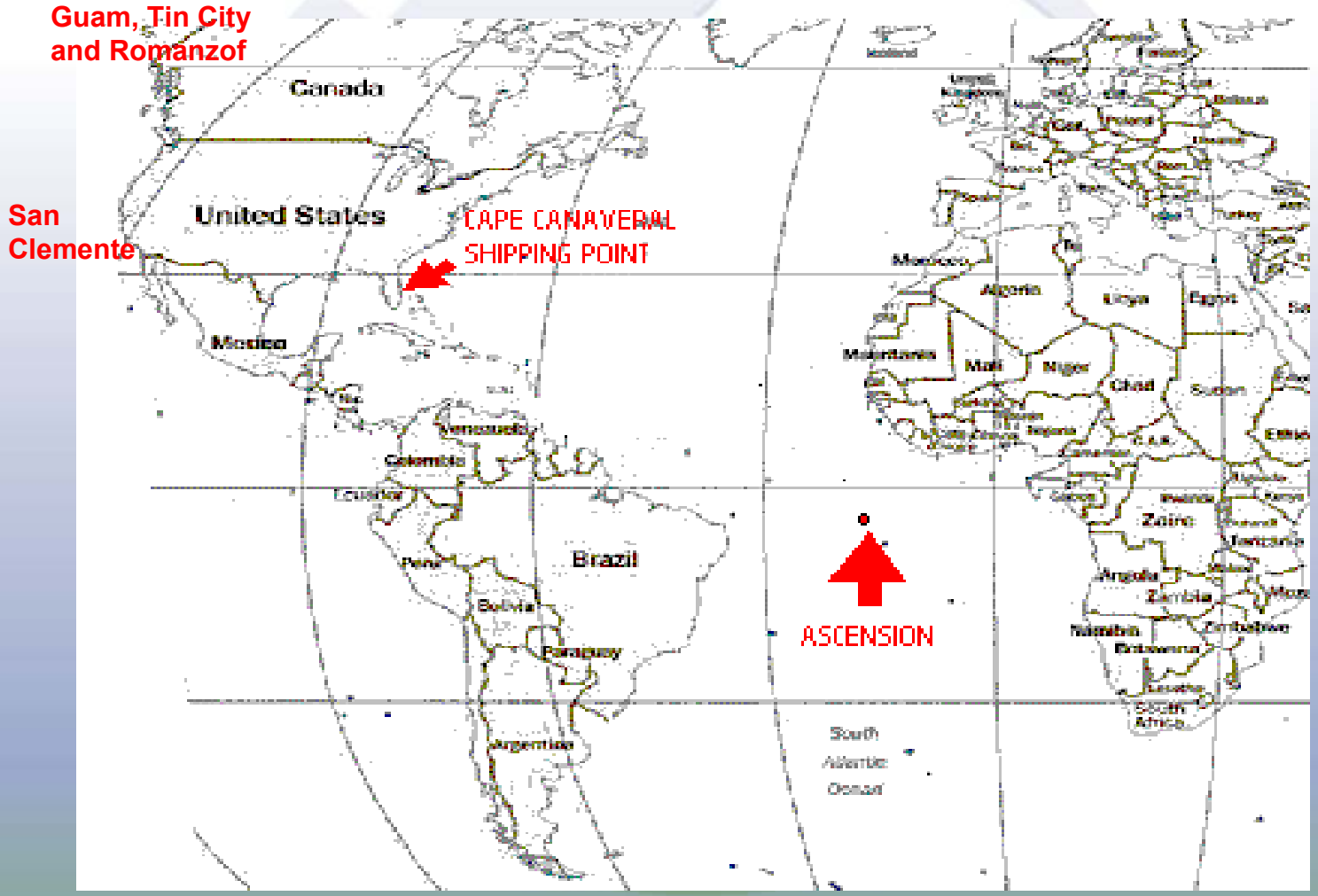
High Penetration Wind Diesel Hybrid DOD Power Generation Systems

Gary Seifert & Kurt Myers

Idaho National Engineering and Environmental Laboratory

September 29, 2004

Background information



Remote Ascension Island

Background information - Ascension

- Air Force power generated by a prime power diesel-electric plant
- Air Force load ranges from 1.6 to 2.4 MW
- Two 1900 kW diesel generators operate in parallel with the wind farm
- Waste engine heat and fuel fired boilers power the desalination system

Wind Farm at Ascension

- ***Phase One – 4-225 KW NEG-Micon Wind Turbines, on-line in 1996***
- ***Phase Two – 2-900 KW NEG-Micon Wind Turbines added, on-line now (2004)***
- ***Phase Two is a high Penetration project, requiring;***
  - ***electronic controlled electric boiler (to help make fresh water from the sea),***
  - ***synchronous condenser,***
  - ***improved controls to the power system***

Before, Diesels and ------

--- and Fuel Fired Boilers to Make Desalinated Water

The Desalination System, Making Fresh Water From Sea Water

Wind farm at Ascension

Before, Phase 1

After, Phase 2

CHALLENGES

- Remote shipping - 5000 miles from Port Canaveral
- Restricted shipping schedules
- Pier restrictions
- Limited crane reach
  - Very short towers
- Limited island access

System Description – Phase One

- Four three-bladed 225 kW MICON wind turbines for a total of 900 kW
- Average Ascension wind speed: 7.8 m/s (17.5 mph)
- 4 Up-wind Micon Turbines (40/225kW EA.)
- 30m Tower Height
- Fixed Pitch Stall Regulated
- 29.8 m Rotor Diameter

System Description – Phase Two

- *Add two, 3-bladed 900 kW MICON, wind turbines for a total wind farm of 2700 kW*
- *30m Tower (very short)*
- *Fixed Pitch Stall Regulated*
- *52 m Rotor Diameter*
- *Synchronous Condensor*
- *2 each 1 MW Electric Boilers with Fast Electronic Controls*

Performance

Phase 1

- ***Average wind power output - 342 kW (38% capacity factor)***
- ***Average Penetration - 14-24%***
- ***Maximum Observed penetration - 46-56%***
- ***Stable Operation***

Performance

Phase 2

- ***Average wind power output of 1026 kW (38% capacity factor)***
- ***Average Penetration - 43-64%***
- ***Maximum penetration - 112 to 169%%***
- ***Other features needed for stable operation***

High Penetration Design

- Synchronous Condenser

  (VAR support and Rotating Mass)
- 2 each (1 MW) electric boilers designed for;
  - steady state average load,
  - control variability - fine tuning
  - automated load/generation leveling
  - boiler controls monitor wind farm output
  - manage boiler load to wind farm output
  - Keep Penetration lower (by adding load)

Phase Two Economics and Operational Impacts

- Fuel Saving will grow
  - 650,000 extra gallons of fuel a year saved
  - a total of more than one million gallons of fuel saved every year
- 70,000 gallons of fresh drinking water - now produced every day with green wind energy, instead of diesel energy
- Simple Payback in 7 years
- Significantly reduces CO2 and NOX Emissions
- Stable, reliable, green, wind energy 5000 miles from home

LESSONS LEARNED

- Perform resource assessments
- Partner at the beginning
- Performance based specifications
- Control system design and integration crucial
- Integrate load management into the control system for stability and high penetration
- Plan and model loads up front
- Wind/Diesel systems are very compatible
- You can have penetration above 25%, but plan and design for high penetration

Tin City LRR, Alaska

Tin City Wind Summary

ESTIMATED ENERGY PRODUCTION

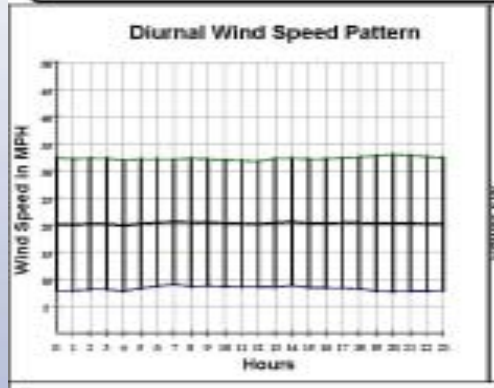
Date Range
2003-09-10 TO 2004-06-27

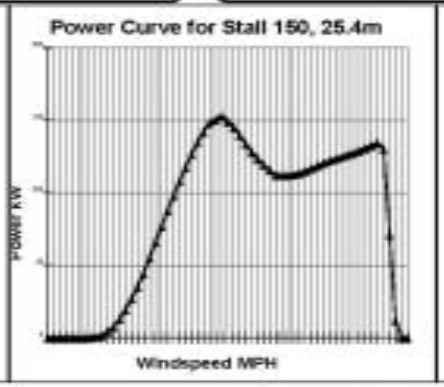
SITE 7011

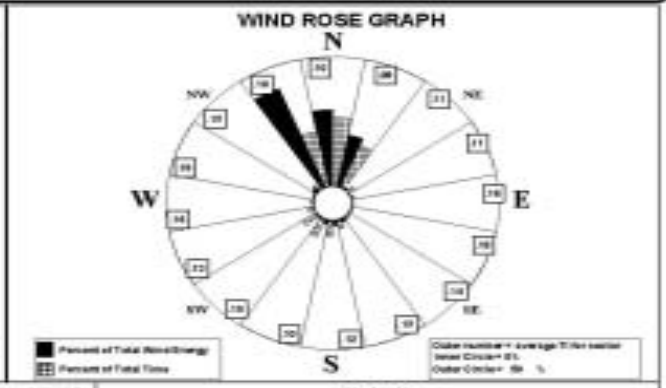
Site Information

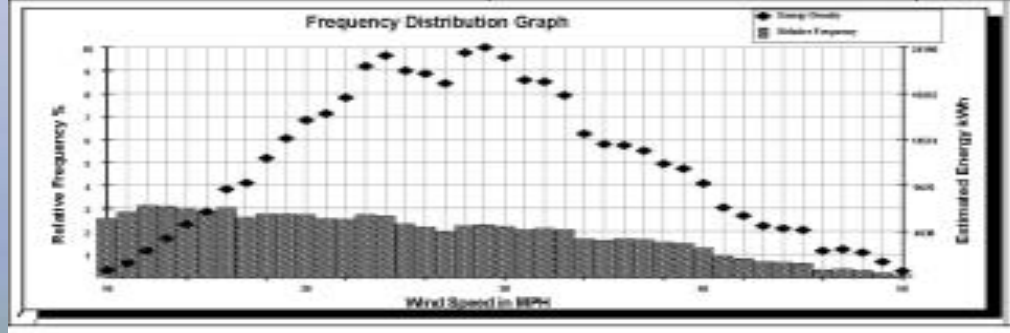
Project:	Alaska Air Force
Location:	Tin City LRR
Site Elevation:	360FT
Averaging Time:	10 min

Sensor 1 Information		*Sensor 2 Information*	
Channel:	1	Channel:	2
Type:	Anemometer	Type:	Direction Vane
Scale:	1.223000000	Scale:	1.000000000
Offset:	1.6000	Offset:	0.0000
Description:	Anemometer	Description:	Direction Vane
Height:	26FT	Height:	26FT









Statistics

Estimated Energy Output	490718 KWH
Calculated Air Density	1.212 kg/m3
(temperature data and pressure based on elevation)	
Average Wind Speed	20.3 MPH
Average Turbulence Intensity	0.13
Mean Energy Wind Direction	NNW
Mean Wind Direction	N
Capacity Factor	0.47
Average Temperature	0.0 F
Turbine Manufacturer	Norwin
Turbine Model	Stall 150, 25.4m
Turbine Rating	150.0 kW
Number of Turbines	1
Estimated Annual Production	616123 KWH/Year

Total hours = 7008 Total hours used in Calculations = 6977 Percent Data used = 99.5

Printed July 26, 2004

NRG Systems MicroSite Version 3.01

Cape Romanzof LRR, Alaska

Cape Romanzof Wind Summary

ESTIMATED ENERGY PRODUCTION

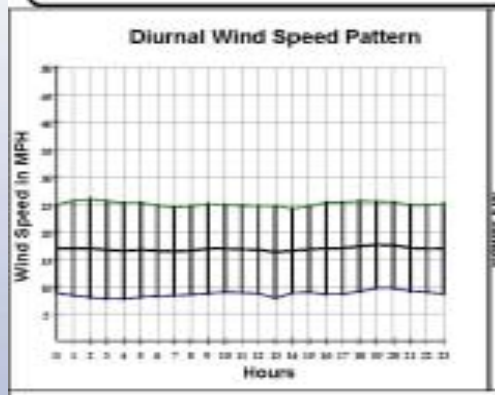
Date Range
2003-09-11 TO 2003-12-29

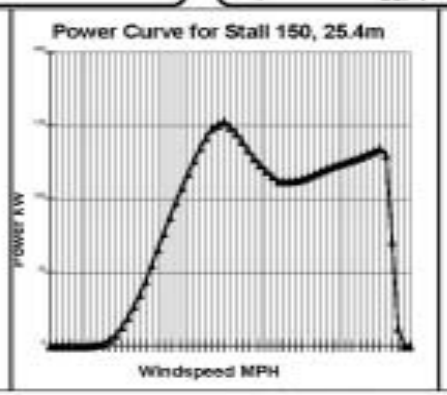
SITE 7012

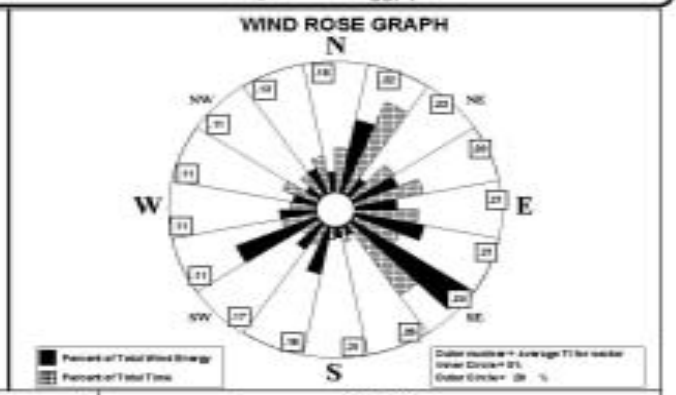
Site Information

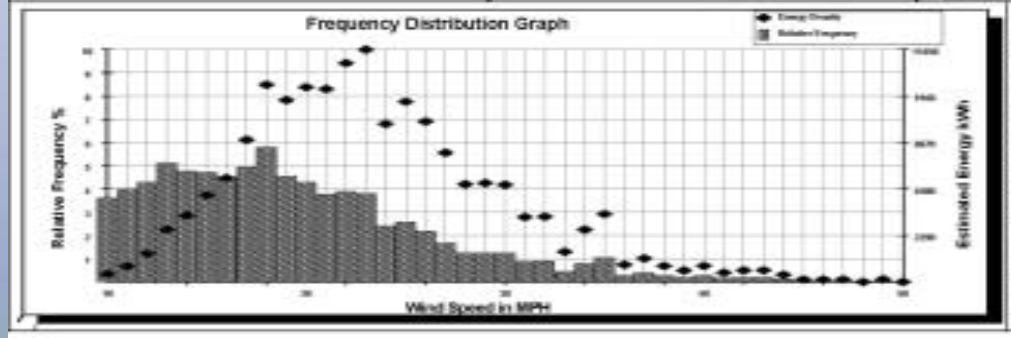
Project:	Alaska Air Force
Location:	Cape Romanzof LRR
Site Elevation:	1432FT
Averaging Time:	10 min

Sensor 1 Information		*Sensor 2 Information*	
Channel:	1	Channel:	2
Type:	Anemometer	Type:	Direction Vane
Scale:	1.223000000	Scale:	1.000000000
Offset:	1.8000	Offset:	0.0000
Description:	Anemometer	Description:	Direction Vane
Height:	66FT	Height:	66FT









Statistics

Estimated Energy Output	159662 KWH
Calculated Air Density	1.170 kg/m3
(temperature data and pressure based on elevation)	
Average Wind Speed	16.8 MPH
Average Turbulence Intensity	0.19
Mean Energy Wind Direction	SE
Mean Wind Direction	NNE
Capacity Factor	0.39
Average Temperature	0.0 F
Turbine Manufacturer	Norwin
Turbine Model	Stall 150, 25.4m
Turbine Rating	150.0 kW
Number of Turbines	1
Estimated Annual Production	515958 KWH/Year

Total hours = 2640 Total hours used in Calculations = 2558 Percent Data used = 96.8

Printed February 5, 2004

NRG Systems MicroSite Version 3.01

Andersen AFB, Guam

Guam - Andersen Wind Summary

Wind Analysis Summary Report

Site Information

Project:	Andersen AFB Site 1
Location:	Andersen AFB Site 1
Site Elevation:	540 ft
Averaging Time:	10 min.
Date Range:	2/12/04 15:00-7/1/04 13:50

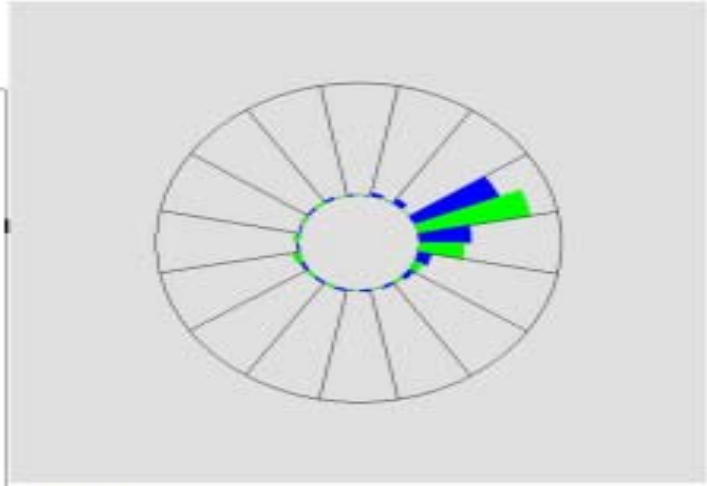
Sensor Information

Channel:	1
Type:	NRG #40 Maximum Anemometer
Height:	165 ft
Channel:	4
Type:	NRG #200P Wind Direction Vane
Height:	165 ft
Offset:	0 degrees

Site Number

1849

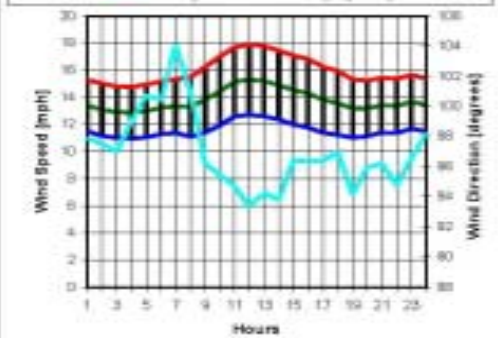
Wind Rose Graph



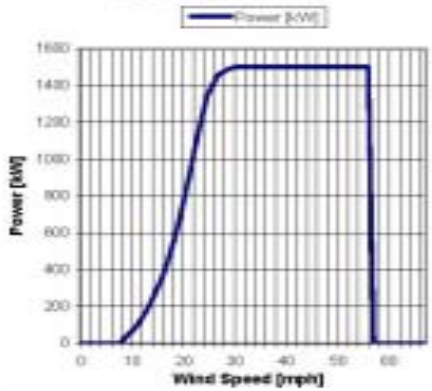
Percent of Total Wind Energy
Percent of Total Time

Inner Circle = 0%
Outer Circle = 70%

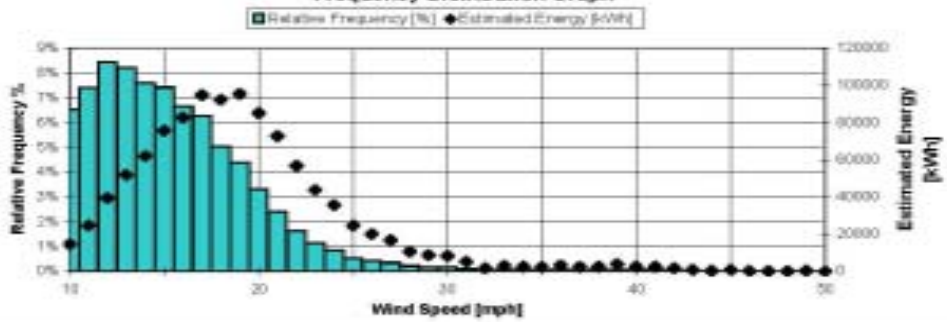
Diurnal Wind Speed Pattern



GE 1.5 S, 70.5m rotor



Frequency Distribution Graph



Statistics

Days Used in Calculation:	139.96
Hours Used in Calculation:	3359.00
Gust Speed:	49.1 mph
Gust Time:	6/28/2004 10:00
Estimated Energy Output:	1057701 kWh
Calculated Air Density:	1.199 kg/m^3
Average Wind Speed:	13.77 mph
Average Wind Direction:	97 degrees
Capacity Factor:	0.21
Turbine Manufacturer:	GE Wind Energy
Turbine Model:	GE 1.5 S, 70.5m rotor
Turbine Rating:	1500 kW
Estimated Annual Production:	2758366 kWh/Year

Capacity Factor, 65m:	0.24
Estimated Energy Output, 65m:	1231832 kWh
Estimated Annual Production, 65m:	3212519 kWh/Year

Annual Average Wind Speed Projections

Based on correlation with long-term data

- ***Tin City LRR: 18-19 mph @ 8-10 meters***
- ***Cape Romanzof LRR: 15-16 mph @ 20 meters***
- ***Andersen AFB, Guam: 13.5-14 mph @ 50 meters***

Next, long term cost analysis and concept designs

Before

Wind Diesel
A great Team

After

Questions?

Gary Seifert

208-521-8385

sei@inel.gov