

# **Sustainable Automation, Inc.**

## **Wind-Diesel Technology Development**

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# Company Direction

- **Focus on technology development for high penetration wind and solar hybrid power systems.**
- **Orient marketing efforts toward high penetration early adopters.**
- **Position company to be a world leader in hybrid systems integration as high penetration market matures.**

# Wind Penetration Definitions

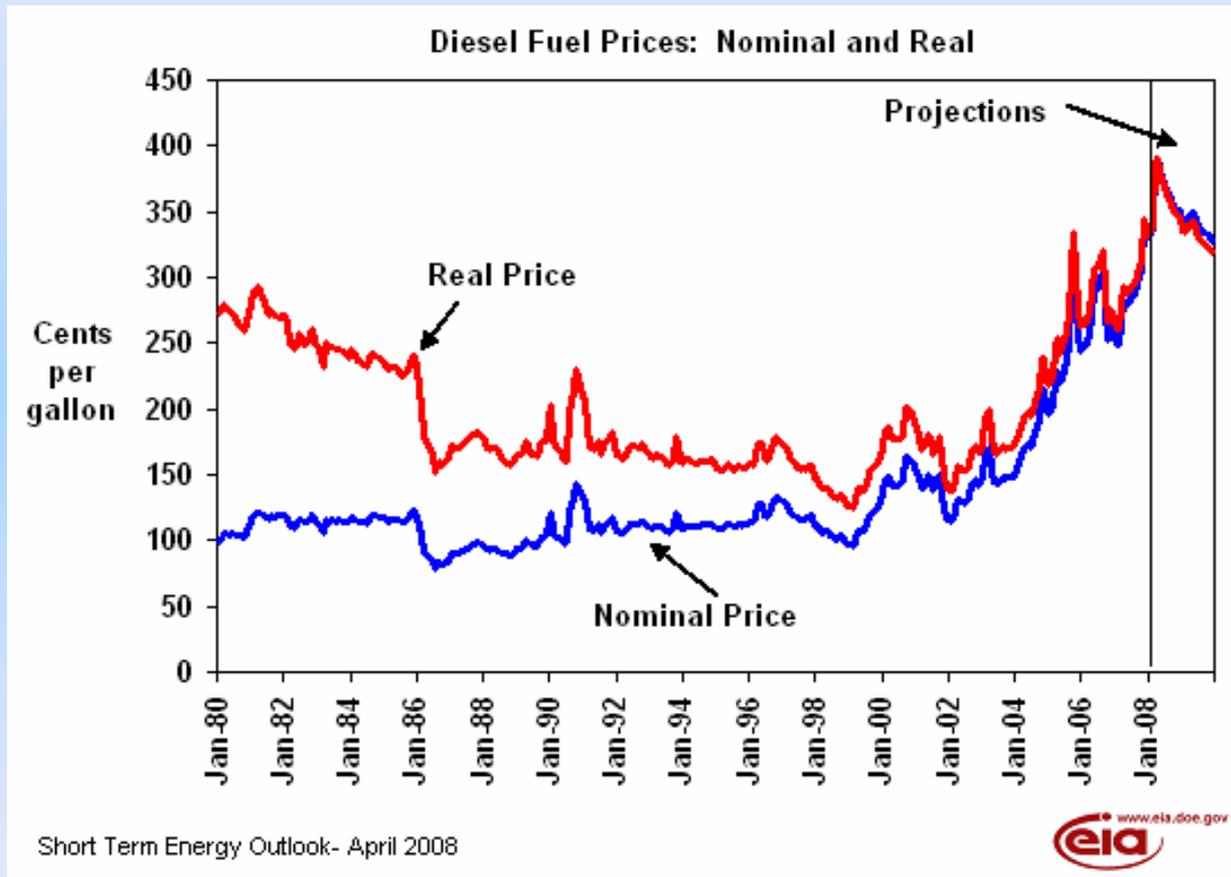
| PENETRATION CLASS | OPERATING CHARACTERISTICS   | FUEL SAVINGS |
|-------------------|---|--------------|
| LOW               | <ul style="list-style-type: none"> <li>• Diesel runs full time</li> <li>• Wind power reduces net load on diesel</li> <li>• All wind energy goes to primary load</li> <li>• No supervisory control system</li> </ul>   | < 15%        |
| MEDIUM            | <ul style="list-style-type: none"> <li>• Diesel runs full time</li> <li>• At high wind power levels, secondary loads dispatched to ensure sufficient diesel loading</li> <li>• Alternatively, wind turbines are curtailed during high winds and low loads</li> <li>• Requires relatively simple control system</li> </ul> | 15 - 40%     |
| HIGH              | <ul style="list-style-type: none"> <li>• Diesels may be shut down during high wind availability</li> <li>• Auxiliary components required to regulate voltage and frequency</li> <li>• Requires sophisticated control system</li> </ul>  | 40 – 90%     |



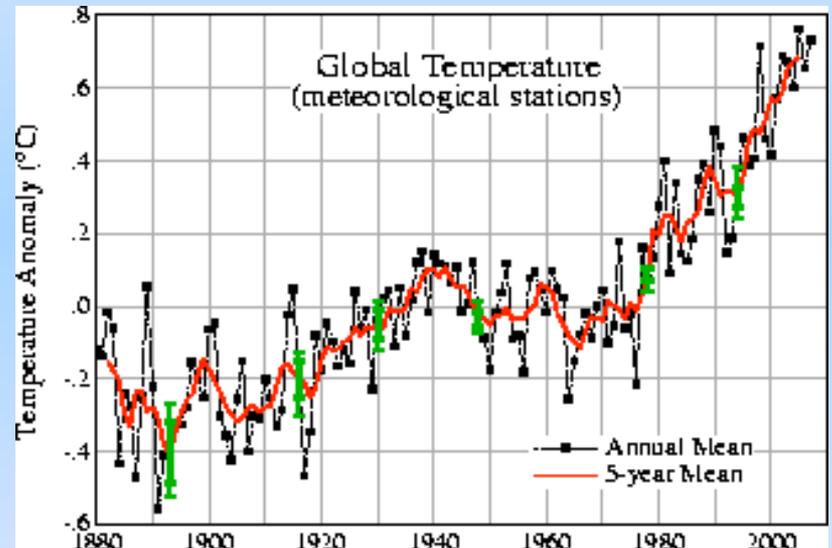
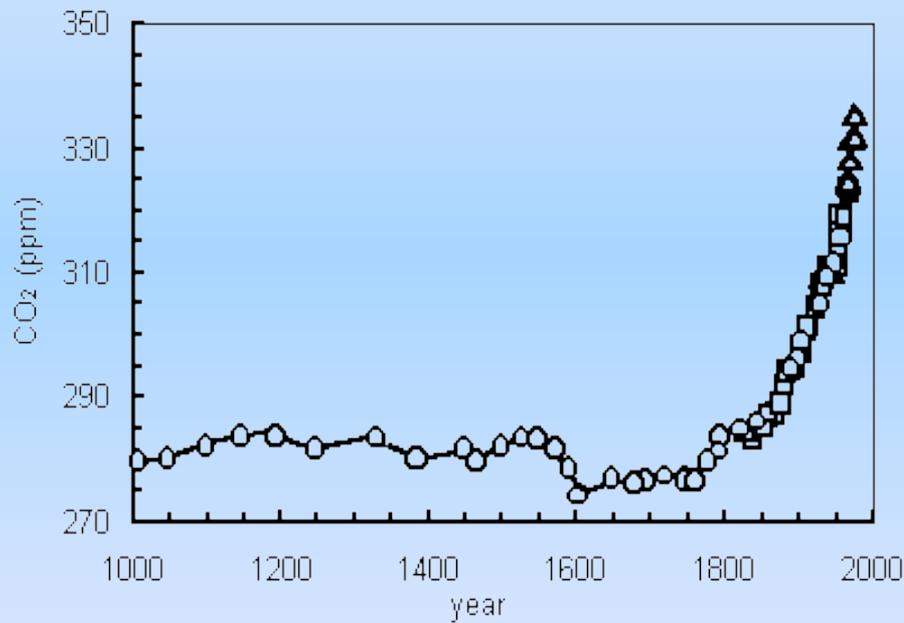
# Why High Penetration?

- Motivating Factors
  - Cost of diesel fuel
  - Global imperative to reduce GHG
  - We like a challenge!
- Enabling Factors
  - Advances in energy storage
  - Relatively low cost global connectivity
  - Reduced cost and increased power of industrial control technologies

# Diesel Fuel Price Trend



# GHG and Global Warming

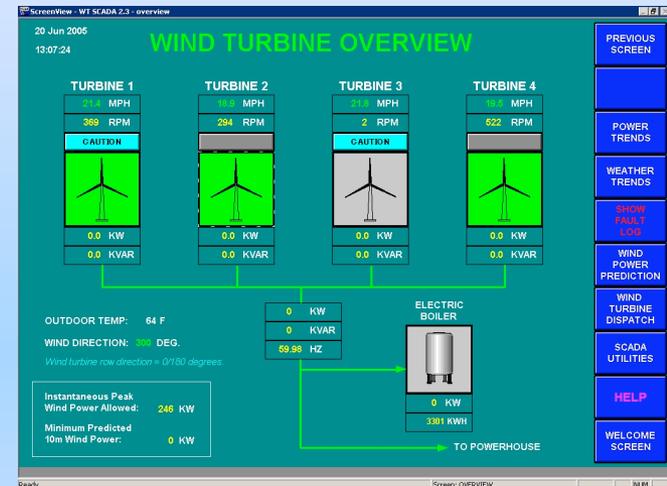


# Product Development Approach

- Develop a complete suite of plug-and-play control and power components to enable rapid deployment of high penetration systems:
  - Local System Control
  - Power Conversion
    - Synchronous Condenser (no storage system)
    - Energy Storage Interface
  - Secondary Load Controller
  - Remote Monitoring

# Hybrid System Controller (in development)

- Touchscreen local operator interface
- On-board datalogging
- Internet ready (accessible via web browser)
- Redundant controllers possible in mission critical applications
- Modular software – modules pre-coded to enable use with all major models of wind turbine and diesel generator controllers.



# Synchronous Condenser (existing product)



- Standalone or diesel-parallel operation
- Assists diesels in meeting reactive power demand
- Regulates voltage in standalone mode
- Ideal for no-storage systems
- Magnetic “mass” provides additional voltage stiffness
- Rotating mass provides additional frequency stiffness



# Energy Storage Grid Interface Power Converter (in development)



- 4-Quadrant – Real and reactive power can flow in either direction
- Stand-alone or diesel-parallel operation
- Very fast response
- Independent phase control - tolerates and corrects 3-phase grid load imbalances

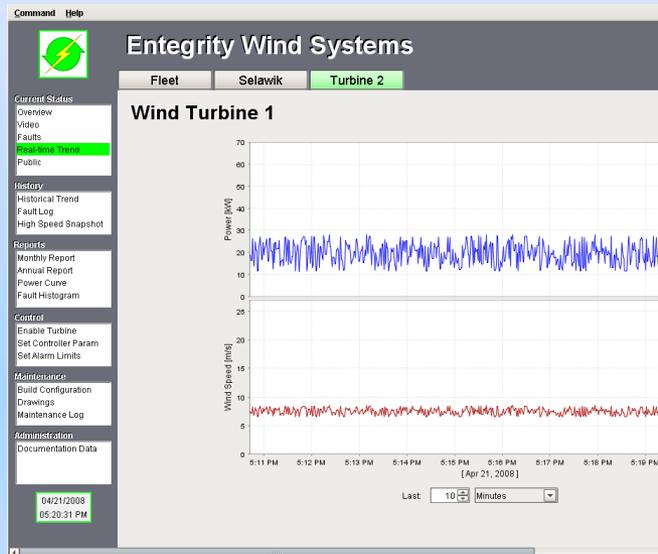
# Secondary Load Controller (existing product)



- Zero-crossing solid state switching → no harmonics
- Fast response – load updates every cycle (16 msec)
- Easily scalable



# Web-Based Remote Monitoring System (in development)



- Web-based ([www.worldvue.net](http://www.worldvue.net))
- Data resides on a secure central server
- Consistent user interface, independent of control platform used in particular systems
- Serves diverse user groups