

# Introduction to RETScreen Energy and Economic Analysis (Part II)

## *Solar Power for On-Grid and Off-Grid Applications*

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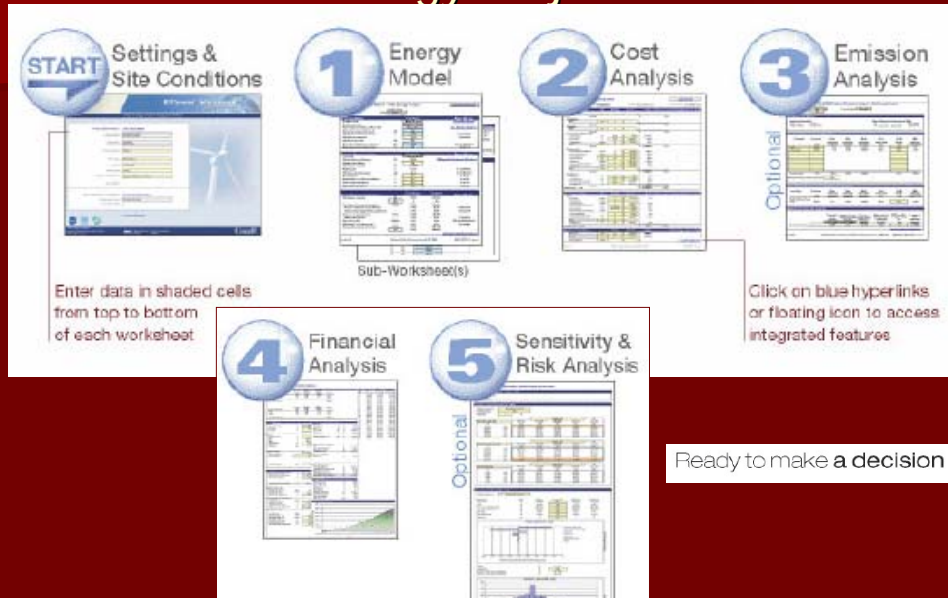
## Outline for This Session

- Quick Review of RETScreen
- Basics for Solar Power
  - Large Scale Example- On-grid
  - Smaller Scale- Off Grid
  - Water Pumping Applications
- Questions?

# A Quick Review on RETScreen

- [www.retscreen.net](http://www.retscreen.net)
- Free online, downloadable tool
- Builds capacity of Planners, Decision-Makers and Industry to implement renewable energy and EE projects

## 5-Step Standard Analysis of Renewable Energy Project



## Analyses Performed by RETScreen

- Site Conditions
  - Using Weather Database
- System Characteristics- with Product Database
- Annual Energy Production
- Performs Greenhouse Gas Analyses
- Pre-feasibility Study Costs
- Financial Analyses
- Sensitivity and Risk Analyses

## Solar Photovoltaic Applications Available on RETScreen

- Off Grid
- On Grid
- Water Pumping

## Let's Take a Look at the Website

- Download RETScreen Model for Solar PV, along with Textbook and User Manuals

## Two Examples for Today

1. Madison, WI- A large commercial application of ON-GRID Photovoltaic
2. Minneapolis, MN – or thereabouts– for a small scale, ISOLATED GRID application
3. And if we have time, a water pumping application

## Important Inputs to Note

- Weather Database
- Products Database (gives model numbers but it's up to you to research their quality)
- On-Grid, Off-Grid, or Water Pumping
  - Each will require a different set of inputs

## Inputs for Weather

- Choose the place you are analyzing
- Look at the Weather Database
- Choose Azimuth and Slope of PV
  - Slope- to maximize daily load throughout year, this should be equal to the latitude
    - If you want to maximize summer, add 15 degrees
  - Azimuth- In Northern Hemisphere, the PV should be facing the south, so azimuth is 0

# Site Latitude and PV Array Orientation

Site Latitude and PV Array Orientation		Estimate	Notes/Ran
Nearest location for weather data		Madison/Dane, WI	<a href="#">See Weather Data</a>
Latitude of project location	°N	43.1	-90.0 to 90
PV array tracking mode	-	Fixed	
Slope of PV array	°	43.1	0.0 to 90.0
Azimuth of PV array	°	0.0	0.0 to 180

## Monthly Inputs

# Monthly Inputs of Solar Radiation

Month	Fraction of month used (0 - 1)	Monthly average daily radiation on horizontal surface (kWh/m <sup>2</sup> /d)	Monthly average temperature (°C)	Monthly average daily radiation in plane of PV array (kWh/m <sup>2</sup> /d)	Monthly solar fraction (%)
January	1.00	1.86	-8.5	3.64	-
February	1.00	2.76	-5.9	4.45	-
March	1.00	3.71	0.6	4.58	-
April	1.00	4.71	7.9	4.89	-
May	1.00	5.76	14.3	5.32	-
June	1.00	6.36	19.6	5.58	-
July	1.00	6.23	22.0	5.59	-
August	1.00	5.39	20.4	5.34	-
September	1.00	4.10	15.6	4.71	-
October	1.00	2.85	9.5	4.00	-
November	1.00	1.74	2.1	2.88	-
December	1.00	1.47	-5.4	2.80	-
			<b>Annual</b>	<b>Season of use</b>	
Solar radiation (horizontal)		MWh/m <sup>2</sup>	1.43	1.43	
Solar radiation (tilted surface)		MWh/m <sup>2</sup>	1.64	1.64	
Average temperature		°C	7.7	7.7	

# Feasibility Studies

- Initial Costs
  - Feasibility Study
  - Development (Permits, Project Mgmt)
  - Engineering (System Design)
  - Energy Equipment Costs
  - Balance of Equipment
- Annual Costs
  - Operation and Maintenance, Property Taxes, Fuel
- Periodic Costs

# Feasibility Analysis

RETScreen® Cost Analysis - Photovoltaic Project

Type of analysis:  Currency:  Cost

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Qu
<b>Feasibility Study</b>						
Site investigation	p-h	10	\$ 60	\$ 600		
Preliminary design	p-h	13	\$ 60	\$ 780		
Report preparation	p-h	13	\$ 60	\$ 780		
Travel and accommodation	p-trip	2	\$ 700	\$ 1,400		
Other - Feasibility study	Cost	1	\$ 4,000	\$ 4,000		
Credit - Base case system	Credit	1	\$ 3,000	\$ (3,000)		
Sub-total :				\$ 4,560	1.6%	
<b>Development</b>						
Permits and approvals	p-h	4	\$ 60	\$ 240		
Project management	p-h	10	\$ 85	\$ 850		
Travel and accommodation	p-trip	1	\$ 2,000	\$ 2,000		
Other - Development	Cost	1	\$ 12,000	\$ 12,000		
Credit - Base case system	Credit	1	\$ 8,000	\$ (8,000)		
Sub-total :				\$ 7,090	2.4%	
<b>Engineering</b>						
PV system design	p-h	10	\$ 60	\$ 600		
Structural design	p-h	15	\$ 60	\$ 900		
Electrical design	p-h	12	\$ 60	\$ 720		
Tenders and contracting	p-h	10	\$ 60	\$ 600		
Construction supervision	p-h	15	\$ 60	\$ 900		
Other - Engineering	Cost	1	\$ 55,000	\$ 27,500		
Credit - Base case system	Credit	1	\$ 5,000	\$ (5,000)		
Sub-total :				\$ 26,220	9.0%	
<b>Energy Equipment</b>						

# Greenhouse Gas Analysis

- Used if you want to gain credit for reducing carbon emissions
- Especially good if you'd like to join Chicago Climate Exchange or if, in the future, our country adopts a carbon tax/cap-and-trade system for carbon.

## An Example Fuel Mix for GHG Analysis

Base Case Electricity System (Baseline)

Fuel type	Fuel mix (%)	CO <sub>2</sub> emission factor (kg/GJ)	CH <sub>4</sub> emission factor (kg/GJ)	N <sub>2</sub> O emission factor (kg/GJ)	Fuel conversion efficiency (%)
Natural gas	25.0%	56.1	0.0030	0.0010	45.0%
Nuclear	15.0%	0.0	0.0000	0.0000	30.0%
Large hydro	10.0%	0.0	0.0000	0.0000	100.0%
Coal	50.0%	94.6	0.0020	0.0030	35.0%
Electricity mix	100.0%	180.8	0.0049	0.0053	

# Financial Summary

## ■ INPUTS:

- Avoided cost of energy
- Input for renewable production credit
- Debt ratio/debt interest rate/debt term
- Energy cost escalation rate
- Any incentives/grants

## ■ RETScreen calculates you:

- Pre-/After-tax IRR and ROI
- Simple Payback/Year to positive cash flow
- NPV and Benefit-cost ratio

# Financial Summary

Annual Energy Balance				
Project name	Off Grid Small Scale			
Project location	Minneapolis/St. Paul, MN			
Renewable energy delivered	MWh	5,738	Nominal PV array power	kWp 3.0
Firm RE capacity	kW	-	Equivalent DC energy demand	MWh 11.1
Application type	Off-grid		Net GHG reduction	t <sub>co2</sub> /yr 3.7
			Net GHG emission reduction - 10 yrs	t <sub>co2</sub> 37.7
			Net GHG emission reduction - 30 yrs	t <sub>co2</sub> 113.1
			Type of fuel displaced	Grid n

Financial Parameters				
Avoided cost of energy	\$/kWh	0.900	Debt ratio	% 75.0
RE production credit	\$/kWh	0.500	Debt interest rate	% 7.0
RE production credit duration	yr	25	Debt term	yr 2
RE credit escalation rate	%	2.0%	Income tax analysis?	yes/no
GHG emission reduction credit	\$/t <sub>co2</sub>	100.0		
GHG reduction credit duration	yr	10		
GHG credit escalation rate	%	2.0%		
Energy cost escalation rate	%	5.0%		
Inflation	%	2.5%		
Discount rate	%	9.0%		
Project life	yr	30		

Project Costs and Savings				
<b>Initial Costs</b>			<b>Annual Costs and Debt</b>	
Feasibility study	5.6%	\$ 6,090	O&M	\$ 95
Development	9.6%	\$ 10,470	Fuel	\$
Engineering	19.3%	\$ 21,025	Debt payments - 25 yrs	\$ 7,02
Energy equipment	16.5%	\$ 18,000	<b>Annual Costs and Debt - Total</b>	<b>\$ 7,97</b>
Balance of equipment	46.0%	\$ 50,199	<b>Annual Savings or Income</b>	
Miscellaneous	3.1%	\$ 3,343	Energy savings/income	\$ 5,16
<b>Initial Costs - Total</b>	<b>100.0%</b>	<b>\$ 109,128</b>	RE production credit income - 25 y	\$ 2,86
Incentives/Grants		\$ 10,000	GHG reduction income - 10 yrs	\$ 37
<b>Periodic Costs (Credits)</b>			<b>Annual Savings - Total</b>	<b>\$ 8,41</b>
Inverter Repair/Replacement		\$ 15,000	Schedule yr #	13,26

# Option for Sensitivity Analysis and Risk Analysis

- Helps the user estimate the sensitivity of important financial indicators in relation to key technical and financial parameters
  - Example: if the cost of electricity goes down by \$0.05, will the project still be viable?

## Sensitivity Analysis

RETScreen® Sensitivity and Risk Analysis - Photovoltaic Project

Use sensitivity analysis sheet?  Yes  
 Perform risk analysis too?  Yes  
 Project name  
 Project location

Yes  
 Yes  
 Off Grid Small Scale  
 Minneapolis/St. Paul, MN

Perform analysis on  After-tax IRR and ROI  
 Sensitivity range   
 Threshold  %

Sensitivity Analysis for After-tax IRR and ROI						
		Avoided cost of energy (\$/kWh)				
Initial costs (\$)		0.7200	0.8100	0.9000	0.9900	1.0800
		-20%	-10%	0%	10%	20%
87,302	-20%	18.5%	22.8%	27.1%	31.4%	35.8%
98,215	-10%	13.0%	16.3%	19.7%	23.1%	26.5%
<b>109,128</b>	0%	9.3%	12.1%	<b>14.9%</b>	17.7%	20.4%
120,040	10%	6.6%	9.1%	11.5%	13.9%	16.2%
130,953	20%	4.5%	6.8%	9.0%	11.1%	13.1%

		Avoided cost of energy (\$/kWh)				
Annual costs (\$)		0.7200	0.8100	0.9000	0.9900	1.0800
		-20%	-10%	0%	10%	20%
760	-20%	10.1%	12.9%	15.7%	18.5%	21.3%
855	-10%	9.7%	12.5%	15.3%	18.1%	20.9%
<b>950</b>	0%	9.3%	12.1%	<b>14.9%</b>	17.7%	20.4%
1,045	10%	8.9%	11.7%	14.5%	17.2%	20.0%
1,140	20%	8.5%	11.3%	14.1%	16.8%	19.6%

		Debt ratio (%)				
Debt interest rate (%)		60.0%	67.5%	75.0%	82.5%	90.0%
		-20%	-10%	0%	10%	20%
5.6%	-20%	13.9%	15.5%	18.1%	23.9%	83.0%
6.3%	-10%	13.2%	14.4%	16.5%	20.7%	51.4%
<b>7.0%</b>	0%	12.4%	13.4%	<b>14.9%</b>	17.8%	30.9%

## Let's Look at the RETScreen Model

- First, the large scale on-grid
- Then, the small-scale off-grid

## Things to remember with RETScreen

- Lots of Inputs– which means many ways to make errors!
  - Good to do research beforehand, and definitely before you actually start a project
- This is thorough pre-assessment, but you may have to go through another assessment when doing the “real thing”

Questions?

Thank you!

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