Introduction to RETScreen Clean Energy Decision Analysis Software

Yawkey Club

June 3rd and 4th, 2008

Wilson Rickerson

Solar Boston Program

SolarBoston

BOSTONIA. CONDITA A.D. 1630.

THOMAS M. MENINO MAYOR

nationalgrid

TODAY!

- Introduction to RETScreen software
- Introduction to solar water heating
- Introduction to the RETScreen solar water heating model
- Overview of financial incentives
- Case studies

Climate Action Plan

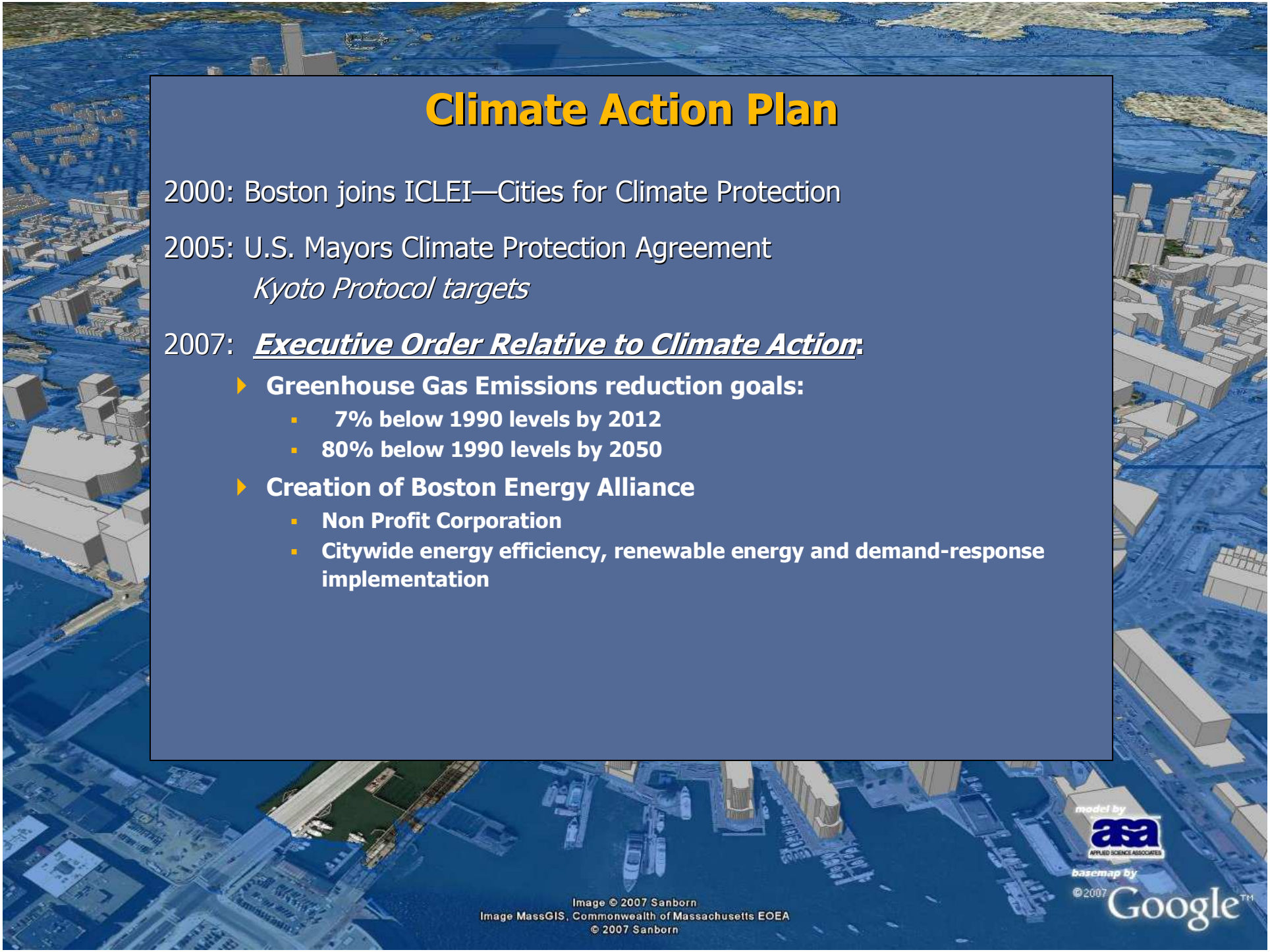
2000: Boston joins ICLEI—Cities for Climate Protection

2005: U.S. Mayors Climate Protection Agreement

Kyoto Protocol targets

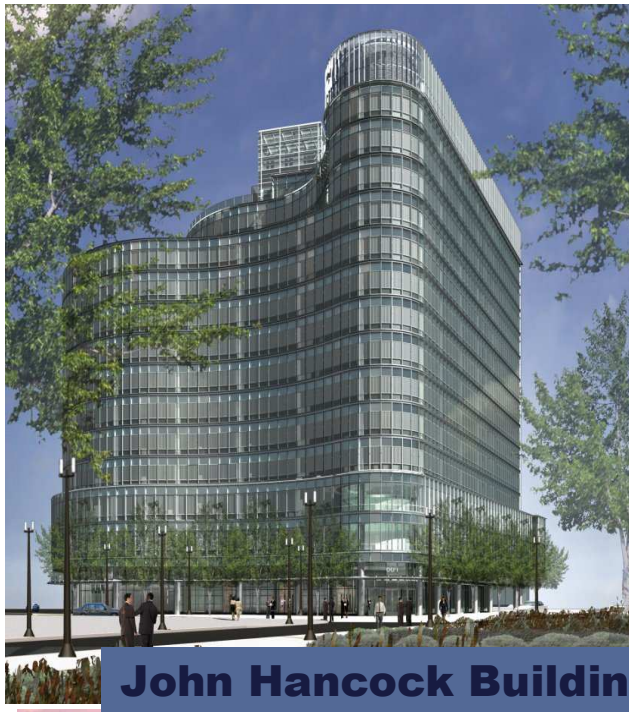
2007: ***Executive Order Relative to Climate Action***:

- **Greenhouse Gas Emissions reduction goals:**
  - **7% below 1990 levels by 2012**
  - **80% below 1990 levels by 2050**
- **Creation of Boston Energy Alliance**
  - **Non Profit Corporation**
  - **Citywide energy efficiency, renewable energy and demand-response implementation**



Green Building Action Plan

- **All private projects over 50,000 square feet must be LEED "Certifiable"**
- **All public projects must be LEED Silver certified**
- ***10 million* square feet of LEED construction is currently in the pipeline.**



John Hancock Buildin

Brigham & Women's Hos

Samuel W. Bodman
US Secretary of Energy

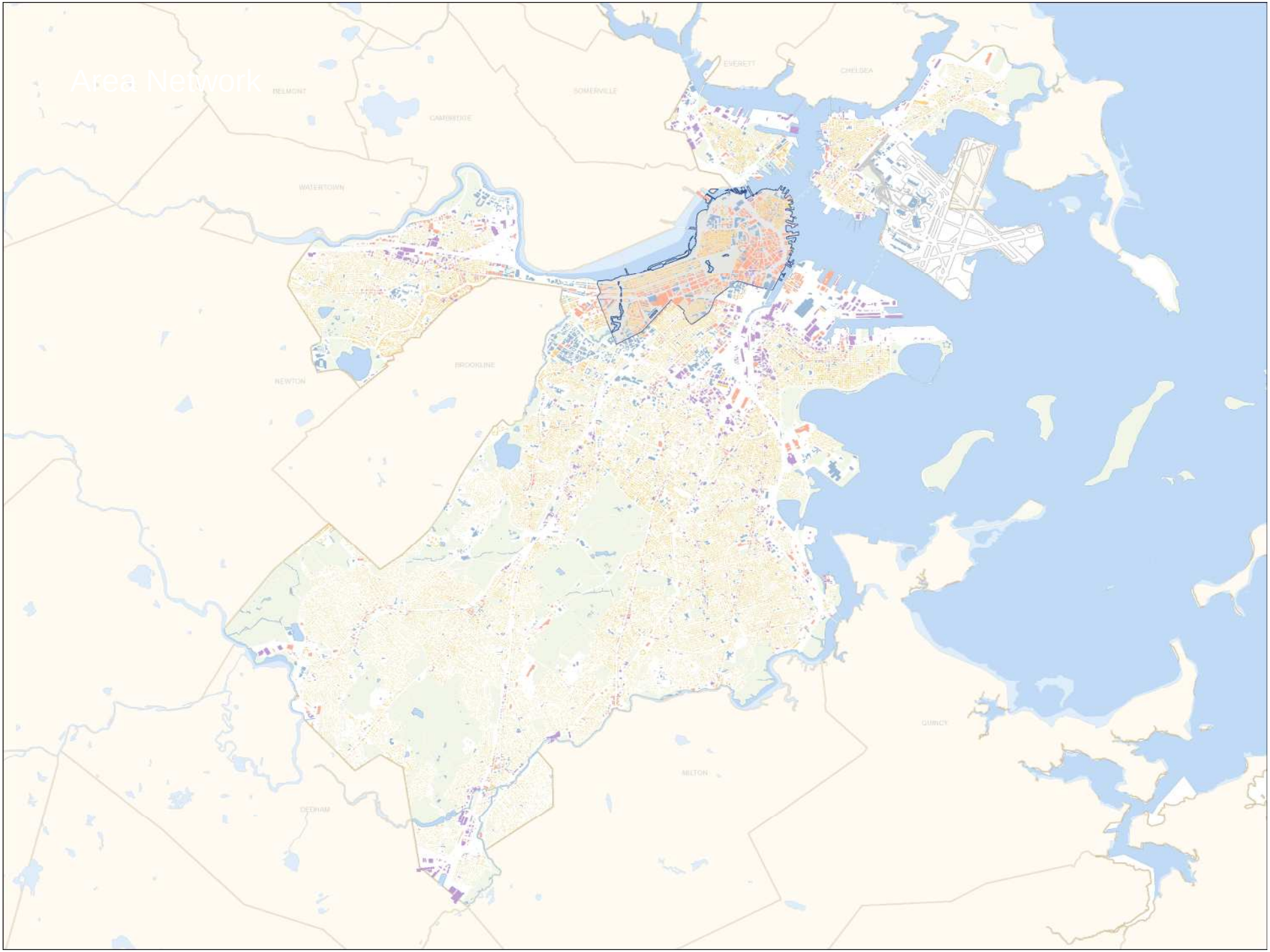
Thomas M. Menino
Mayor of Boston

Fenway Park
April 9, 2008

THOMAS M. MENINO
MAYOR

Fenway Park Event

- Mayor announces:
  - 25 MW by 2015 for Boston
  - $500,000 for four municipal PV projects
  - NREL on roof of Police HQ (Otto Van Geet)
- Red Sox announce solar hot water to meet 37% of demand
- Commonwealth of Massachusetts announces $50,000 grant for 15 SWH engineering studies on City buildings


Area Network
BELMONT
CAMBRIDGE
SOMERVILLE
EVERETT
CHELSEA
WATERTOWN
BROOKLINE
NEWTON
QUINCY
MILTON
DEDHAM

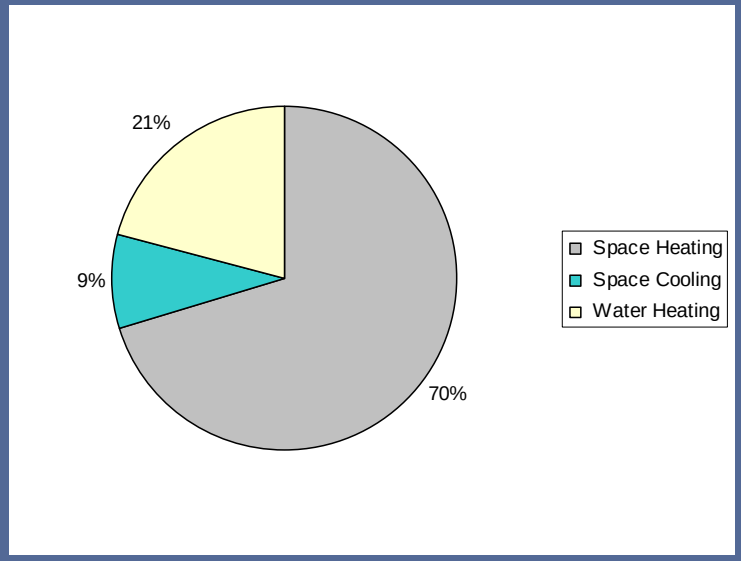
The Answer? Solar Water Heating

- No grid interaction
- Cheaper than PV
- Quicker payback than PV
- No-brainer for heated swimming pools

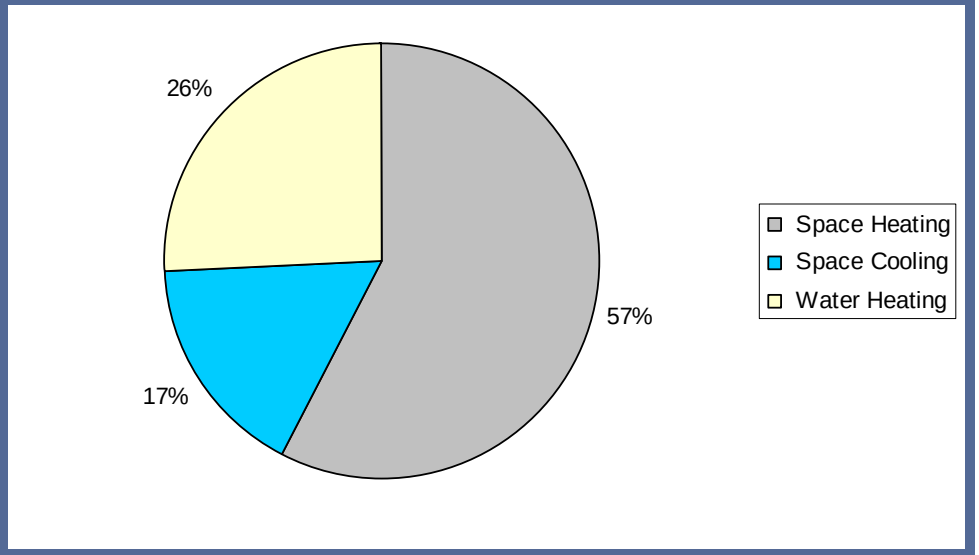
SWH in China

Credit: Paradigma

Heating and Cooling in the US



67% of Residential Energy Use

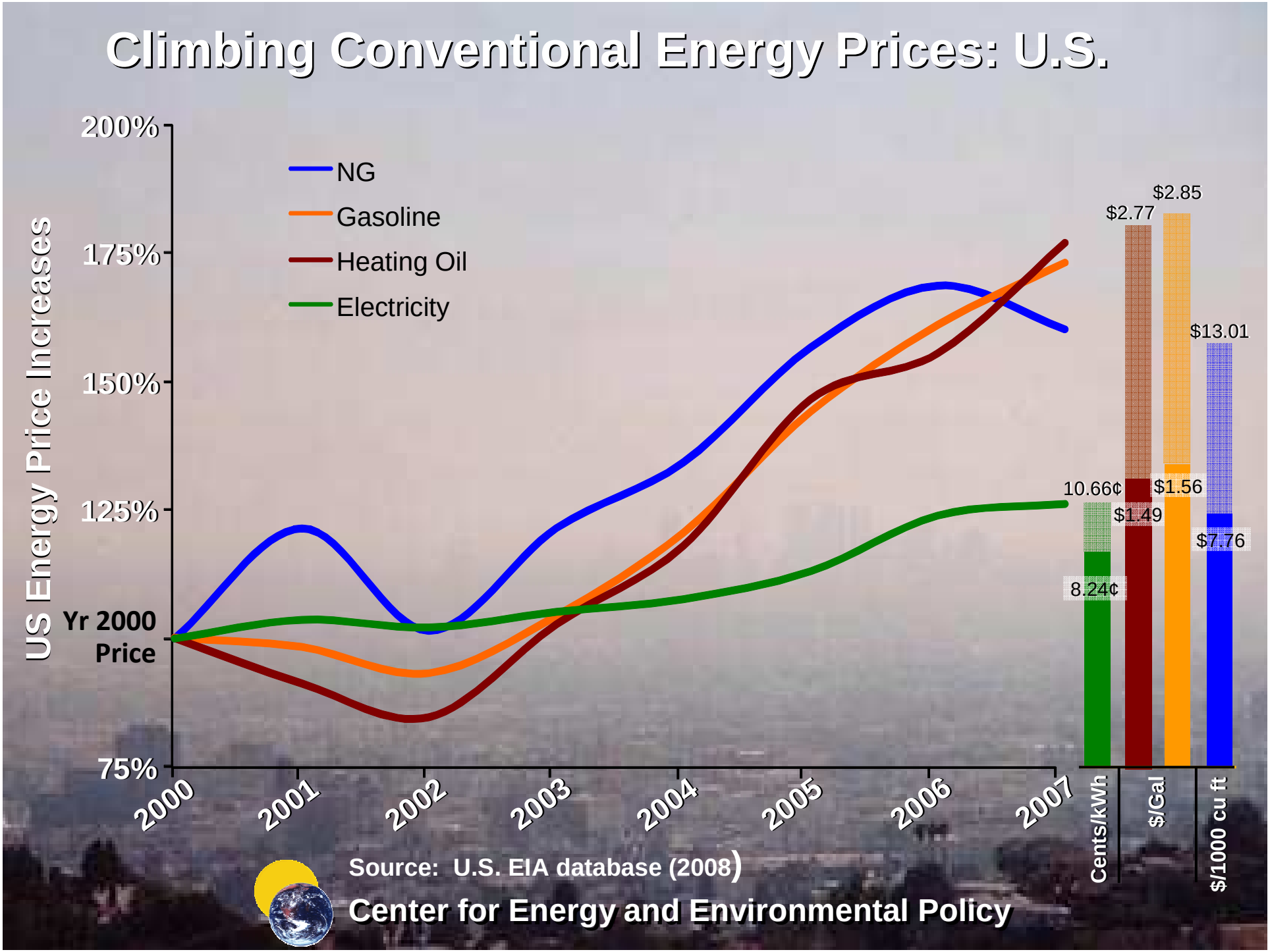


33% of Commercial Energy Use

Electricity = 2.33 quads

Fossil Fuels = 8.45 quads

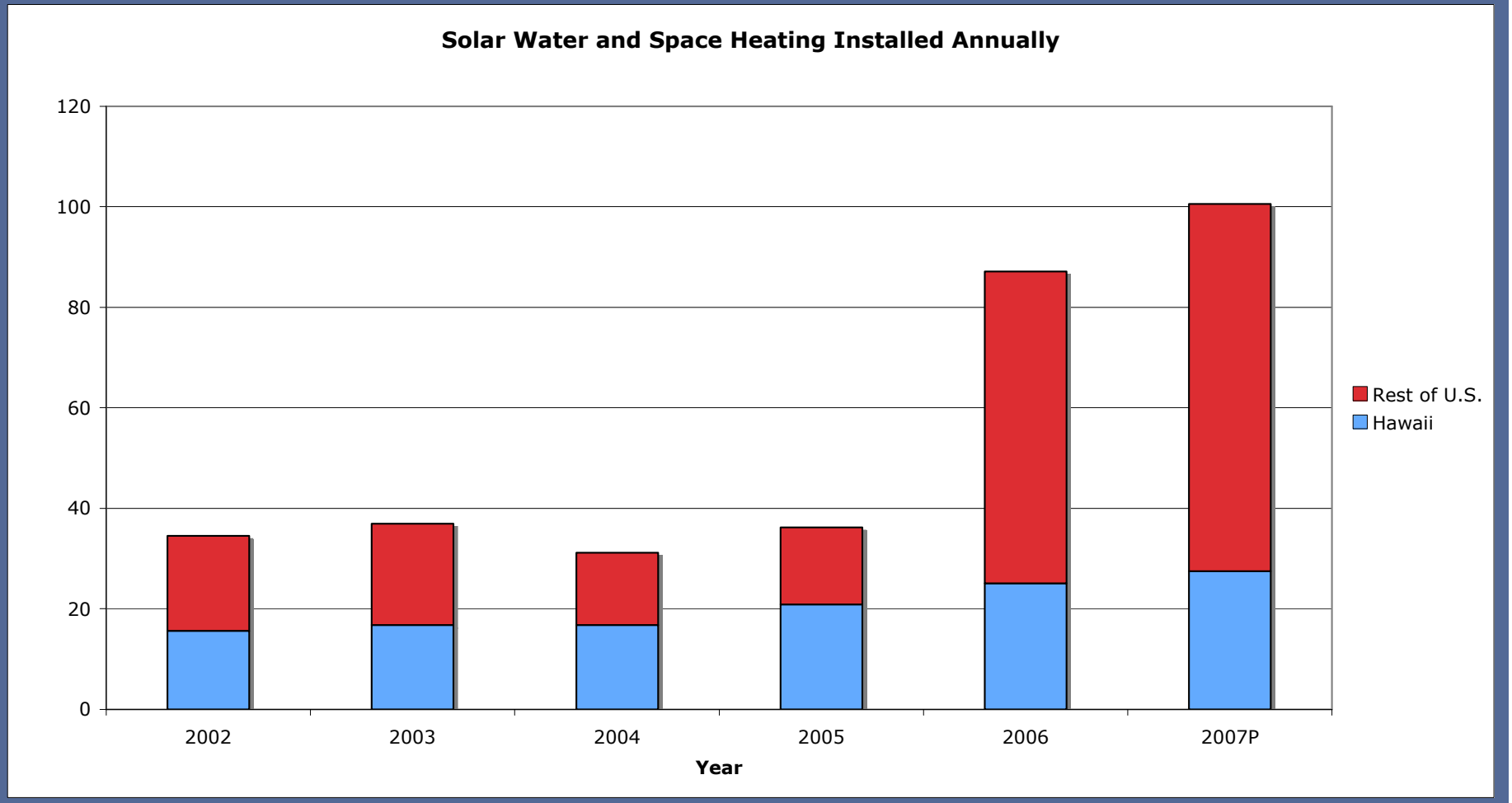
Climbing Conventional Energy Prices: U.S.



Solar Heating

- US solar water and air heating markets collapsed in 1986
- Currently 1,554 MWth SWH installed…
- Excluding 18,844 MWth pool heating (#1!)

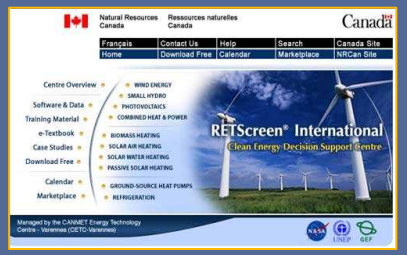
Recent Solar Thermal Growth



Solar Water Heating per capita

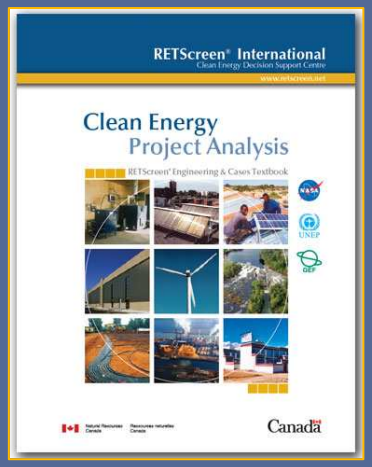
RETScreen® International
Clean Energy Decision Support Centre

- Free renewable energy analysis software sponsored by the Canadian government
- Targets cost reductions in project assessment
- Developed over 10 years and supported by full-time technical staff
- Training & technical support provided via an international network of RETScreen® Trainers
- Can used without licensing fees



e-Textbook & Case Studies

- Clean Energy Project Analysis: RETScreen® Engineering & Cases
  - Professional and University-level electronic textbook
  - Background of technologies
  - Detailed description of RETScreen® algorithms
  - 60+ international case studies of real projects
  - Available free-of-charge in English & French



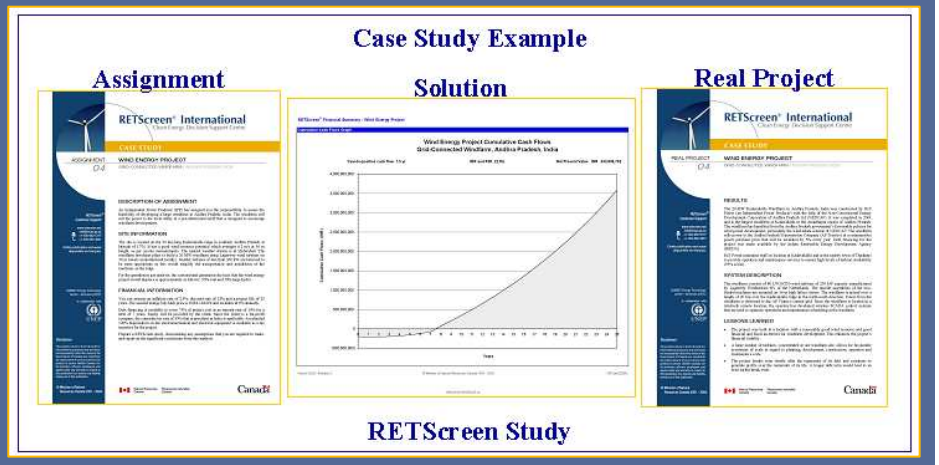
RETScreen® International : CLEAN ENERGY PROJECT CASE STUDIES

Wind Energy Project Case Studies:
These files are a collection of project case studies, including assignments, worked-out solutions (RETScreen Software Analysis) and information about how the projects fared in the real world.

Requirements: Adobe Acrobat Reader 4.0 or higher.

Click on the buttons below to open or download the PDF files (approx. 250 KB each).

File Name	Project Name	Location	Country	Assignment	Solution	Real Project
WIND01	Remote Community	Yukon Territory	Canada			
WIND02	Windfarm Repowering	Alberta	Canada			
WIND03	Green Power Production	Alberta	Canada			
WIND04	Grid-Connected Windfarm	Andhra Pradesh	India			
WIND05	Large Wind Turbines	Niedersachsen	Germany			
WIND06	Offshore Windfarm	Copenhagen	Denmark			



Energy Project Implementation Process

Pre-feasibility Analysis

Feasibility Analysis

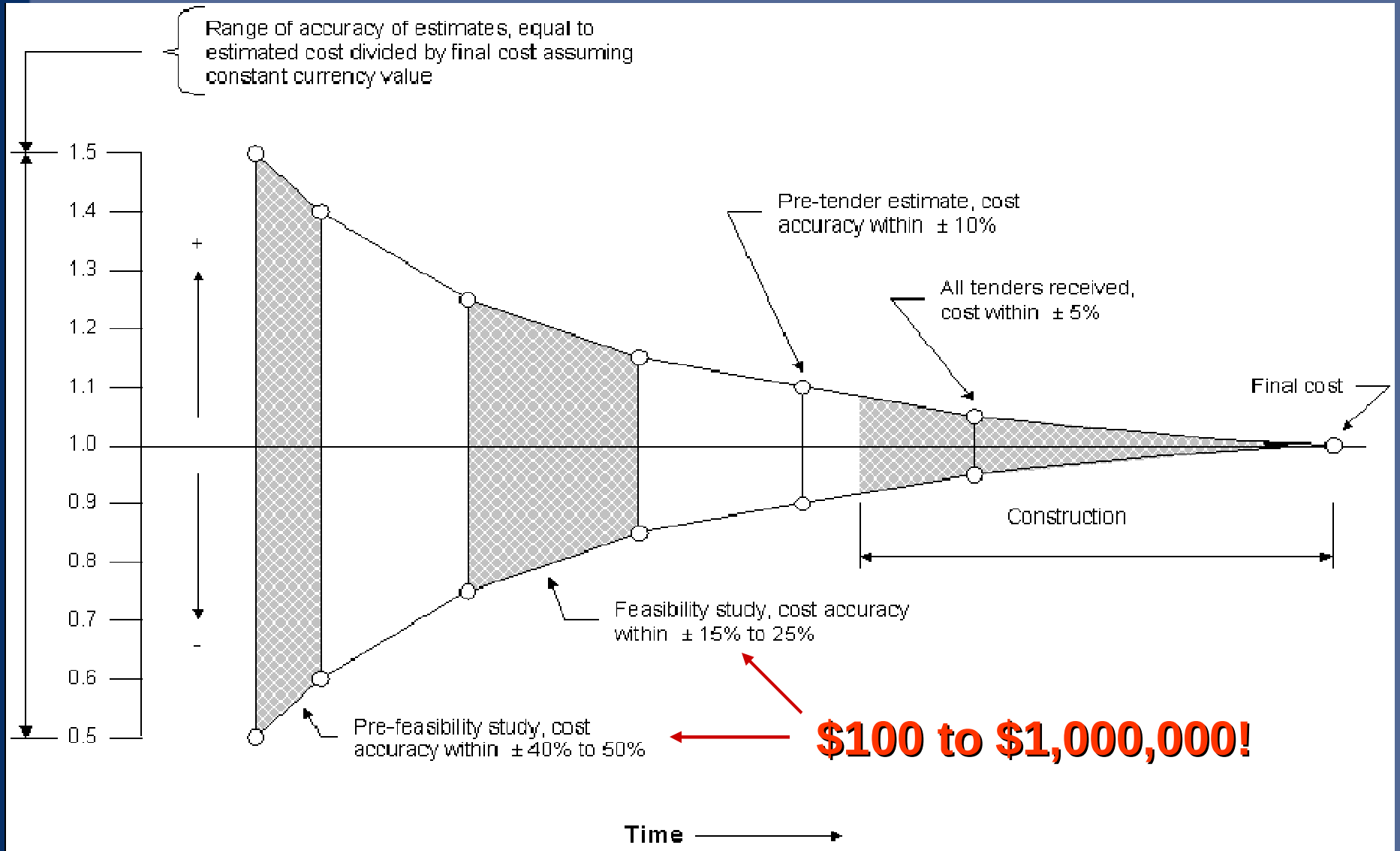
Development & Engineering

Construction & Commissioning

Significant barrier

Clean Energy projects not being routinely considered up-front!

Accuracy vs. Investment Cost Dilemma

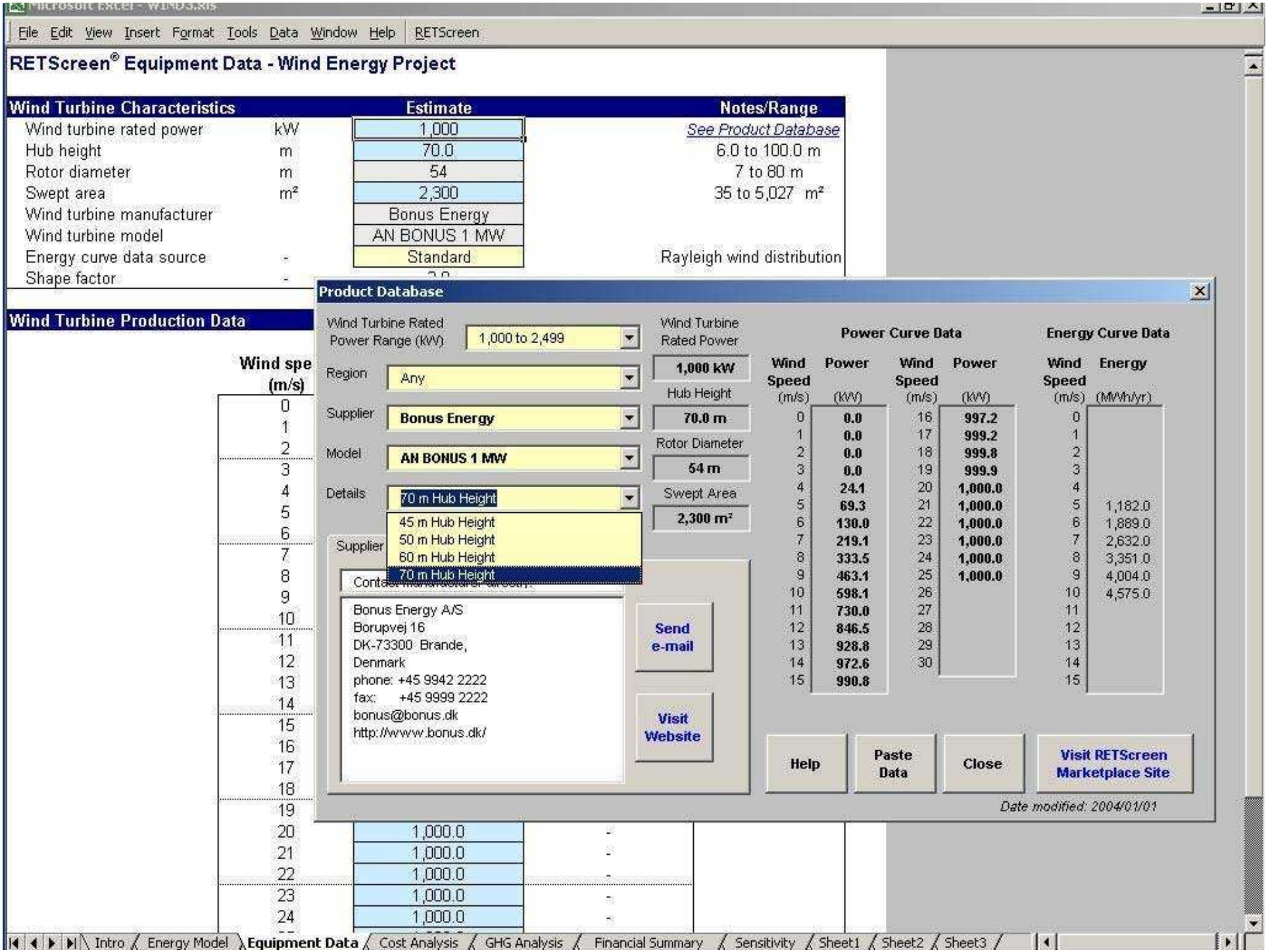


Cell Colour Coding

Input and Output Cells

white	Model output - calculated by the model.
yellow	User input - required to run the model.
blue	User input - required to run the model and online databases available.
grey	User input - for reference purposes only. Not required to run the model.

Site Conditions		Estimate	Notes/Range
Project name		Wind Farm	See Online Manual
Project location		Andhra, India	
Wind data source		Wind speed	
Nearest location for weather data		Hyderabad	See Weather Database
Annual average wind speed	m/s	6.2	
Height of wind measurement	m	30.0	3.0 to 100.0 m
Wind shear exponent	-	0.16	0.10 to 0.40
Wind speed at 10 m	m/s	5.2	
Average atmospheric pressure	kPa	94.4	60.0 to 103.0 kPa
Annual average temperature	°C	27	-20 to 30 °C


File Edit View Insert Format Tools Data Window Help RETScreen
RETScreen® Equipment Data - Wind Energy Project
Wind Turbine Characteristics
Estimate
Notes/Range
Wind turbine rated power kW 1,000 See Product Database
Hub height m 70.0 6.0 to 100.0 m
Rotor diameter m 54 7 to 80 m
Swept area m² 2,300 35 to 5,027 m²
Wind turbine manufacturer Bonus Energy
Wind turbine model AN BONUS 1 MW
Energy curve data source - Standard
Shape factor - Rayleigh wind distribution
Wind Turbine Production Data
Wind spe (m/s)
Product Database
Wind Turbine Rated Power Range (kW) 1,000 to 2,499
Region Any
Supplier Bonus Energy
Model AN BONUS 1 MW
Details 70 m Hub Height
45 m Hub Height
50 m Hub Height
60 m Hub Height
70 m Hub Height
Wind Turbine Rated Power 1,000 kW
Hub Height 70.0 m
Rotor Diameter 54 m
Swept Area 2,300 m²
Power Curve Data
Energy Curve Data
Wind Speed (m/s) Power (kW) Wind Speed (m/s) Power (kW) Wind Speed (m/s) Energy (MWh/yr)
0 0.0 16 997.2 0
1 0.0 17 999.2 1
2 0.0 18 999.8 2
3 0.0 19 999.9 3
4 24.1 20 1,000.0 4
5 69.3 21 1,000.0 5 1,182.0
6 130.0 22 1,000.0 6 1,889.0
7 219.1 23 1,000.0 7 2,632.0
8 333.5 24 1,000.0 8 3,351.0
9 463.1 25 1,000.0 9 4,004.0
10 598.1 26 10 4,575.0
11 730.0 27 11
12 846.5 28 12
13 928.8 29 13
14 972.6 30 14
15 990.8 15
Supplier
Contact manufacturer or distrib.
Bonus Energy A/S
Borupvej 16
DK-73300 Brande,
Denmark
phone: +45 9942 2222
fax: +45 9999 2222
bonus@bonus.dk
http://www.bonus.dk/
Send e-mail
Visit Website
Help
Paste Data
Close
Visit RETScreen Marketplace Site
Date modified: 2004/01/01
20 1,000.0 -
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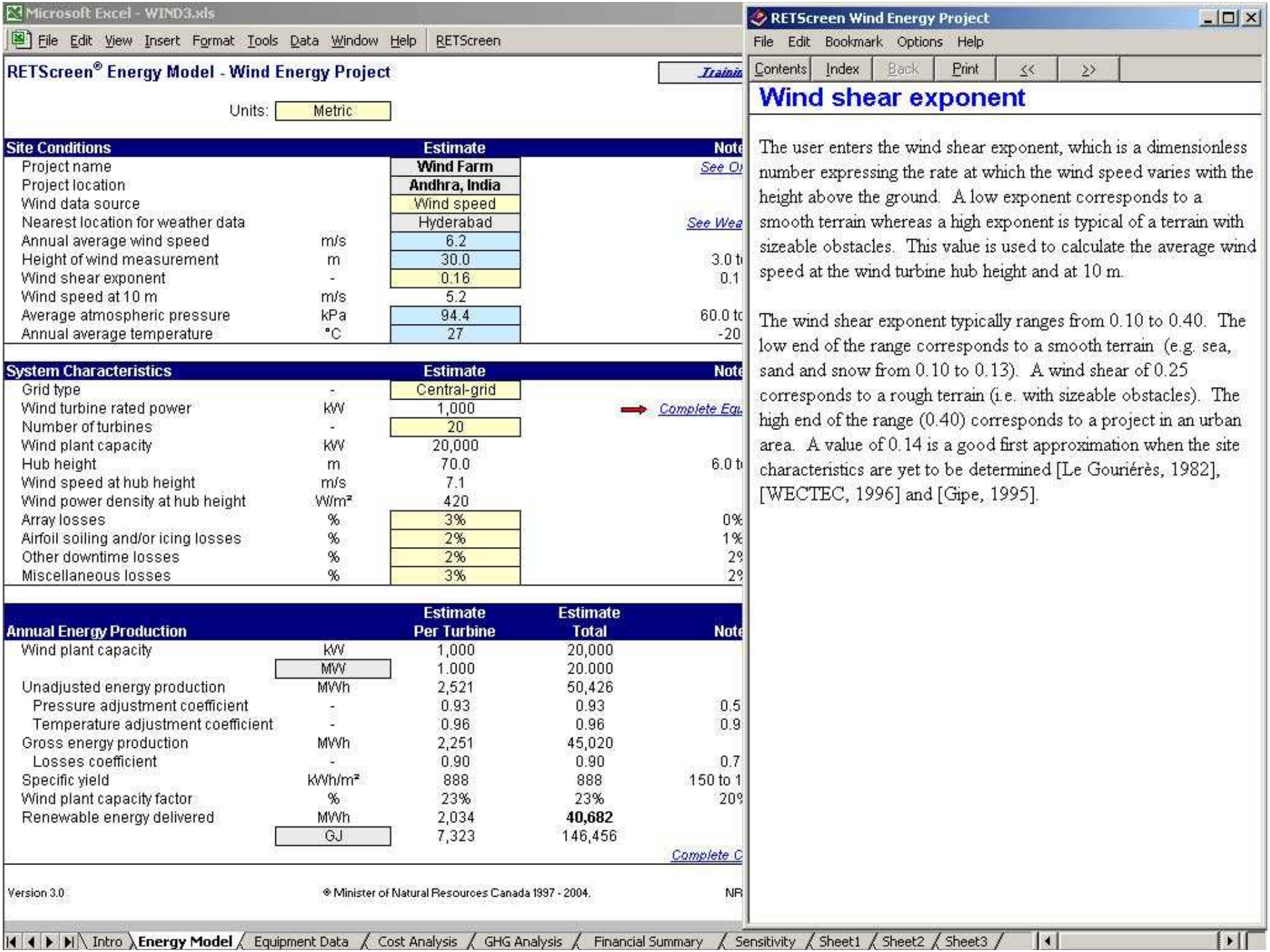
22 1,000.0 -
23 1,000.0 -
24 1,000.0 -
Intro Energy Model Equipment Data Cost Analysis GHG Analysis Financial Summary Sensitivity Sheet1 Sheet2 Sheet3



Microsoft Excel - WIND3.xls

File Edit View Insert Format Tools Data Window Help | RETScreen

RETScreen® Energy Model - Wind Energy Project

Trainin

Units: Metric

Site Conditions		Estimate	Note
Project name		Wind Farm	See Ou
Project location		Andhra, India	
Wind data source		Wind speed	
Nearest location for weather data		Hyderabad	See Wea
Annual average wind speed	m/s	6.2	
Height of wind measurement	m	30.0	3.0 t
Wind shear exponent	-	0.16	0.1
Wind speed at 10 m	m/s	5.2	
Average atmospheric pressure	kPa	94.4	60.0 to
Annual average temperature	°C	27	-20

System Characteristics		Estimate	Note
Grid type	-	Central-grid	
Wind turbine rated power	kW	1,000	Complete Equ
Number of turbines	-	20	
Wind plant capacity	kW	20,000	
Hub height	m	70.0	6.0 t
Wind speed at hub height	m/s	7.1	
Wind power density at hub height	W/m²	420	
Array losses	%	3%	0%
Airfoil soiling and/or icing losses	%	2%	1%
Other downtime losses	%	2%	2%
Miscellaneous losses	%	3%	2%

Annual Energy Production		Estimate Per Turbine	Estimate Total	Note
Wind plant capacity	kW	1,000	20,000	
	MW	1.000	20.000	
Unadjusted energy production	MWh	2,521	50,426	
Pressure adjustment coefficient	-	0.93	0.93	0.5
Temperature adjustment coefficient	-	0.96	0.96	0.9
Gross energy production	MWh	2,251	45,020	
Losses coefficient	-	0.90	0.90	0.7
Specific yield	kWh/m²	888	888	150 to 1
Wind plant capacity factor	%	23%	23%	20%
Renewable energy delivered	MWh	2,034	**40,682**	
	GJ	7,323	146,456	

Complete C

Version 3.0 © Minister of Natural Resources Canada 1997 - 2004. NR

Intro | Energy Model | Equipment Data | Cost Analysis | GHG Analysis | Financial Summary | Sensitivity | Sheet1 | Sheet2 | Sheet3

RETScreen Wind Energy Project

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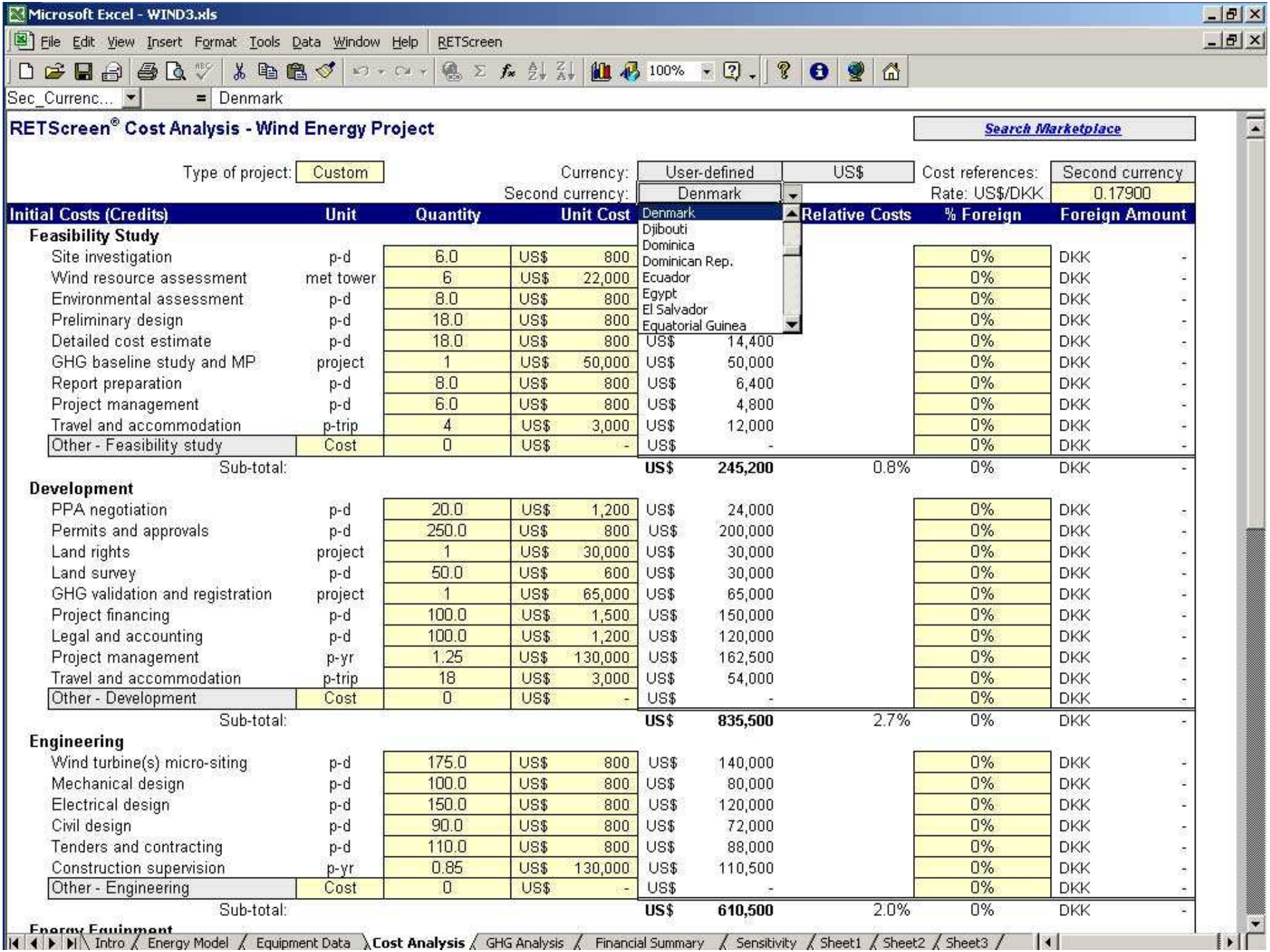
Wind shear exponent

The user enters the wind shear exponent, which is a dimensionless number expressing the rate at which the wind speed varies with the height above the ground. A low exponent corresponds to a smooth terrain whereas a high exponent is typical of a terrain with sizeable obstacles. This value is used to calculate the average wind speed at the wind turbine hub height and at 10 m.

The wind shear exponent typically ranges from 0.10 to 0.40. The low end of the range corresponds to a smooth terrain (e.g. sea, sand and snow from 0.10 to 0.13). A wind shear of 0.25 corresponds to a rough terrain (i.e. with sizeable obstacles). The high end of the range (0.40) corresponds to a project in an urban area. A value of 0.14 is a good first approximation when the site characteristics are yet to be determined [Le Gouriérès, 1982], [WECTEC, 1996] and [Gipe, 1995].


Microsoft Excel - WIND3.xls
File Edit View Insert Format Tools Data Window Help RETScreen
Sec_Currenc... = Denmark
RETScreen® Cost Analysis - Wind Energy Project
Search Marketplace
Type of project: Custom
Currency: User-defined US$
Second currency: Denmark
Cost references: Second currency
Rate: US$/DKK 0.17900
Denmark
Djibouti
Dominica
Dominican Rep.
Ecuador
Egypt
El Salvador
Equatorial Guinea
Initial Costs (Credits) Unit Quantity Unit Cost Relative Costs % Foreign Foreign Amount
Feasibility Study
Site investigation p-d 6.0 US$ 800 0% DKK -
Wind resource assessment met tower 6 US$ 22,000 0% DKK -
Environmental assessment p-d 8.0 US$ 800 0% DKK -
Preliminary design p-d 18.0 US$ 800 0% DKK -
Detailed cost estimate p-d 18.0 US$ 800 US$ 14,400 0% DKK -
GHG baseline study and MP project 1 US$ 50,000 US$ 50,000 0% DKK -
Report preparation p-d 8.0 US$ 800 US$ 6,400 0% DKK -
Project management p-d 6.0 US$ 800 US$ 4,800 0% DKK -
Travel and accommodation p-trip 4 US$ 3,000 US$ 12,000 0% DKK -
Other - Feasibility study Cost 0 US$ - US$ - 0% DKK -
Sub-total: US$ 245,200 0.8% 0% DKK -
Development
PPA negotiation p-d 20.0 US$ 1,200 US$ 24,000 0% DKK -
Permits and approvals p-d 250.0 US$ 800 US$ 200,000 0% DKK -
Land rights project 1 US$ 30,000 US$ 30,000 0% DKK -
Land survey p-d 50.0 US$ 600 US$ 30,000 0% DKK -
GHG validation and registration project 1 US$ 65,000 US$ 65,000 0% DKK -
Project financing p-d 100.0 US$ 1,500 US$ 150,000 0% DKK -
Legal and accounting p-d 100.0 US$ 1,200 US$ 120,000 0% DKK -
Project management p-yr 1.25 US$ 130,000 US$ 162,500 0% DKK -
Travel and accommodation p-trip 18 US$ 3,000 US$ 54,000 0% DKK -
Other - Development Cost 0 US$ - US$ - 0% DKK -
Sub-total: US$ 835,500 2.7% 0% DKK -
Engineering
Wind turbine(s) micro-siting p-d 175.0 US$ 800 US$ 140,000 0% DKK -
Mechanical design p-d 100.0 US$ 800 US$ 80,000 0% DKK -
Electrical design p-d 150.0 US$ 800 US$ 120,000 0% DKK -
Civil design p-d 90.0 US$ 800 US$ 72,000 0% DKK -
Tenders and contracting p-d 110.0 US$ 800 US$ 88,000 0% DKK -
Construction supervision p-yr 0.85 US$ 130,000 US$ 110,500 0% DKK -
Other - Engineering Cost 0 US$ - US$ - 0% DKK -
Sub-total: US$ 610,500 2.0% 0% DKK -
Energy Equipment
Intro Energy Model Equipment Data Cost Analysis GHG Analysis Financial Summary Sensitivity Sheet1 Sheet2 Sheet3

Microsoft Excel - WIND3.xls

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E50 = No

RETScreen® Greenhouse Gas (GHG) Emission Reduction Analysis - Wind Energy Project

Use GHG analysis sheet? Yes
Potential CDM project? No
Type of analysis: Standard

Background Information

Project Information

Project name	Wind Farm	Project capacity	20.0 MW	21	tonnes CO_2 =	1 tonne CH_4	(IPCC 1996)
Project location	Andhra, India	Grid type	Central-grid	310	tonnes CO_2 =	1 tonne N_2O	(IPCC 1996)

Global Warming Potential of GHG

Base Case Electricity System (Baseline)

Fuel type	Fuel mix (%)	CO_2 emission factor (kg/GJ)	CH_4 emission factor (kg/GJ)	N_2O emission (kg/GJ)	Fuel conversion efficiency (%)	T & D losses (%)	GHG emission (t_{CO2}/MWh)
Coal	50.0%	94.6	0.0020	0.0030	35.0%	12.0%	1.117
Large hydro	50.0%	0.0	0.0000	0.0000	100.0%	12.0%	0.000
Electricity mix	100%	153.6	0.0032	0.0049		12.0%	0.559

Does baseline change during project life? No

Proposed Case Electricity System (Wind Energy Project)

Fuel type	Fuel mix (%)	CO_2 emission factor (kg/GJ)	CH_4 emission factor (kg/GJ)	N_2O emission (kg/GJ)	Fuel conversion efficiency (%)	T & D losses (%)	GHG emission (t_{CO2}/MWh)
Electricity system							
Wind	100.0%	0.0	0.0000	0.0000	100.0%	12.0%	0.000

GHG Emission Reduction Summary

	Base case GHG factor (tCO2/MWh)	Proposed case GHG emission factor (tCO2/MWh)	End-use annual energy delivered (MWh)	Gross annual GHG emission reduction (t_{CO2})	GHG credits transaction fee (%)	Net annual GHG reduction (t_{CO2})
Electricity system	0.559	0.000	35,800	19,996	0.0%	**19,996**

Complete Financial Summary sheet

Intro | Energy Model | Equipment Data | Cost Analysis | GHG Analysis | Financial Summary | Sensitivity | Sheet1 | Sheet2 | Sheet3

Coming up next...

An introduction to solar water heating