



Wind - Hybrids: Power for Islands

Wind Energy in New England Islands

Lawrence H. Mott



NORTHERN
POWER SYSTEMS
power without limits



Company Overview

- World Class Systems Integrator
 - Engineering, Procurement, and Construction Contractor (EPC)
 - In House - Technology Expertise
 - Systems Controls
 - Power Electronics
 - Wind Turbine innovation
-



Company Overview

- Founded in 1974
- Over 800 distributed power systems installed
 - 40 countries
 - 7 continents
- 94 employees
 - 50% + with engineering & technical degrees
- History of solving difficult engineering problems
- Blue Ribbon customer list: Bechtel, Fluor, Williams Bros. NASA, NSF, USAF, Chevron, Haliburton, TVA, Sprint, ATT, Yale, PG&E, Niagara Mohawk, Lockheed Martin,



Renewable Energy Integration



Providing renewable and hybrid power systems that reduce and stabilize energy costs for Utilities, Developers, Commercial & Industrial sectors, and resort clients.



Isolated Grids

Islands

- 50 kW to 10 MW
- Significant Renewable Resource
- Utility Grade Power
- High Fuel Costs
- High Maintenance Costs
- Environmental Considerations





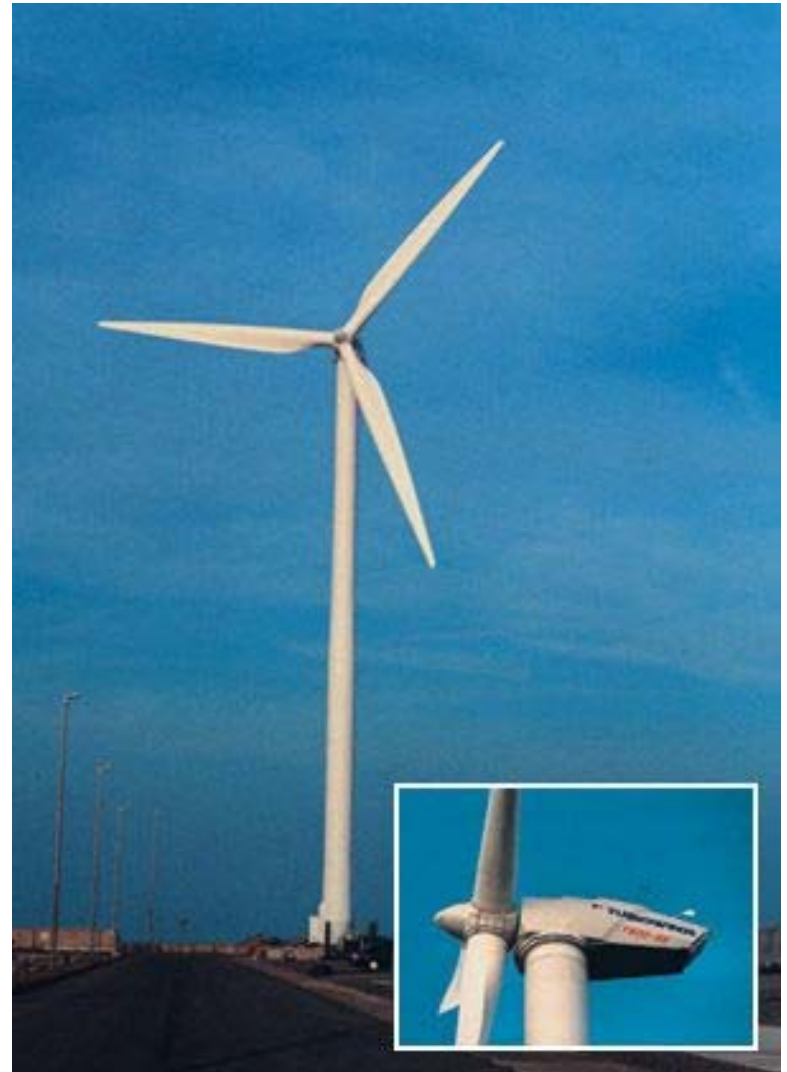
Presentation Outline

- Why Wind – Diesel
 - Wind - Diesel Economics
 - Power Quality
 - Wind – Diesel Basics
 - Project Example
 - Hybrid Controls
-



Why Wind Energy?

- The cost of wind energy has fallen by more than 80% since the early 1980's
 - 38¢ to 3-6¢ per kWh
- Costs are expected to drop by an additional 20+% by 2010
- Indigenous resource
- Wind is a technology success





Why Wind-Diesel ?

- There are many isolated diesel powered grids in regions with good wind resources and high energy costs.
- Adding renewables to Island power plants:
 - ✓ Reduces fuel use, fuel storage, energy costs
 - ✓ Increases long term stability of energy costs
 - ✓ Reduces environmental impacts/risks
 - ✓ Increases system reliability

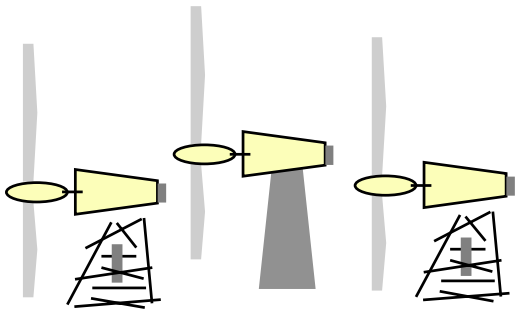


Wind - Diesel Compatibility

“Fuel Diversity”

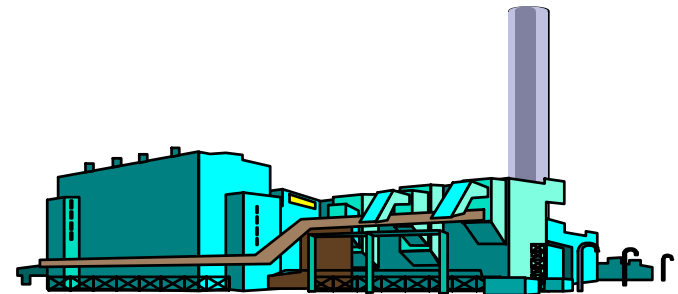
Wind

Low Operating Cost
High Capital Cost
Non-Dispatchable
No Fuel Supply/Cost Risk
No Emissions



Diesel/Oil

High Operating Cost
Low Capital Cost
Dispatchable
Fuel Supply/Cost Risk
Smog/GHG Emissions





Wind-Diesel Economics

- Diesel generated power costs are dominated by fuel cost and maintenance.
- Wind power system costs are dominated by upfront capital costs.
- Hybrid system economics are dependant on:
 - Available wind resources
 - Cost of capital
 - Delivered price of fuel
 - Fuel price risk over the life of the project



Costs: Life Cycle & Installed

Distributed System (100kW - 5 MW) - [US\$]

<u>SOURCE</u>	<u>\$/kWh</u>	<u>\$/MW</u>
Diesel	.15-.30	0.7m
Wind Energy	.07-.12	1.5m
Wind-Diesel	.11-.22	2.0m
Solar Energy	.20-.28	8.0m
Battery	.10 (energy storage cost)	
Flywheels (high speed)	<i>very high</i>	
Hydrogen	<i>very high</i>	



Wind-Diesel Hybrid System

“Penetrate the system with as much wind power as is effective”

System Architecture:

- Low penetration
- Medium penetration
- High penetration/No storage
- High penetration/ Storage

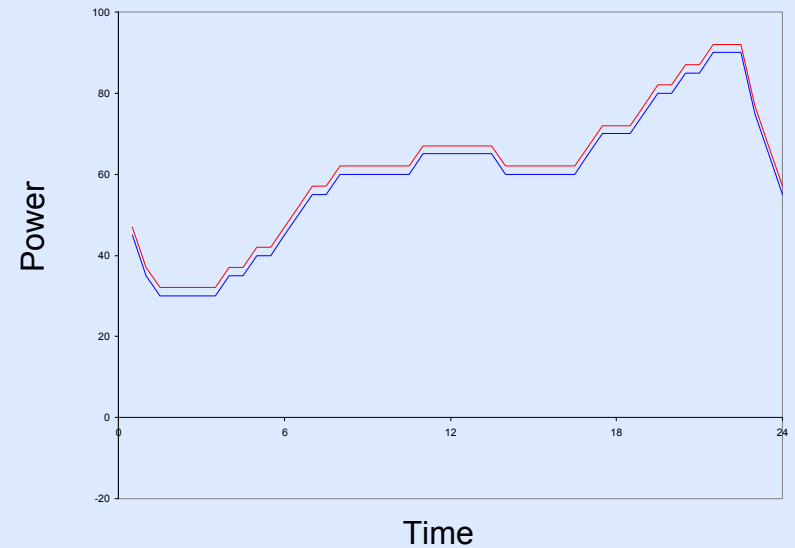
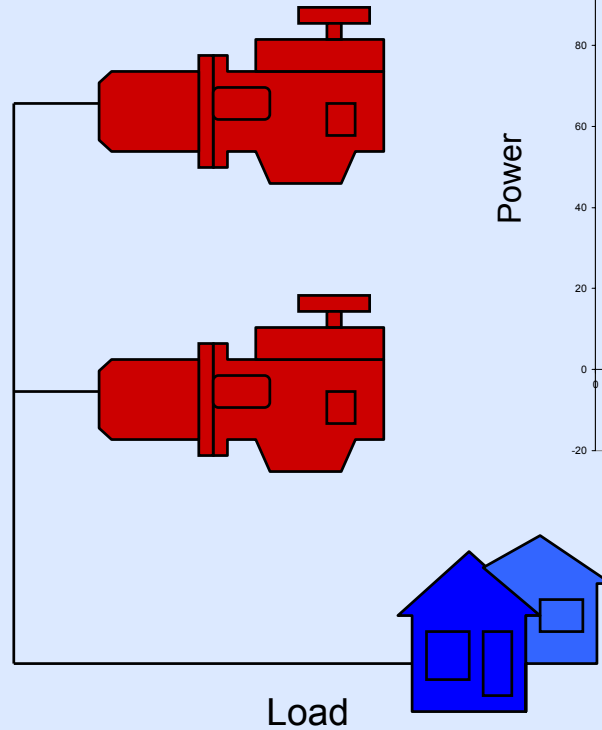


Power Integration Design Issues

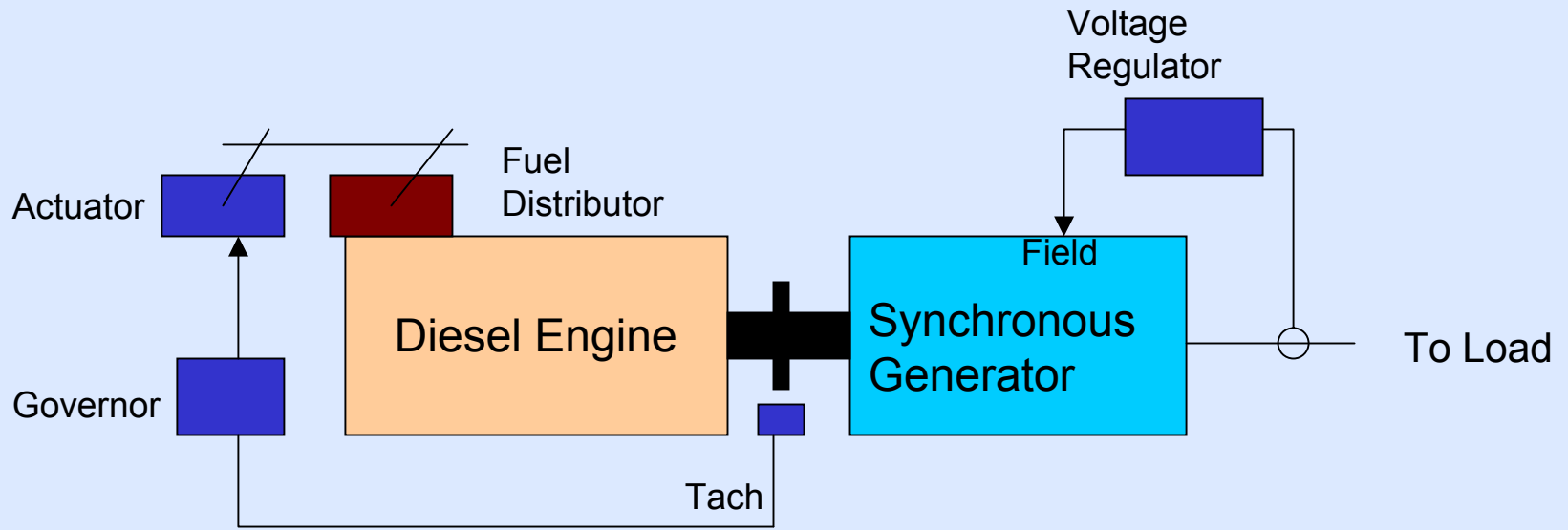
- Impacts on diesel engines/generators
 - Efficiency
 - Maintenance
 - Operations
- Power Quality
 - Frequency control
 - Voltage control
 - Grid stability
 - “flicker”, harmonics, distribution system effects

“Diesel Only” System Control

Diesel Generators



Generator Control



Frequency Control

Voltage Control



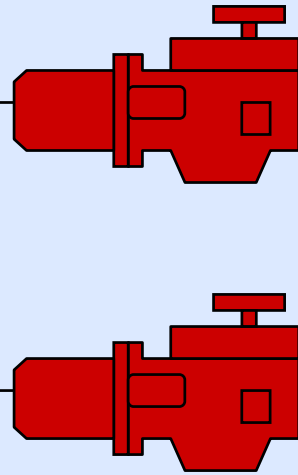
Wind-Diesel Architecture

Low Penetration

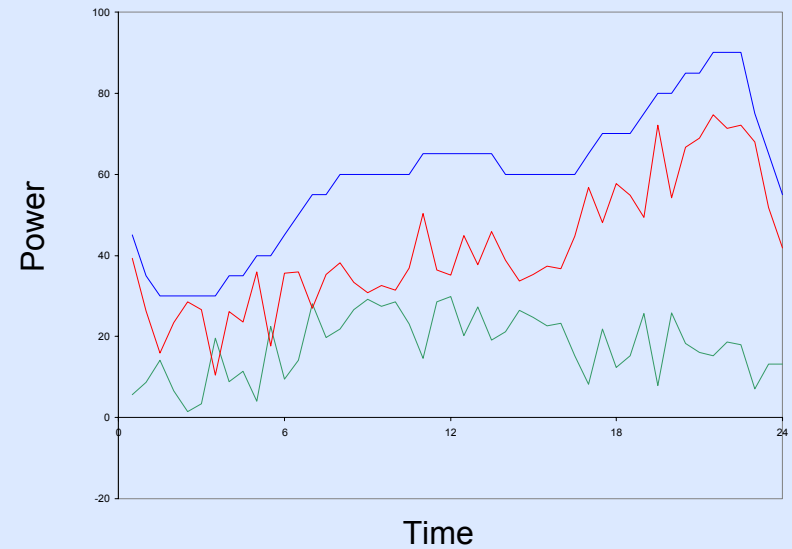
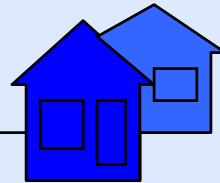
Wind Turbine



Diesel Gensets



Load

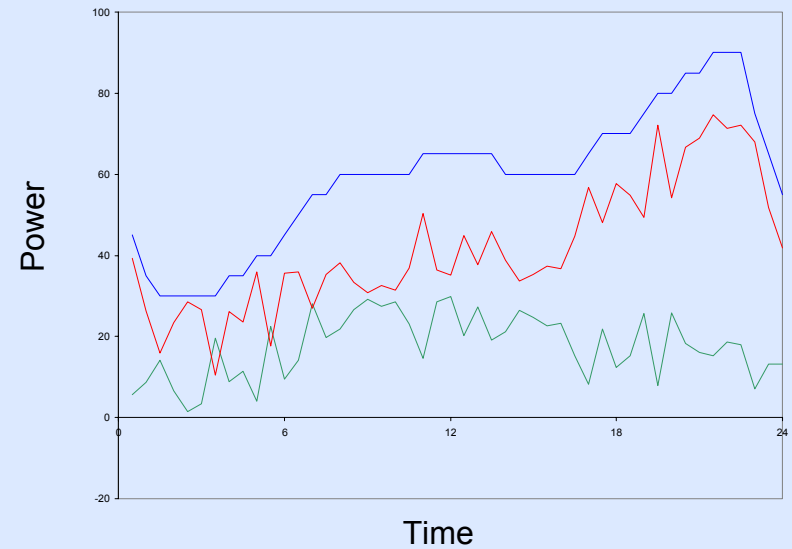
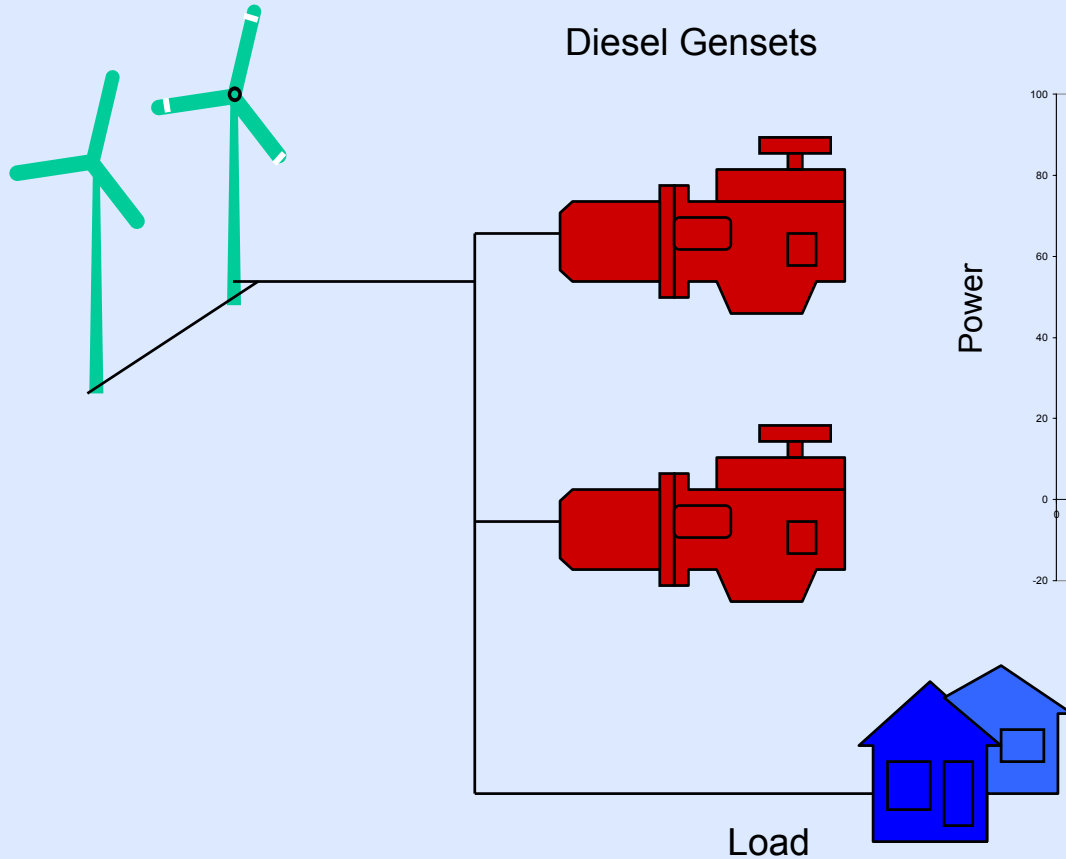


Wind-Diesel Architecture

Medium Penetration

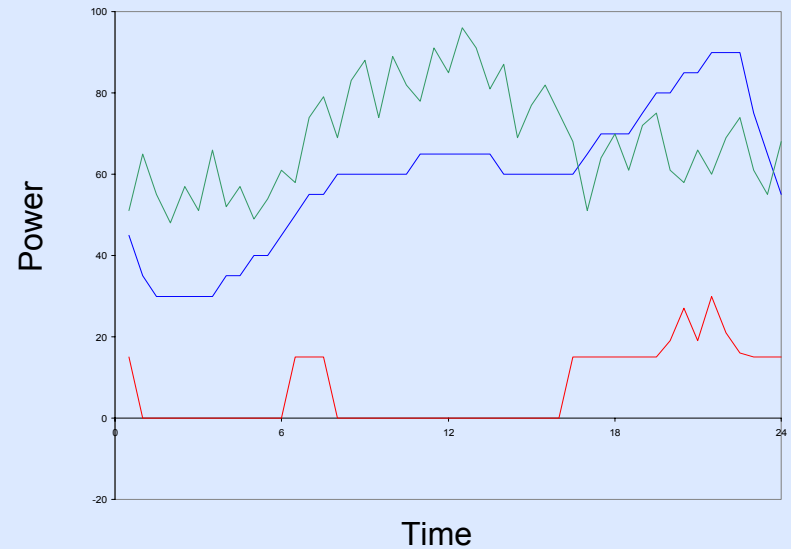
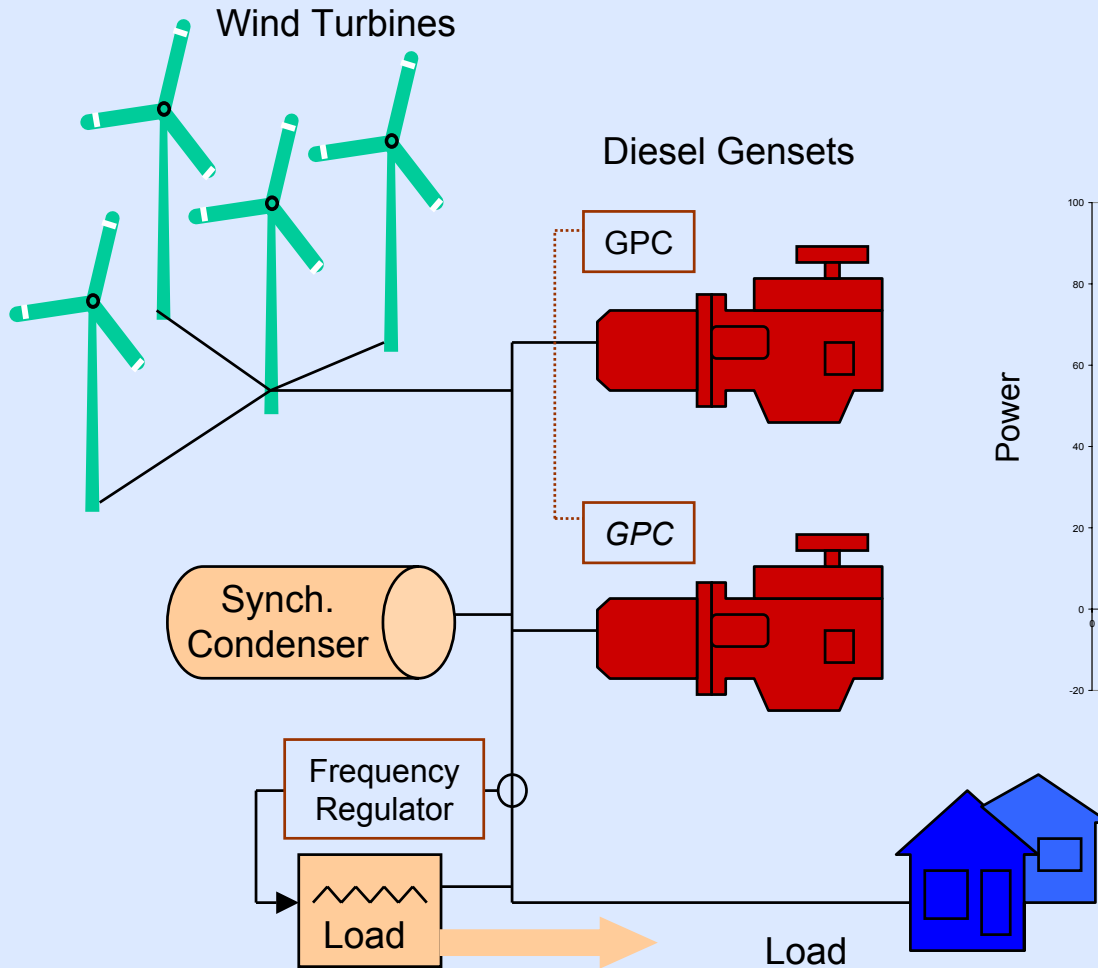
Wind Turbines

Diesel Gensets

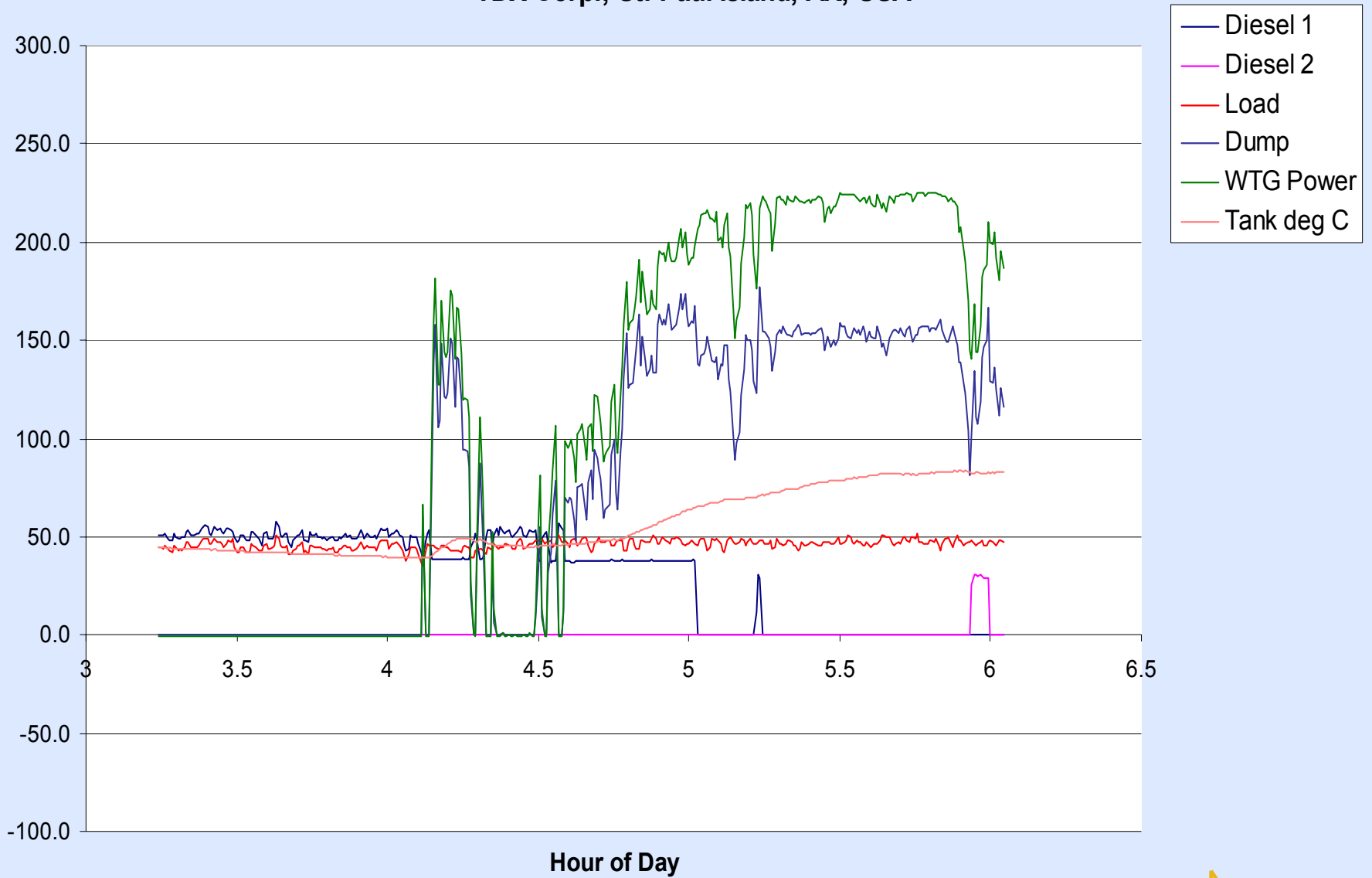


Wind-Diesel Architecture

High Penetration



10-Minute Data, NPS Hybrid Wind/Diesel Power System TDX Corp., St. Paul Island, AK, USA





Isolated Community - Project



Wind/Diesel

225 kW Wind Turbine

2 x 150 kW Diesel Gensets

No Battery Bank Required

Digital Engine Controls

NPS Components

System Controllers/RemoteView

Synchronous Condenser

Heating and Thermal Plant

Integrated Control Shelter

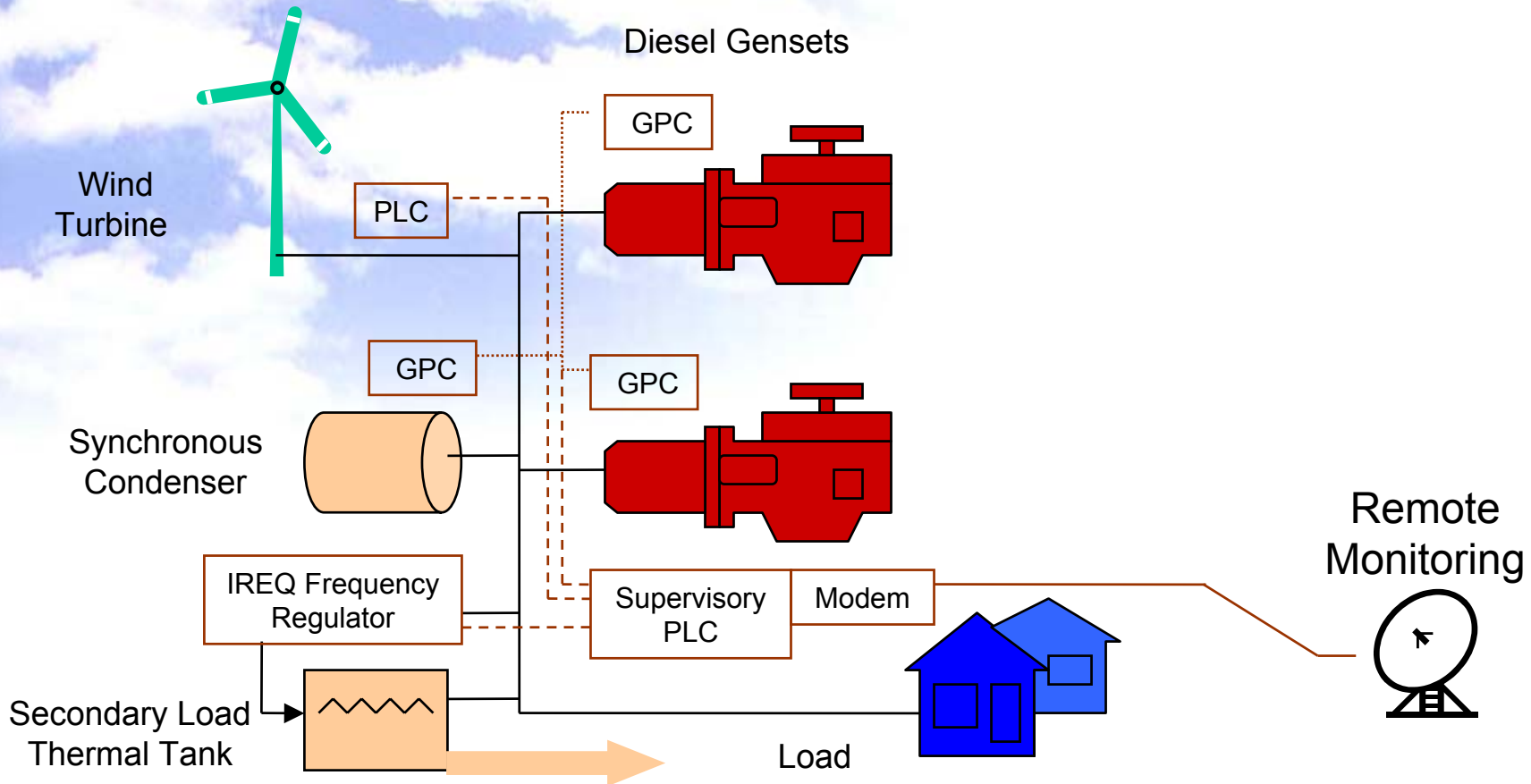
Secondary Load Regulator

St. Paul Island, Alaska

*Public power supply providing electricity and space heat
to an industrial/airport facility*



St. Paul Island



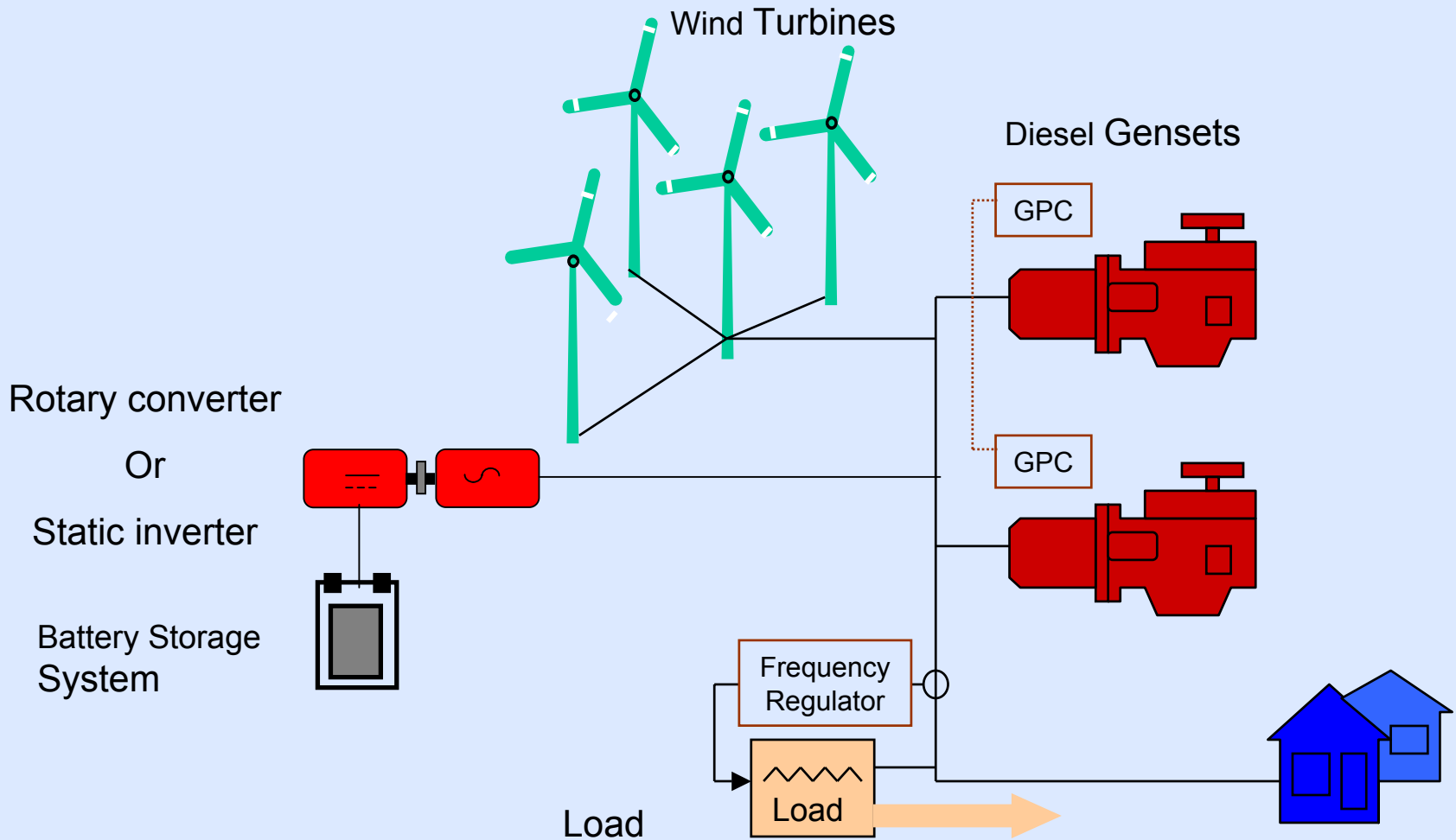


Storage vs. No Storage

- Advantages
 - Greater utilization of available wind energy
 - Increase savings in fuel and maintenance of diesels
- Disadvantages
 - Costs
 - Maintenance
 - Environmental impacts
- Storage Technology is lagging Generation Technology

Wind-Diesel Architecture

High Penetration/ with Storage

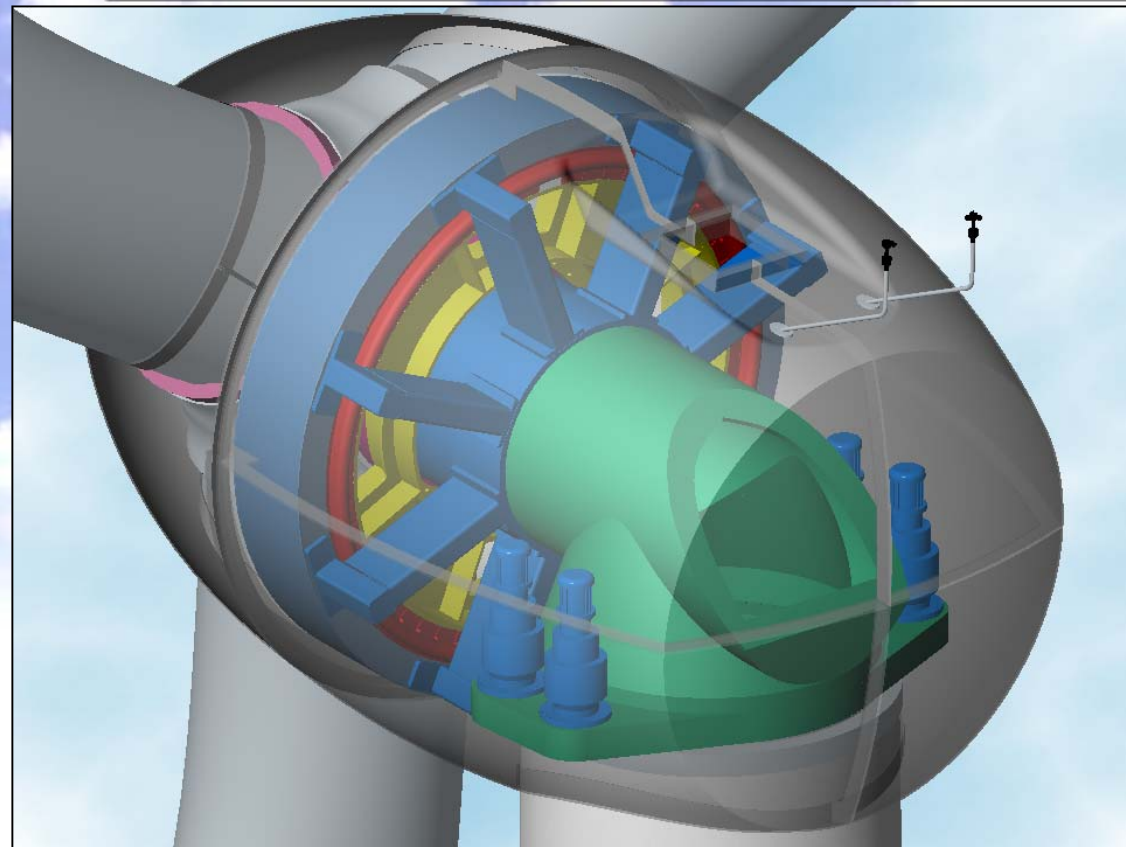




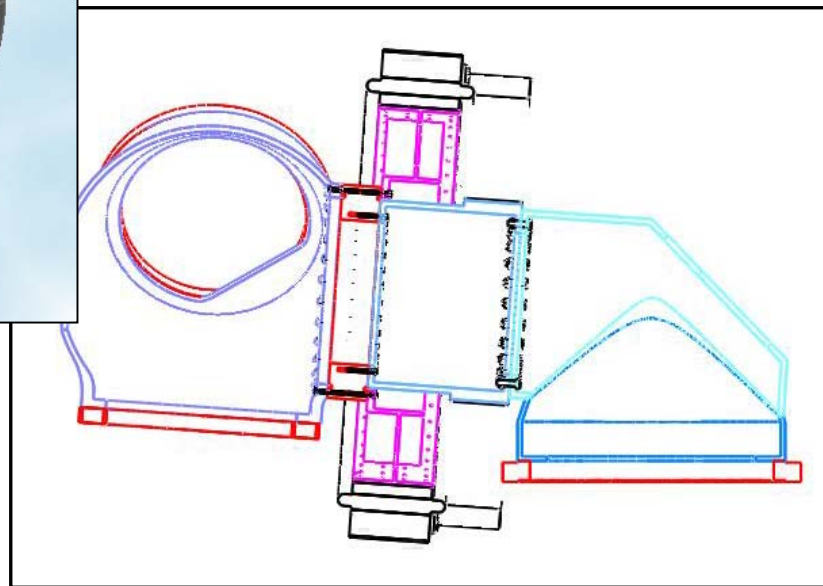
Turbine Type Considerations

1. Wind Farm with Asynchronous wind turbines
2. Distributed with Asynchronous wind turbines
3. Either application with Synchronous wind turbines

Direct Drive/Power Electronics

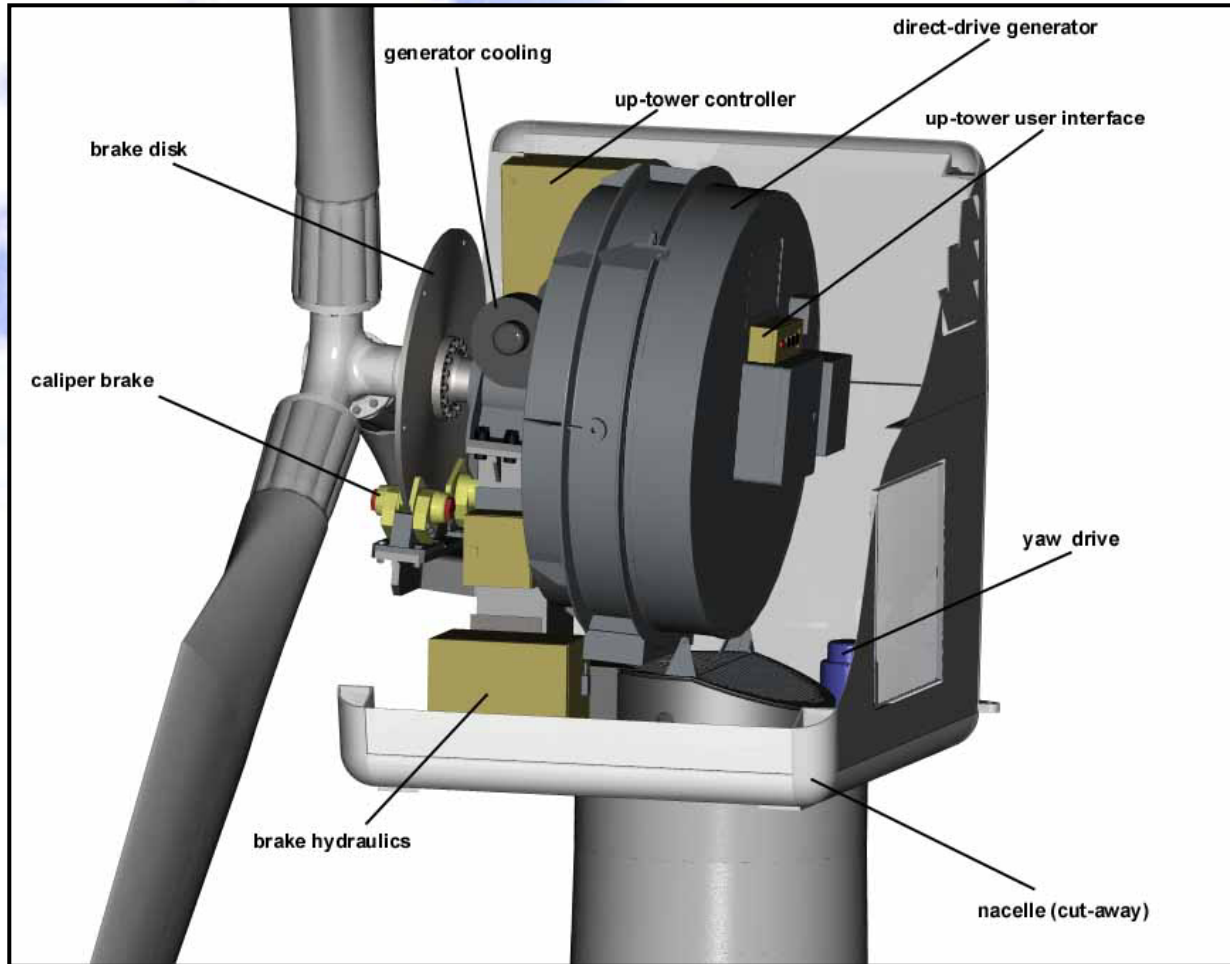


Northern Power Systems
1.5 MW





NW100 – 100kW - w/Power Electronics





Controls and Power Conditioning

- Without hybrid system controls and power conditioning gear - wind turbine capacity is currently limited to about 20% of the diesel capacity on line.
- The installation of hybrid components along with wind power allows the wind turbine capacity to exceed diesel generator capacity and can allow all diesels to be shut off under favorable wind and load conditions.
- Hybrid wind-diesel systems allow significant penetration of wind power to islands who rely on diesel powered electrical grids.

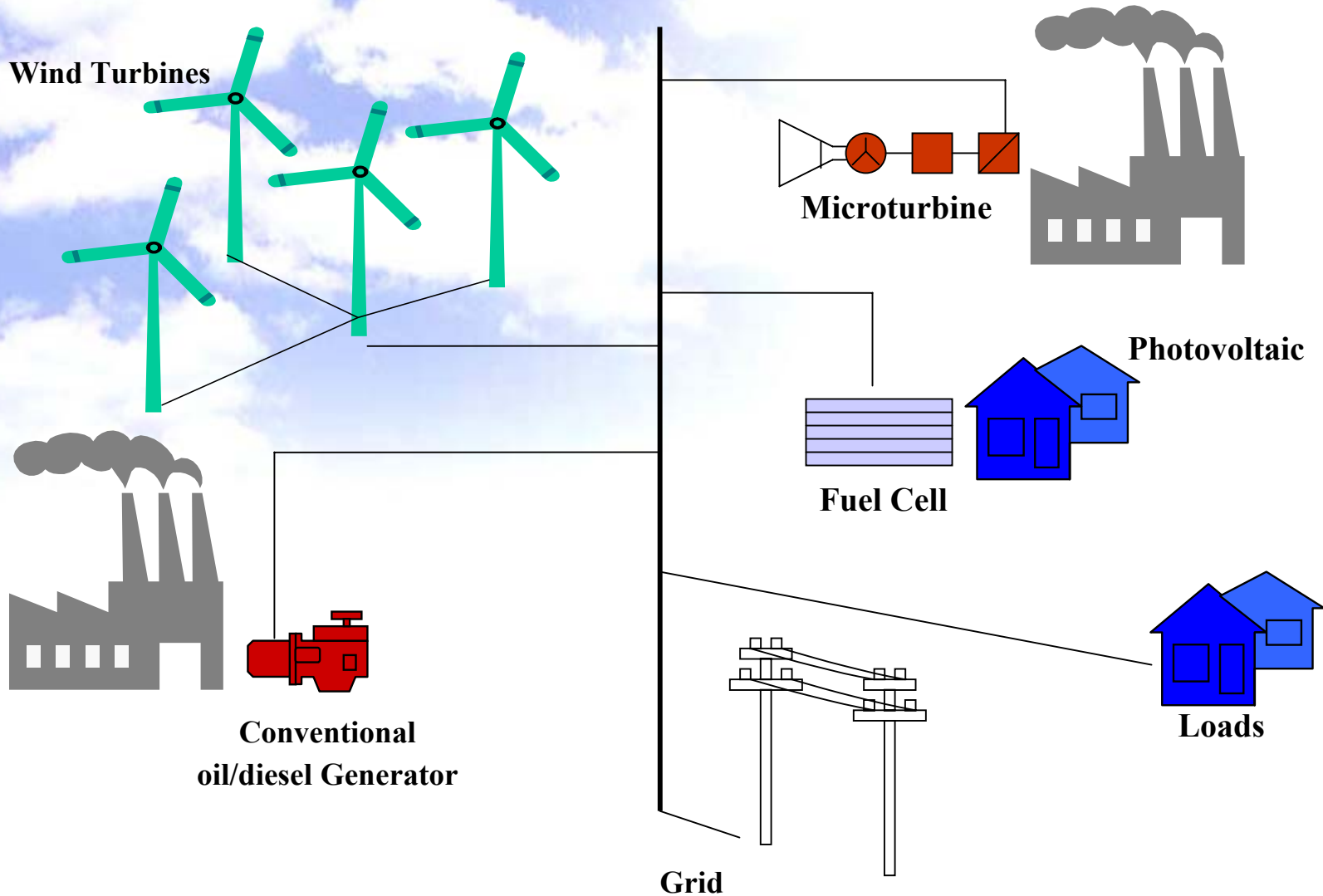


Commercial Components

- In the past, hybrid controllers and systems have been custom built for a few prototype installations or for small systems.
 - Now, commercial controls and power electronic conversion components are available to integrate large, utility scale wind turbines with modern generators, and also provide local and/or remote monitoring.
-



Distributed Power Mix



Power without limits



Reliable power. Proven worldwide.