations.
- If we have time we can have discussion at the end.
- After this session lunch will be provided in the Sheffield room.
Agenda

• Diesel Efficiency Overview
  – Alan Fetters, Project Manager, Alaska Energy Authority

• Diesel Heat Recovery
  – Brian Gray, Professional Engineer, Alaska Energy and Engineering

• Impact of Renewables on Diesel Efficiency
  – David Lockard, Project Manager and Professional Engineer, Alaska Energy Authority

• Case Studies and Real Time SCADA Demonstration
  – Bob Havemeister, Rural Utility Worker, Alaska Energy Authority
To begin our course on "Fundamentals of Electricity," let us start with the source.

-- The Electric Tree. We use its juice to make all of our electric power.

In the old days, we had to extract it with the drip-and-bucket method, then wait until it hardened into wax for candles and lamps—The whole thing was a very long, slow process.
Diesel Efficiency Overview

Alan Fetters, Project Manager, Alaska Energy Authority
Diesel Efficiency Overview

Reality of Power Generation in Rural Alaska PCE Communities

- **Hydro**: 6.7% at 26,988,631 kWh
- **Diesel**: 92.4% at 372,983,621 kWh
- **Wind**: 0.9% at 3,587,822 kWh

From FY2010 annual Power Cost Equalization (PCE) report. Does not include Kodiak, Juneau, Sitka, Valdez, etc. that are not PCE eligible communities.
Diesel Efficiency Overview

- Select efficient engine generator set to match load considering other generation such as renewables

- Consider heat output of the diesel generation and all potential heat loads

- Distribution or load considerations

- On going and continued maintenance of the system not just the powerhouse
UNABLE TO REPAIR THE ON/OFF SWITCH, THE ELECTRICIAN SIMPLY RELabeled IT.
Satellite Communication
Diesel Generation Standards

3 AAC 52.620. Generation Efficiency and Line Loss Standards, in the Power Cost Equalization Program

Quote - Generation efficiency and line loss standards are established to encourage efficient and economical generation, transmission, and distribution of electricity. The standards represent the minimum acceptable level of performance by a participating electric utility.
Diesel Generation Standards

Minimum efficiency standards for a utility that uses diesel fuel to generate **80% or more** of total kWhs generated, and that generates:

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<tr>
<th>Less than</th>
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<td>9.5 kWh/gal</td>
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<td>11.5 kWh/gal</td>
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Minimum efficiency standards for a utility that uses diesel fuel to generate **less than 80%** of total kWhs generated, and that generates:

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Diesel Efficiency Improvement

Chignik Bay Diesel Efficiency Improvement kWh per Gallon

New Powerhouse placed Online in May 2009
### Diesel kWh/Gallon

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<tr>
<th>STATUS</th>
<th>DEMAND</th>
<th>BUS</th>
<th>TURBINES</th>
<th>GEN 4</th>
<th>GEN 3</th>
<th>GEN 2</th>
<th>GEN 1</th>
<th>HRS</th>
<th>VFD</th>
<th>ALARM</th>
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#### System Mode
- Manual
- Auto

#### Status
- HZ: 59.98
- KVAR: 167.66
- KW: 430
- PF: 0.93

#### Peak Demand
- 571

#### KWH
- 39810

#### Total Fuel Used
- 187911

#### Diesel kW/Gallon
- 15.82

### Feeder 1
- OPEN
- CLOSED

### Boiler Breaker
- OPEN
- CLOSED

### Station Service
- OPEN
- CLOSED

#### Capacitor Bank
- KVAR Output: 0
- Sensitivity: 60%
- PF Setpoint: 92
- Time Delay: 60
- Temperature: 82F

#### SS KW
- 8

#### Boiler KW
- 0

#### AMPS
- A: 12
- B: 13
- C: 9

#### KWH
- 72444
- 60249
Quote - A line loss standard of 12 percent applies to all electricity sold, and is measured as all kilowatt-hours (kWh) generated or purchased, from whatever source, minus kWh sold, divided by all kWh generated or purchased.

At least 88% of the electricity generated should be delivered to a load or used. Only 12% allowed in loss.
Diesel Generation Standards

Distribution systems have inherent loss through conductors and transformers, other “loss” may be from:

— Metering Accuracy
  • poor reads or logging
  • accuracy of the meters and related instruments
  • wrong multipliers when CTs or PTs used

— Leakage from deteriorated underground conductor insulation, overhead insulators and transformers

— Unmetered unaccounted for street lighting

— Power Theft

Related power factor and load balance have a direct impact on reliability and efficiency
Diesel Generator Energy Outputs

Gallon of Fuel Allocation for Diesel Generation by the Old Rule of Thumb

- **Usable Electrical Output**
  - 43,300 Btu
  - 12.69 kW
  - 34%

- **Wasted Exhaust Heat**
  - 43,300 BTU
  - 12.69 kW
  - 33%

- **Wasted Jacket Heat**
  - 43,300 Btu
  - 12.69 kW
  - 33%
Diesel Generator Energy Outputs

Gallon of Fuel Allocation for New Technology Diesel Generation

- **Useable Electrical Output**
  - 14.7kW
  - 38%

- **Useable High Grade Jacket Water Heat**
  - 5.3kW
  - 14%

- **Useable Low Grade After Cooler Heat**
  - 2.8kW
  - 7%

- **Usable Low Grade Atmosphere Heat**
  - 2.7kW
  - 7%

- **Exhaust Heat**
  - 12.9kW
  - 34%
Diesel Generator Energy Outputs
Diesel Generator Energy Outputs

Gallon of Fuel Allocation for New Technology Diesel Generation Marine Jacket

- **Usable Electrical Output**: 14.7kW (38%)
- **Exhaust Heat**: 8.6kW (23%)
- **Usable High Grade Jacket Water Heat**: 9.6kW (25%)
- **Usable Low Grade After Cooler Heat**: 2.8kW (7%)
- **Usable Low Grade Atmosphere Heat**: 2.7kW (7%)
Stack Robber
Demand

Lower Demand at Night and Early Morning

Higher Demand During Day

Lunch

Dinner

Savings potential from dispatch of most efficient source to match demand
Diesel Generation Fuel Curves

John Deere Tier 2 Marine & Tier 3 Options

- 6090 AFM 210e kW Prime, Tier 2 Marine
- 6081-HF070-T206 260e kW Prime, Tier 2
- 6090 SFM 260e kW Prime, Tier 2 Marine
- 6090HF485-T304 - 250 eKW Prime, Tier 3
- 4045-300HF485 117e kW Prime, Tier 3

kW Load vs. kWh/gal
Diesel Generation Fuel Curves

CAT 3456 vs. CAT C27 and CAT 3412

The graph shows the fuel consumption per kW load for three different types of diesel engines: CAT 3456, CAT 3412, and CAT C27. The graph plots kWh/gal (kilowatt-hours per gallon) on the y-axis and kW load on the x-axis.
Diesel Generation Fuel Curves

Cat Engine Options for Yakutat
Diesel Efficiency Overview
Potential Diesel Generation Efficiency Improvements

**Categories**
- Generation
- Switchgear & Control
- Powerhouse
- Distribution
- Management

**Technologies**
- Electronic Engine Controller
- Electronic Fuel Injection
- High Grade Heat Recovery Receptors
- Low Grade Heat Recovery Receptors
- Organic Rankin Cycle, Hydrogen Injection, Friction Reduction
- Constant Load Monitoring, Automatic Generator Dispatch, Coordination with Other Sources
- Faster Troubleshooting & Power Restoration
- Burn Used Oil
- Increased Facility Efficiency
- Balance Loads, Line Loss Reduction
- Efficient Transformers/Proper Size
- Automatic Flags/Improved Response
- Troubleshooting Skills
- Comprehensive Maintenance
- Peak Shaving
- Voluntary Conservation

**Efficiency Gains**
- 10-20%
- 10-20%
- 5-15%
- Needs Vetting
- 10-15%
- Lower O & M
- 1-2% (Plus Lower O & M Costs)
- 2-5%
- Lower O & M Costs
- 10-20% Less Demand
The EPA recognizing the circumstances in remote Alaska promulgated several amendments for engines used in remote Alaska. The EPA:

• exempted all pre-2014 model year engines from diesel fuel sulfur requirements;

• allowed owners and operators of stationary compression ignition engines located in remote areas of Alaska to use engines certified to marine engine standards, rather than land-based nonroad engine standards; and
• removed requirements to use after treatment devices for NOx, in particular, SCR, for engines used in remote Alaska;

• removed requirements for use after treatment devices for PM until the 2014 model year; and

• allowed the blending of used lubricating oil, volumes up to 1.75 percent of the total fuel, in the sulfur content of the used fuel is less than 200ppm and the used lubricating oil is "on-spec," i.e., it meets the onSpecification levels and properties of 40 CFR 279.11.

• [http://www.dec.state.ak.us/air/anpms/ulsd/ulsdnsps.htm](http://www.dec.state.ak.us/air/anpms/ulsd/ulsdnsps.htm)
After his first day, Lester, the new accountant for Acme Solar, Wind & Biomass Energy, Corp., realized he had become a green bean counter.
Diesel Heat Recovery
Brian Gray, Professional Engineer, Alaska Energy and Engineering
Cat 3500B Series

1. CAT 3516B, 1322 ekW Prime, Low BSFC Strategy
2. CAT 3512B, 1050ekW Prime
3. 3508B, 633 ekW Prime

Engine Options for Yakutat

kWh/gal vs. kW Load:
- CAT 3516B, 1322 ekW Prime, Low BSFC Strategy
- CAT 3512B, 1050ekW Prime
- 3508B, 633 ekW Prime

11.0 to 16.0 kWh/gal
100 to 1,400 kW Load
Passive Heat Utilization
After Cooler Heat Recovery
Direct Drive vs. VFD Electric Fan