


# Photovoltaic Hybrid System Sizing and Simulation Tools: Status and Needs



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PV-Horizon

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Presentation from [www.RERinfo.ca](http://www.RERinfo.ca)

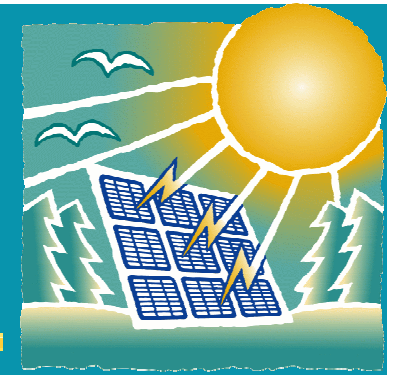


Natural Resources  
Canada

Ressources naturelles  
Canada

CANMET-EDRL 

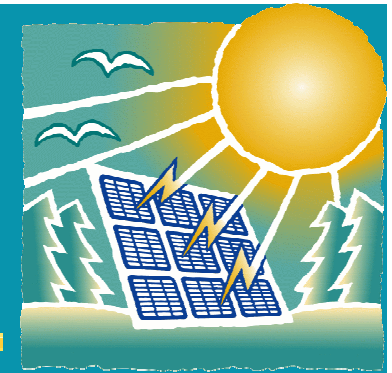
# Overview



- Categories of Software + Examples
- Trends and Promising Directions
- Achievements
- Remaining Challenges



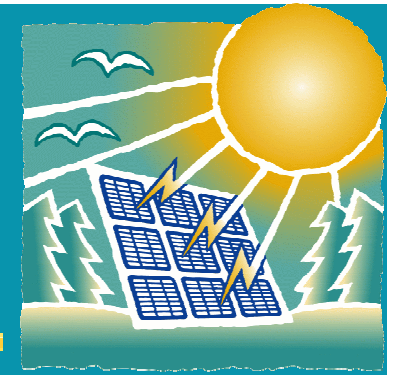
# A Vast Range of Software



- 15+ software packages for PV hybrid systems
- range in complexity, ease-of-use, and cost
- how to differentiate them?



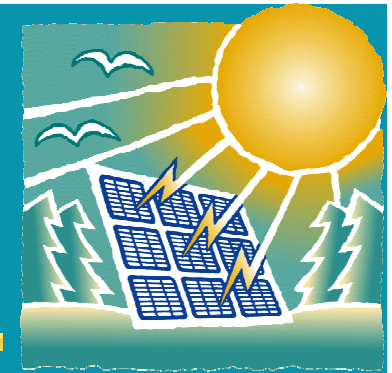
# Four Categories



- Based on purpose, form, inputs/outputs:
  - ◆ Prefeasibility
  - ◆ Sizing
  - ◆ Simulation
  - ◆ Open-architecture environments



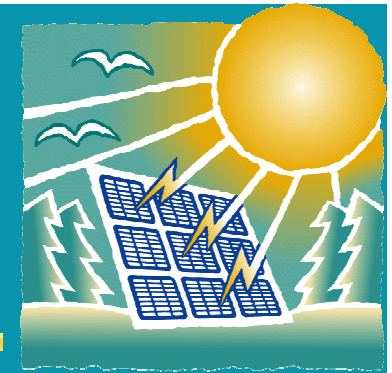
# Prefeasibility Tools



- Provides a quick first assessment
- Minimal input requirements
- Provide summary of key outputs
- Energy calculations approximate
- Cost, financial analysis well developed
- Environmental attributes included



# Example: RETScreen



Microsoft Excel - PV2000

RETScreen

RETScreen® Cost Analysis - Photovoltaic Project

Type of project: Custom Currency: \$ Cost references: None

Initial Costs (Credits)	Unit	Quantity	Unit Cost	Amount	Relative Costs	Quantity Range	Unit Cost Range
<b>Feasibility Study</b>							
Site investigation	p-h	8	\$ 65	\$ 520	-	-	-
Preliminary design	p-h	20	\$ 65	\$ 1,300	-	-	-
Report preparation	p-h	10	\$ 65	\$ 650	-	-	-
Travel and accommodation	p-trip	1	\$ 1,200	\$ 1,200	-	-	-
Other	Cost	0	\$ -	\$ -	-	-	-
Credit - Base case system	Credit	1	\$ 3,000	\$ (3,000)	-	-	-
Sub-total :				\$ 670	1.5%	-	-
<b>Development</b>							
Permits and approvals	p-h	4	\$ 65	\$ 260	-	-	-
Project management	p-h	50	\$ 85	\$ 4,250	-	-	-
Travel and accommodation	p-trip	1	\$ 2,000	\$ 2,000	-	-	-
Other	Cost	0	\$ -	\$ -	-	-	-
Credit - Base case system	Credit	1	\$ 5,000	\$ (5,000)	-	-	-
Sub-total :				\$ 1,510	3.4%	-	-
<b>Engineering</b>							
PV system design	p-h	15	\$ 65	\$ 975	-	-	-
Structural design	p-h	20	\$ 65	\$ 1,300	-	-	-
Electrical design	p-h	32	\$ 65	\$ 2,080	-	-	-
Tenders and contracting	p-h	11	\$ 65	\$ 715	-	-	-
Construction supervision	p-h	15	\$ 65	\$ 975	-	-	-
Other	Cost	0	\$ -	\$ -	-	-	-
Credit - Base case system	Credit	1	\$ 4,000	\$ (4,000)	-	-	-
Sub-total :				\$ 2,045	4.5%	-	-
<b>Renewable Energy (RE) Equipment</b>							
PV module(s)	kWp	1.30	\$ 7,850	\$ 10,205	-	-	-
Transportation	project	1	\$ 800	\$ 800	-	-	-
Other	Cost	0	\$ -	\$ -	-	-	-
Credit - RE Equipment	Credit	0	\$ -	\$ -	-	-	-
Sub-total :				\$ 11,005	24.5%	-	-
<b>Balance of Equipment</b>							
Module support structure	m <sup>2</sup>	10.0	\$ 100	\$ 1,000	-	-	-
Inverter	Watt	0.5	\$ 1,200	\$ 600	-	-	-

Prêt

- 17,000+ users
- 8 technologies
- policy and training applications
- developed by NRCan

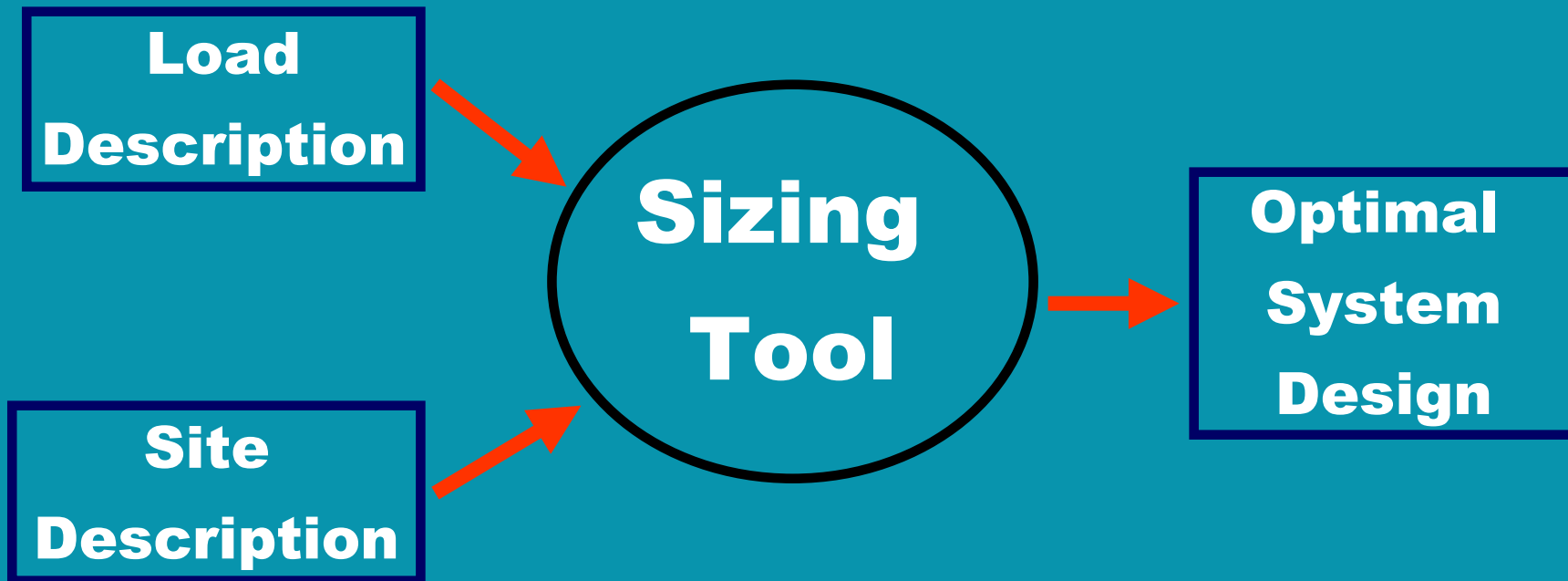
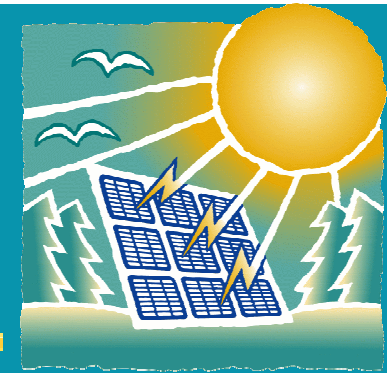


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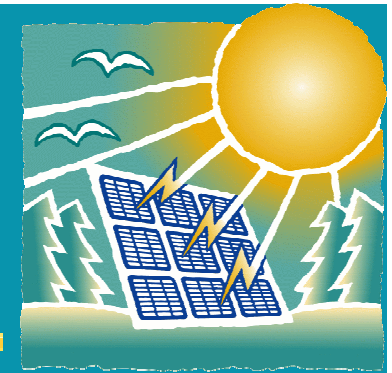
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# Sizing Tools



# Sizing Tools, cont.

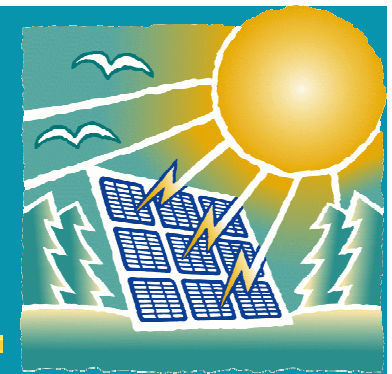


- Used by system vendors and installers
- Typically have an easy-to-use interface
- Detailed calculations of energy flows





# Example: HOMER



**HOMER Pro - [PV\_Wind\_Genset\_10\_kWh\_per\_day]**

File View Inputs Outputs Window Help

Inputs: Loads... Components... Resources... Optimization...

Control: Start Stop

Status: Ready

Simulations: 0 of 2240 Sensitivities: 0 of 100

Search Space: PV: 0, 0.5, 1, 2, 3, 4, 5 kW; Generic 1kW: 0, 1, 2, 3, 4; Generic 3kW: 0, 1, 2, 3; Genset: 0, 2 kW; Battery: 0, 2, 4, 6, 8, 12, 16, 24, ... 48 kWh; Inverter: 0, 2 kW; Dispatch Strategies: CM

Sensitivity Variables: Wind Speed: 2.5 m/s; Fuel Price: 0.4 \$/L; Max. Unserved: 0 %

Sensitivity Results...

Controlled Rankings Overall Rankings Graphic Display

Double click on a solution for details.

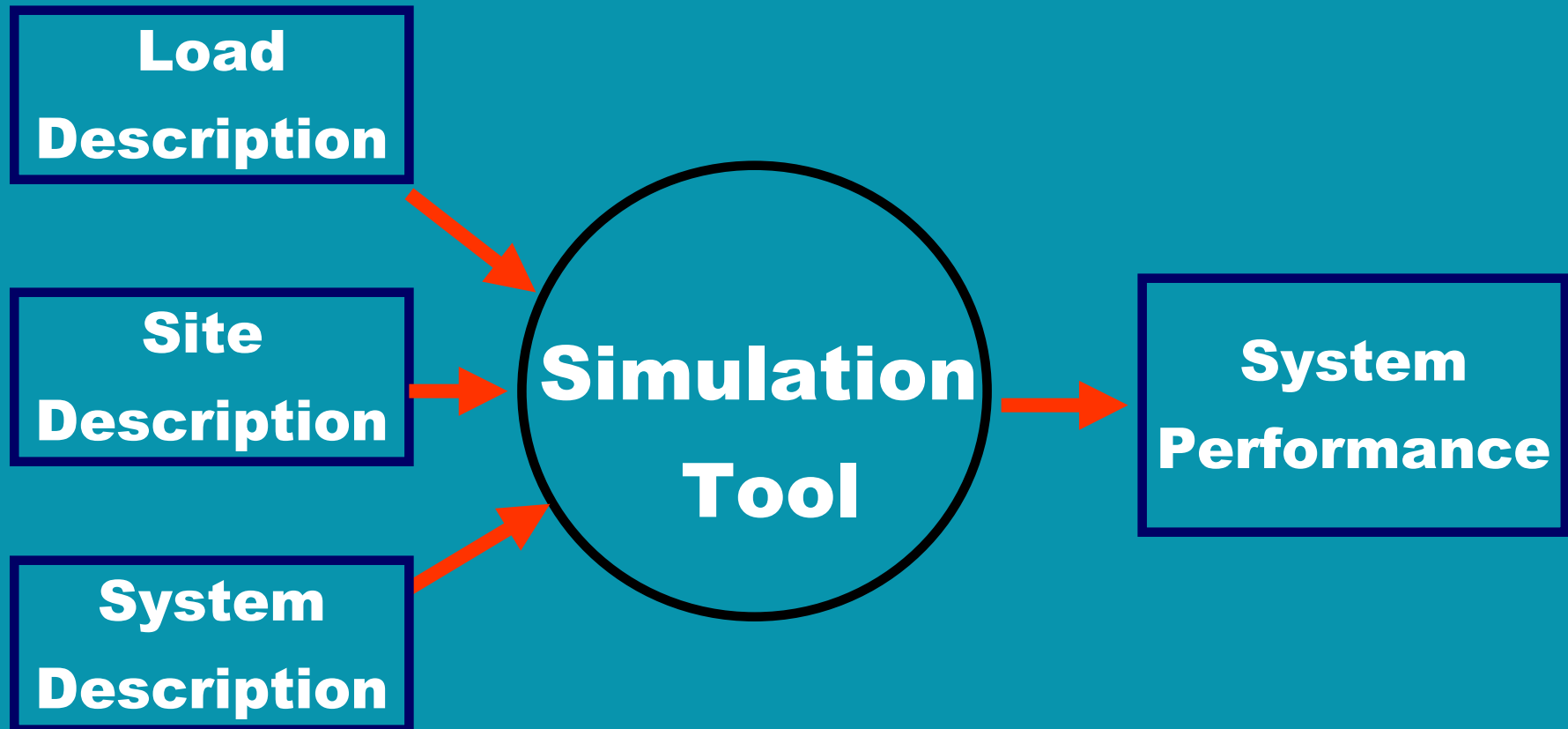
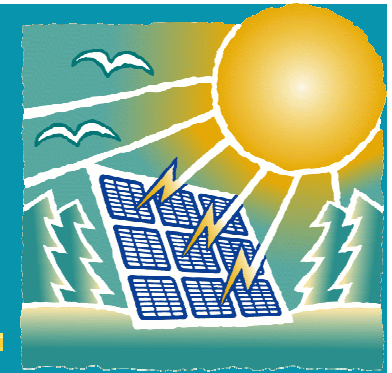
					PV (kW)	WT 1	Gen. (kW)	Batt. (kWh)	Inv. (kW)	Total Capital	Total NPC	COE (\$/kWh)	Ren. Frac.	Excess Frac.	Batt. (yr)
				<input checked="" type="checkbox"/>	1.0	0	2	6	2	\$ 9,050	\$ 25,632	0.564	0.35	0.05	1
				<input checked="" type="checkbox"/>	1.0	1	2	6	2	\$ 9,950	\$ 26,639	0.586	0.39	0.07	1
				<input checked="" type="checkbox"/>	0.0	0	2	12	2	\$ 4,500	\$ 30,802	0.677	0.00	0.00	1
				<input checked="" type="checkbox"/>	0.0	1	2	12	2	\$ 5,400	\$ 30,991	0.681	0.05	0.00	1
				<input checked="" type="checkbox"/>	1.0	0	2	0	2	\$ 8,450	\$ 37,319	0.820	0.23	0.42	7
				<input checked="" type="checkbox"/>	0.0	0	2	0	0	\$ 1,500	\$ 37,647	0.828	0.00	0.41	7
				<input checked="" type="checkbox"/>	1.0	1	2	0	2	\$ 9,350	\$ 37,703	0.829	0.26	0.41	7
				<input checked="" type="checkbox"/>	0.0	2	2	0	2	\$ 4,900	\$ 41,846	0.920	0.06	0.41	7

For Help, press F1

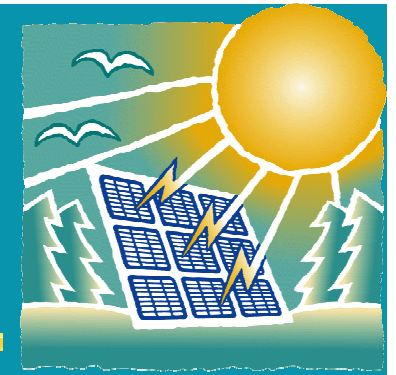
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# Simulation Tools



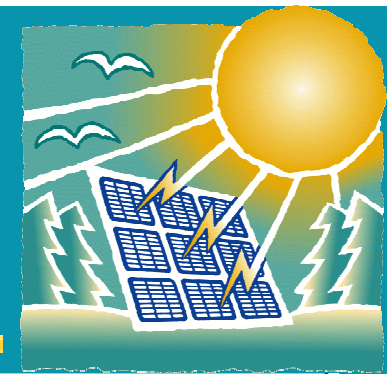
# Simulation Tools, cont.



- 10+ tools available
- used by people with good technical understanding of the system
- detailed output
- can be used for sizing



# Example: Watsun PV



MS WatsunPV

Files Run Analyze Windows Options Help

Simulation Data .DAT  
Array Data .ARR  
Battery Data .BTR  
Generator Data .GNR  
Inverter Data .INU  
Load Data .LOD

Save F2  
Save as shift-F2  
Close F3

Change dir...

eXit Alt-X

File C:\WATSUNPV\EXAMP.GNR

System type: Generator Data (GENE).

Title:

The following blocks of data can be edited:

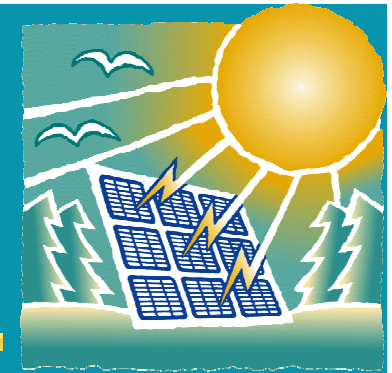
G: Generator Data  
C: Converter (AC to DC) Data

		Value	Units
G1	Generator Size (Nominal Power Rating).....	10.000	kW
G2	AC Line Voltage.....	12.000	V
G3	AC Load Threshold to Start Generator.....	100.000	W
G4	Max. Time Between Maint'ce Runs (0=no runs)..	0.000	hr
G5	Fuel Consumption vs. Load Derating.....	PROFILE	
G6	Performance Derating vs. Altitude.....	PROFILE	

F10 Menu Alt-X Exit Esc Done/Close



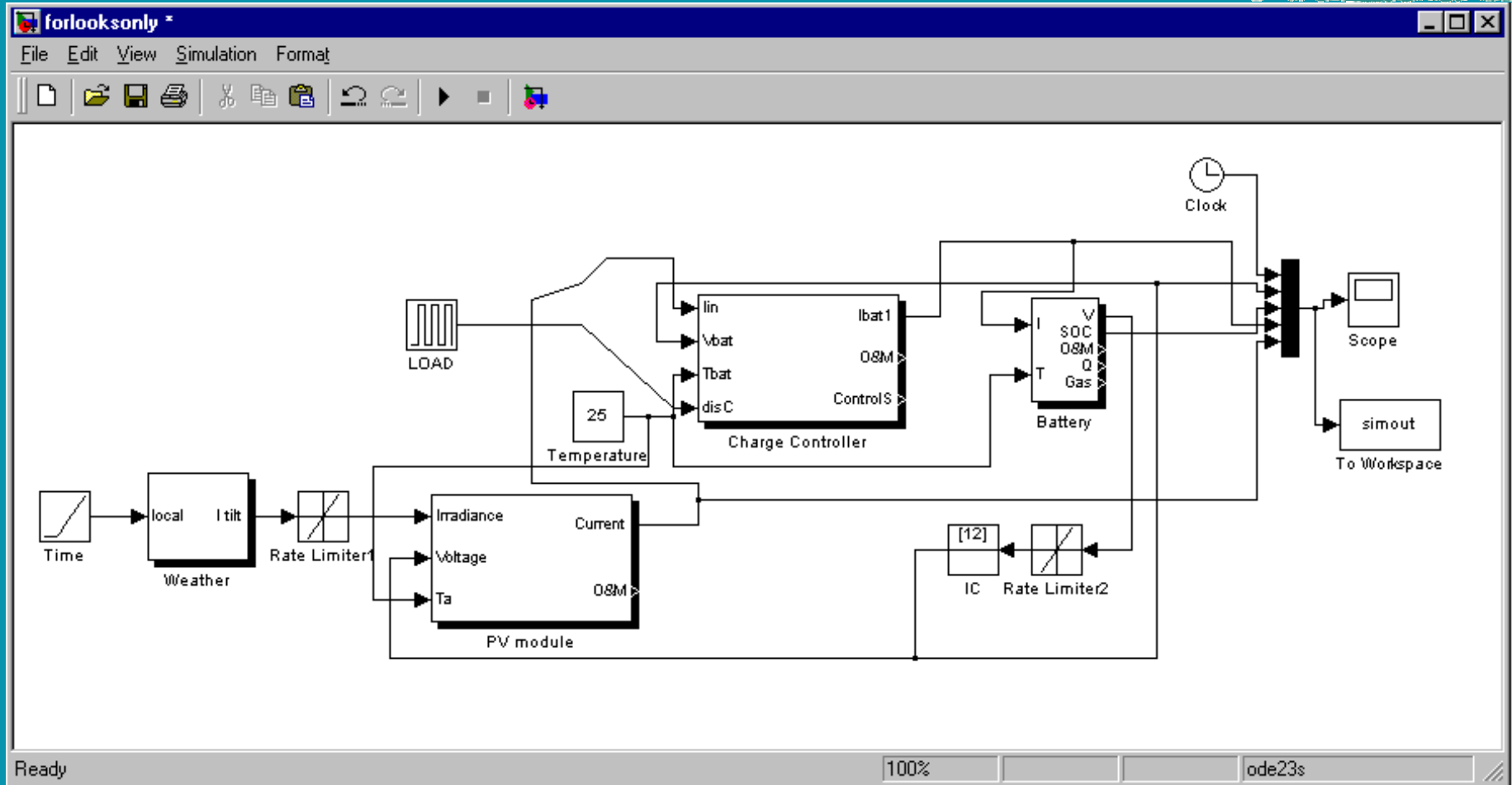
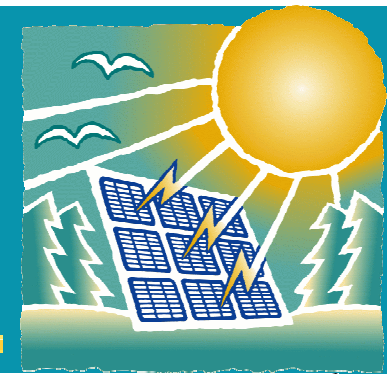
# Open Architecture Environments



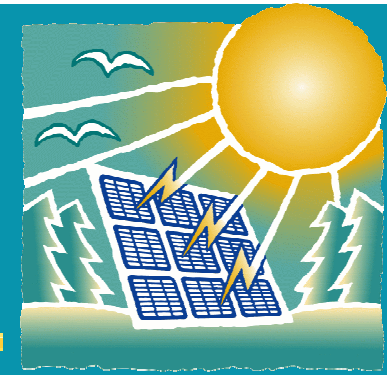
- Environments consisting of component models, a linking framework, and solvers
- For research and development
- Greatest flexibility and control over configuration and system control strategy
- Greatest investment of time and effort



# Example: Matlab/Simulink



# Why Classify Software?



- Different goals exist
- No one approach satisfies everyone
- User must know his or her goal
- New software developers should identify goal and look for niche

