

SOLAR ENERGY TECHNOLOGY

ETC ENERGY

Modeling Software for RE Systems

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CASINDO

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Structure of this Presentation

- Software categories
- Examples of available software
- Where to get software
- Evaluation of different software
- HOMER software

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Software Categories

- Pre-feasibility Tools
- Sizing Tools
- Simulation Tools
- Open architecture environment

Trend:
Engineers tools => wider audiences

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Considerations

- Software is a tool => it requires an expert to manipulate the tool
- Garbage in => Garbage out
- Software needs to be verifiable
- May not be designed for this region
- First obtain an idea of what is having the largest effect, before starting with details

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Software Examples (1)

Program	Function	Plant	Outputs
RET Screen	Prefeasibility	Hybrids	Power, LCC, GHG Emissions
NSOL!	Sizing	Mainly PV	Power, Fuel Consumption
HOMER	Sizing, Optimisation	Hybrids	Cost, Configuration
Hybrid Designer	Sizing	Hybrids	Cost, Configuration
PVSYST	Sizing, Simulation	PV	Cost, Configuration

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Software Examples (2)

PV*SOL	Sizing	PV	Cost, Emissions
VIPOR	Optimisation	Any	Costs/Profit, Configuration (mini-grid or stand alone)
Hybrid 2	Simulation	Hybrids	Performance predictions, Costs
PV Design Pro-S	Simulation	PV	Power, Load Consumption, Costs
SOMES	Simulation, Optimisation	Hybrids	Power, Reliability, Costs
Solar Pro	Simulation	PV	Power

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Where to Get? (1)

- RETScreen
http://retscreen.gc.ca
- FATE2-P3.1.1
www.nrel.gov/international/tools/tools.html
- NSOL!
Www.orionenergy.com/Nsol/nsolhome.html
- HOMER
www.nrel.gov/homer
- Hybrid Designer
www.edr.uct.ac.za
- PVSYS3.21
www.unige.ch/cuepe/pvsyst/index.htm
- PV*SOL Pro 2.2
www.valentin.de

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Where to Get? (2)

- PV*SOL Pro 2.2
www.valentin.de
- ViPOR
www.nrel.gov/international/vipor
- Hybrid2
www.ecs.umass.edu/mie/labs/rerl
- Solar Design Studio v5.0
www.mauisolarsoftware.com
- SOMES
www.che.uu.nl
- Solar Pro
www.lapsys.co.jp/english/e_index.html
- SUNDI
www.ftp://emsolar.ee.tu-berlin.de/pub/progs/sundi

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Photovoltaic System Builder

- Developed in South Africa
- Inputs: load power, days autonomy, panel type, battery type, weather data, array tilt angle, system voltage, inverter efficiency, depth of discharge
- Outputs: number of batteries and panels, excess power

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PSB Data Input Screen

The screenshot shows the 'Photovoltaic System Builder 1.2' interface. It includes fields for Client/Site (Chicken farm), File name (chick1.psb), System location (Gaborone), System voltage (12V), Battery type (DELTEC 1250), and Module type (SHELL RSM6DC). It also displays calculated values such as Minimum modules (1), Total array power (60W), and Total load (16.3 Ahrs/day). There are buttons for 'Add / Remove modules' and 'Add/change input data'.

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PSB Output Screen

The screenshot shows the 'Sizing Output' window for a 'PHOTOVOLTAIC SYSTEM BUILDER'. It provides a summary of system parameters:

Category	Parameter	Value
SYSTEM	Location	Gaborone
SYSTEM	Peak Sun/Hours	5.70
SYSTEM	Array tilt angle	30
SYSTEM	System voltage	12V
ARRAY	Module type used	SHELL RSM6
ARRAY	Total number of modules	1
ARRAY	Module charge current	3.70 Amp
ARRAY	Peak array power	60 W
ARRAY	Number of series modules	1
ARRAY	Excess generator capacity	29.8 %
ARRAY	Number of parallel modules	1
BATTERIES	Battery type used	DELTEC 1250
BATTERIES	Total useable ahrs to load shed	126 Ahrs
BATTERIES	Number of series batteries	1
BATTERIES	DOD at load shed	60 %
BATTERIES	Number of parallel batteries	2
BATTERIES	Days autonomy to load shed	7.8 days
BATTERIES	Total number of batteries	2
BATTERIES	Battery recharge days	26.0 days
BATTERIES	Unit capacity (100 ah)	105 Ahrs
BATTERIES	Daily battery cycling	7.7%
BATTERIES	Total capacity (100 ah)	210 Ahrs
LOAD	Total DC load	195 Whrs/d
LOAD	Daily Amp hour load	16 Ahrs/day
LOAD	Total AC load	Whrs/d
LOAD	Inverter efficiency	85 %
LOAD	Total load	195 Whrs/d
LOAD	Safety factor	10 %

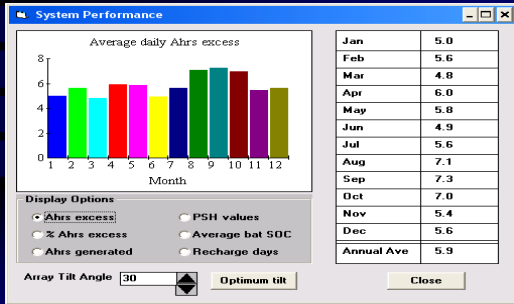
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PSB Ah Generated

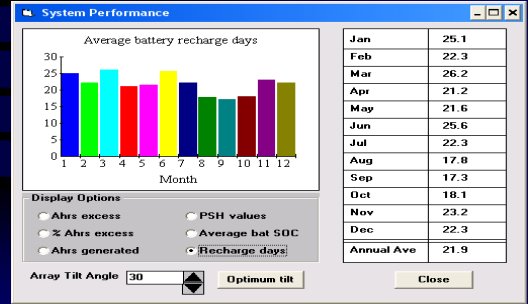
The screenshot shows the 'System Performance' window. It features a bar chart titled 'Average daily Ahrs generated' showing values for each month from 1 to 12. To the right is a table of monthly Ahrs generated values.

Month	Ahrs generated
Jan	21.3
Feb	21.9
Mar	21.1
Apr	22.2
May	22.1
Jun	21.2
Jul	21.9
Aug	23.3
Sep	23.5
Oct	23.2
Nov	21.7
Dec	21.9
Annual Ave	22.1

PSB Daily Ahr Excess



PSB Battery Recharge Days



RETScreen (PV2000)

- Pre-feasibility tool
- Developed by CEDRL Canada
- Excel based
- Freeware <http://retscreen.gc.ca>
- Sizing and costing
- Outputs: Power, LCC, GHG Emissions

RETScreen International is a standardized and integrated renewable energy project analysis software. This tool provides a common platform for both decision-support and ease-of-building purposes. RETScreen can be used worldwide to evaluate the energy production, life-cycle costs and greenhouse gas emissions reduction for various renewable energy technologies. RETScreen is made available free-of-charge by the Government of Canada through Natural Resources Canada's CANMET Energy Conversion Research Laboratory (CEDRL). The user is encouraged to properly register at the RETScreen website so that CEDRL can report on the global use of RETScreen.

Photovoltaic Project Model

TO START (click here)

- Brief Calculation & Model Flow Chart
- Cell Colour Coding

RETScreen is available free-of-charge at:
<http://retscreen.gc.ca>

RETScreen Features (click to access info)

- Online Manual
- Product Data
- Weather Data
- Cost Data
- Currency Options

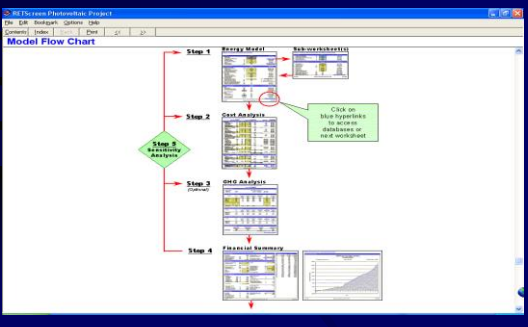
Model Worksheets (click to access sheets)

- Energy Model
- Solar Resource & System Load
- Cost Analysis
- Greenhouse Gas Analysis
- Financial Summary
- Blank Worksheets (3)

Contributors:

- Technology Support
- Collaborating Organizations
- UNEP
- NASA

RETScreen Flow Chart



Site and System Characteristics

RETScreen® Energy Model - Photovoltaic Project			
Site Conditions	Estimate	Notes/Range	
Project Name	RETScreen		
Project location	Natural Map, Argentina		
Nearest location for weather data	Mendoza	Closest RETScreen User	
Latitude of project location	-39.0	-90.0 to 90.0	
Annual solar radiation (flat surface)	1.62		
Annual average temperature	14.5	-20.0 to 30.0	
DC energy demand for months analysed	MWh 2.845		
AC energy demand for months analysed	MWh 2.102		
System Characteristics			
Application type	Estimate	Notes/Range	
PV system configuration	Grid-connected		
Base Case Power System			
Source	Generator		
Fuel type	Diesel (2.0)		
Specific fuel consumption	L/kWh 0.550000		
Power Conditioning			
Suggested inverter (DC to AC) capacity	kW (AC) 0.36		
Inverter capacity	kW (AC) 0.5		
Average inverter efficiency	% 90%	80% to 98%	
Miscellaneous power conditioning losses	% 0%	0% to 10%	
Battery			
Days of autonomy required	d 2.0	1.0 to 16.0	
Nominal battery voltage	V 25.0	12.0 to 120.0	
Battery efficiency	% 80%	50% to 95%	
Maximum depth of discharge	% 70%	20% to 98%	
Charge controller (DC to DC) efficiency	% 95%	80% to 98%	
Battery temperature control	Minimum		
Minimum battery temperature	-C	0.0 to 16.0	
Average battery temperature derating	% 3%	0% to 50%	
Suggested nominal battery capacity	Ah 1.770		
Nominal battery capacity	Ah 1.770		
PV Array			
PV module type	mono-Si		
PV module manufacturer / model #	13.9%		See Product Database
Nominal PV module efficiency	% 13.9%	4.0% to 16.0%	
NOCT	-C 45	40 to 55	
PV temperature coefficient	% / -C 0.42%	0.10% to 0.52%	
PV array controller	% 0%		
Miscellaneous PV array losses	% 0.0%	0.0% to 20.0%	
Suggested nominal PV array power	kWp 1.30		
Nominal PV array capacity	kWp 1.30		

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Inputs - Grid

Rate	Price (\$/kWh)	Demand (\$/kW/yr)	Demand (\$/kW/yr)
0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000

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Help System

Size (kW)	Capital (\$)	Replacement (\$)	O&M (\$/yr)
0.000	1.000	0.000	0.000
0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000

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Help System

Size (kW)	Capital (\$)	Replacement (\$)	O&M (\$/yr)
0.000	1.000	0.000	0.000
0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000

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HOMER Calculates Life-Cycle Cost

- ◆ The total cost of a system over its useful life
 - Initial capital costs
 - Operating and maintenance costs
 - Fuel costs
 - Component replacement costs
 - Grid purchases and sales
 - Salvage value
- ◆ Expressed as a lump sum in "today's dollars"

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Outputs

Component	Initial Capital (\$)	Annualized Capital (\$/yr)	Annualized Replacement (\$/yr)	Annual O&M (\$/yr)	Annual Fuel (\$/yr)	Total Annualized (\$/yr)
PV Array	1,200	94	0.0	0	0	94
SW/AC/DC	1,200	94	29.2	20	0	143
Battery	250	20	13.8	8	0	42
Total	2,650	208	43.0	28	0	275

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Outputs - Optimization

- ◆ What size PV array?
- ◆ How many wind turbines?
- ◆ How many batteries?
- ◆ What size generator?
- ◆ RET vs. Generator

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Optimization

Wind Turbine Inputs

Choose a wind turbine type and enter at least one quantity and capital cost value in the Costs table. Include the cost of the tower, controller, wiring, installation, and labor. Set it searches for the optimal system, HOMER considers each quantity in the Size to Consider table.

Hold the pointer over an element or click Help for more information.

Turbine type: **WT-13.1**

Turbine properties:
 Abbreviation: WT1 (used for column headings)
 Manufacturer: Ringo Windpower
 Website: www.ringowind.com
 Current: DC

Quantity	Capital (\$)	Replacement (\$)	DCM (\$/kW)
1	2900	2900	109

Size to consider:
 Quantity: 0, 1, 2

Other:
 Lifetime (yr): 20
 Hub height (m): 15

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Optimization

PV (Photovoltaic) Inputs

Enter at least one size and capital cost value in the Costs table. Include all costs associated with the PV (photovoltaic) system, including modules, mounting hardware, and installation. Set it searches for the optimal system. HOMER considers each PV array capacity in the Size to Consider table.

Note that by default, HOMER sets the slope value equal to the value from the Solar Resource Input window. Hold the pointer over an element or click Help for more information.

Costs:

Size (kW)	Capital (\$)	Replacement (\$)	DCM (\$/kW)
1.000	1000	5000	0
0.500	0	0	0.000
0.750	0	0	0.750
1.000	0	0	1.000
2.000	0	0	2.000
4.000	0	0	4.000

Properties:
 Lifetime (years): 25
 Degrading factor (%): 30
 Tracking system: No Tracking
 Slope (degrees): 48
 Azimuth (degrees W of S): 0
 Ground reflectance (%): 20

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Optimization

Battery Inputs

Choose a battery type and enter at least one quantity and capital cost value in the Costs table. Include all costs associated with the battery bank, such as mounting hardware, installation, and labor. Set it searches for the optimal system. HOMER considers each quantity in the Size to Consider table.

Hold the pointer over an element or click Help for more information.

Battery type: **Trojan T12P**

Battery properties:
 Manufacturer: Trojan Battery Company
 Website: www.trojanbattery.com
 Nominal voltage: 6 V
 Nominal capacity: 380 Ah (2.16 kWh)
 Lifetime (cycles): 1,075

Quantity	Capital (\$)	Replacement (\$)	DCM (\$/kWh)
1	220	220	4.00

Size to consider:
 Quantity: 0, 6, 12, 18, 24, 30, 36, 42

Advanced:
 Minimum battery life (yr): 1

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Optimization Results

Sensitivity Results

Double-click on a system below for simulation results.

	PV (kW)	Gen (kW)	Batt. (kWh)	Conv. (%)	Initial Capital (\$)	Total NPC (\$)	COE (\$/kWh)	Ren. Freq. (%)	Capacity Shortage (%)	Gasoline (L)	Gen (kWh)
1.00	1	2.6	12	1.00	\$15,100	\$25,400	0.952	0.70	0.00	726	800
2.00	1	2.6	12	2.00	\$12,840	\$25,589	0.682	0.70	0.00	829	858
2.00	2	2.6	12	2.00	\$23,360	\$28,400	0.739	1.00	0.01	799	976
2.00	2.6	12	2.00	\$18,290	\$29,059	0.746	0.69	0.00	0.00	2,415	2,400
4.00	2.6	32	2.00	\$36,540	\$42,554	1.113	1.00	0.02	0.00	0.00	0.00
2.6	2	2.6	1.00	\$9,450	\$48,091	1.234	0.62	0.00	0.00	3,298	6,299
2.6	1.00	2.6	1.00	\$16,450	\$48,305	1.242	0.66	0.00	0.00	2,637	5,114
2.6	2.6	2.6	1.00	\$300	\$59,893	1.306	0.00	0.00	0.00	4,570	8,750
2.6	0.75	2.6	0.75	\$8,463	\$52,783	1.354	0.26	0.00	0.00	4,039	7,753

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Outputs - Sensitivity Analysis

Primary Load: 1,400 kWh/d, 127 kW peak

75 kW Diesel, 150 kW Diesel

AC, Converter, DC, Battery

- ◆ Key variables may be uncertain
 - Wind speed
 - Fuel price
 - Wind turbine life
- ◆ What if our guesses are wrong?

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Sensitivity Analysis

Gasoline Inputs

Enter the fuel price. The fuel proportion can only be changed when creating a new fuel blend. (See the Generator Input or Boiler Input window.)

Hold the pointer over an element or click Help for more information.

Price (\$/L): **0.6**

Unit usage to \$-5/yr: 50.00

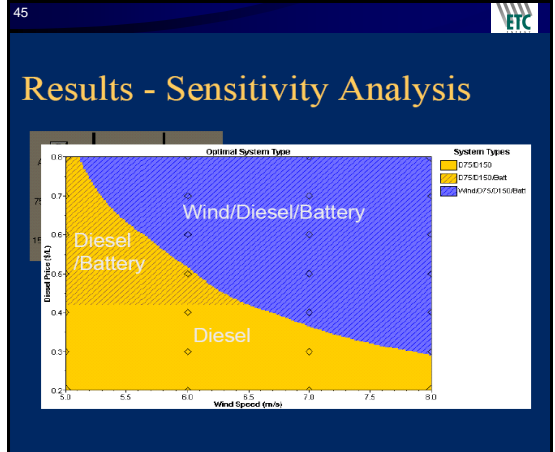
Fuel properties:
 Lower heating value: 44 MJ/kg
 Density: 740 kg/m³
 Carbon content: 86 %
 Sulfur content: 0.32 %

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Sensitivity Analysis

Enter the fuel price. The fuel proportion can only be changed if there are no other Diesel in the Diesel Input or Diesel Input list. Add the price over an internet name or click Help for more.

Variable	Value	Unit
Gasoline Price	0.600	\$/L
1	0.200	
2	0.400	
3	0.800	
4	1.000	
5		
6		
7		
8		
9		
10		



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Many Other Kinds Of Systems

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Other Features

- ◆ Cogen systems
- ◆ Net Metering
- ◆ Multiple Grid Rates

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HTML Input Summary

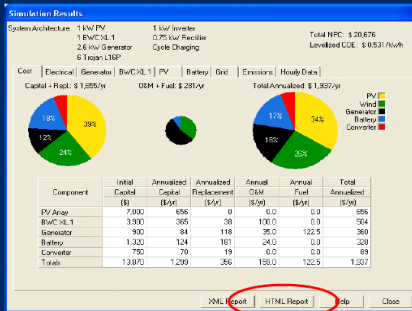
Variable	Value	Unit
1	1	CC
2	1	CC
3	1	CC
4	1	CC
5	1	CC
6	1	CC
7	1	CC
8	1	CC
9	1	CC
10	1	CC
11	1	CC
12	1	CC
13	1	CC
14	1	CC
15	1	CC
16	1	CC
17	1	CC
18	1	CC
19	1	CC
20	1	CC
21	1	CC
22	1	CC
23	1	CC
24	1	CC
25	1	CC
26	1	CC
27	1	CC
28	1	CC
29	1	CC
30	1	CC
31	1	CC
32	1	CC

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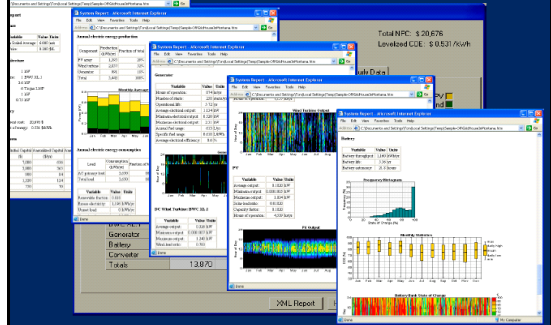
HTML Input Summary



HTML System Summary



HTML System Summary



HOMER summary - Pros

- ◆ Directly compares and optimizes system alternatives
- ◆ More realistic model of relationship between resource and load
 - although not too detailed keeping it manageable to build
 - often as good as the estimates you can make
- ◆ Excellent graphical outputs
- ◆ Sensitivity analysis
- ◆ Flexibility

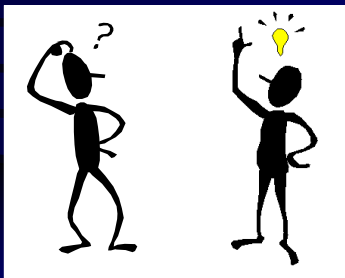


HOMER Summary - Cons

- ◆ Cannot model purely thermal systems
- ◆ More complex model to build
 - and see
 - building model is non-linear
- ◆ Required input data is often not available and needs to be simulated
 - note: simulations can be made with reasonable accuracy and ease
 - still better than a single number input



QUESTIONS ?



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