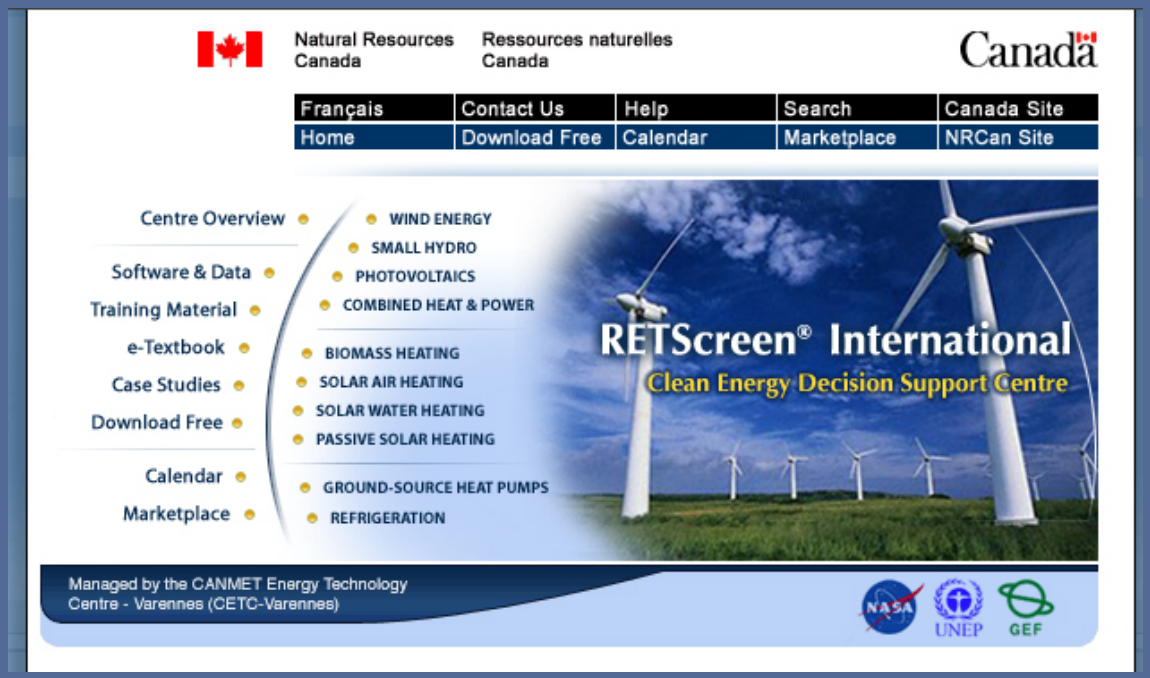
RETScreen
A pre-feasibility tool

RETSCREEN® INTERNATIONAL www.retscreen.net



Presentation by: Urban Ziegler, May 10, 2004

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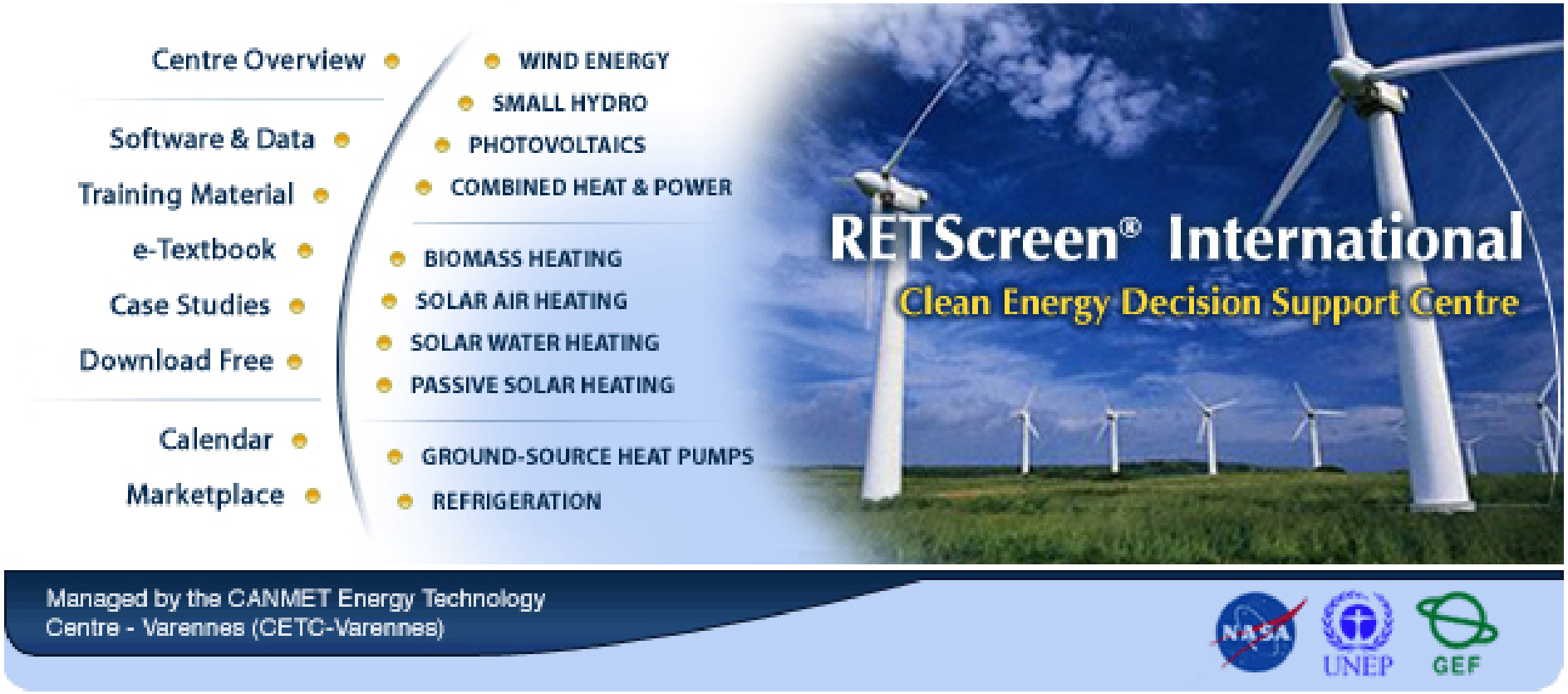

Managed by the CANMET Energy Technology Centre - Varennes (CETC-Varennes)

NASA UNEP GEF

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Develop decision-making tools that reduce the cost of pre-feasibility studies

RETScreen Version 1
May 1998

- **Wind**
- **Small Hydro**
- **Photovoltaics**
- **Solar Air Heating**
- **Biomass Heating**
- Energy, Cost & Finance

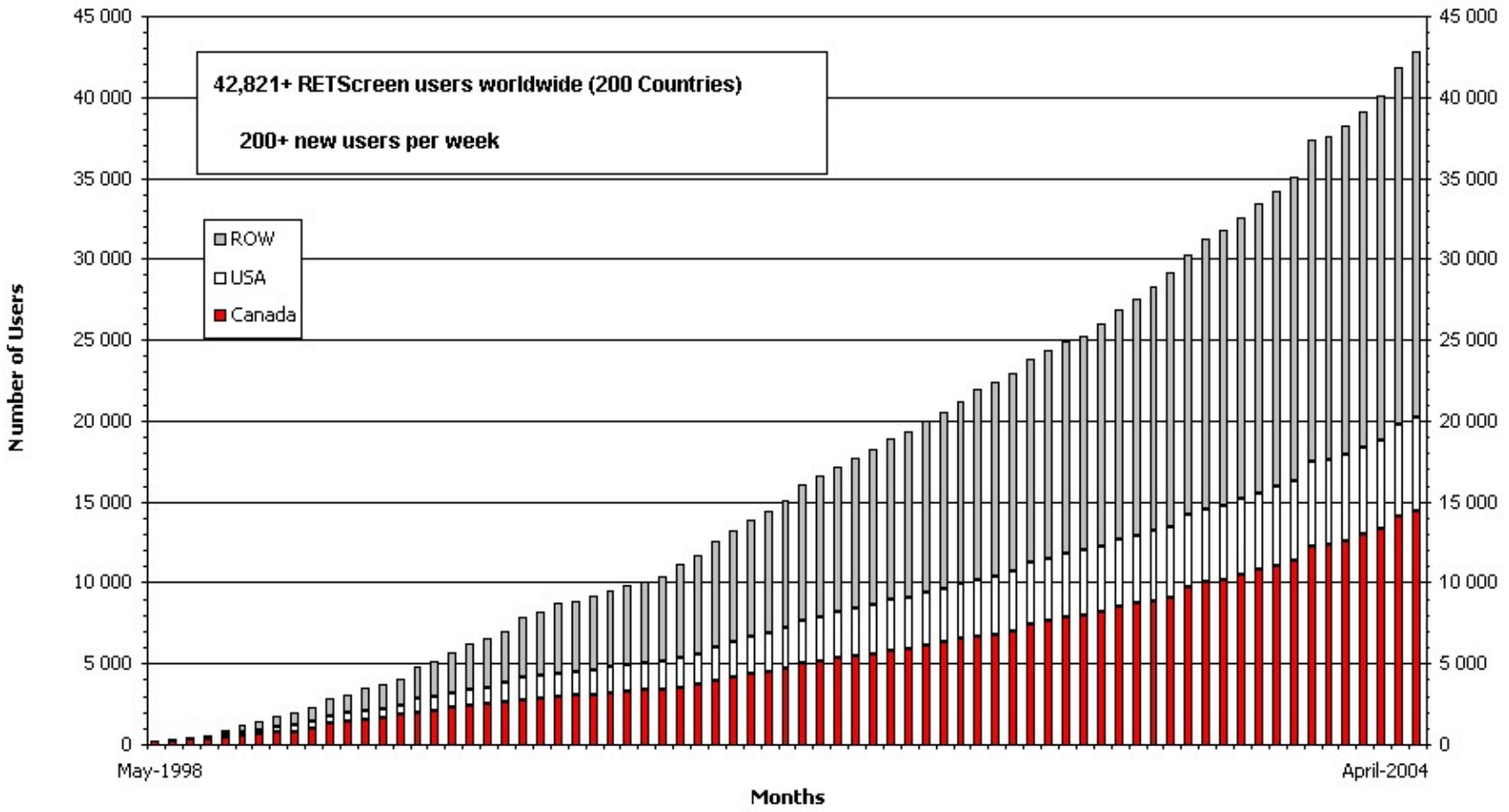
RETScreen Version 2
September 2000

- **Solar Water Heating**
- **Ground-Source Heat Pumps**
- **Passive Solar Heating**
- Online Manual
- Product & Weather Data
- NASA Satellite Data
- GHG & Tax Analysis, etc.
- e-Textbook & Case Studies
- Training Course
- Workshop & Seminar
- Website Automation

RETScreen Version 3
December 2003+

- Kyoto Protocol; Unit & Language Switch; Sensitivity & Risk Analysis; Link to Website & Training Products; Integration with Databases by Others. Series of New Models:

- **Combined Heat & Power Model**
  - Reciprocating engines, Gas turbines, Gas turbine combined cycle, Fuel cells, Steam turbines, Microturbines, Geothermal, etc.
  - Landfill gas, Biomass, Bagasse, Biodiesel, Hydrogen, Natural gas, Oil/Diesel, Coal, Municipal waste, etc.
  - Heating only, Power only and Cooling only; Combined Heat & Power; Single or multiple buildings; Communities (district energy); and Industrial processes, etc.
- **Refrigeration Model**
  - Supermarkets, skating arenas & curling rinks
- **Additional Energy Efficiency Models**
  - Commercial/Institutional Buildings
  - Industrial Facilities, Communities, etc.?



Wind Energy	>20,400	Solar air heating	>12,000	Ground source heat pumps	>12,500
Small Hydro	>14,200	Solar water heating	>15,000	Biomass	>10,000
Photovoltaics	>16,600	Passive solar heating	>11,800	CD's	>14,000

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Varennes, June 2002

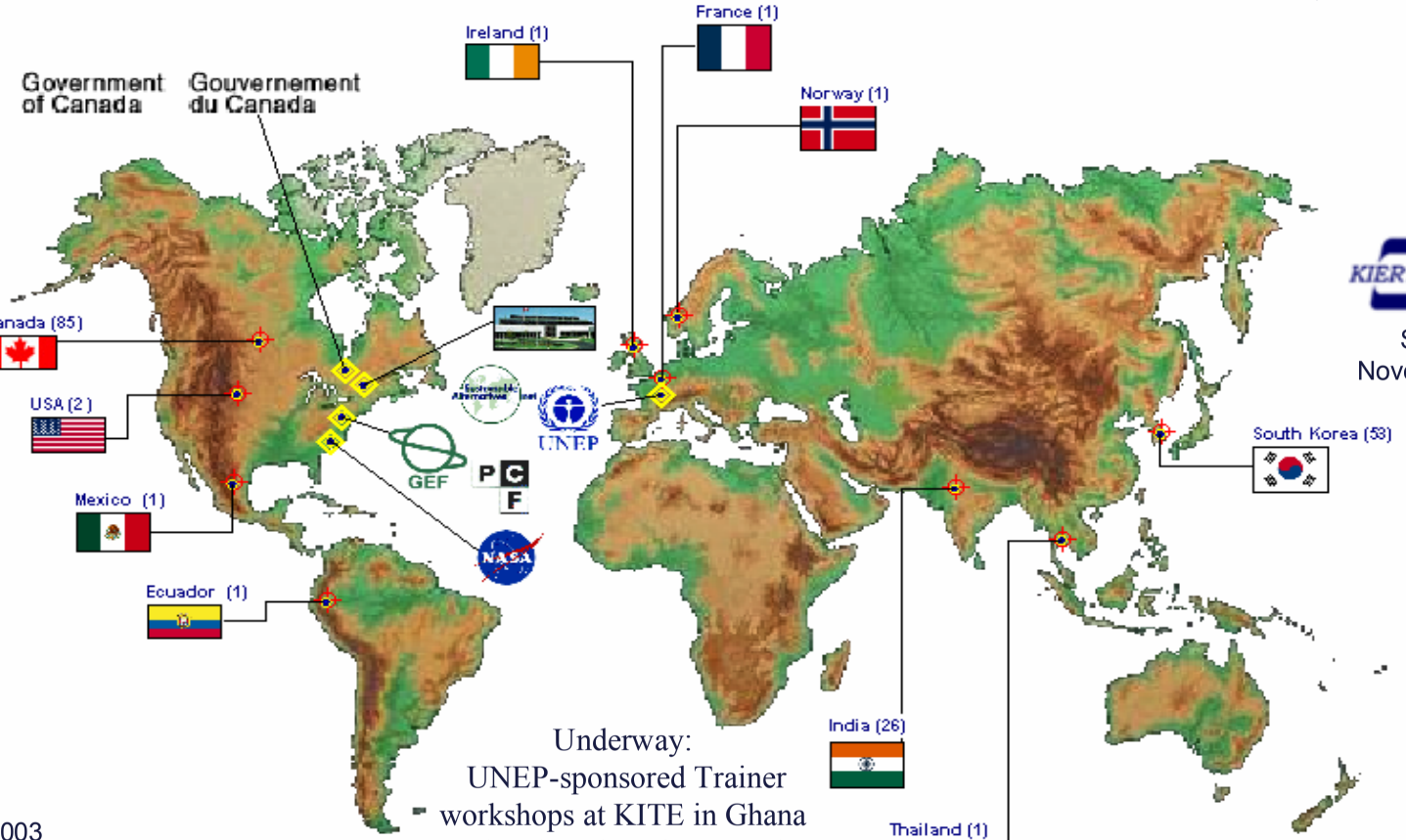
RETScreen International Partners & Network of Trainers

(November, 2003)

New Delhi, October 2002

Government of Canada / Gouvernement du Canada

1,861 Canadians trained at 69 seminars across Canada past 2 years



KIER

Seoul, November 2003

Queen's University

Kingston, August 2003

McGill

Montreal, May 2003

Underway:
UNEP-sponsored Trainer workshops at KITE in Ghana and University of Twente in The Netherlands

Plus seminars in Mexico, India, Thailand and Barbados

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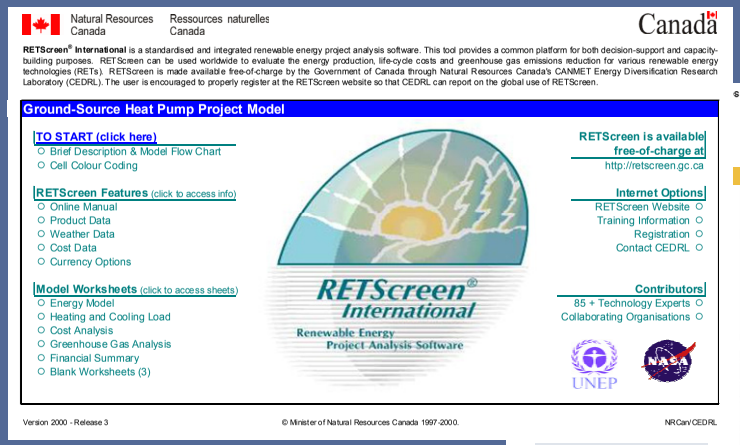
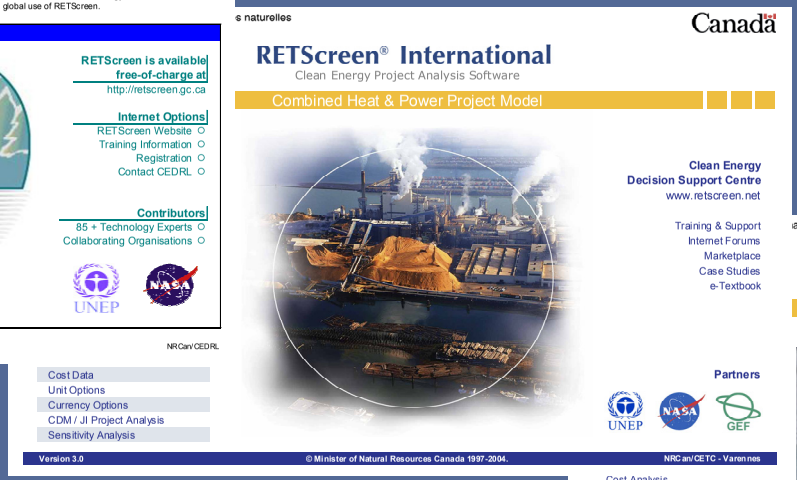
Refrigeration Models

- Ground source heat pumps, 12,387 (April 22nd 2004)
- CHP - (October 2004)
- Refrigeration (Ice rinks and supermarkets) – (January 05)





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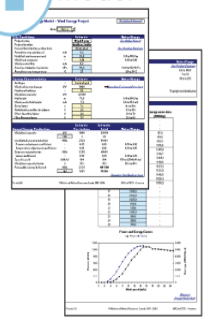
Five steps

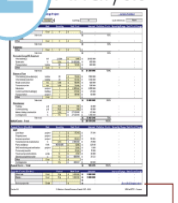
Five Step Standard Analysis

1 Energy Model



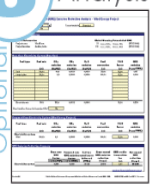
Sub-Worksheet(s)

2 Cost Analysis



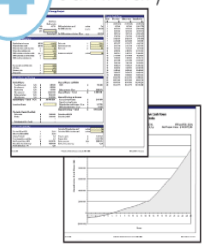
Optional

3 GHG Analysis



click on blue hyperlinks
or floating icon to access data

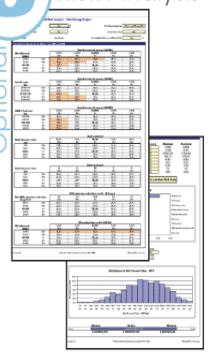
4 Financial Summary



Project Cash Flows

Optional

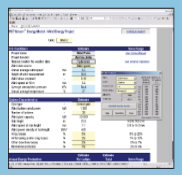
5 Sensitivity & Risk Analysis



Ready to make a decision

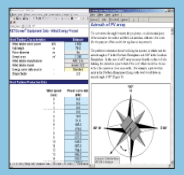
Integrated Features

Weather Data



Product Data

Online Manual



- Training Course
- Engineering Textbook
- Case Studies
- Online Marketplace
- Internet Forums

urces Canada 2001 – 2002.

Live presentation of CHP model

- Sample will be converting a large apartment building using CHP micro-turbine with absorption chiller.

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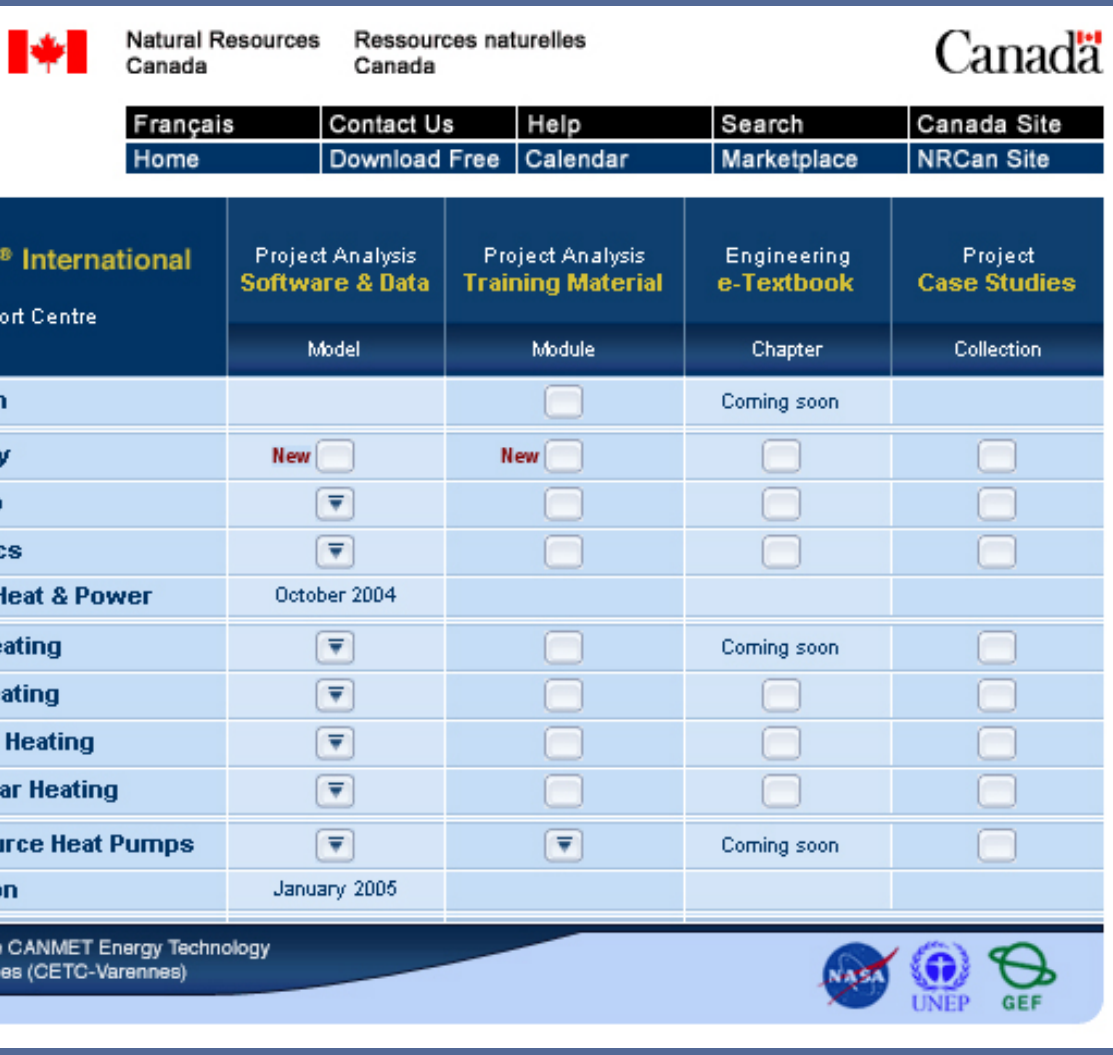
Questions?



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Material presented

- The following slides shows some of the features that will be demonstrated in the live presentation of the CHP model.

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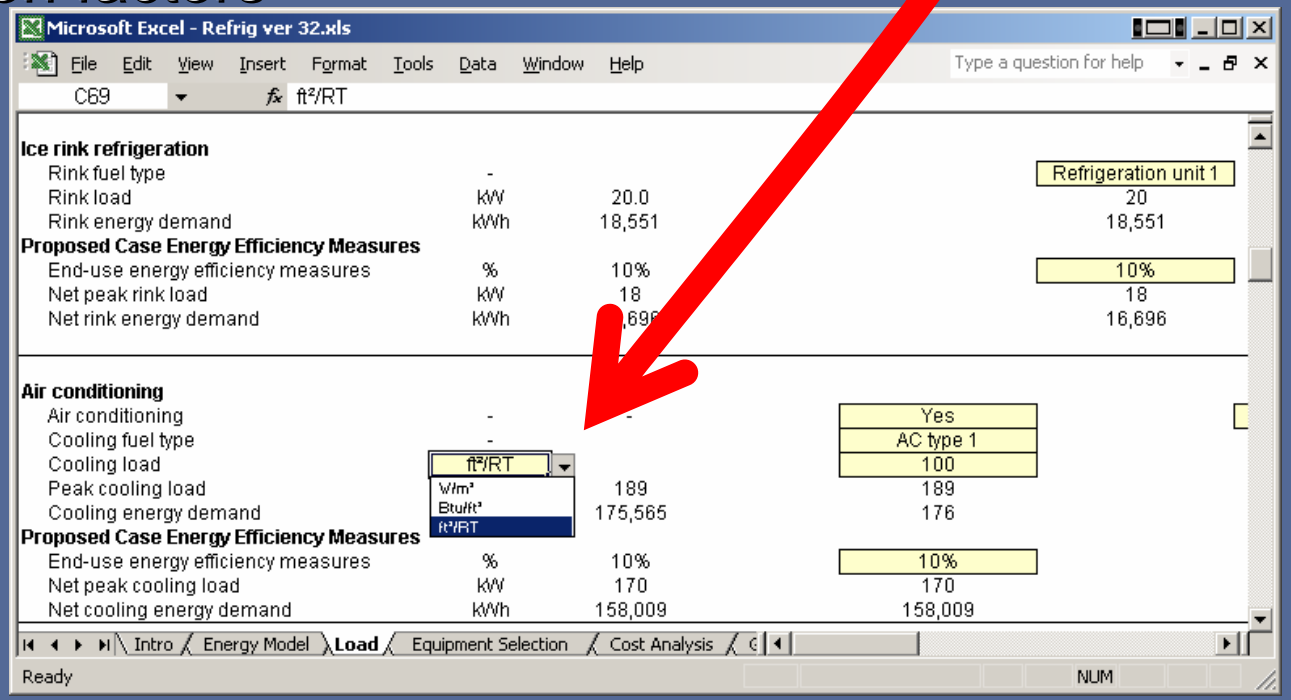
Units

- Input - User defined units (multiple options)
- Output – Metric or Imperial
- Unit converter in Tools sheet
- Exact conversion factors

Units: Metric



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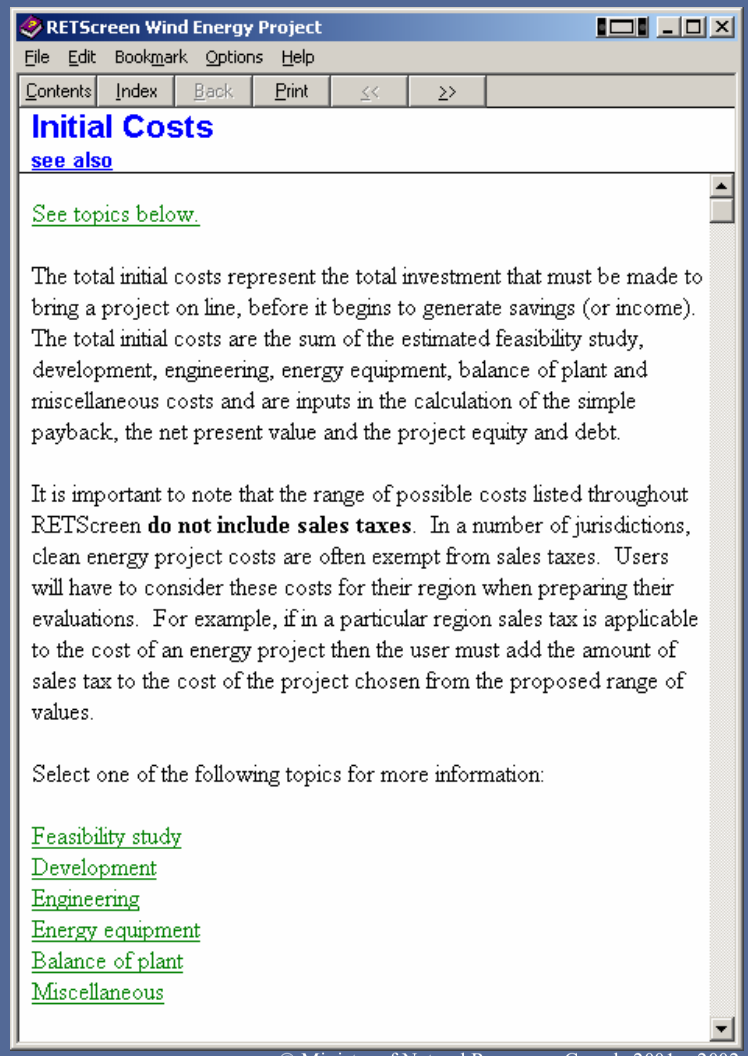
Online help

- Cells linked to online help
- Standardized text



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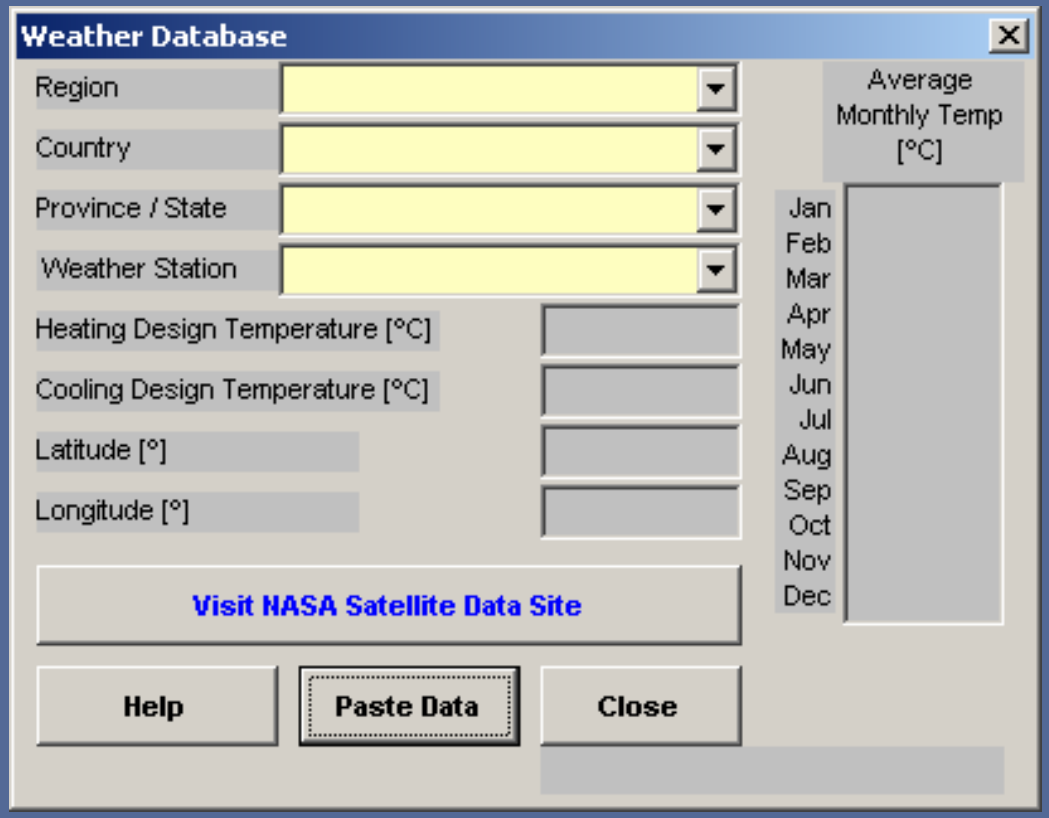
Climatic input

Built-in weather database

- Over 1000 stations
- Heating design temp
- Heating degree days
- Cooling design temp
- Cooling degree days
- Link to NASA data site



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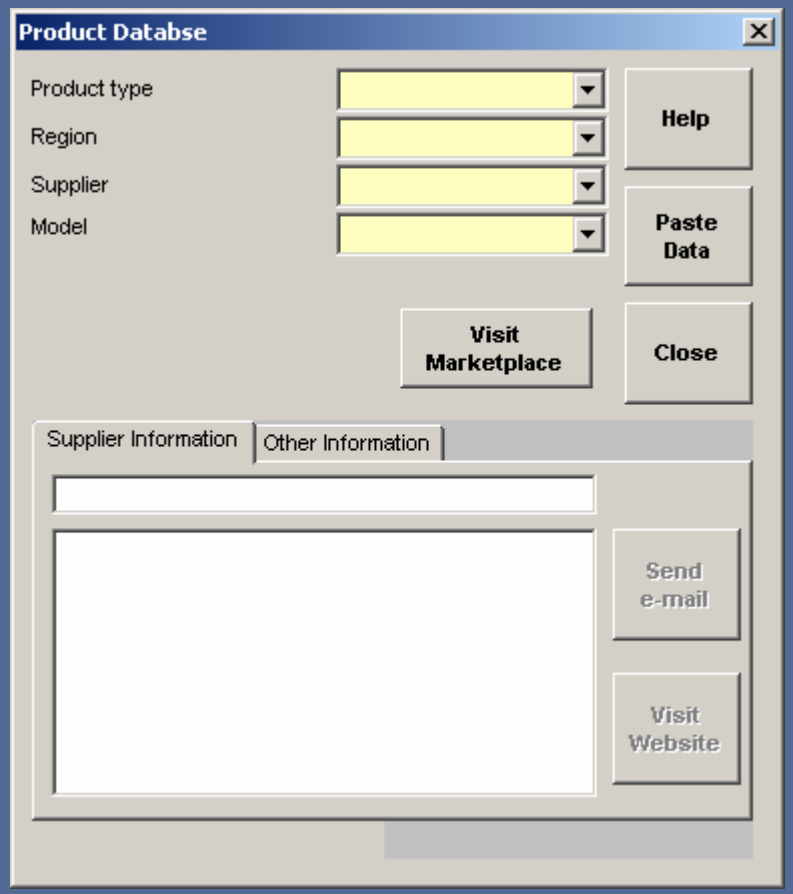
Online Product data

- Comprehensive database
- About 2000 products
- 265 manufacturer



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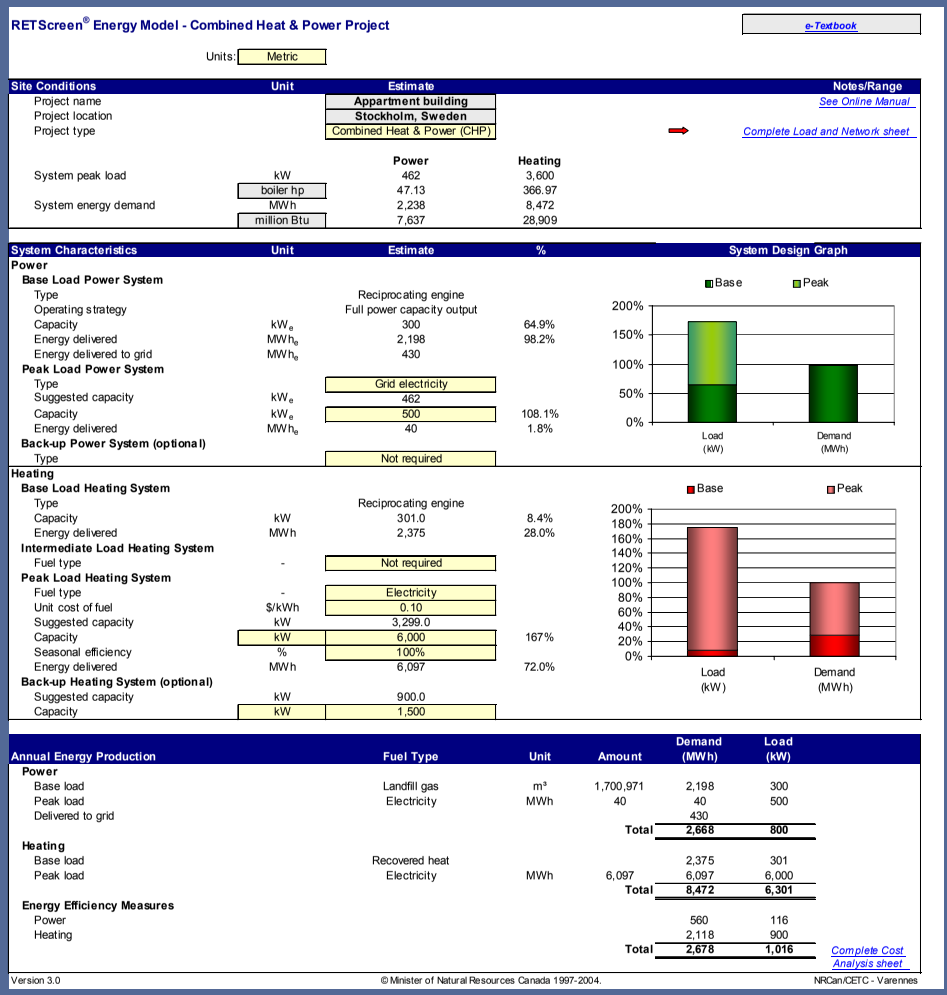
Energy Model

- Unit switch
- Site conditions
  - Project type selection
- System characteristics
  - Summary of project
  - System design graphs
- Annual Energy production
  - Summary of fuel usage
  - Summary of energy efficiency measures



RETScreen® Energy Model - Combined Heat & Power Project

e-Textbook

Units: Metric

Site Conditions	Unit	Estimate		Notes/Range
Project name		Appartment building		See Online Manual
Project location		Stockholm, Sweden		
Project type		Combined Heat & Power (CHP)		Complete Load and Network sheet
		Power	Heating	
System peak load	kW	462	3,600	
	boiler hp	47.13	366.97	
System energy demand	MWh	2,238	8,472	
	million Btu	7,637	28,909	

System Characteristics	Unit	Estimate	%	System Design Graph
Power				
Base Load Power System				
Type		Reciprocating engine		
Operating strategy		Full power capacity output		
Capacity	kW_e	300	64.9%	
Energy delivered	MWh_e	2,198	98.2%	
Energy delivered to grid	MWh_e	430		
Peak Load Power System				
Type		Grid electricity		
Suggested capacity	kW_e	462		
Capacity	kW_e	500	108.1%	
Energy delivered	MWh_e	40	1.8%	
Back-up Power System (optional)				
Type		Not required		
Heating				
Base Load Heating System				
Type		Reciprocating engine		
Capacity	kW	301.0	8.4%	
Energy delivered	MWh	2,375	28.0%	
Intermediate Load Heating System				
Fuel type	-	Not required		
Peak Load Heating System				
Fuel type	-	Electricity		
Unit cost of fuel	$/kWh	0.10		
Suggested capacity	kW	3,299.0		
Capacity	kW	6,000	167%	
Seasonal efficiency	%	100%		
Energy delivered	MWh	6,097	72.0%	
Back-up Heating System (optional)				
Suggested capacity	kW	900.0		
Capacity	kW	1,500		

Annual Energy Production	Fuel Type	Unit	Amount	Demand (MWh)	Load (kW)
Power					
Base load	Landfill gas	m^3	1,700,971	2,198	300
Peak load	Electricity	MWh	40	40	500
Delivered to grid				430	
			Total	**2,668**	**800**
Heating					
Base load	Recovered heat			2,375	301
Peak load	Electricity	MWh	6,097	6,097	6,000
			Total	**8,472**	**6,301**
Energy Efficiency Measures					
Power				560	116
Heating				2,118	900
			Total	**2,678**	**1,016**

Complete Cost Analysis sheet

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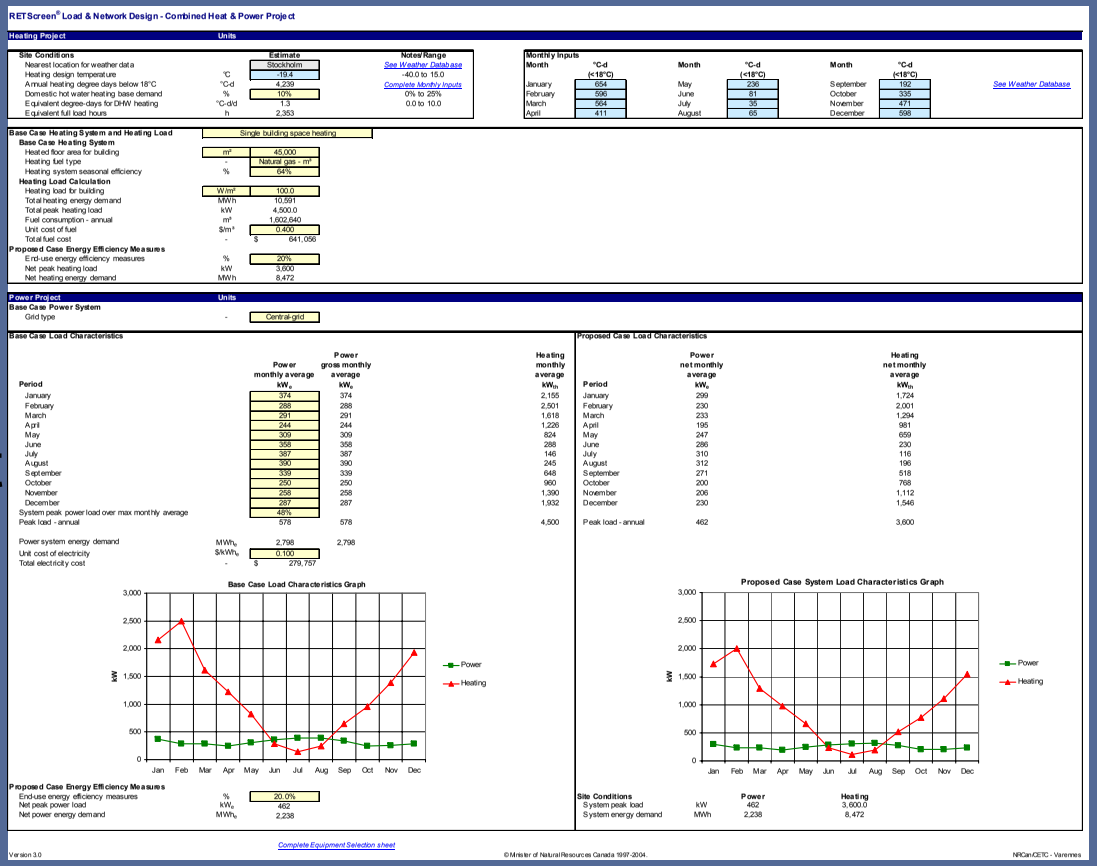
Load & Network

- Weather conditions
  - Selected inputs
- Base case system definitions
  - Comprehensive inputs
- Proposed case district heating & cooling network design
- Load characteristics graphs



RETScreen® Load & Network Design - Combined Heat & Power Project

Heating Project — Units

Site Conditions

		Estimate	Notes/Range
Nearest location for weather data		Stockholm	See Weather Database
Heating design temperature	°C	-19.4	-40.0 to 15.0
Annual heating degree days below 18°C	°C-d	4,239	Complete Monthly Inputs
Domestic hot water heating base demand	%	10%	0% to 25%
Equivalent degree-days for DHW heating	°C-d/d	1.3	0.0 to 10.0
Equivalent full load hours	h	2,353	

Monthly Inputs

Month	°C-d (<18°C)	Month	°C-d (<18°C)	Month	°C-d (<18°C)
January	654	May	236	September	192
February	596	June	81	October	335
March	564	July	35	November	471
April	411	August	65	December	598

See Weather Database

Base Case Heating System and Heating Load		Single building space heating
Base Case Heating System		
Heated floor area for building	m²	45,000
Heating fuel type	-	Natural gas - m³
Heating system seasonal efficiency	%	64%
Heating Load Calculation		
Heating load for building	W/m²	100.0
Total heating energy demand	MWh	10,591
Total peak heating load	kW	4,500.0
Fuel consumption - annual	m³	1,602,840
Unit cost of fuel	$/m³	0.400
Total fuel cost	-	$ 641,056
Proposed Case Energy Efficiency Measures		
End-use energy efficiency measures	%	20%
Net peak heating load	kW	3,600
Net heating energy demand	MWh	8,472

Power Project — Units

Base Case Power System

Grid type	-	Central-grid

Base Case Load Characteristics

Period	Power monthly average kW$_e$	Power gross monthly average kW$_e$	Heating monthly average kW$_h$
January	374	374	2,155
February	288	288	2,501
March	291	291	1,618
April	244	244	1,226
May	309	309	824
June	358	358	288
July	387	387	146
August	390	390	245
September	339	339	648
October	250	250	960
November	258	258	1,390
December	287	287	1,932
System peak power load over max monthly average	48%		
Peak load - annual	578	578	4,500
Power system energy demand	MWh$_e$	2,798	2,798
Unit cost of electricity	$/kWh$_e$	0.100	
Total electricity cost	-	$ 279,757	

Base Case Load Characteristics Graph

Proposed Case Energy Efficiency Measures

End-use energy efficiency measures	%	20.0%
Net peak power load	kW$_e$	462
Net power energy demand	MWh$_e$	2,238

Proposed Case Load Characteristics

Period	Power net monthly average kW$_e$	Heating net monthly average kW$_h$
January	299	1,724
February	230	2,001
March	233	1,294
April	195	981
May	247	659
June	286	230
July	310	116
August	312	196
September	271	518
October	200	768
November	206	1,112
December	230	1,546
Peak load - annual	462	3,600

Proposed Case System Load Characteristics Graph

Site Conditions		Power	Heating
System peak load	kW	462	3,600.0
System energy demand	MWh	2,238	8,472

Complete Equipment Selection sheet

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Equipment Selection

- Proposed case system selection
  - Cooling
  - Heating
  - Power
- Fuel selection
  - Single fuel
  - Monthly fuel
  - Fuel mixtures
- Operating strategy

RETScreen® Equipment Selection - Combined Heat & Power Project ☑ Show alternative units

Proposed Case Power System			%		Notes/Range
System Selection		Base Load System			
Base Load Power System					
Type		Reciprocating engine			
Availability	%		100%	8,760 h	
Fuel selection method		Single fuel			
Fuel type		Landfill gas			
Unit cost of fuel	$/m³	0.10			
Reciprocating engine #1					
Power capacity	kW_e	300	64.9%		
Minimum capacity		30%			
Energy delivered	MWh_e	2,198	98.2%		
Engine manufacturer	-	ABC Inc.			See product database
Engine model		xyz 123			
Heat rate	kJ/kWh	12,000			
Heat recovery efficiency	%	43%			
Fuel consumption	GJ/h	3.6		million Btu/h	3.4
Heating capacity	kW	301.0	8%	million Btu/h	1.0

Operating strategy - base load power system			
Base case heating fuel cost	$/MWh	$	60.53
Base case power purchase cost	$/MWh	$	100.00
Proposed case power fuel cost	$/MWh	$	19.42
Proposed case power sales price	$/MWh	$	100.00
Proposed case power purchase cost	$/MWh	$	100.00

Operating methods	Power produced & consumed MWh_e	Power produced & sold MWh_e	Power purchased MWh_e	Heating recovered MWh	Heating peak energy MWh	Power fuel consumed MWh	Operating profit (loss) $	Efficiency kJ/kWh
Full power capacity output	**2,198**	**430**	**40**	**2,375**	**6,097**	**8,760**	**$ 236,462**	**6,303**
Power load following	2,198	0	40	1,954	6,519	7,328	$ 195,811	6,354
Heating load following	1,947	420	291	2,375	6,097	7,890	$ 227,258	5,990

Selection of operating strategy
Select operating method: Full power capacity output

Return to Energy Model sheet

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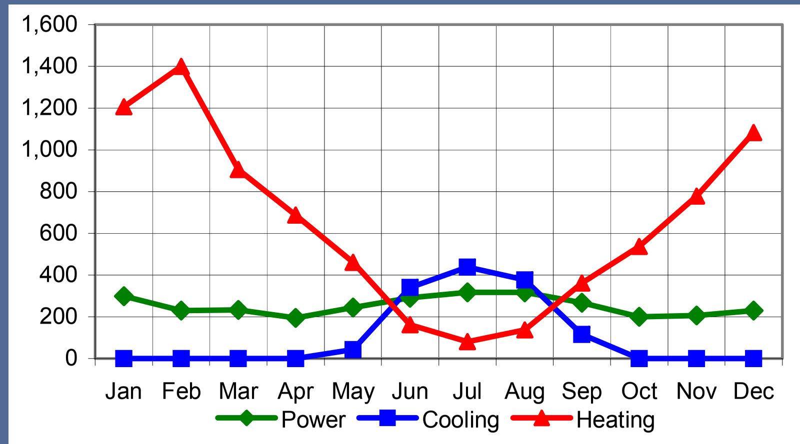
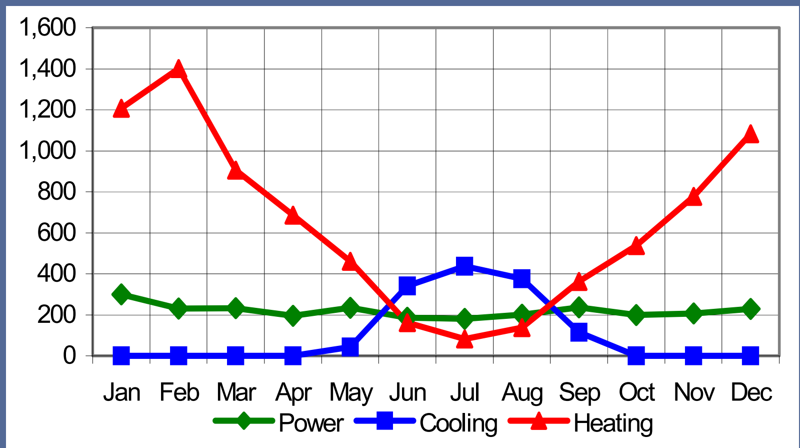
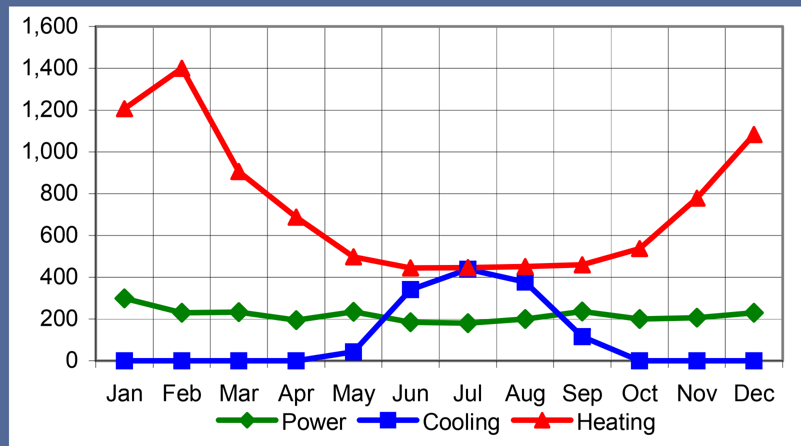
Equipment Selection

- Heating & power load depending on system
  - Compressor driven chillers
  - Absorption chillers
  - Free cooling







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Cost Analysis

- Standard
  - Selected inputs
- Custom
  - Comprehensive inputs
- Currency switch
- Cost reference

RETScreen® Cost Analysis - Combined Heat & Power Project — Search Marketplace

Type of project: Standard | Currency: $ | Cost references: None

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
Feasibility Study							
Feasibility study	Cost	1	$ 23,000	$ 23,000		-	-
Sub-total:				**$ 23,000**	3.0%		
Development							
Development	Cost	1	$ 45,000	$ 45,000		-	-
Sub-total:				**$ 45,000**	5.8%		
Engineering							
Engineering	Cost	1	$ 67,000	$ 67,000		-	-
Sub-total:				**$ 67,000**	8.7%		
Power Equipment							
Base load - Reciprocating engine	kW_e	300	$ 700	$ 210,000		-	-
Peak load - Grid electricity	kW_e	500	$ -	$ -		-	-
Road construction	miles	0.00		$ -		-	-
Transmission line	miles	0.00		$ -		-	-
Substation	project	1	$ 50,000	$ 50,000		-	-
Energy efficiency measures	project	1	$ 100,000	$ 100,000		-	-
Power Equipment	Cost	1	$ 123,000	$ 123,000		-	-
Power Equipment	Credit	0	$ -	$ -		-	-
Sub-total:				**$ 483,000**	62.8%		
Heating Equipment							
Base load - Reciprocating engine	kW	385	$ -	$ -		-	-
Peak load system	kW	6,000	$ -	$ -		-	-
Back-up system	kW	1,500	$ -	$ -		-	-
Energy efficiency measures	project	1	$ 23,000	$ 23,000		-	-
Heating Equipment	Cost	1	$ 12,000	$ 12,000		-	-
Heating Equipment	Credit	0	$ -	$ -		-	-
Sub-total:				**$ 35,000**	4.5%		
Balance of Plant & Miscellaneous							
Balance of Plant & Misc.	Cost	1	$ 45,000	$ 45,000		-	-
Contingencies	%	5.0%	$ 698,000	$ 34,900		-	-
Interest during construction	10.0%	12 month(s)	$ 732,900	$ 36,645		-	-
Sub-total:				**$ 116,545**	15.1%		
Initial Costs - Total				**$ 769,545**	100.0%		

Annual Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
O&M							
Parts and labour	-	0	$ 75	$ -		-	-
O&M	Cost	1	$ 55,000	$ 55,000		-	-
Contingencies	%	10%	$ 55,000	$ 5,500		-	-
Sub-total:				**$ 60,500**	13.1%		
Fuel							
Natural gas	m^3	848,399	$ 0.100	$ 84,840		-	-
Electricity	MWh	3,175	$ 100.000	$ 317,514		-	-
Parasitic electricity	kWh	0	$ -	$ -		-	-
Sub-total:				**$ 402,354**	86.9%		
Annual Costs - Total				**$ 462,854**	100.0%		

Periodic Costs (Credits)		Period	Unit Cost	Amount	Interval Range	Unit Cost Range
Overhaul	Cost	10 yr	65,000	**$ 65,000**	-	-
				$ -	-	-
				$ -	-	-
End of project life	Credit			$ -		Go to GHG Analysis sheet

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Greenhouse Gas Emissions

- Optional worksheet
- Standard
  - GHG factors from database
- Custom
  - GHG factors user input
- User defined
  - GHG factor t_{CO_2}/MWh user input
- Base line change option
  - For all types

RETScreen® Greenhouse Gas (GHG) Emission Reduction Analysis - Combined Heat & Power Project

Use GHG analysis sheet?	Yes	Type of analysis	Standard		
Potential CDM project?	No	Use simplified baseline methods?	No	Switches on this row are not activated	

Background Information

Project Information				Global Warming Potential of GHG		
Project name	Appartment building	Project capacity	0.8 MW	21 tonnes CO_2 = 1 tonne CH_4	(IPCC 1996)	
Project location	Stockholm, Sweden	Grid type	Central-grid	310 tonnes CO_2 = 1 tonne N_2O	(IPCC 1996)	

Base Case Electricity System (Baseline)

Fuel type	Fuel mix (%)	CO_2 emission factor (kg/GJ)	CH_4 emission factor (kg/GJ)	N_2O emission factor (kg/GJ)	Fuel conversion efficiency %	T & D losses (%)	GHG emission factor (t_{CO_2}/MWh)
#6 oil	24.5%	77.4	0.0030	0.0020	30.0%	0.0%	0.937
Coal	63.5%	94.6	0.0020	0.0030	35.0%	0.0%	0.983
Large hydro	0.0%	0.0	0.0000	0.0000	100.0%	0.0%	0.000
Natural gas	12.0%	56.1	0.0030	0.0010	45.0%		0.452
Electricity mix	100%	249.8	0.0069	0.0073		0.0%	0.908

Does baseline change during project life? No

Base Case System (Baseline)

Fuel type	Fuel mix (%)	CO2 emission factor (kg/GJ)	CH4 emission factor (kg/GJ)	N2O emission factor (kg/GJ)	Fuel consumption (GJ)	GHG emission factor (tCO2/MWh)
Natural gas	81.5%	56.1	0.0030	0.0010	44,480	0.203
Electricity	18.5%	249.8	0.0069	0.0073	11,617	0.908
Energy mix	100.0%	91.9	0.0037	0.0022	56,098	0.333

Note: Electricity includes power delivered to grid in the Proposed Case System

Proposed Case System (Combined Heat & Power (CHP) project)

Fuel type	Fuel mix (%)	CO2 emission factor (kg/GJ)	CH4 emission factor (kg/GJ)	N2O emission factor (kg/GJ)	Fuel consumption (GJ)	GHG emission factor (t_{CO_2}/MWh)
Natural gas	73.4%	56.1	0.0030	0.0010	31,536	0.203
Electricity	26.6%	249.8	0.0069	0.0073	11,431	0.908
Energy mix	100%	107.6	0.0040	0.0027	42,967	0.391
Power delivered to grid	MWh	430				
T & D losses	%	12.0%				

GHG Emission Reduction Summary

	Base case GHG emission factor (tCO2/MWh)	Proposed case GHG emission factor (tCO2/MWh)	End-use annual energy delivered (MWh)	Gross annual GHG emission reduction (t_{CO_2})	GHG credits transaction fee (%)	Net annual GHG emission reduction (t_{CO_2})
Combined Heat & Power (CHP) System	0.333	0.391	12,313	485	0%	**485**

Complete Financial Summary sheet

Version 3.0

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Financial Summary

- Identical to all Version 3 models
- Tax analysis
- Project cost and savings summary
- Financial feasibility factors
  - IRR
  - Simple payback
  - Year-to-positive cash flow
  - NPV
  - Annual life cycle savings
  - Benefit-Cost ratio

RETScreen® Financial Summary - Combined Heat & Power Project

Annual Energy Balance

Project name		Appartment building			
Project location		Stockholm, Sweden			
Heating sales premium/rebate	%	10.0%		t_{CO2}/yr	
			Net GHG reduction	t_{CO2}/yr	484.6
Power sales premium/rebate	%	0.0%	Net GHG emission reduction - 30 yrs	t_{CO2}	14,538
Power delivered to grid	MWh	430	Net GHG emission reduction - 25 yrs	t_{CO2}	12,115

Financial Parameters

Power sales price	$/kWh	0.100	Debt ratio	%	70.0%
Power purchase cost	$/kWh	0.100	Debt interest rate	%	14.0%
RE production credit	$/kWh	-	Debt term	yr	15
			Income tax analysis?	yes/no	No
GHG emission reduction credit	$/$t_{CO2}$	-			
Energy cost escalation rate	%	2.0%			
Inflation	%	2.0%			
Discount rate	%	12.0%			
Project life	yr	25			

Project Costs and Savings

Initial Costs				**Annual Costs and Debt**		
Feasibility study	3.0%	$	23,000	O&M	$	60,500
Development	5.8%	$	45,000	Fuel/Electricity	$	402,354
Engineering	8.7%	$	67,000	Debt payments - 15 yrs	$	87,702
Power equipment	62.8%	$	483,000	**Annual Costs - Total**	**$**	**550,556**
Heating equipment	4.5%	$	35,000			
				Annual Savings or Income		
Balance of plant & misc	15.1%	$	116,545	Energy savings/income	$	806,278
Initial Costs - Total	100%	**$**	**769,545**	Power sales savings/income	$	42,950
Incentives/Grants		$	-	**Annual Savings - Total**	**$**	**849,228**
Periodic Costs (Credits)						
Overhaul		$	65,000	Schedule yr # 10,20		
		$	-			
		$	-			
End of project life		$	-			

Financial Feasibility

			Calculate energy production cost?	yes/no	No
Pre-tax IRR and ROI	%	135.3%			
After-tax IRR and ROI	%	135.3%	Calculate GHG reduction cost?	yes/no	No
Simple Payback	yr	2.0		$_{CO2}$	
Year-to-positive cash flow	yr	0.8	Project equity	$	230,864
Net Present Value - NPV	$	2,696,969	Project debt	$	538,682
Annual Life Cycle Savings	$	343,863	Debt payments	$/yr	87,702
Benefit-Cost (B-C) ratio	-	12.68	Debt service coverage	-	4.49

Yearly Cash Flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	(230,864)	(230,864)	(230,864)
1	306,399	306,399	75,536
2	314,281	314,281	389,817
3	322,321	322,321	712,138
4	330,522	330,522	1,042,660
5	338,886	338,886	1,381,546
6	347,418	347,418	1,728,964
7	356,120	356,120	2,085,084
8	364,997	364,997	2,450,081
9	374,051	374,051	2,824,131
10	304,051	304,051	3,128,182
11	392,705	392,705	3,520,888
12	402,314	402,314	3,923,201
13	412,114	412,114	4,335,315
14	422,110	422,110	4,757,425
15	432,306	432,306	5,189,732
16	530,409	530,409	5,720,141
17	541,017	541,017	6,261,158
18	551,837	551,837	6,812,995
19	562,874	562,874	7,375,869
20	477,545	477,545	7,853,414
21	585,614	585,614	8,439,028
22	597,326	597,326	9,036,355
23	609,273	609,273	9,645,628
24	621,458	621,458	10,267,086
25	633,888	633,888	10,900,974

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Project evaluation - Sensitivity analysis

- Sensitivity for main project factors
  - After-tax IRR and ROI
  - Year-to-positive cash flow
  - Net present value - NPV

- Multiple tables
- Variable sensitivity range
- Threshold indicator

RETScreen® Sensitivity and Risk Analysis - Combined Heat & Power Project

Use sensitivity analysis sheet?	Yes	Perform analysis on	After-tax IRR and ROI	
Perform risk analysis too?	No	Sensitivity range	20%	
Project name	Appartment building	Threshold	15	%
Project location	Stockholm, Sweden			

Click here to Calculate Sensitivity Analysis

Sensitivity Analysis for After-tax IRR and ROI

		Initial costs ($)				
		615,636	692,591	**769,545**	846,500	923,454
Fuel/Electricity ($)		-20%	-10%	0%	10%	20%
433,104	-20%	142.8%	123.0%	107.3%	94.4%	83.7%
487,242	-10%	113.0%	96.6%	83.5%	72.8%	64.0%
541,380	0%	83.3%	70.2%	**59.9%**	51.4%	44.5%
595,518	10%	53.7%	44.1%	36.6%	30.7%	26.0%
649,656	20%	25.3%	19.9%	16.0%	13.0%	10.6%

		O&M ($)				
		48,400	54,450	**60,500**	66,550	72,600
Initial costs ($)		-20%	-10%	0%	10%	20%
615,636	-20%	89.9%	86.6%	83.3%	80.0%	76.6%
692,591	-10%	76.1%	73.2%	70.2%	67.3%	64.4%
769,545	0%	65.1%	62.5%	**59.9%**	57.2%	54.6%
846,500	10%	56.2%	53.8%	51.4%	49.1%	46.7%
923,454	20%	48.8%	46.6%	44.5%	42.3%	40.2%

		Fuel/Electricity ($)				
		433,104	487,242	**541,380**	595,518	649,656
Initial costs ($)		-20%	-10%	0%	10%	20%
615,636	-20%	142.8%	113.0%	83.3%	53.7%	25.3%
692,591	-10%	123.0%	96.6%	70.2%	44.1%	19.9%
769,545	0%	107.3%	83.5%	**59.9%**	36.6%	16.0%
846,500	10%	94.4%	72.8%	51.4%	30.7%	13.0%
923,454	20%	83.7%	64.0%	44.5%	26.0%	10.6%

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Project evaluation - Risk analysis

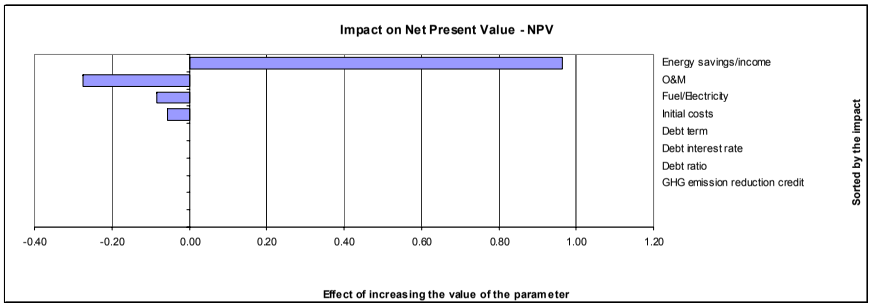
- **Risk analysis for:**
  - After-tax IRR and ROI
  - Year-to-positive cash flow
  - Net present value – NPV

- User defined ranges
- Monte Carlo Simulation
- Model recalculated 500 times
- Normal distribution of data
- Standard deviation 0.33

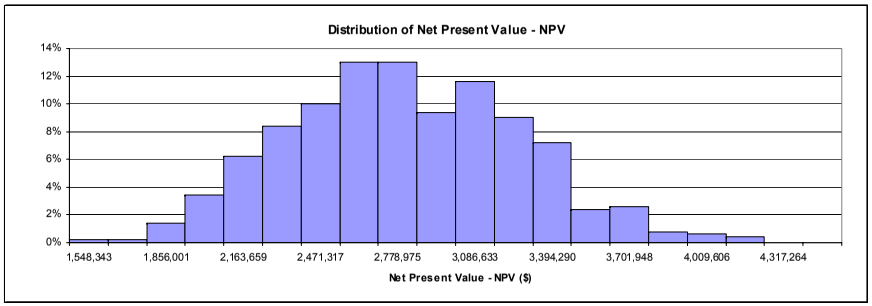
- Impact graph
- Distribution graph
- Confidence graph

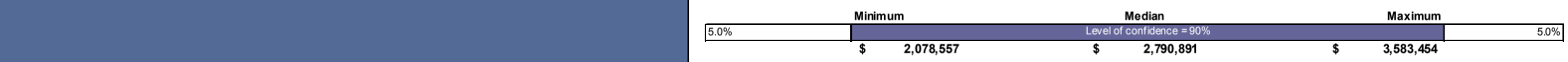
Risk Analysis for Net Present Value - NPV

Parameter	Unit	Value	Range (+/-)	Minimum	Maximum
Initial costs	$	242,991	30%	170,094	315,888
O&M	$	269,500	15%	229,075	309,925
Fuel/Electricity	$	93,455	10%	84,110	102,801
Energy savings/income	$	559,023	20%	447,218	670,827
GHG emission reduction credit	$/$t_{CO2}$	2.0	0%	2.0	2.0
Debt ratio	%	70%	0%	70%	70%
Debt interest rate	%	14.0%	15%	11.9%	16.1%
Debt term	year	15	0%	15	15



Median	$	2,790,891
Level of risk	%	10%
Minimum within level of confidence	$	2,078,557
Maximum within level of confidence	$	3,583,454





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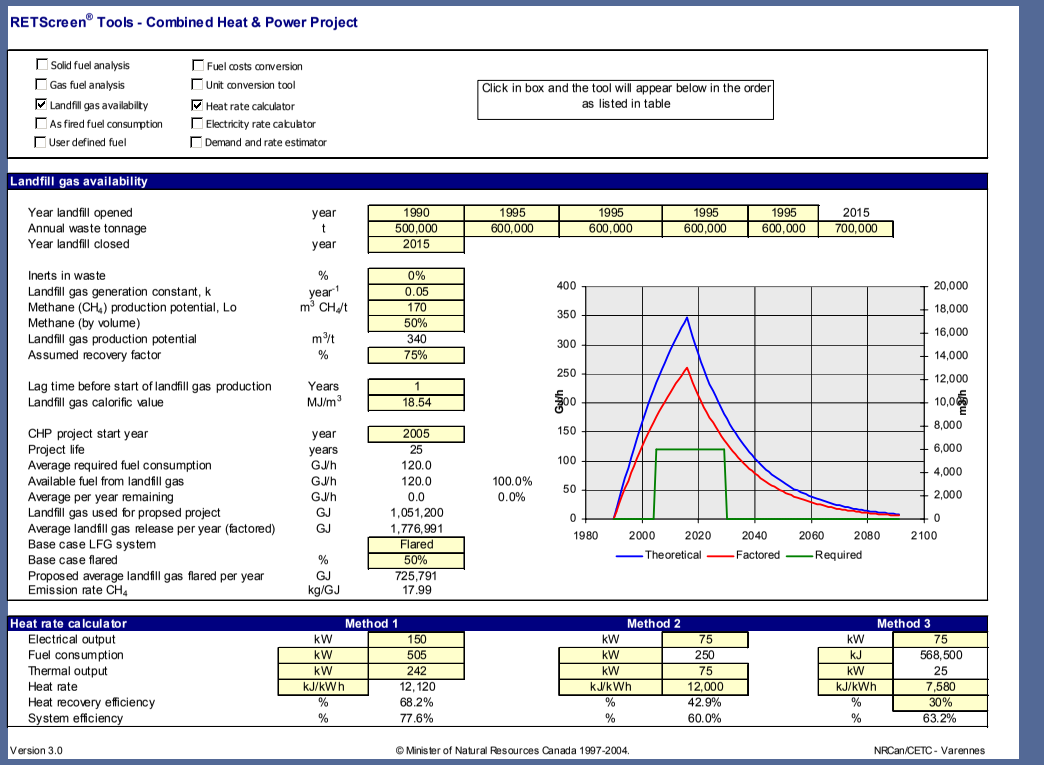
Tools

- Worksheet with engineering tools
  - Solid fuel analysis
  - Gas fuel analysis
  - Landfill gas availability
  - As fired fuel consumption
  - User defined fuel
  - Fuel cost conversion
  - Unit conversion
  - Heat rate calculator
  - Electricity rate calculator
  - Demand & rate estimator



RETScreen® Tools - Combined Heat & Power Project

☐ Solid fuel analysis ☐ Fuel costs conversion
☐ Gas fuel analysis ☐ Unit conversion tool
☑ Landfill gas availability ☑ Heat rate calculator
☐ As fired fuel consumption ☐ Electricity rate calculator
☐ User defined fuel ☐ Demand and rate estimator

Click in box and the tool will appear below in the order as listed in table

Landfill gas availability

Year landfill opened	year	1990	1995	1995	1995	1995	2015
Annual waste tonnage	t	500,000	600,000	600,000	600,000	600,000	700,000
Year landfill closed	year	2015					
Inerts in waste	%	0%					
Landfill gas generation constant, k	year^{-1}	0.05					
Methane (CH_4) production potential, Lo	m^3 CH_4/t	170					
Methane (by volume)		50%					
Landfill gas production potential	m^3/t	340					
Assumed recovery factor	%	75%					
Lag time before start of landfill gas production	Years	1					
Landfill gas calorific value	MJ/m^3	18.54					
CHP project start year	year	2005					
Project life	years	25					
Average required fuel consumption	GJ/h	120.0					
Available fuel from landfill gas	GJ/h	120.0	100.0%				
Average per year remaining	GJ/h	0.0	0.0%				
Landfill gas used for propsed project	GJ	1,051,200					
Average landfill gas release per year (factored)	GJ	1,776,991					
Base case LFG system		Flared					
Base case flared	%	50%					
Proposed average landfill gas flared per year	GJ	725,791					
Emission rate CH_4	kg/GJ	17.99					

Heat rate calculator	Method 1		Method 2		Method 3	
Electrical output	kW	150	kW	75	kW	75
Fuel consumption	kW	505	kW	250	kJ	568,500
Thermal output	kW	242	kW	75	kW	25
Heat rate	kJ/kWh	12,120	kJ/kWh	12,000	kJ/kWh	7,580
Heat recovery efficiency	%	68.2%	%	42.9%	%	30%
System efficiency	%	77.6%	%	60.0%	%	63.2%

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Case Studies

- Prepared after model completion
- Printed
- Available on web site

RETScreen® International
Clean Energy Decision Support Centre

CASE STUDY

ASSIGNMENT 09

PHOTOVOLTAIC PROJECT
REMOTE SCHOOL / NEUQUÉN, ARGENTINA

DESCRIPTION OF ASSIGNMENT

A local public utility has undertaken an electrification program for rural schools in the province of Neuquén in the remote mountainous region of Patagonia, Argentina. The schools are generally far away from the electrical grid and the two main power supply options being considered are diesel gensets and stand-alone photovoltaic (PV) systems. You are an engineer at the utility in the provincial capital and you have been asked to evaluate the financial viability of using PV to supply electricity to a school in one particular village.

SITE INFORMATION

The school is located in the foothills of the Andes (39°S, 71°W), on the Aucapan reservation of the Mapuche people, one of the region's indigenous populations. The nearest major town is the provincial capital Neuquén, some 430 km to the northeast.

The school consists of classrooms and an apartment for a visiting teacher (who generally comes from an urban centre). The climate is harsh: hot and dry in the summer and cold, with high snowfalls, in the winter. Since the snow makes access particularly difficult, the school holidays take place in the winter (June through August) and the building is unoccupied at that time. When the school is open, its electric loads are estimated as follows (the lights and radio telephone use DC power while all other loads are AC):

Description Load	(kW)	Usage (hrs/day)	Days / Week
Lights – school (17 x 15 W)	0.255	2	5
Lights – apartment (4 x 15 W)	0.060	2	7
TV 0.080		2	7
VCR 0.027		0.5	7
Radio & tape player	0.025	1	7
Radio telephone (transmit)	0.120	0.5	7
Radio telephone (standby)	0.006	8	7

Based on your previous experience with similar projects, you decide to use imported polycrystalline PV modules from BP Solar rated at 50 W_p. Due to the occasional long periods of cloud cover in the mountains, you design the system for 6 days of autonomy.

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Cette publication est aussi disponible en Français.

CANMET Energy Technology Centre - Varennes (CETC)

In collaboration with: UNEP

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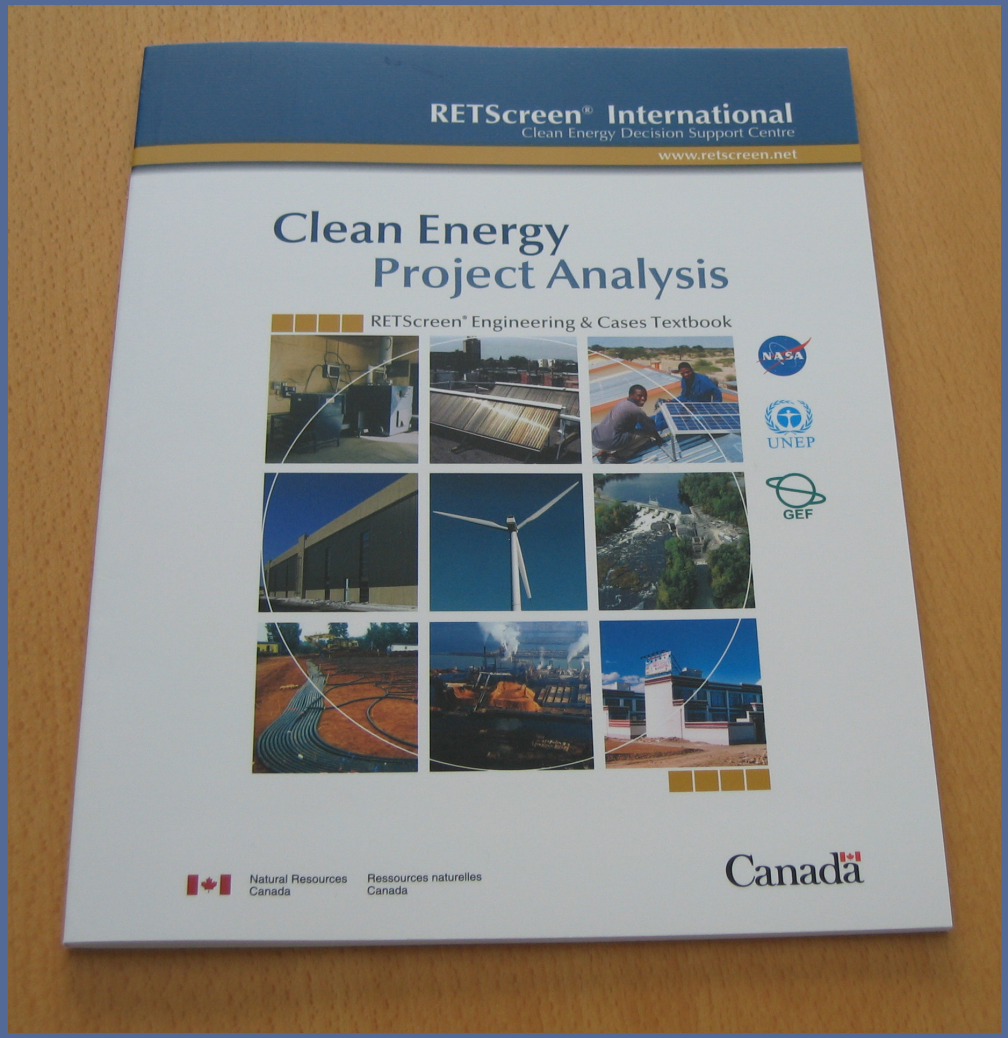
e-Textbook

- Engineering textbook
  - Professionals
  - University students
- Technology background
- Description of algorithms
- Printed
- Available on web site



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