Modeling & Feasibility Studies

James Jensen
Alaska Energy Authority

WEATS
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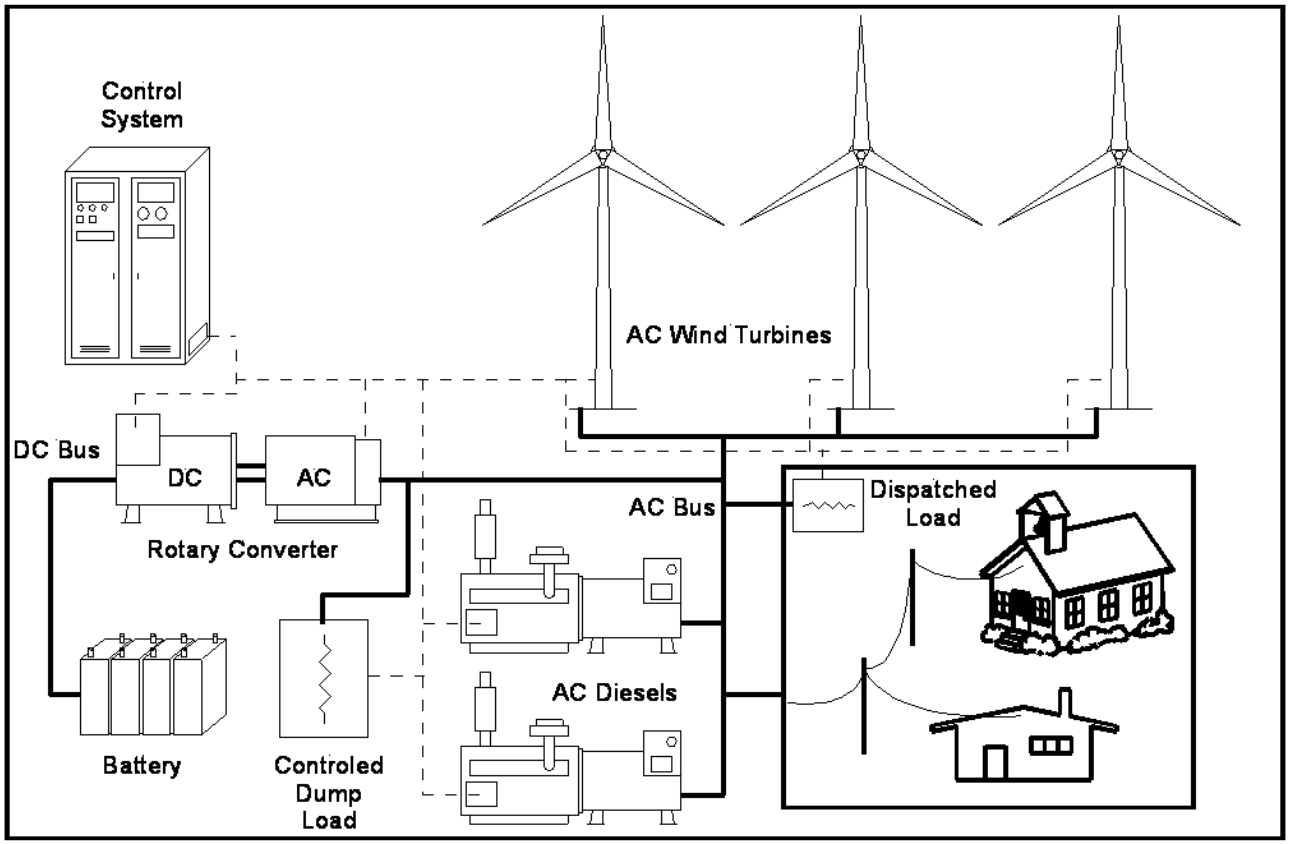
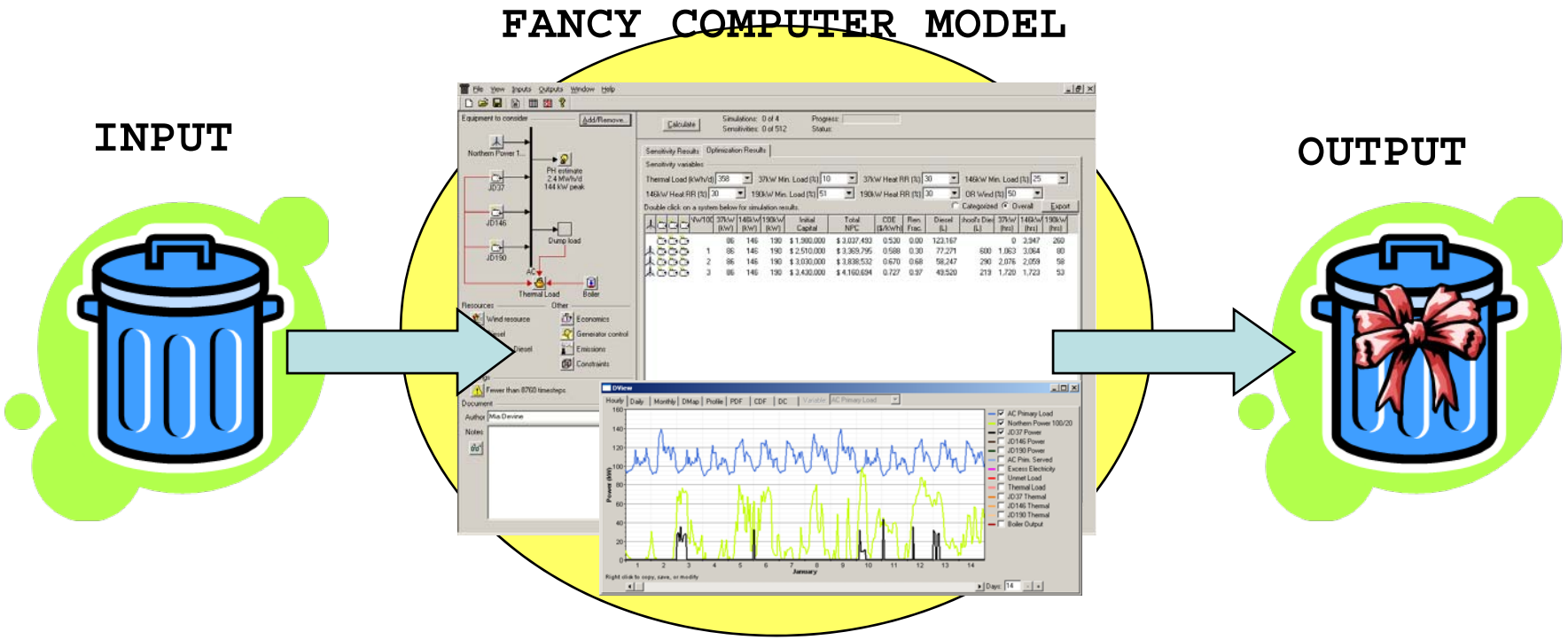
Modeling of Hybrid Power Systems



- **Electric load**
- **Thermal load**
- **Renewable resource**
- **Diesel generators**
- **Energy storage**
- **Economics**

Modeling Tools



Garbage In = Garbage Out

Modeling Inputs

- Wind Resource
- Electric Load
- Thermal Load
- Potential Load Growth
- Economics

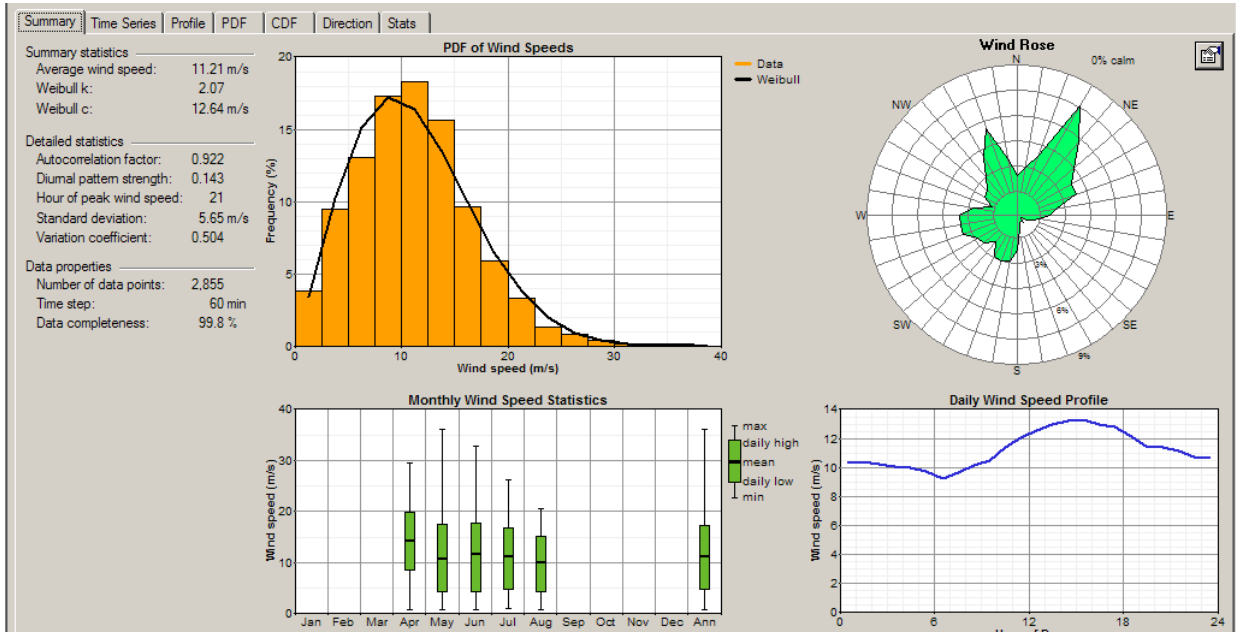
Wind Resource

Power = ½ x air density x swept area

x WIND SPEED

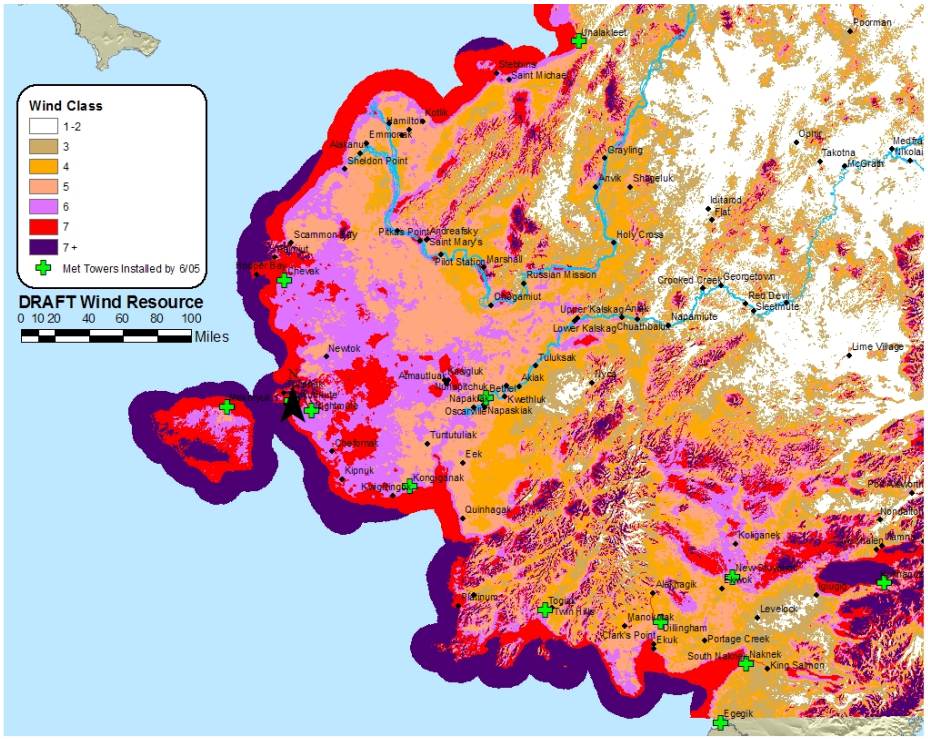
x WIND SPEED

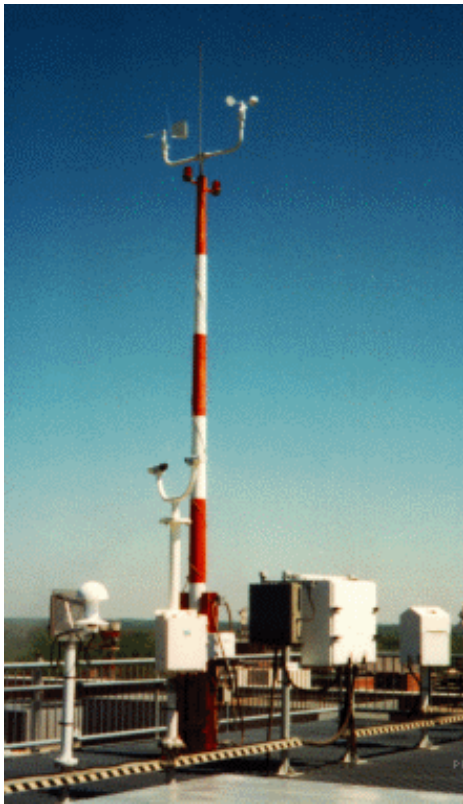
x WIND SPEED



Wind Resource

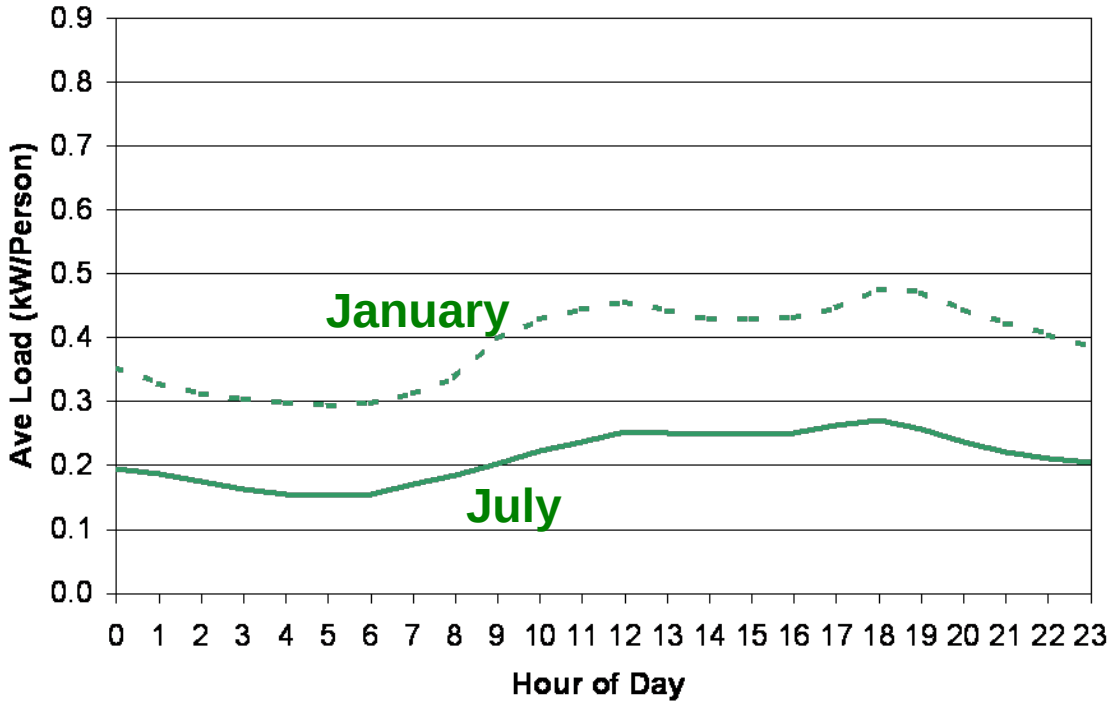
- AEA's Anemometer Loan Program
- Wind Resource Map
- Airport Weather Stations





Village Electric Load

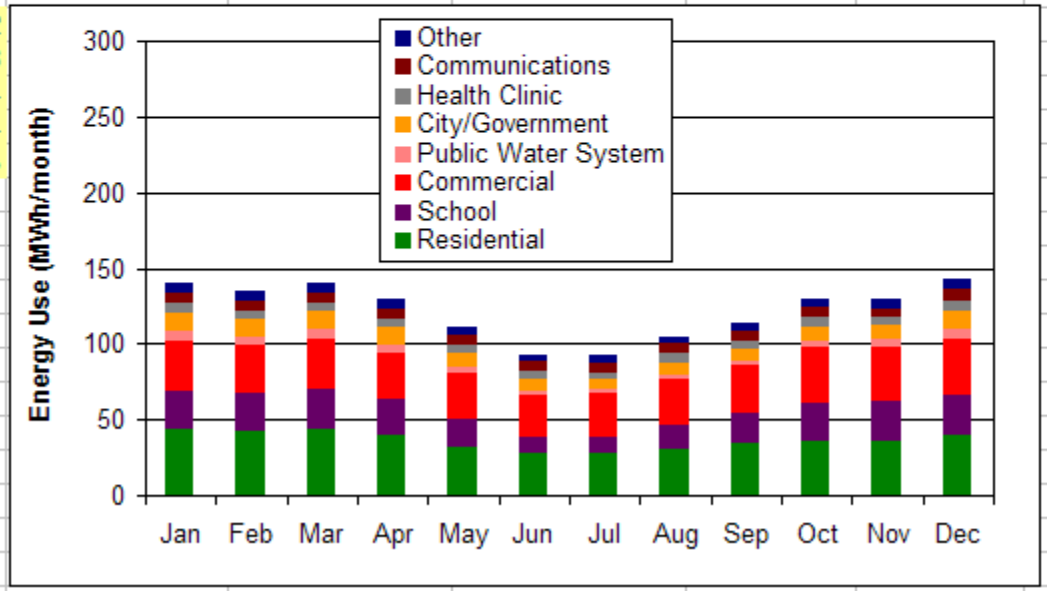
- Take direct measurements
- Estimate based on historical data in other villages



AK Village Electric Load Calculator

Village Name:	Village Name					
Population:	500			Description of Categories:		
	Category (1-5)	1	2	3	4	5
Median Household Income:	1	less than $26,000	about $30,000	more than $35,000	-	-
K-12 School:	2	Low	Average	High	-	-
Public Water System:	3	Level 2 Low	Level 2 High	Level 1 Low	Level 1 Med	Level 1 High
Health Clinic:	2	Local Clinic	Sub-regional Clinic	-	-	-
Communications:	2	Basic	Advanced	-	-	-

# of Small Businesses	2
# of Large Commercial:	3
# of Community Buildings:	4
# of Government Offices:	4
Other (usually 1-5%):	5%



Village Thermal Load

- Space Heat

- Hot Water

Village Thermal Load

- Estimate based on energy audit information and average temperatures

- Take direct measurements

Economics

- Capital cost of wind turbines and related equipment
- Installation cost
- Annual O&M costs
- Inflation Rate
- Cost of diesel fuel

Factors that Can’t be Modeled

- Land Use
- FAA
- Avian Issues
- Geotechnical Issues
- Noise and Visual Impact
- Community Acceptance

Feasibility Study Example

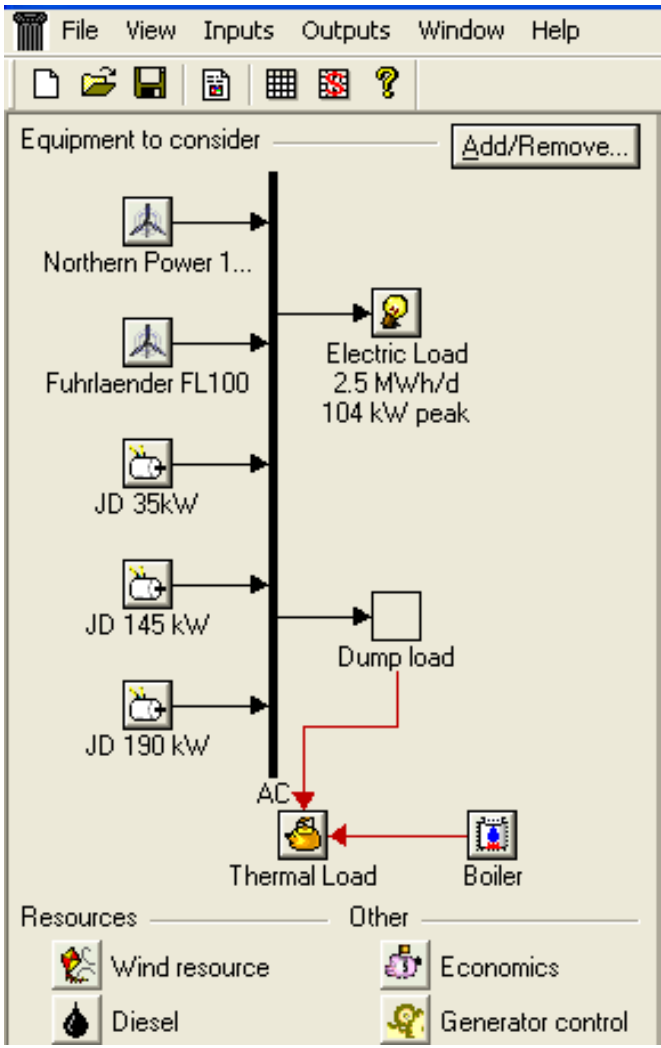
- Port Heiden, AK

The Computer Model

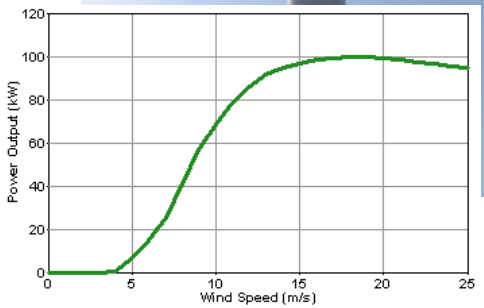
HOMER

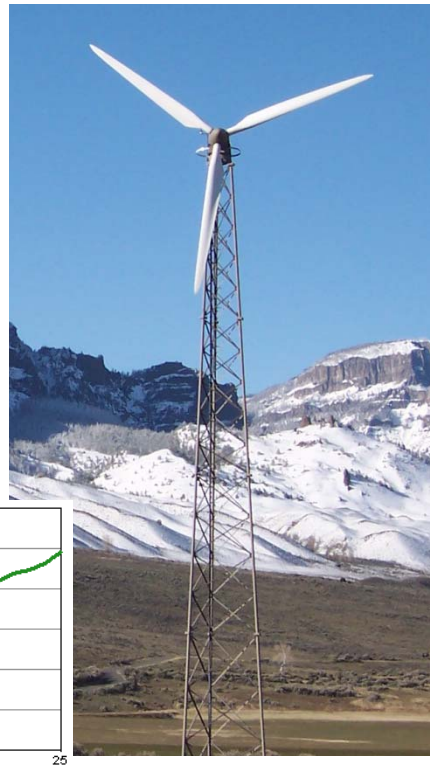
THE OPTIMIZATION MODEL FOR DISTRIBUTED POWER

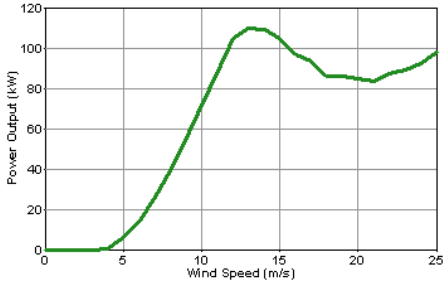
- HOMER is available FREE at www.nrel.gov/homer
- Developed by the National Renewable Energy Laboratory
- Other Models (Hybrid2 and RETScreen)

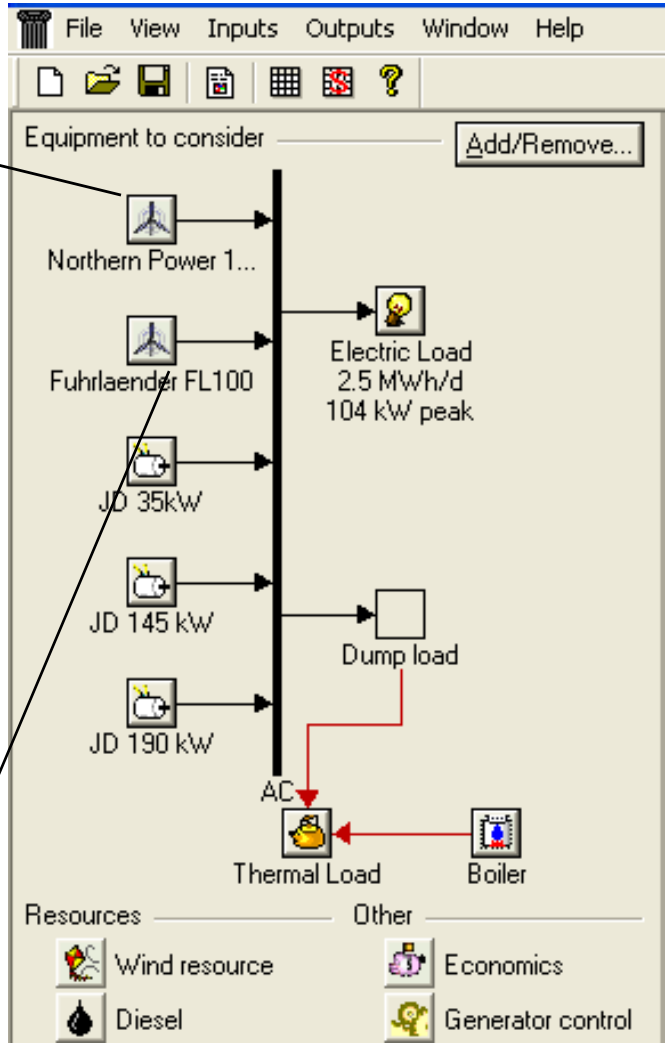


Wind Turbines in Port Heiden

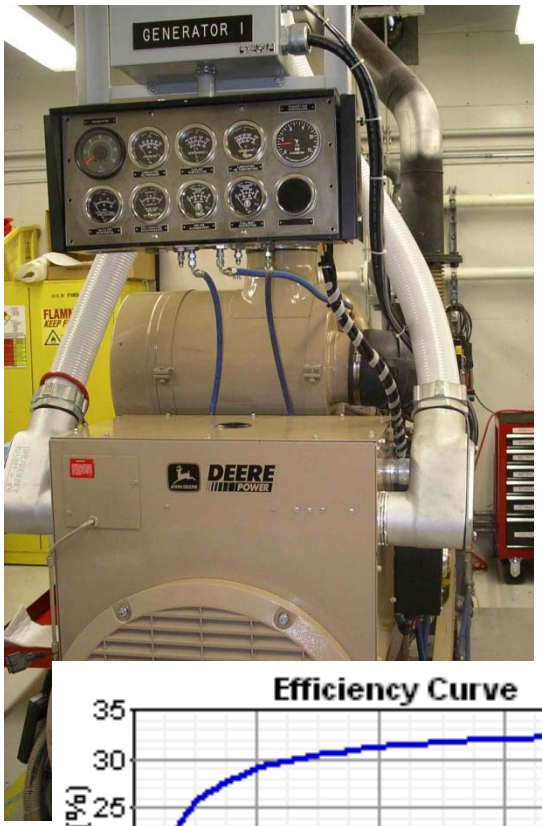


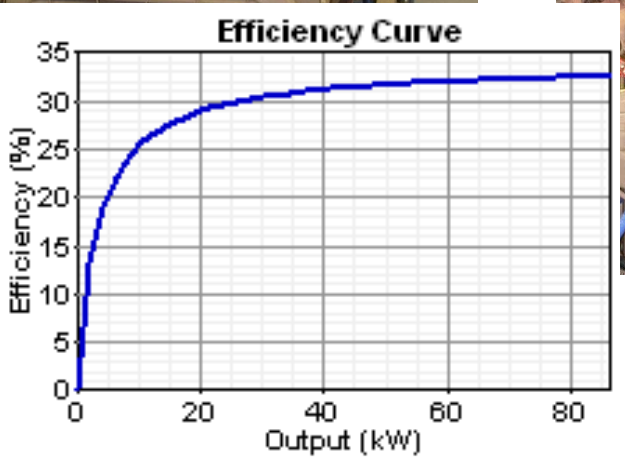


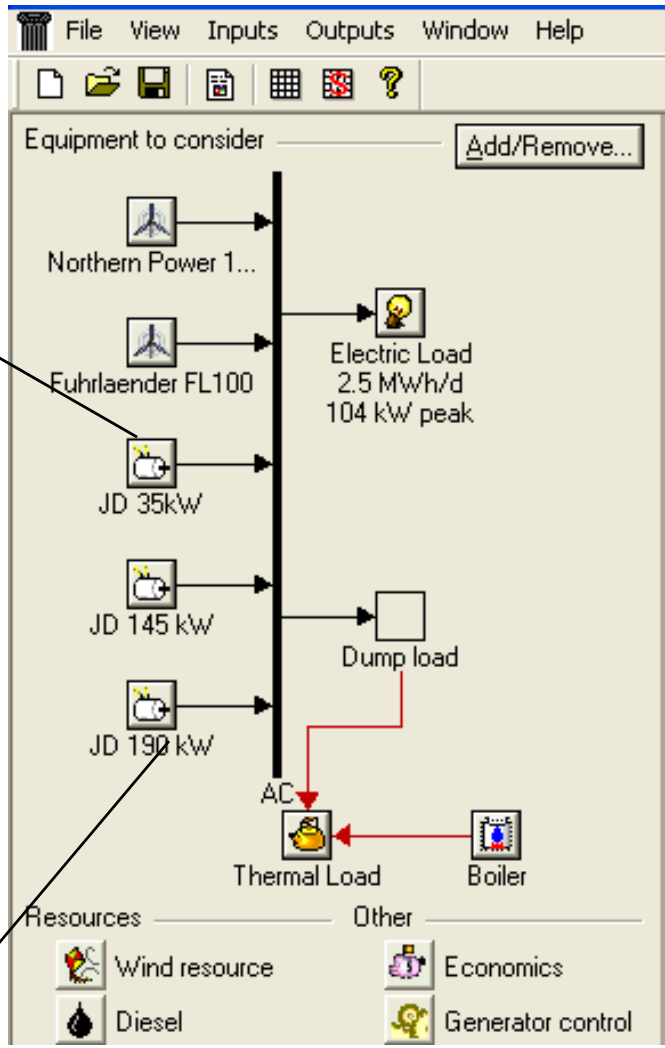




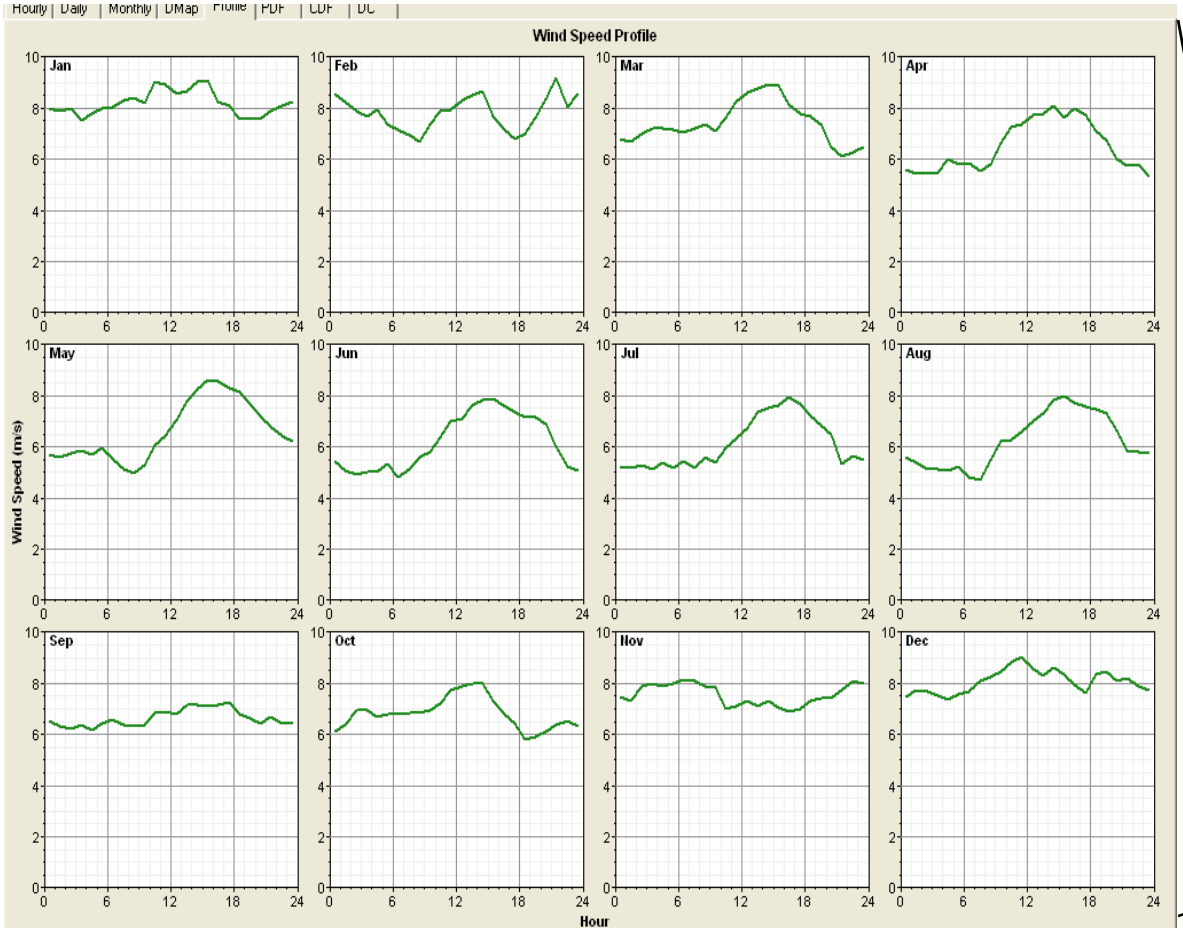
Diesel Generators in Port Heiden

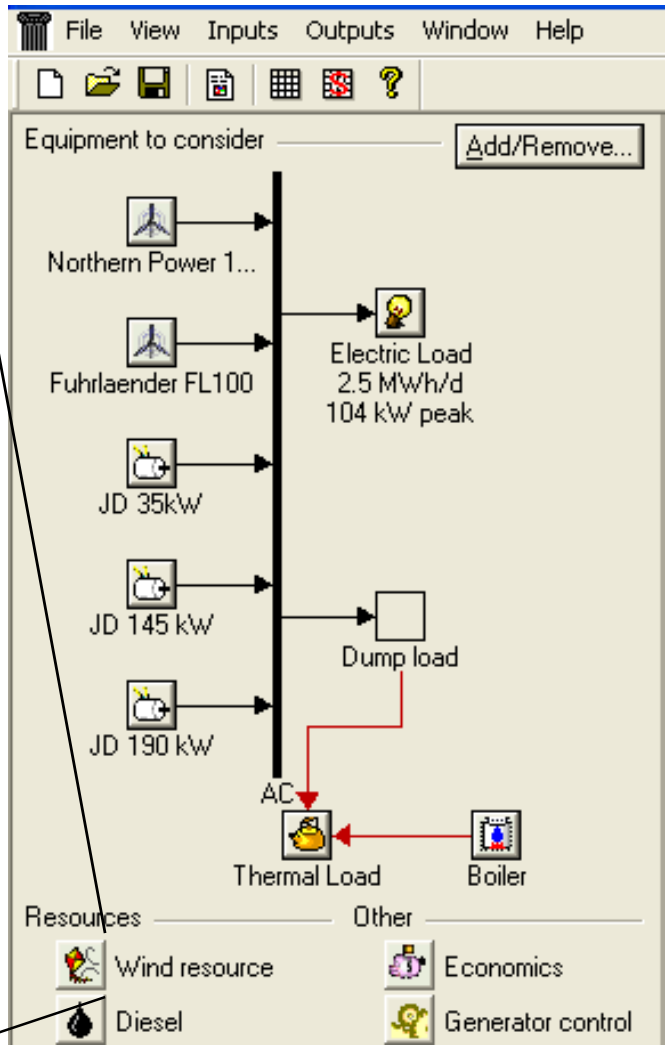




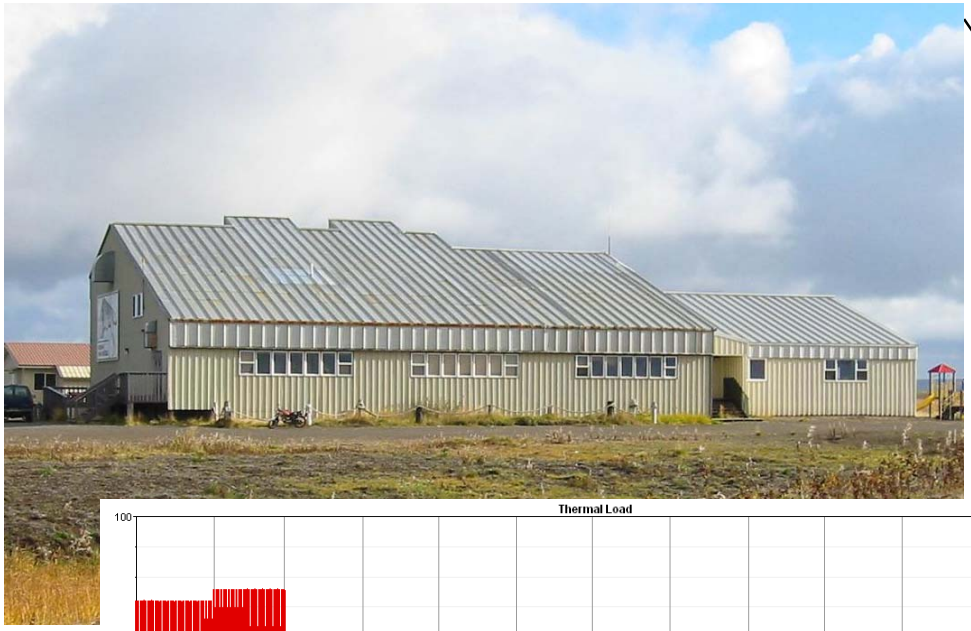


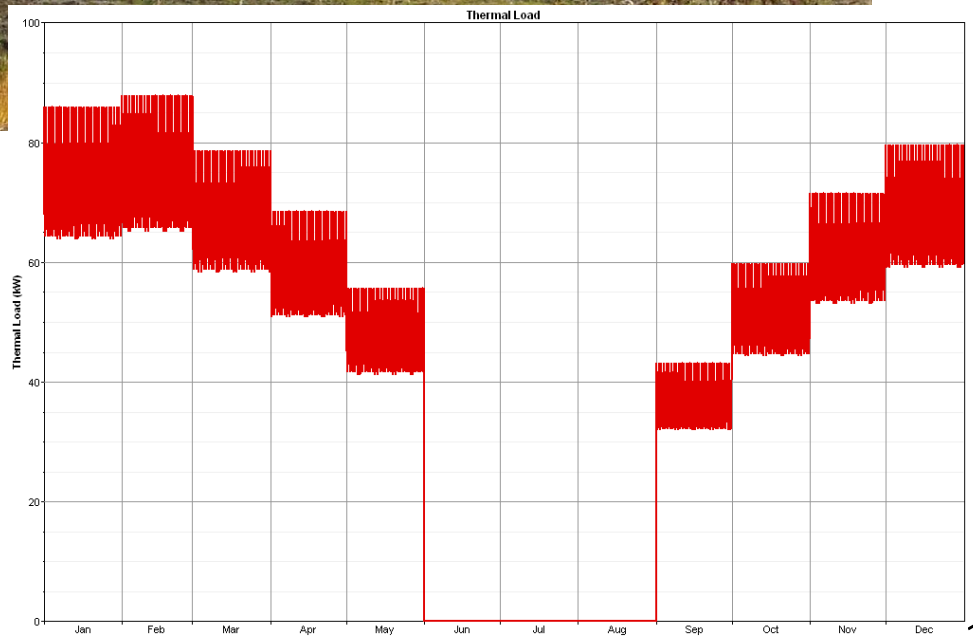
Wind Resource in Port Heiden

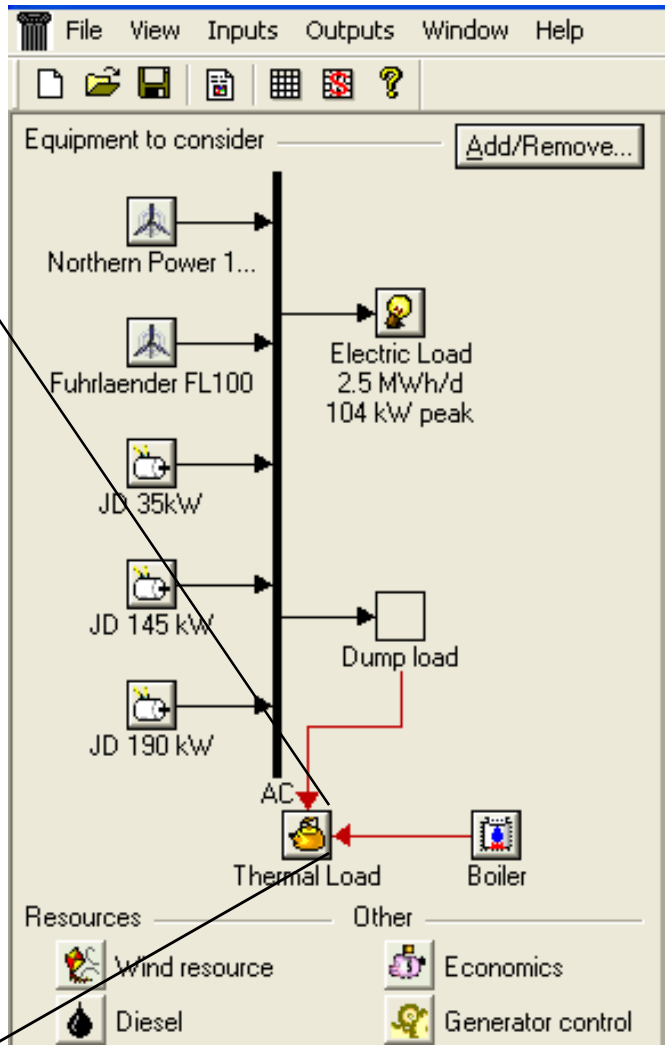




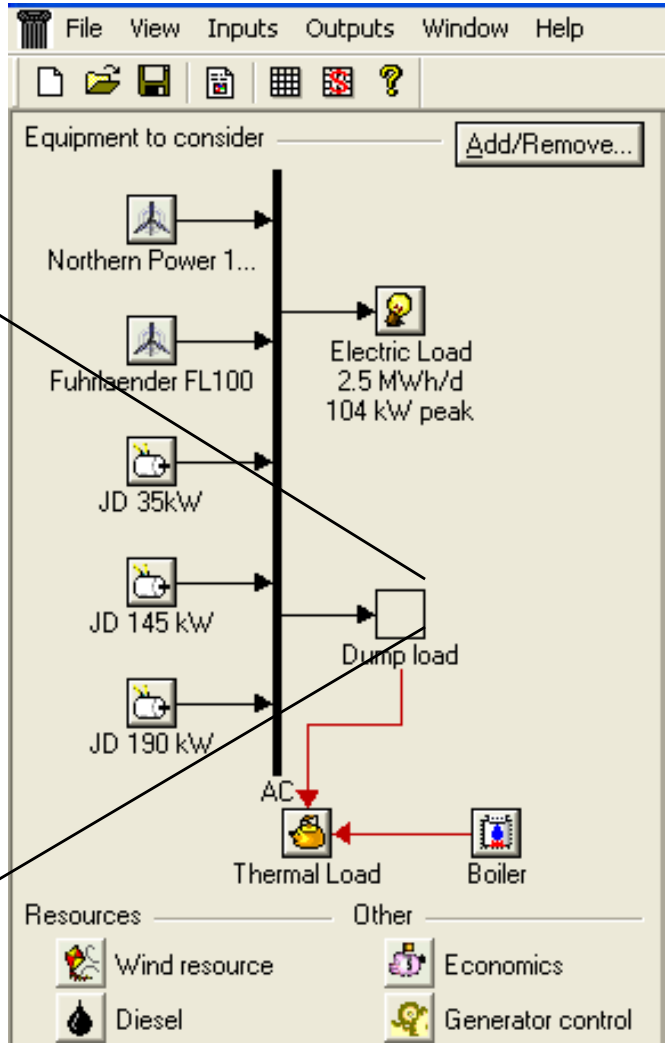
Thermal Load in Port Heiden



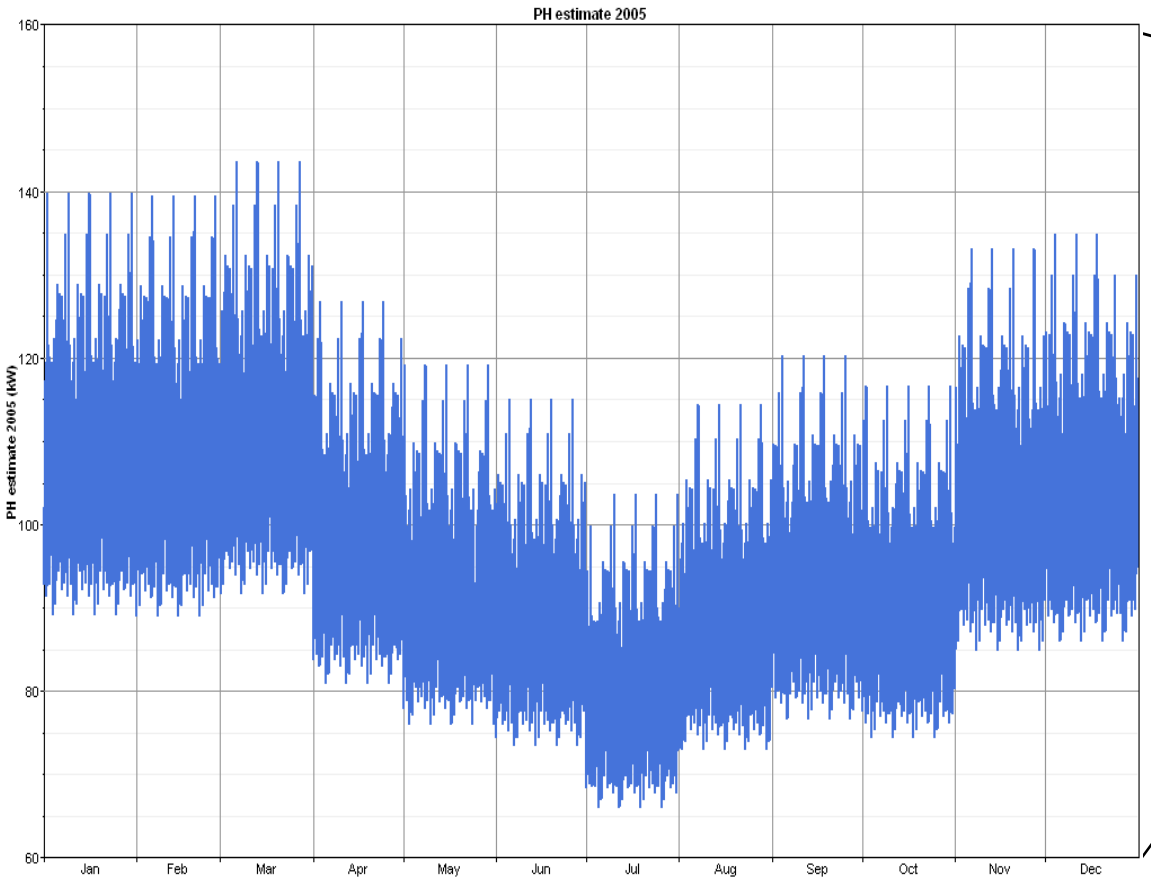


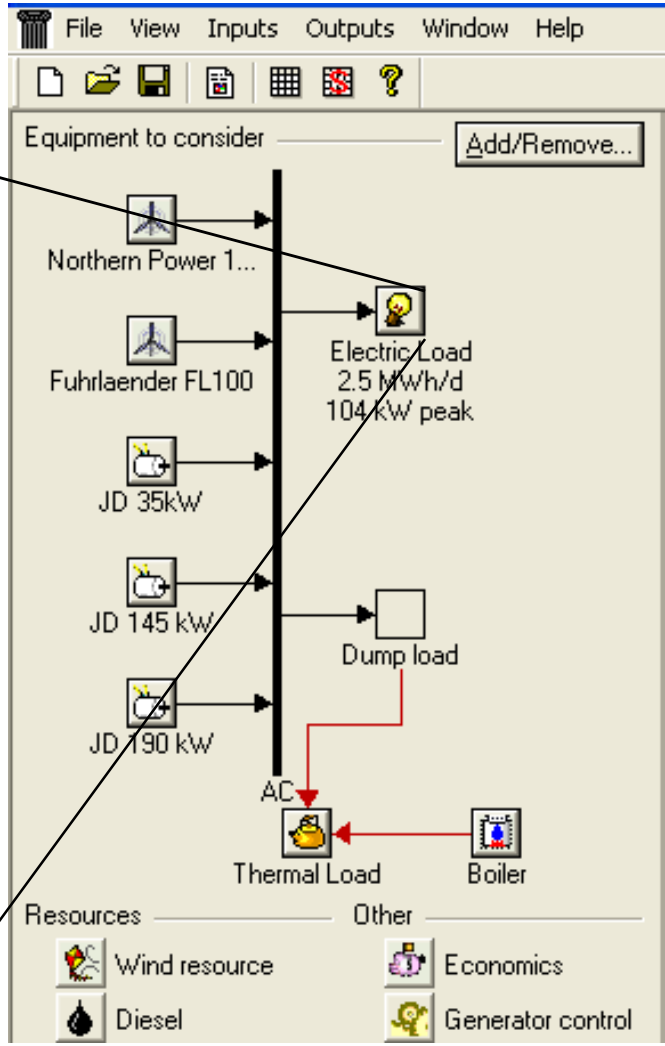


Dump Load in Port Heiden

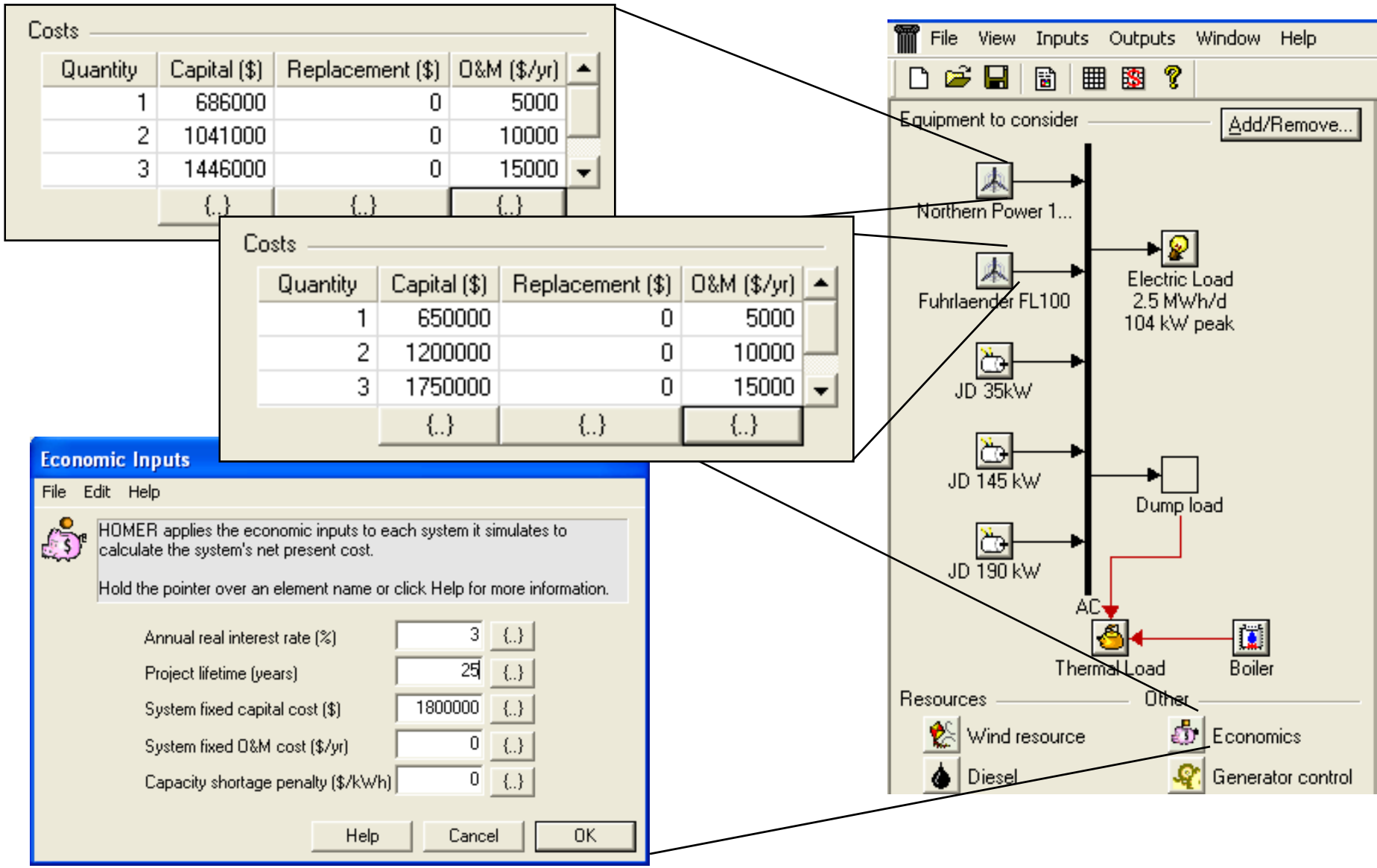


Electric Load in Port Heiden





Economics of Port Heiden System



Generator Control

Operating reserve

As percent of load

Hourly load (%) 20 {..}

Annual peak load (%) 0 {..}

As percent of renewable output

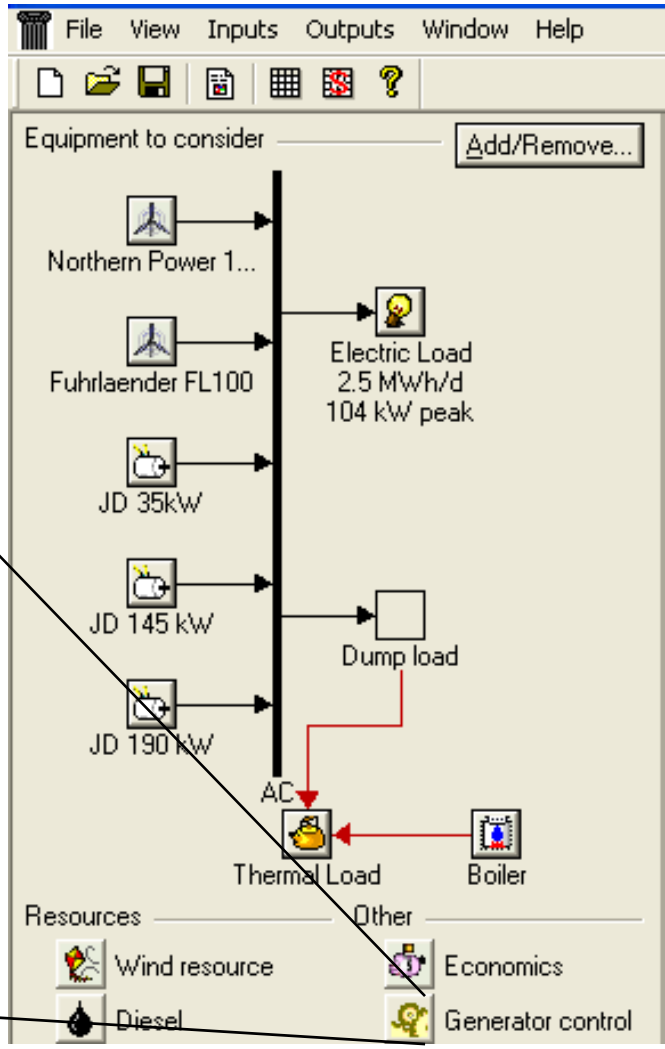
Solar power output (%) 0 {..}

Wind power output (%) 15 {..}

Note:

HOMER calculates the total required operating reserve for each hour by multiplying each of these four inputs by the load or output value for that hour and adding the results.

Help Cancel OK



Uses for HOMER

- **Optimization**
  - least cost solution
- **Simulation**
  - simulate time step by time step operation for the entire year
- **Sensitivity Analysis**
  - what if….?

Optimization for Port Heiden

Sensitivity Results | Optimization Results

Sensitivity variables

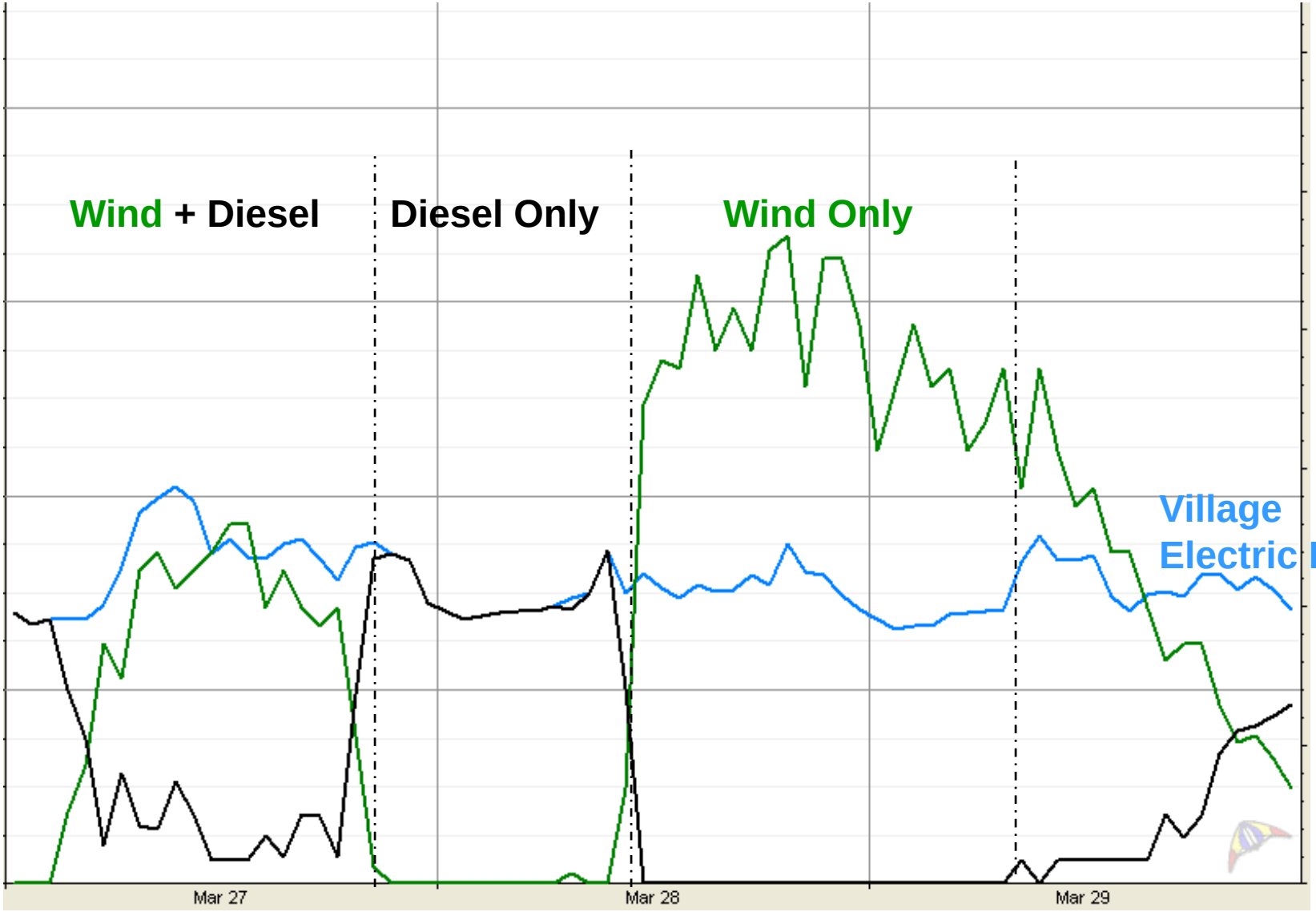
Wind Speed (m/s) 7.7 | Arctic Diesel Price ($/L) 0.79 | NW100 Capital Multiplier 1 | FL100 Capital I

Double click on a system below for simulation results.

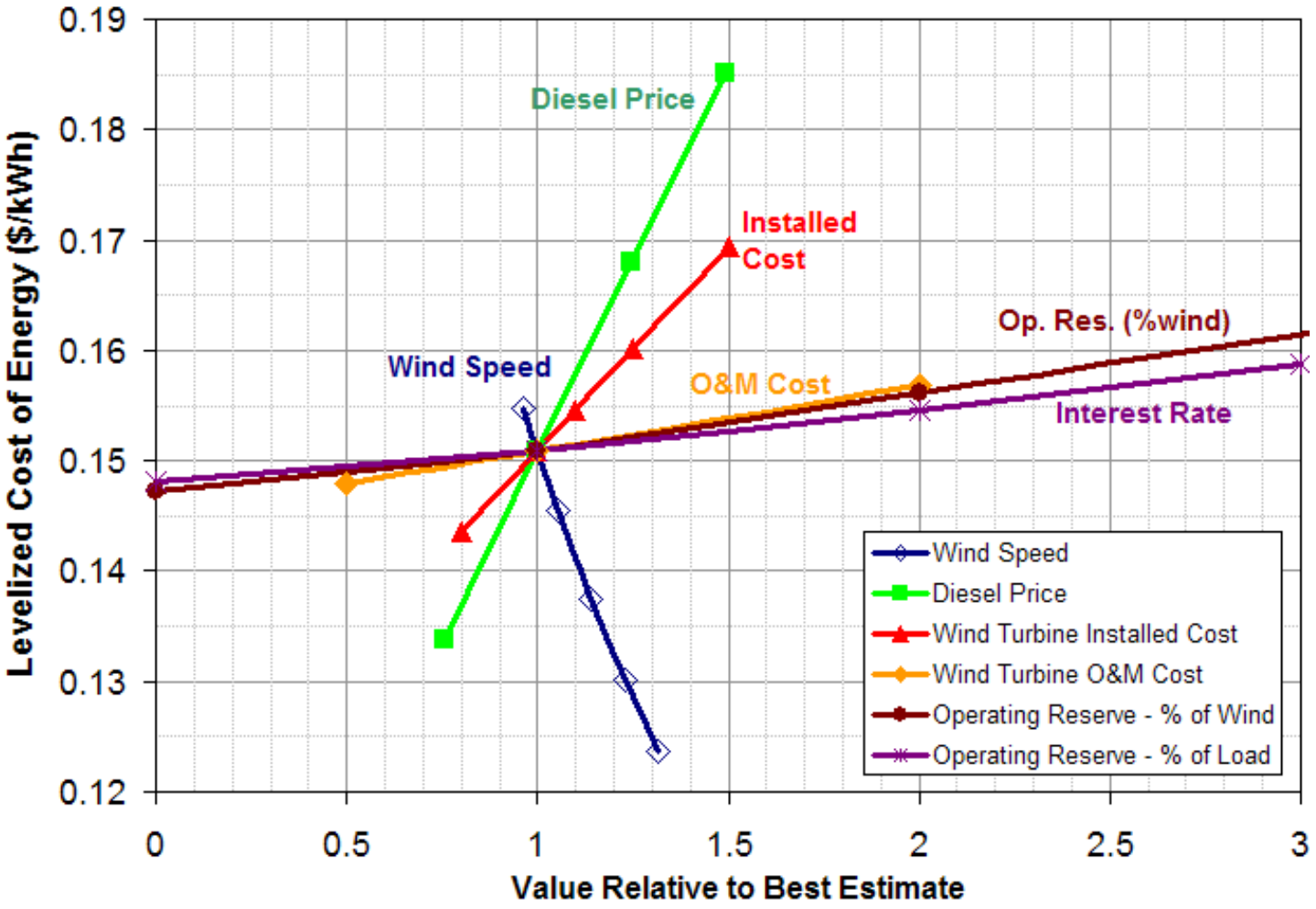
NW100	FL100	86kW (kW)	150kW (kW)	192kW (kW)	Initial Capital	Total NPC	COE ($/kWh)	Ren. Frac.	School's Diesel (L)	Arctic Diese (L)
	2	86	150	192	$ 2,850,000	$ 4,765,854	0.378	0.76	17,268	106,803
	1	86	150	192	$ 2,300,000	$ 4,824,032	0.383	0.34	26,710	143,141
2		86	150	192	$ 2,691,000	$ 4,931,266	0.392	0.55	20,508	125,597
3		86	150	192	$ 3,096,000	$ 5,093,768	0.404	0.82	16,698	108,022
1		86	150	192	$ 2,336,000	$ 5,119,719	0.407	0.23	26,948	163,866
	3	86	150	192	$ 3,400,000	$ 5,128,356	0.407	1.06	14,246	91,807
		86	150	192	$ 1,650,000	$ 5,236,627	0.416	0.00	17,974	236,720

Ranked by lowest Total Net Present Cost

Simulation for Port Heiden



Sensitivity Analysis



HOMER is Versatile

- **Quick analysis based on rough estimates**

  - Annual averages for resources and loads

  - Cost per kW or unit for equipment

- **Detailed analysis for project feasibility**

  -measured data at hourly or shorter time steps

  - accurate price quotes and cost curves

- **But never for design**

HOMER Limitations

- Load Growth
- Diesel Price Fluctuations
- Turbine Availability
- Solution: Additional spreadsheet analysis