Software and Assessment Tools

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Northeast CHP Application Center

University of Massachusetts - Amherst

How to Conduct a Site-Specific Feasibility Study

New York, NY

June 9, 2008

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Northeast Regional CHP Application Center

Mission

Accelerate the market penetration of energy efficient and environmentally superior CHP in order to improve the environment, raise productivity in buildings and industry, lower regional energy costs, strengthen energy security, enhance consumer choice and reduce price risks for end-users.

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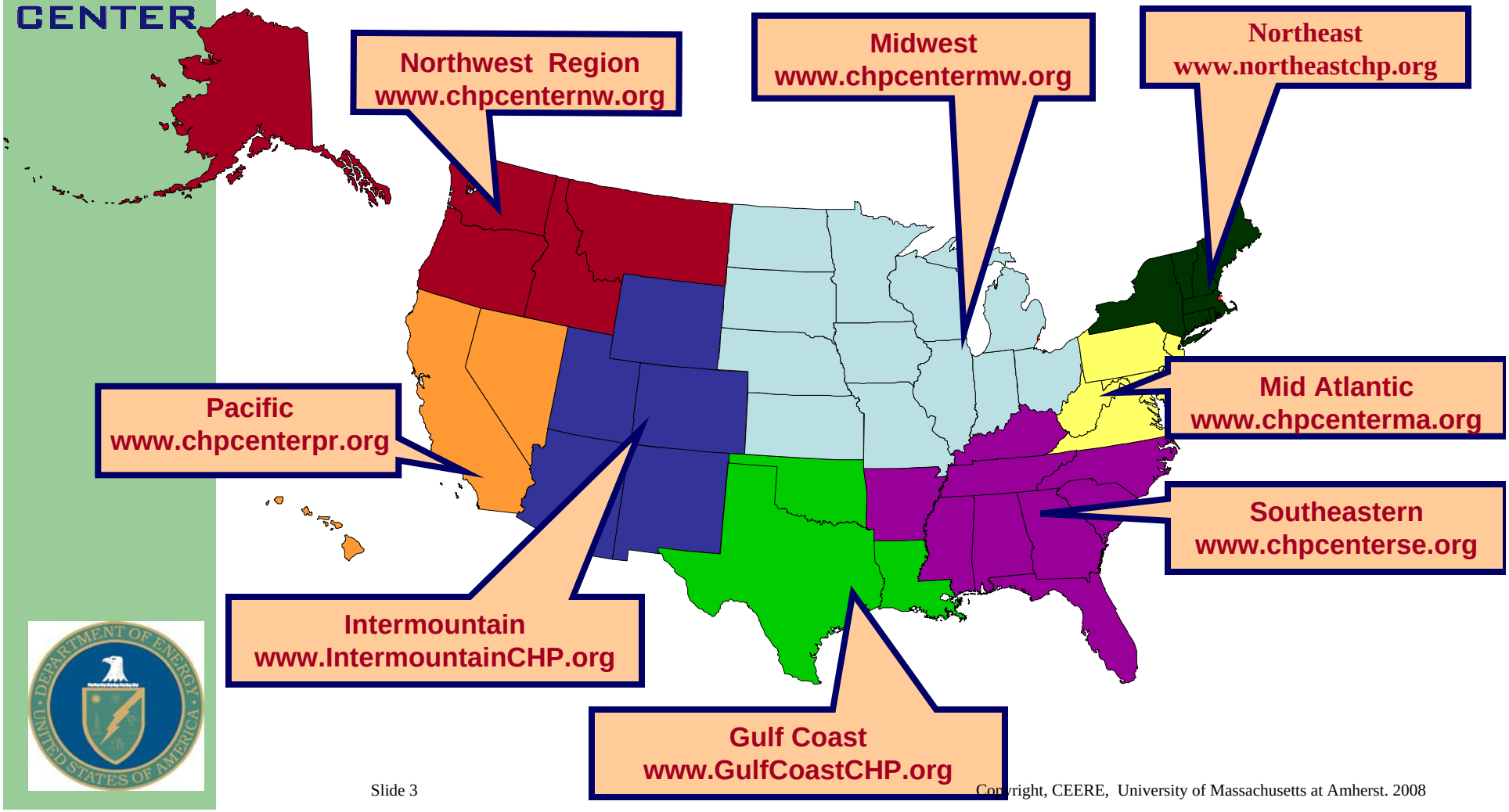
Regional Application Centers

The regional application centers promote combined heating and power (CHP) technology and practices, serve as a central repository and clearinghouse of CHP information, and identify and help implement regional CHP projects.



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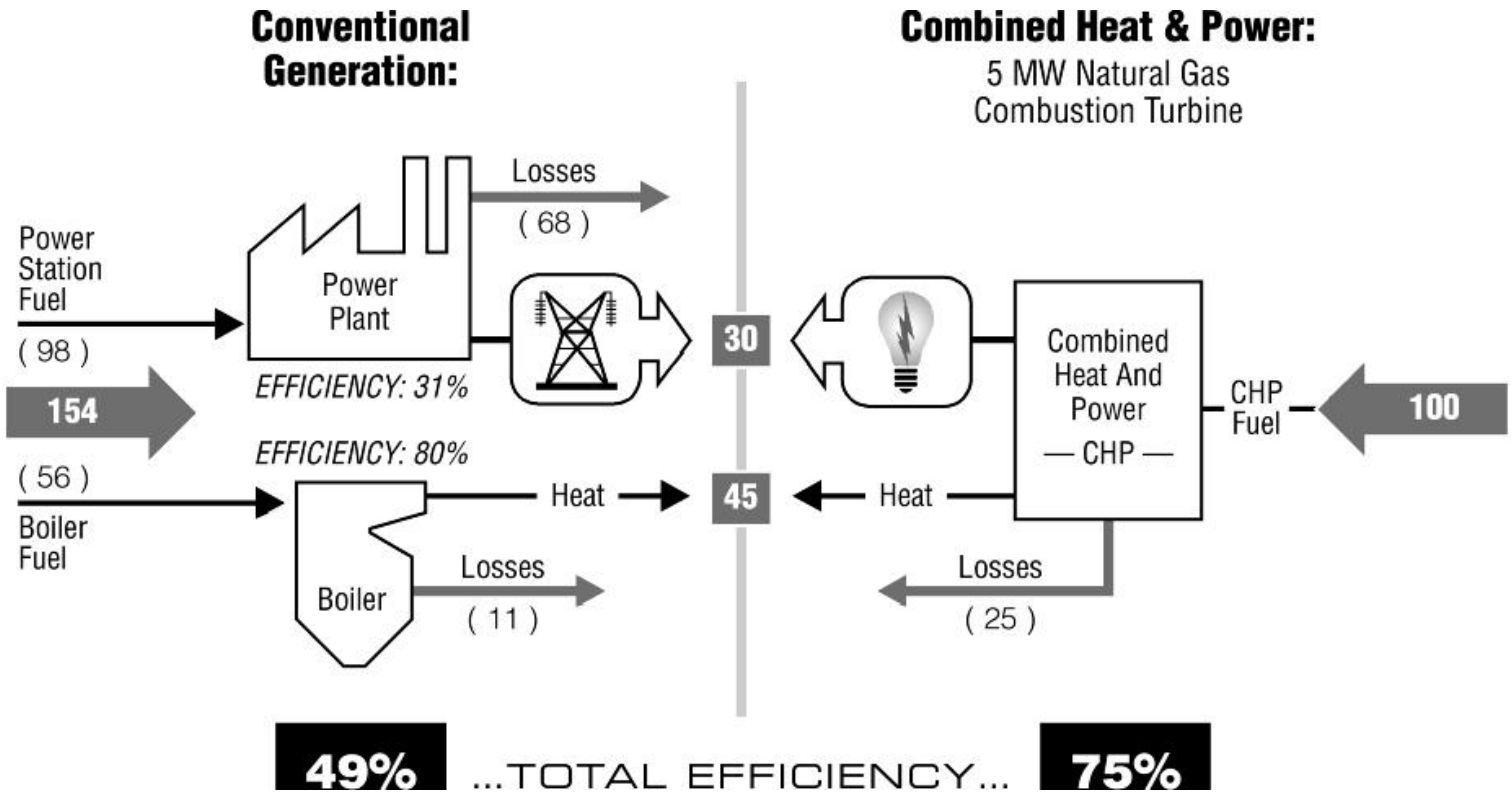
Efficiency Advantages of CHP



Source: Bruce Hedman, ICF Consulting - May 2007

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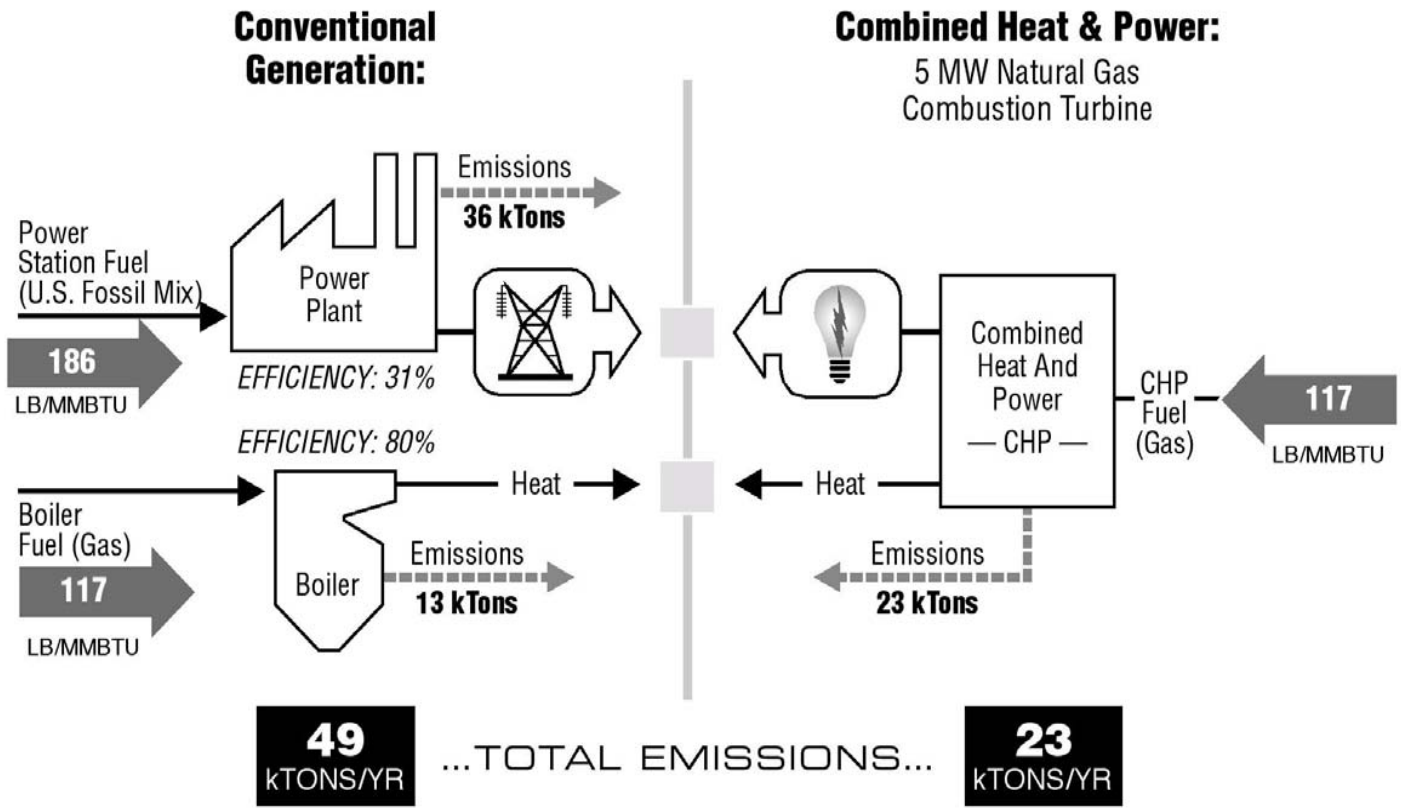
Environmental Benefits of CHP- CO_2



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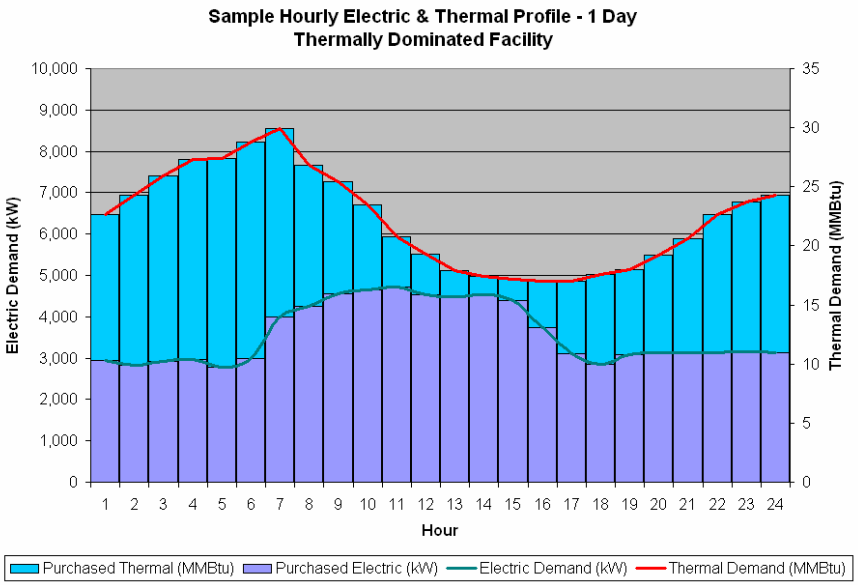
Important Design Considerations

- Cost of Buying Electric Power from the Grid Relative to the Cost of Natural Gas *a.k.a "Spark Spread"*
- Coincident Needs for Power & Thermal Energy
- Installed Cost Differential Between a Conventional and a CHP System



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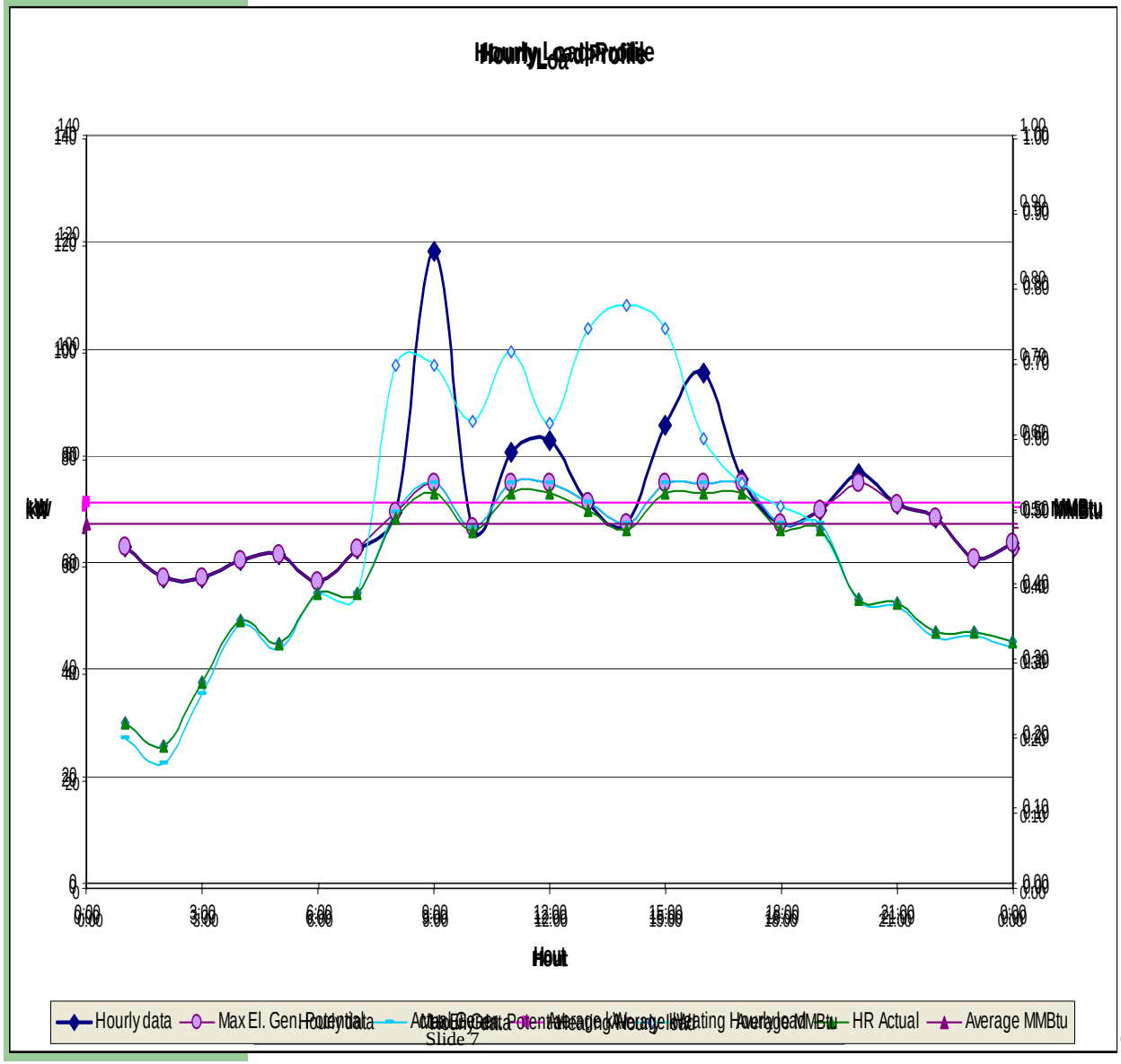
Load Considerations - Winter



Average Load: 71.18 kW
Average Thermal: 0.41 MMBtu

Actual numbers:
-24 hr operation (same)
-85% heat recovered
-84% electricity generated
-323 kWh not delivered

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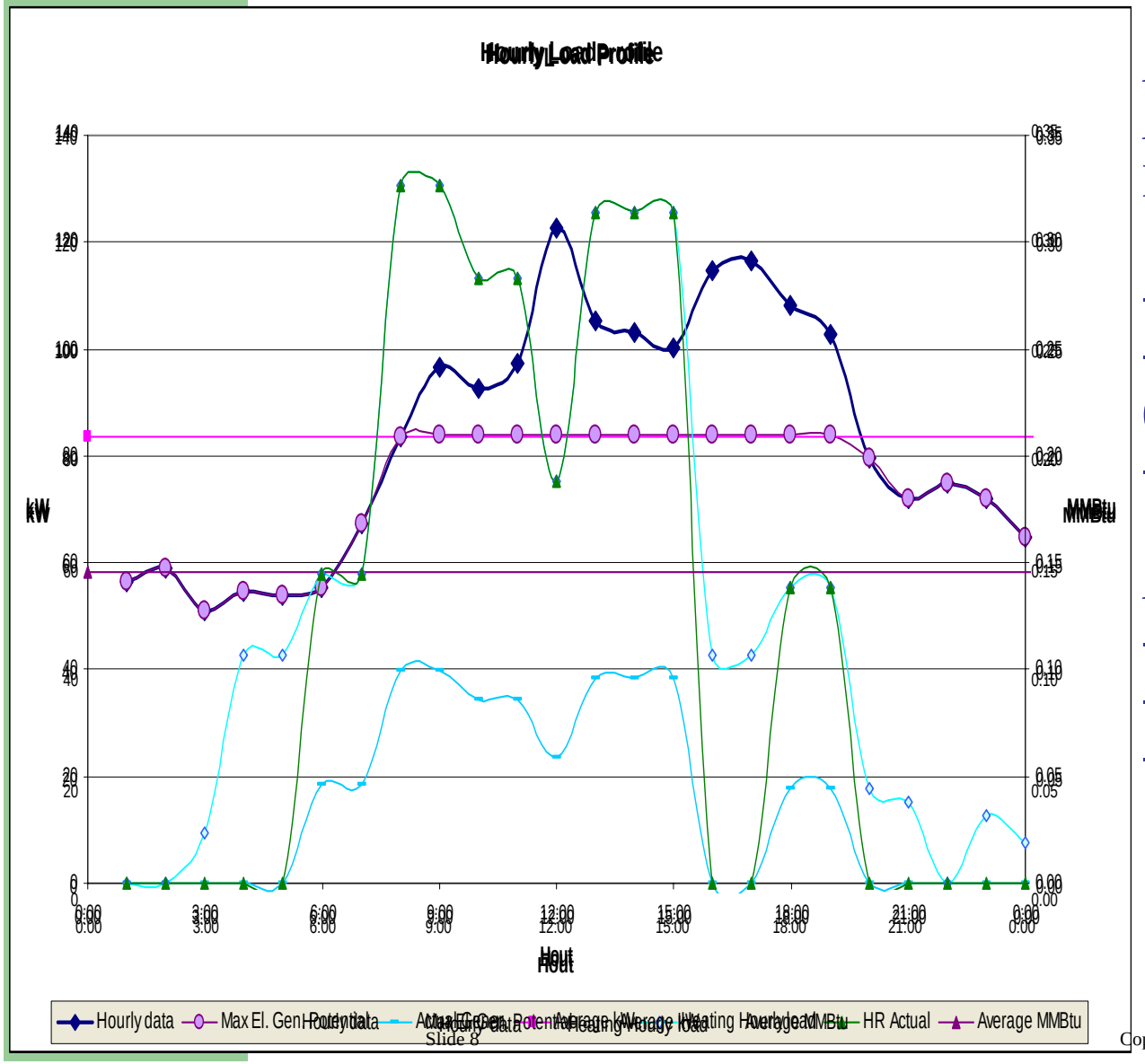
Load Considerations - Summer



Average Load: 83.49 kW
Average Thermal: 0.15 MMBtu

-No min. load considerations
-No max load considerations (for most situations)
-24 hr operation

Actual numbers:
-12 hr operation
-83% heat recovered
-81% electricity generated

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CHP Software

Screening Level Tools

- BCHP Tool
- ***RETScreen International***
- Cogen Pro
- Building Energy Analyzer
- ***D-Gen Pro***
- HUD - Feasibility Screening for CHP in Multifamily Housing
- EPA - CHP Emissions Calculator

Steam Turbine Tools

- SSAT

Detailed Design Tools

- ***Gate Cycle***
- Recipro
- ***Heatmap CHP***
- GT-Pro
- SOAPP-CT.25

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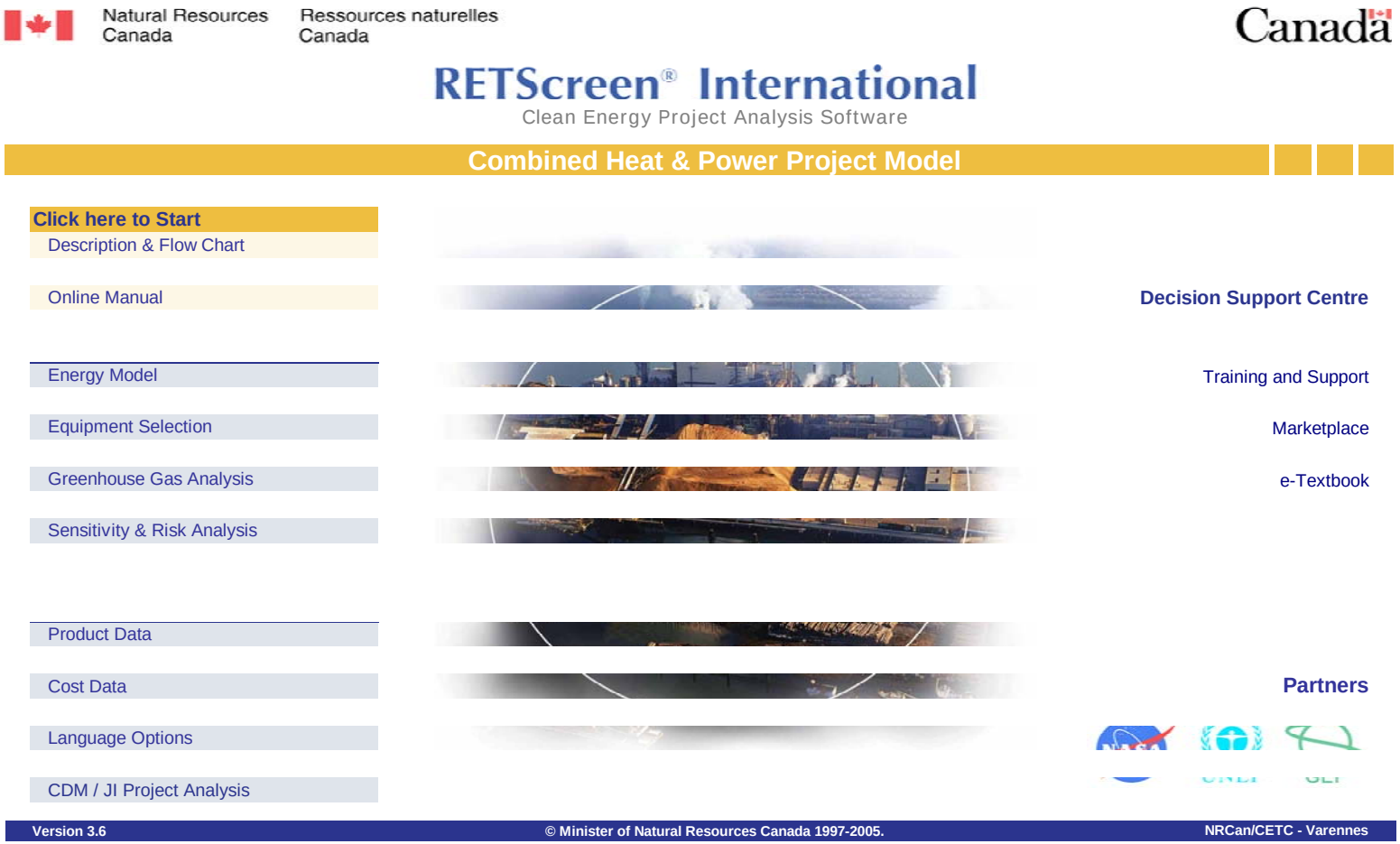
RETScreen CHP Tool



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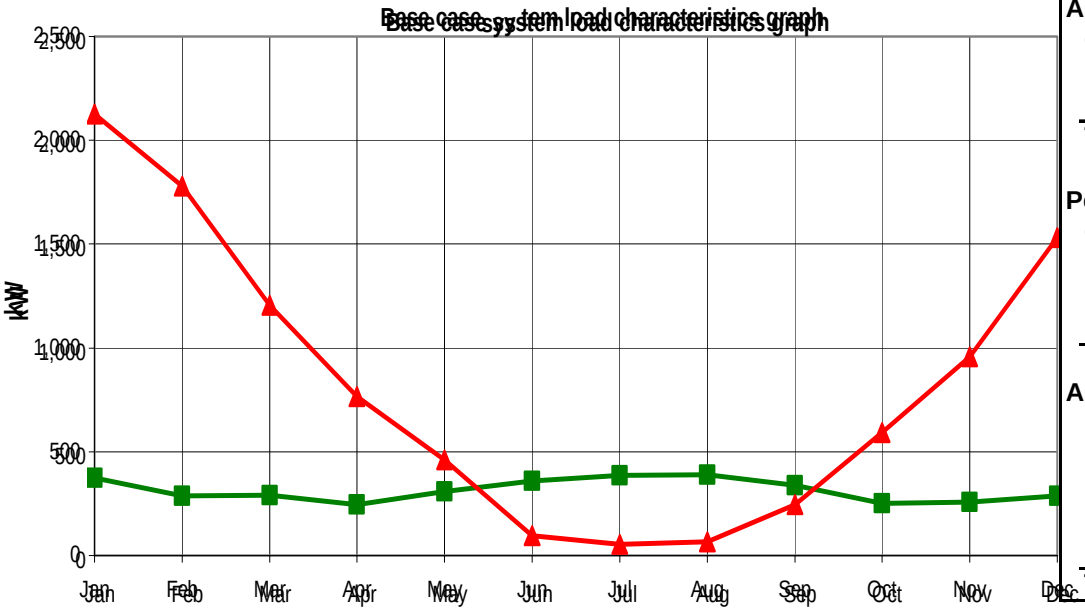
RETScreen CHP Tool



Project costs and savings/income summary			
Initial costs			
Feasibility study	3.1%	$	13,000
Development	3.4%	$	14,000
Engineering	3.6%	$	15,000
Power system	71.8%	$	299,000
Heating system	4.9%	$	20,200
Balance of system & misc.	13.3%	$	55,286
Total initial costs	100.0%	**$**	**416,486**
Annual costs and debt payments			
O&M		$	4,200
Fuel cost - proposed case		$	566,031
Debt payments - 10 yrs		$	41,509
Total annual costs		**$**	**611,740**
Periodic costs (credits)			
Overhaul - 5 yrs		$	6,000
Power			
Heating			
Annual savings and income			
Fuel cost - base case		$	695,697
Total annual savings and income		**$**	**695,697**

Financial viability		
Pre-tax IRR - equity	%	72.0%
Pre-tax IRR - assets	%	24.2%
After-tax IRR - equity	%	72.0%
After-tax IRR - assets	%	24.2%
Simple payback	yr	3.3
Equity payback	yr	1.4
Net Present Value (NPV)	$	966,358
Annual life cycle savings	$/yr	106,462
Benefit-Cost (B-C) ratio	-	8.73
Debt service coverage	-	3.08
GHG reduction cost	$/tCO2	(531)

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Software Details

D-Gen Pro

- **Developer: Gas Technology Institute**
- **Screening level analysis tool**
- **Load Model**
  - Hourly load profile & Monthly energy bills
- **System Model**
  - Recip engines, Gas turbines, Microturbines
  - No cooling
- **Economics: In-depth**
- **Emissions: CO_2, NO_X, SO_X**
- **Cost: $675**
- **More information:**

  http://www.interenergysoftware.com

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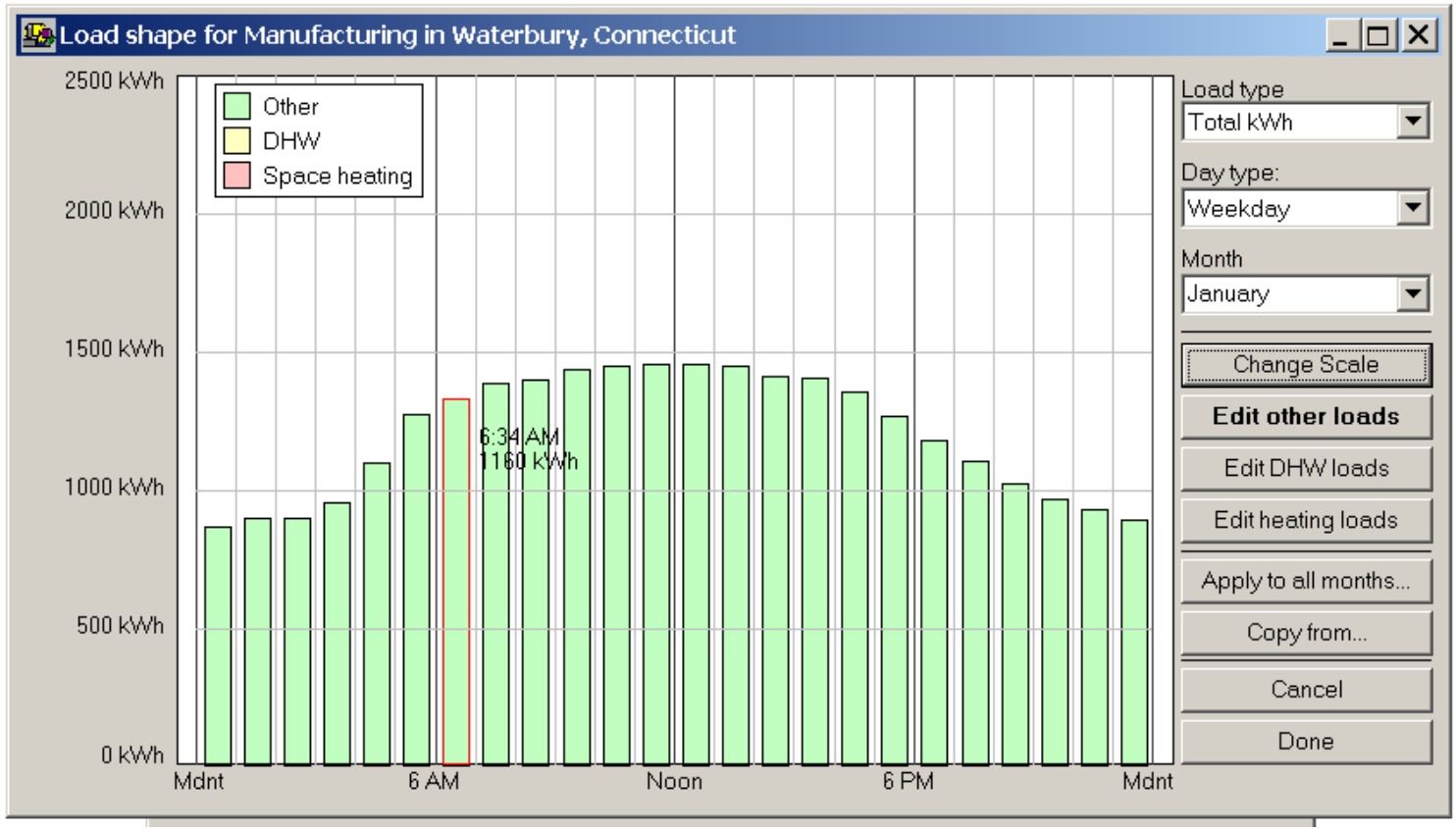
Hourly Profile with D-Gen Pro

Hourly Load Profile



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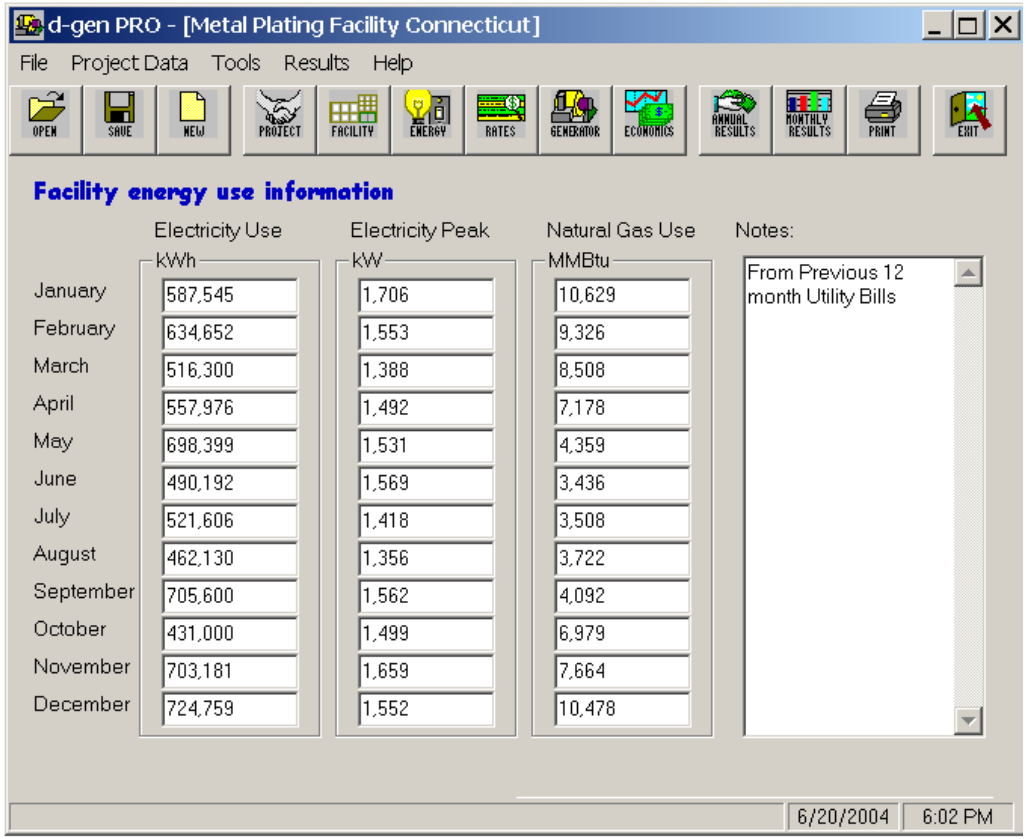
Energy Consumption With D-Gen Pro

Monthly Energy Consumption

Import Monthly or Hourly Data



	Electricity Use kWh	Electricity Peak kW	Natural Gas Use MMBtu
January	587,545	1,706	10,629
February	634,652	1,553	9,326
March	516,300	1,388	8,508
April	557,976	1,492	7,178
May	698,399	1,531	4,359
June	490,192	1,569	3,436
July	521,606	1,418	3,508
August	462,130	1,356	3,722
September	705,600	1,562	4,092
October	431,000	1,499	6,979
November	703,181	1,659	7,664
December	724,759	1,552	10,478

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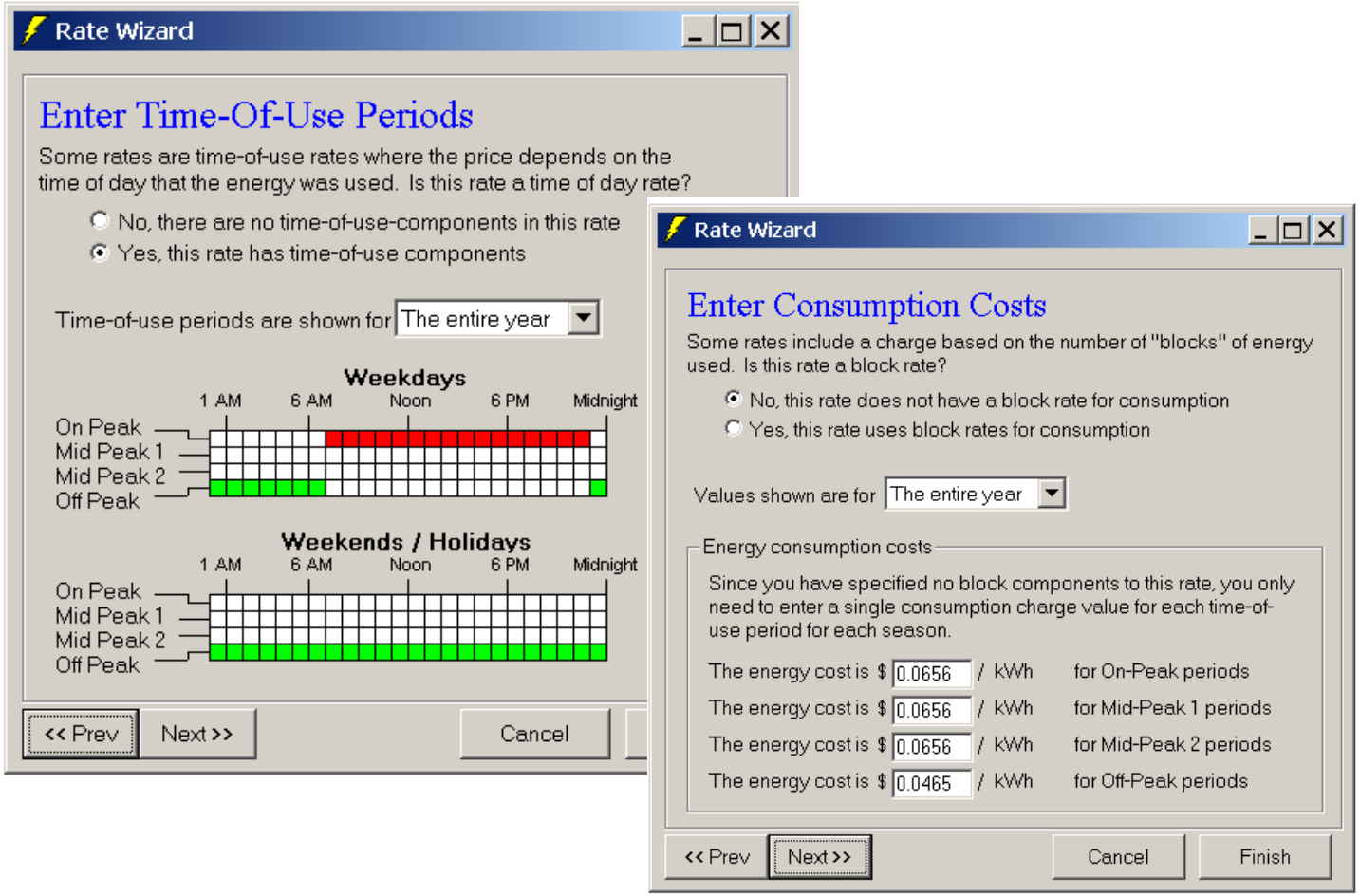
Utility Rate Structure With D-Gen Pro

Detailed Utility Rate Model



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D-Gen Pro Results

Economic Summary			
Installation Cost:	$12,300,000	Fuel cost escalation rate:	3.0%
Incentives:	$893,175	Interest Loan Rate:	5.00%
First Year Savings:	$2,237,789	Project Term:	10 years
Emission Reduction Credits:	$0	Simple Payback:	5.1 years

Annual Energy Consumption and Cost Summary				
	Base System	Proposed System	System Savings	
Utility Consumption				
Electricity	59,931,552 kWh	25,884,064 kWh	34,047,488 kWh	56.8%
Peak Electric Demand	11,983 kW	10,074 kW	1,909 kW	15.9%
Fuel Oil	129,752 MMBtu	71,398 MMBtu	58,354 MMBtu	45.0%
Natural Gas	135,049 MMBtu	406,546 MMBtu	-271,497 MMBtu	-
Utility Generated				
Electricity	0 kWh	34,047,488 kWh	-	-
Waste Heat Recovered	0 MMBtu	119,090 MMBtu	119,090 MMBtu	45.0%
Annual Utility Costs				
Electricity	$8,989,733	$3,882,610	$5,107,123	56.8%
Fuel Oil	$1,205,401	$663,291	$542,110	45.0%
Natural Gas (includes incentive)	$1,438,267	$4,329,711	-$2,891,444	-
O&M and Overhaul	$0	$520,000	-$520,000	-
Total Utility Costs	$11,633,400	$9,395,611	$2,237,789	19.2%
Electric Generation Efficiency			35.0%	
Combined Heat and Power System Efficiency			70.8%	
Full Load Equivalent Run Hours			6,920 hours	

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GateCycle
Features and Benefits

GateCycle software accurately predicts the effects of:

- Changing fuel types
- Ambient variations
- Guide-vane settings
- Multiple-pressure HRSG
- Sliding pressure operation
- Component fouling
- Part-load operation
- Pressure losses
- Parallel HRSG sections
- Steam injection
- Fossil boiler operations
- Hardware modifications
- Cooling tower operations

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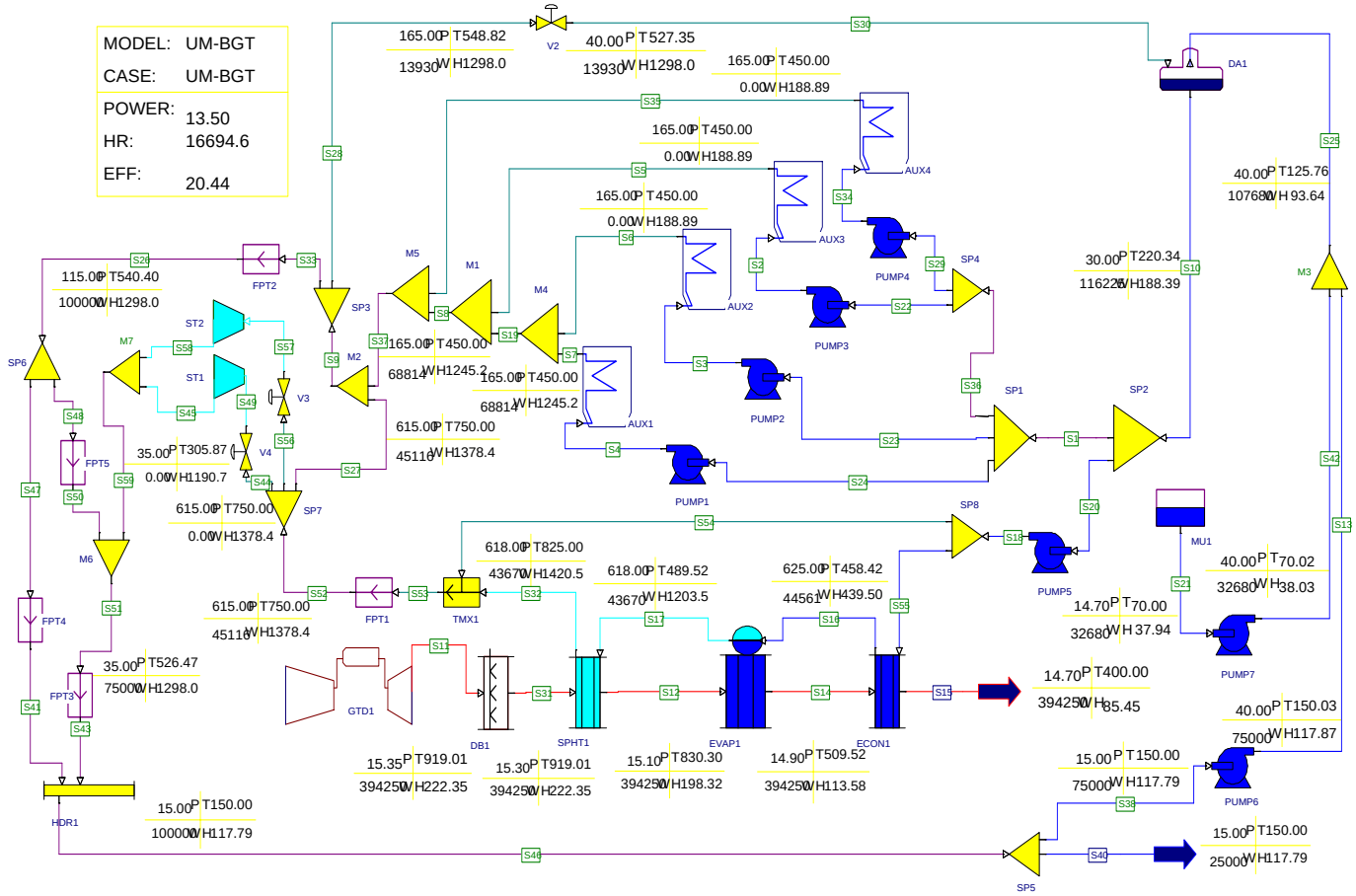
GateCycle Example



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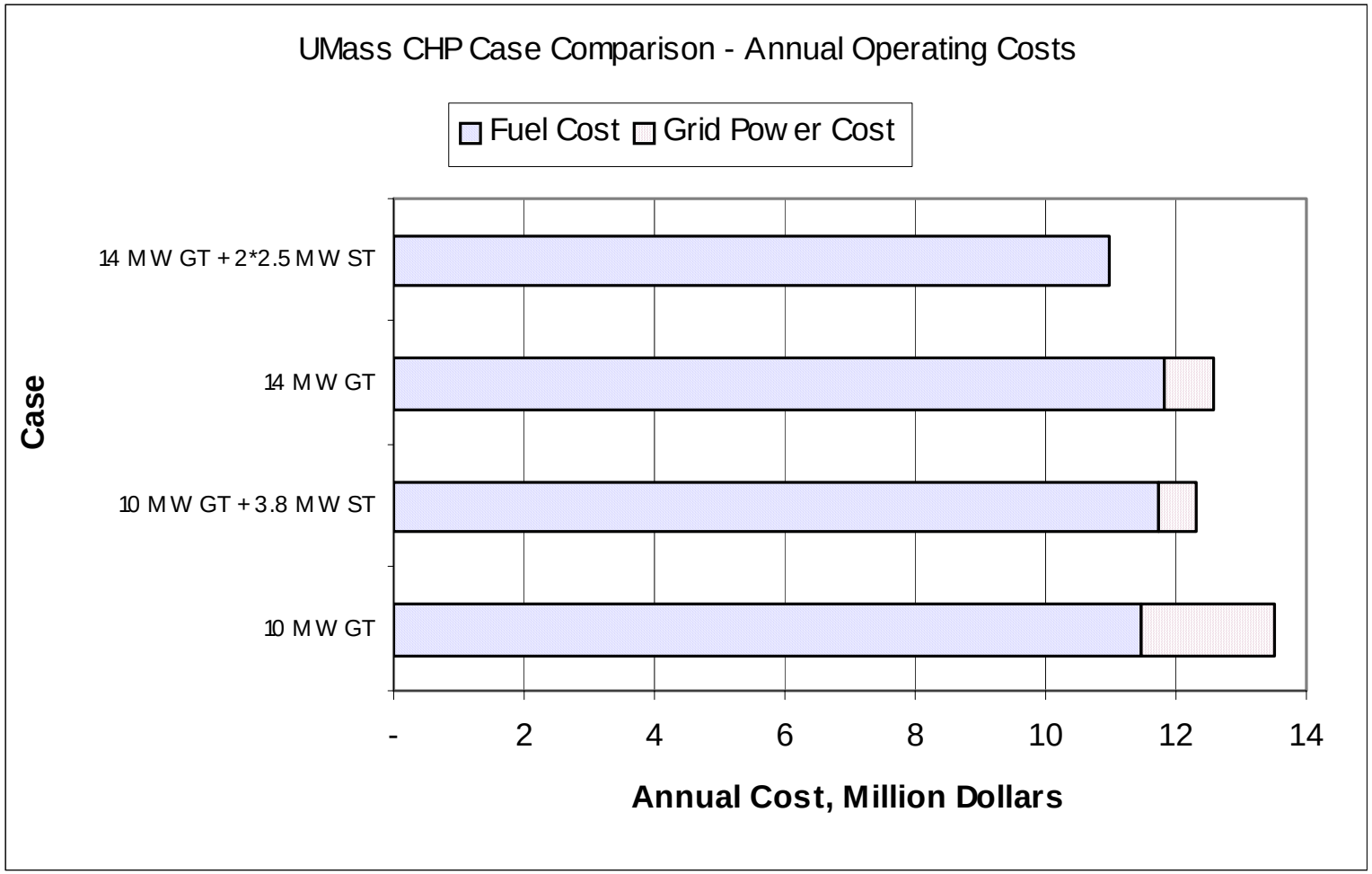
GateCycle Example



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HEATMAP

Standard---Basic District Energy Program.

Combined Heat & Power---Adds DOE-2 Power Plant Module.

Geothermal---Adds Geo Production & Injection Wells.

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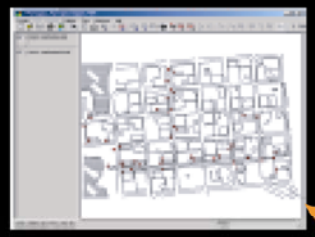
HEATMAP-Dynamic Interface

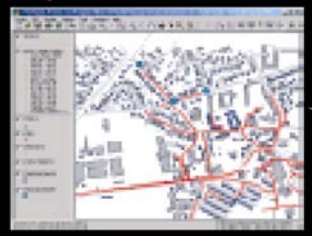
TERMIS©

Termis is an extremely powerful dynamic & quasi steady state district heating network simulation tool.



Offline, online & real-time analysis capabilities

HEATMAP GIS & Billing System



TERMIS Model Manager

TERMIS Real-Time Model

TERMIS Data Manager

SCADA

Termis software distributed by the
Washington State University Cooperative Extension Energy Program
Developed and produced by
Seven Technologies of Denmark

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HEATMAP CHP Will:

- Assess the economic feasibility of proposed central energy systems for:
  - **Heating**
  - **Cooling**
  - **Water or Steam**
  - **Combined Heat & Power**
  - **Thermal Storage**
- Model performance of existing systems
- Evaluate expansion of existing systems
- Assess environmental benefits

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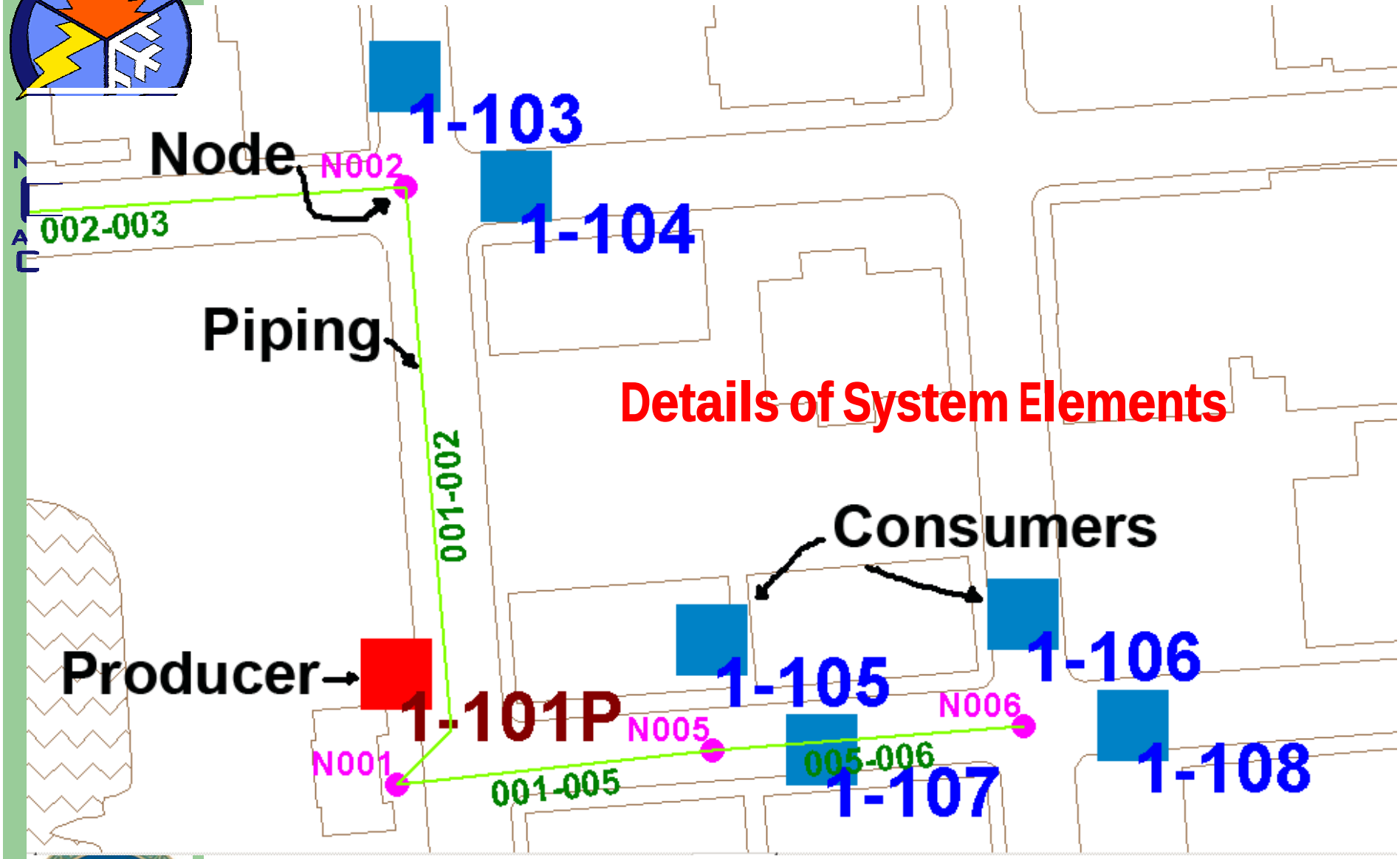

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HEATMAP-CHP's Output Includes:

- Annual fuel use and cost
- Estimated annual and peak consumer loads
- Capacity & cost of energy plant
- Size & cost of distribution system
- Distribution system flow, temperature, pressure, and heat transfer
- Combined Heat & Power Provisions
  - **Utility Rate Schedules**
  - **Thermal vs. Electrical Tracking**
- Cost of Energy

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Evaluating CHP Potential

Steps to Evaluating CHP Potential

1. **Examine energy consumption & cost.**
2. **Develop hourly electrical & thermal load profiles for 1-year period.**
3. **Decide on CHP operating strategy & size system.**
4. **Perform simple payback and life cycle cost analysis .**
5. **Examine other factors.**

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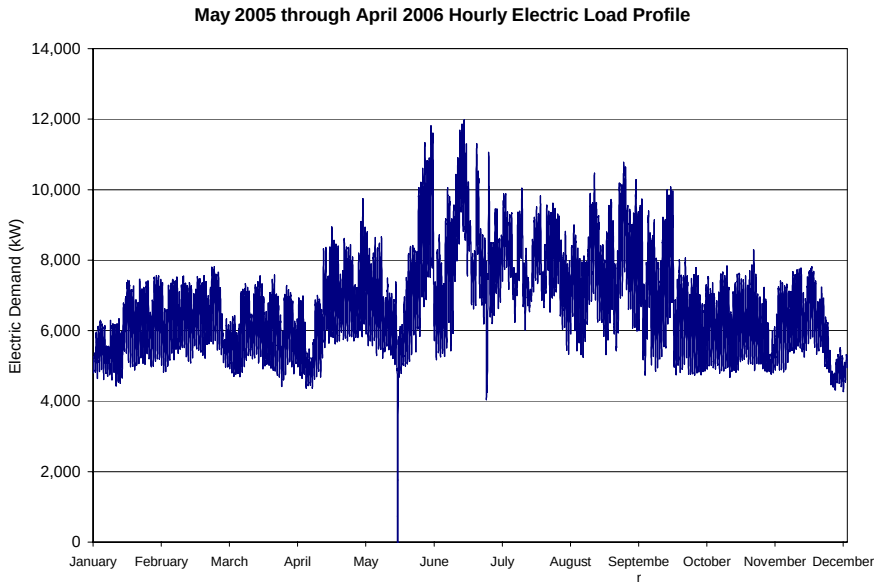
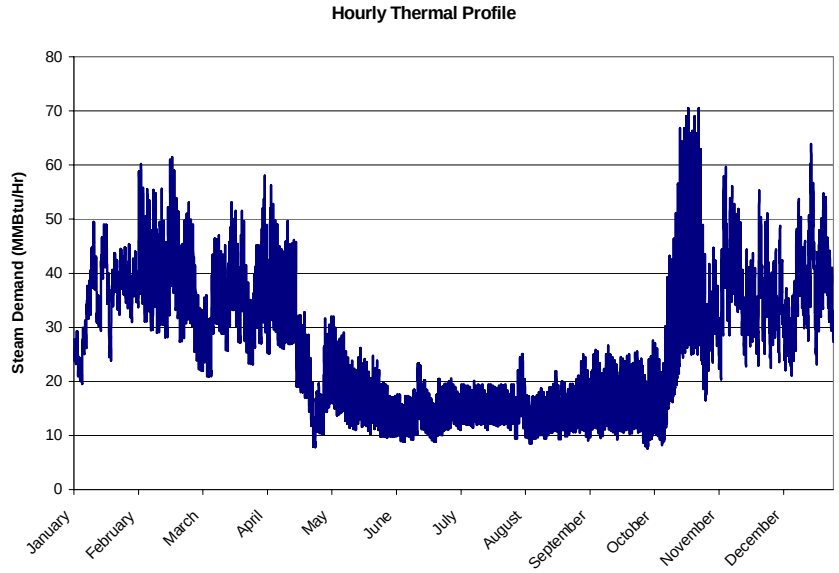
Example

- **Electricity:**
  - ~60,000,000 kWh
  - $8,5300,000
- **Natural Gas:**
  - 136,000 MMBtu
  - $1,720,000
- **#6 Fuel Oil:**
  - 129,000 MMBtu
  - $1,200,000





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Annual Savings, Installed Cost, and Simple Payback

		Without KeySpan Incentive		With KeySpan Incentive[2]	
Combined Heat and Power System Design Options	**Annual Cost Savings[1]**	**Estimated Installed Cost**	**Simple Payback**	**Estimated Installed Cost**	**Simple Payback**
Option #1: 200 kW *CHP* Plant 200 kW Backpressure steam turbine	$113,749	$600,000	5.3 years	$600,000	5.3 years
Option #2: 400 kW *CHP* Plant Two 200 kW Backpressure steam turbine	$188,704	$1,200,000	6.4 years	$1,200,000	6.4 years
Option #3: 2,460 kW *CHP* Plant Three 820 kW Gas Reciprocating Engines with Heat Recovery	$1,224,801	$6,150,000	5.0 years	$5,665,875	4.6 years
Option #4: 4,920 kW *CHP* Plant Six 820 kW Gas Reciprocating Engines with Heat Recovery	$2,237,789	$12,300,000	5.5 years	$11,406,825	5.1 years
Option #5: 1,500 kW *CHP* Plant One 1,500 kW Gas Turbine with Heat Recovery Steam Generator (HRSG)	$670,879	$3,700,000	5.5 years	$2,958,760	4.4 years
Option #6: 3,000 kW *CHP* Plant Two 1,500 kW Gas Turbines with HRSG	$1,198,687	$7,400,000	6.2 years	$6,041,090	5.0 years
Option #7: 4,000 kW *CHP* Plant Two 2,000 kW Gas Turbines with HRSG	$1,744,785	$10,320,000	6.2 years	$8,575,215	5.1 years

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Questions ?

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Contacts

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