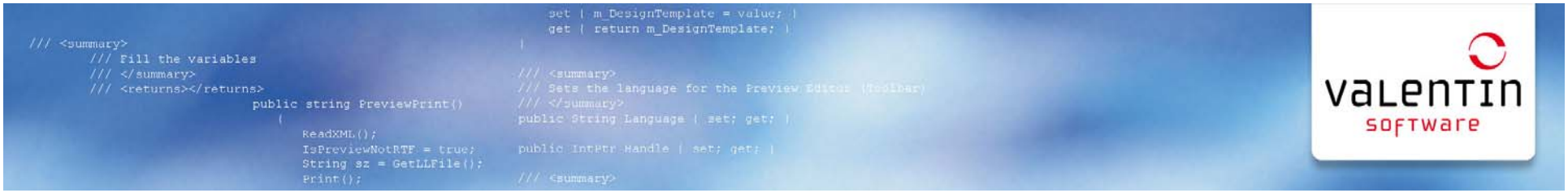
Planning, Simulation and Yield Calculation of Solar Power Plants

Dr. Gerhard Valentin

Valentin Software

Berlin, Germany



Agenda

- Introduction
- Simulation of Solar Heating Systems
- Impact of Environmental Factors
- Simulation of Grid Connected PV-Systems
- Simulation of Off-Grid PV-Systems

Dr. Valentin EnergieSoftware GmbH

- **Software Development, Design for Solar Heating and Photovoltaic Systems**
- **Established 1988**
- **40 employees**

Dr. Valentin EnergieSoftware GmbH

Stralauer Platz 34

Berlin, **Germany**

www.valentin.de

Valentin Software Inc.

Temecula CA, **USA**

www.valentin-software.com\

Main Software Products

T*SOL Pro

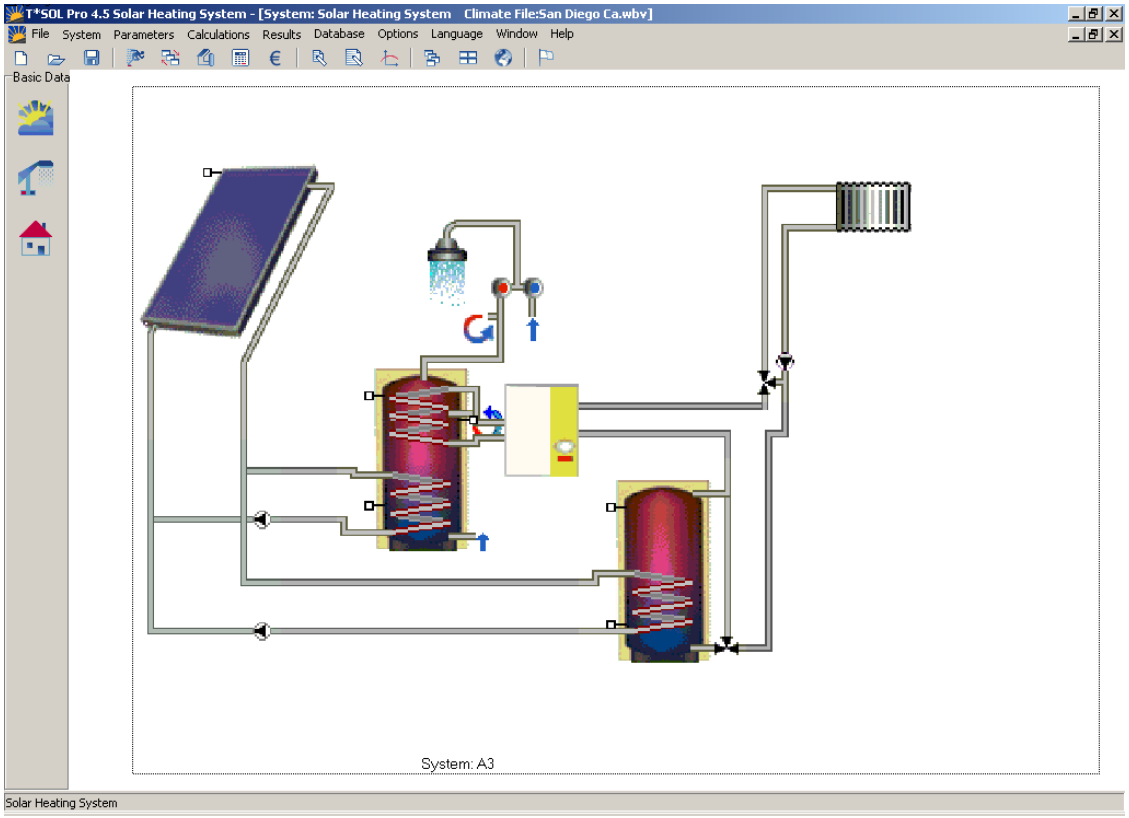
- The dynamic simulation program for the design and optimization of solar heating systems

PV*SOL Expert

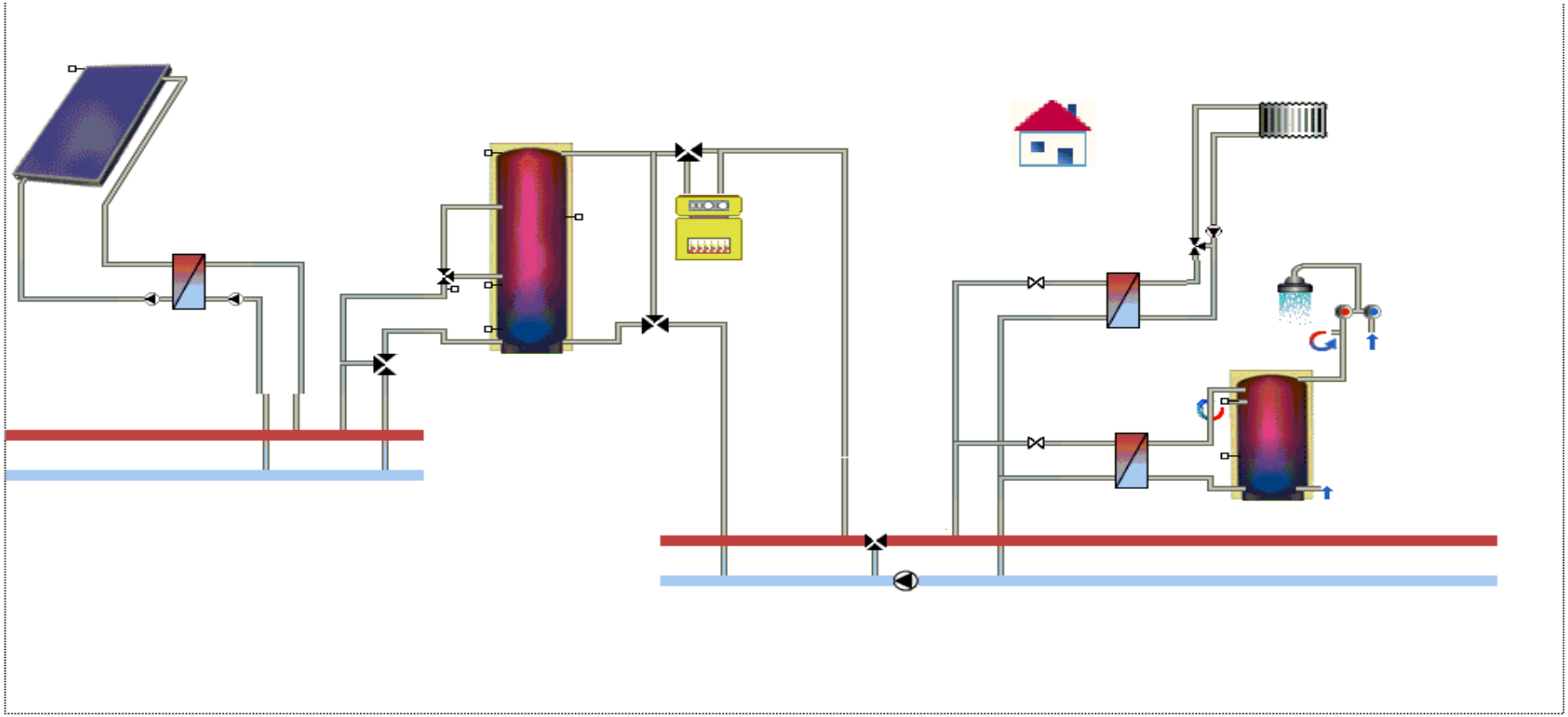
- The dynamic simulation program for the professional design and calculation of grid-connected and stand-alone photovoltaic systems

T*SOL Pro

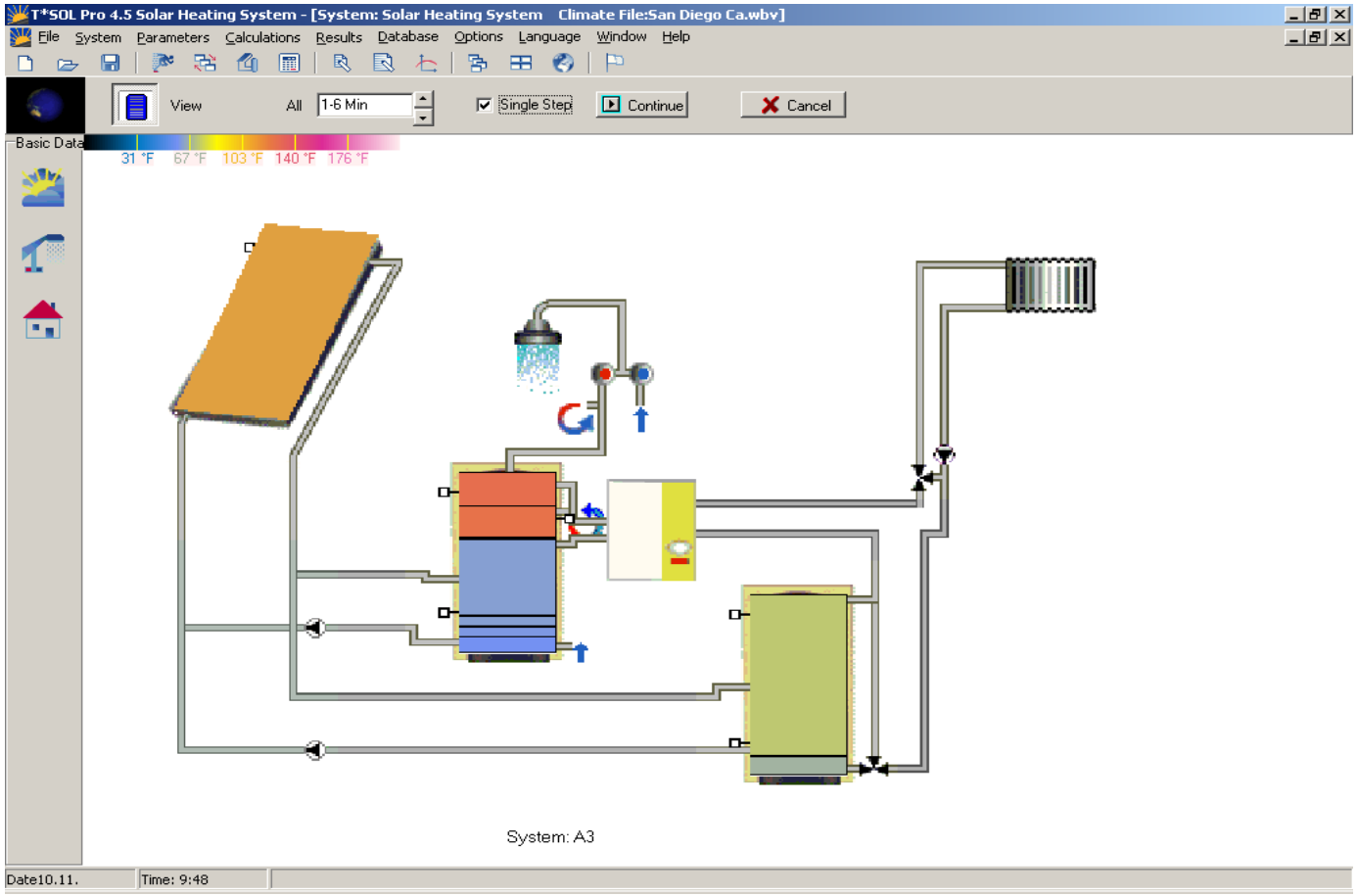
For engineers, planners and heating or building technicians planning an individual solar heating system



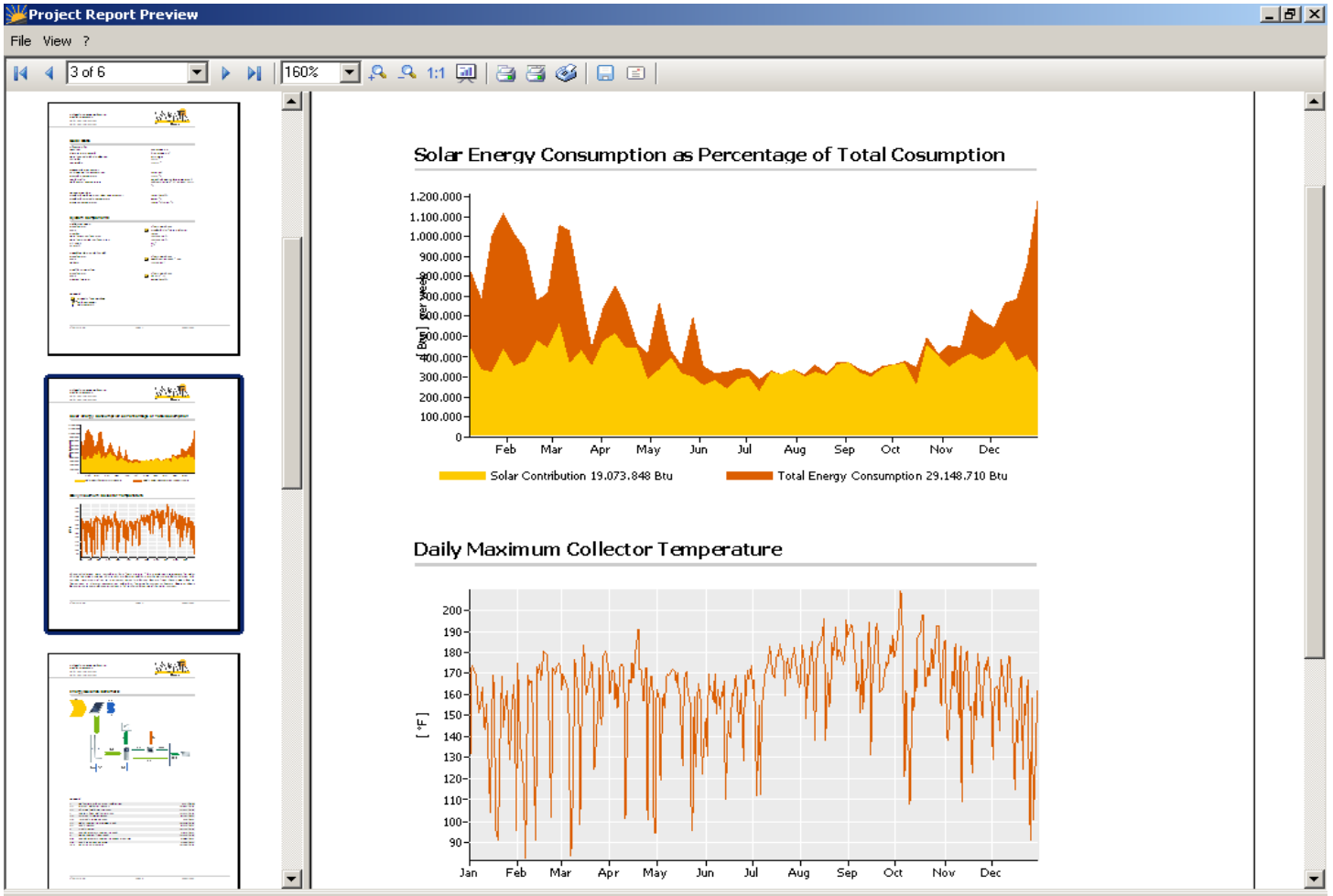
Select a System
District Heating Systems



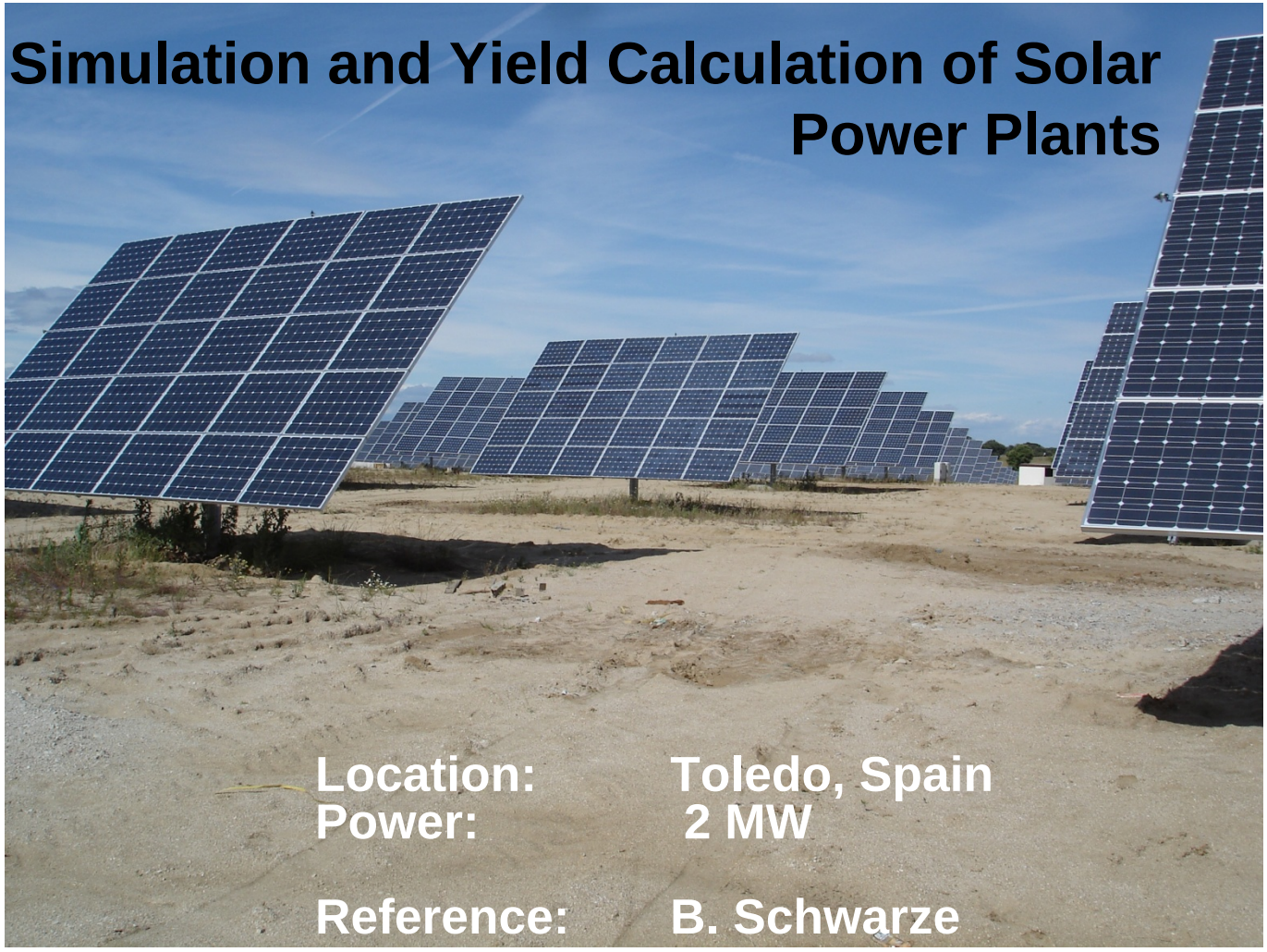
Simulation


T*SOL Pro 4.5 Solar Heating System - [System: Solar Heating System Climate File:San Diego Ca.wbv]
File System Parameters Calculations Results Database Options Language Window Help
View
All
1-6 Min
Single Step
Continue
Cancel
Basic Data
31 °F 67 °F 103 °F 140 °F 176 °F
System: A3
Date10.11.
Time: 9:48

Results


Project Report Preview
File View ?
3 of 6
160%
Solar Energy Consumption as Percentage of Total Cosumption
1.200.000
1.100.000
1.000.000
900.000
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0
[Btu] per week
Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Solar Contribution 19.073.848 Btu
Total Energy Consumption 29.148.710 Btu
Daily Maximum Collector Temperature
200
190
180
170
160
150
140
130
120
110
100
90
[°F]
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

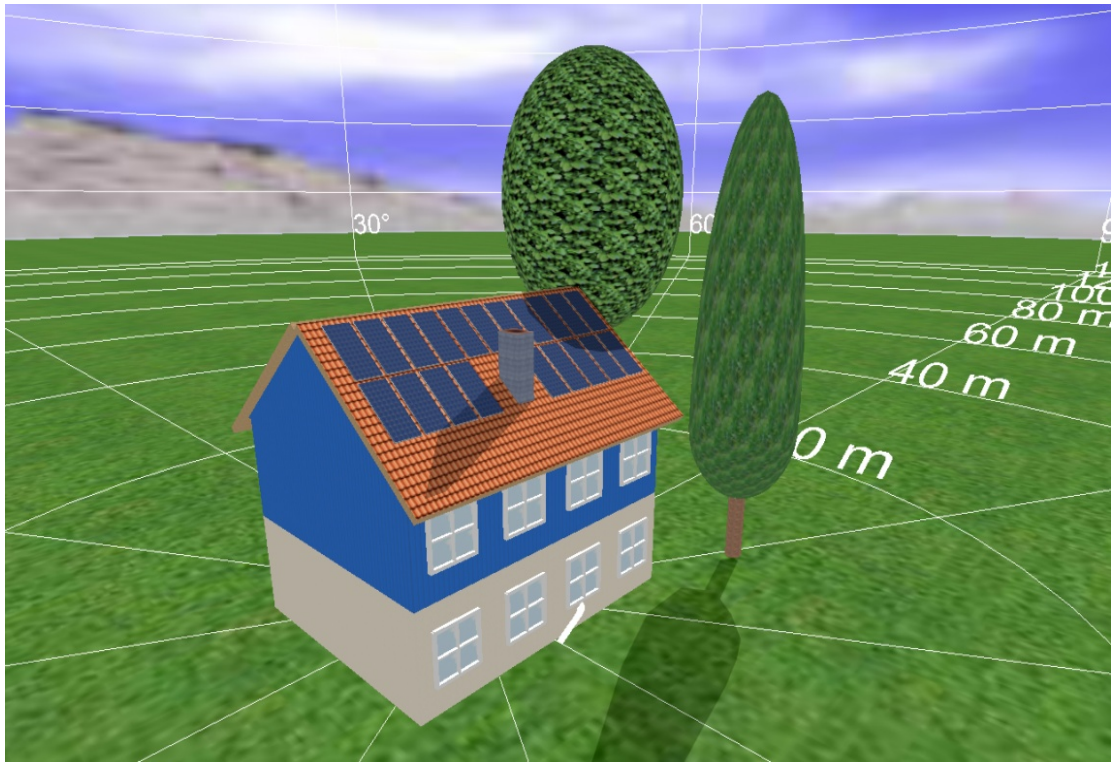
Simulation and Yield Calculation of Solar Power Plants



Location: Toledo, Spain
Power: 2 MW

Reference: B. Schwarze

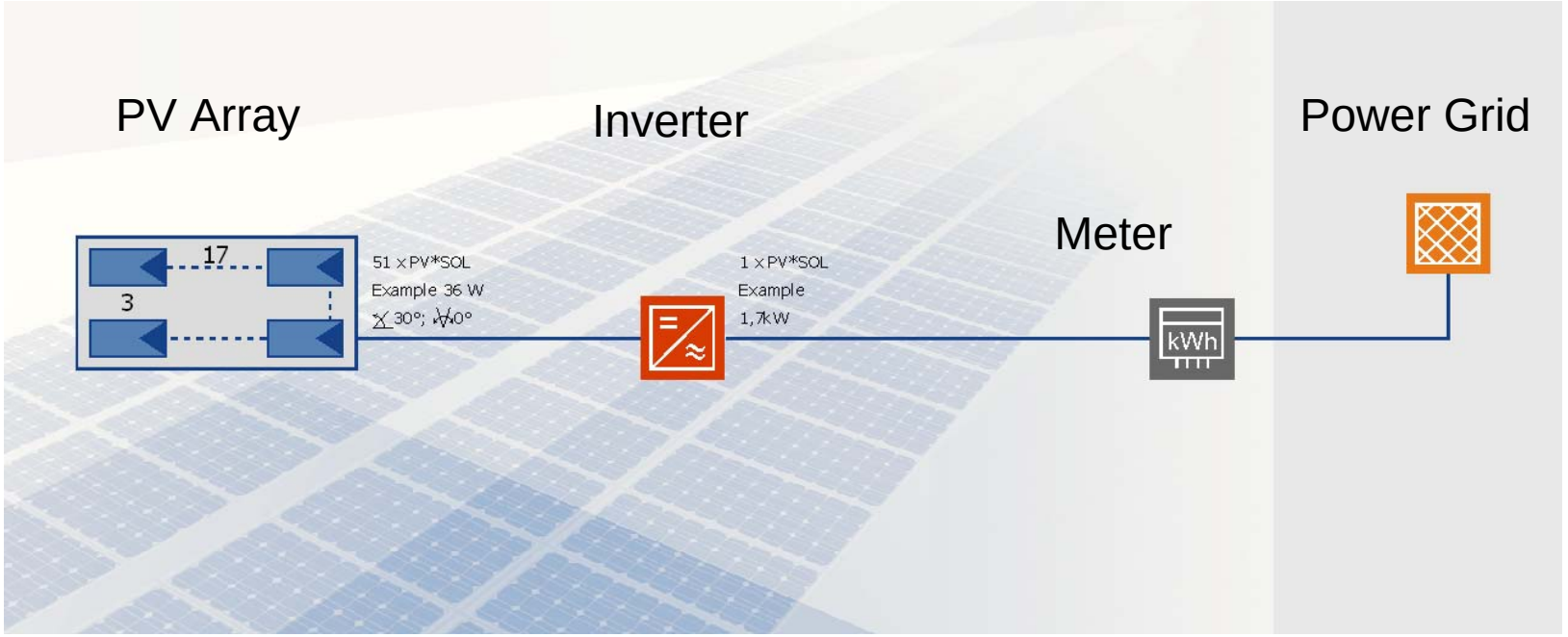
PV*SOL Pro



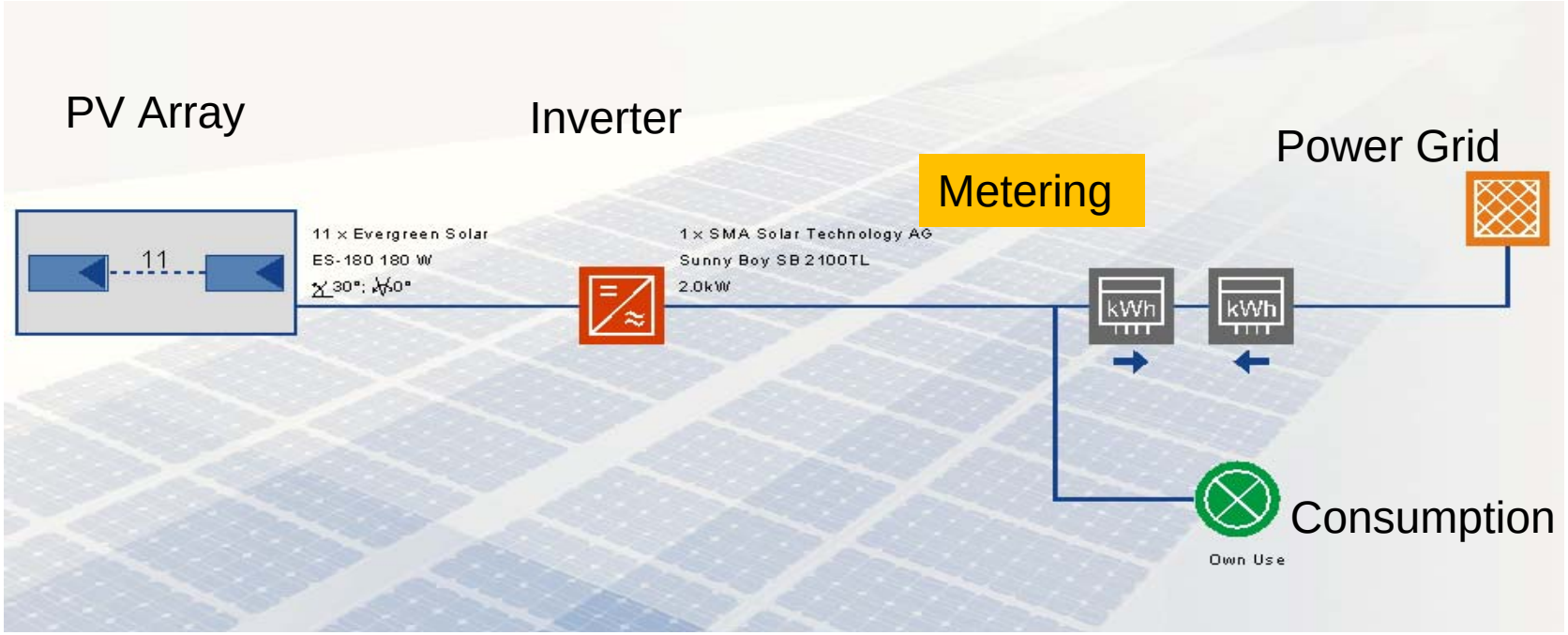
Dynamic Simulation Program for the Design and Yield Calculation of Grid-Connected and Off-Grid Photovoltaic Systems

PV*SOL Pro

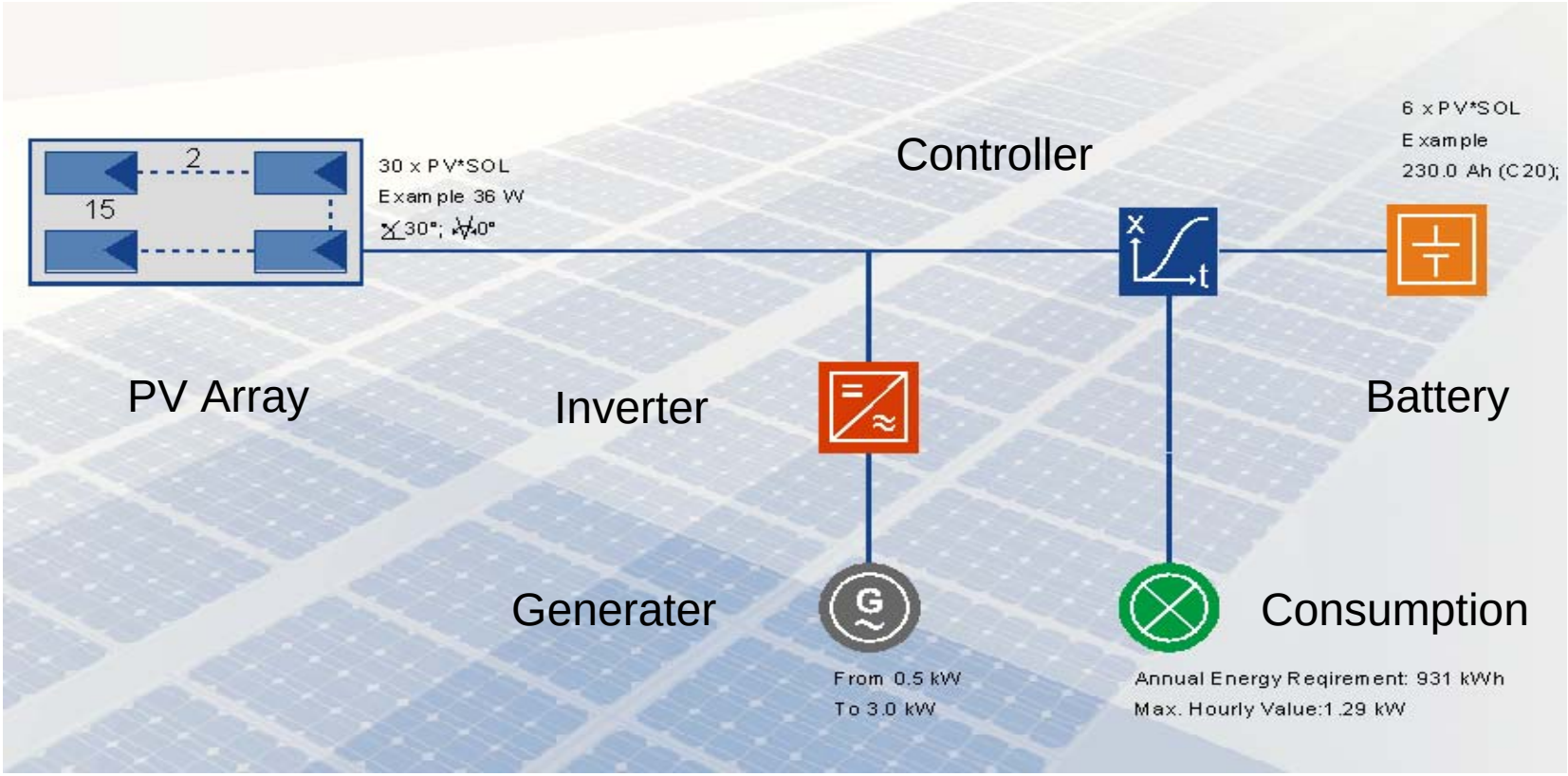
PV*SOL
Full Feed-In System



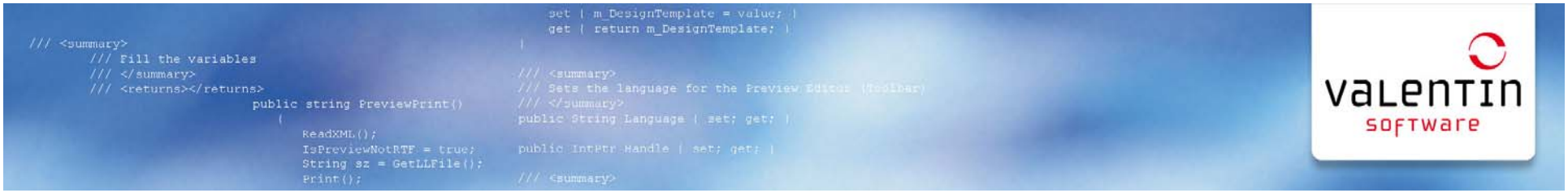
PV*SOL
Net Metering System



PV*SOL
Stand Alone System



Why is Simulation Software needed



Many Factors Influence Power Plant System Yield & Module Selection

Location

- Strength of sunlight
- Module Temperature

Site Area

- Is space limited or abundant

Orientation of Module

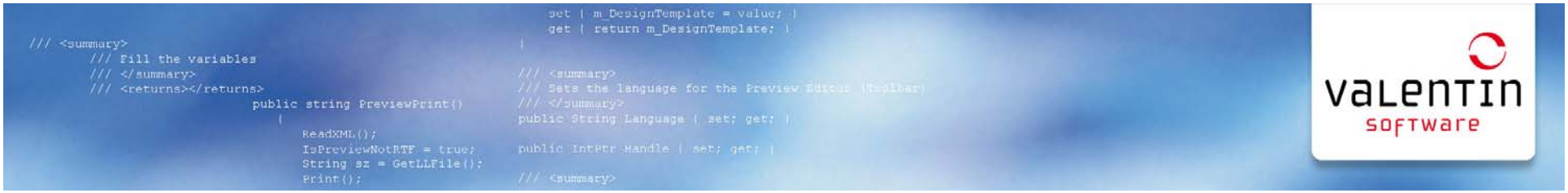
- Optimal irradiation

Module spacing

- Partial shading from rows in array

Installation Cost

- Per kWp



No Clear Answer in Respect to System Design and Energy Yield

Too many variables need consideration

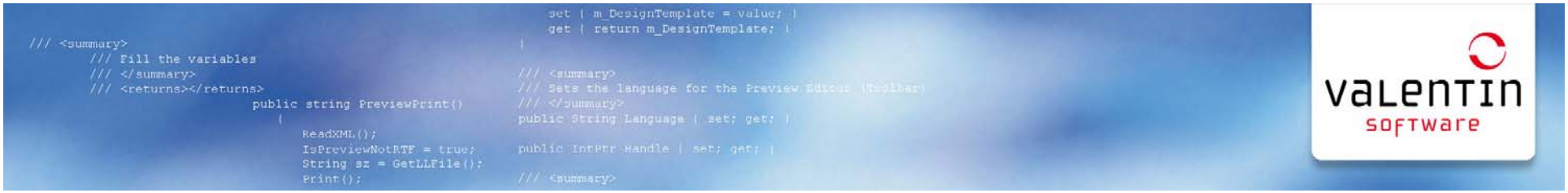
- PV*SOL allows you to analyze all these factors.

Simulation is required.

The Calculated yield estimates will differ for each module type based on the site specific design criteria.

Design Approach with PV*SOL

- Focus on the system and environmental criteria, such as:
  - Location for climate data
  - Space (area for array)
  - Orientation
  - Module and inverter preference
- PV*SOL performs the analysis and calculates the yields



Input

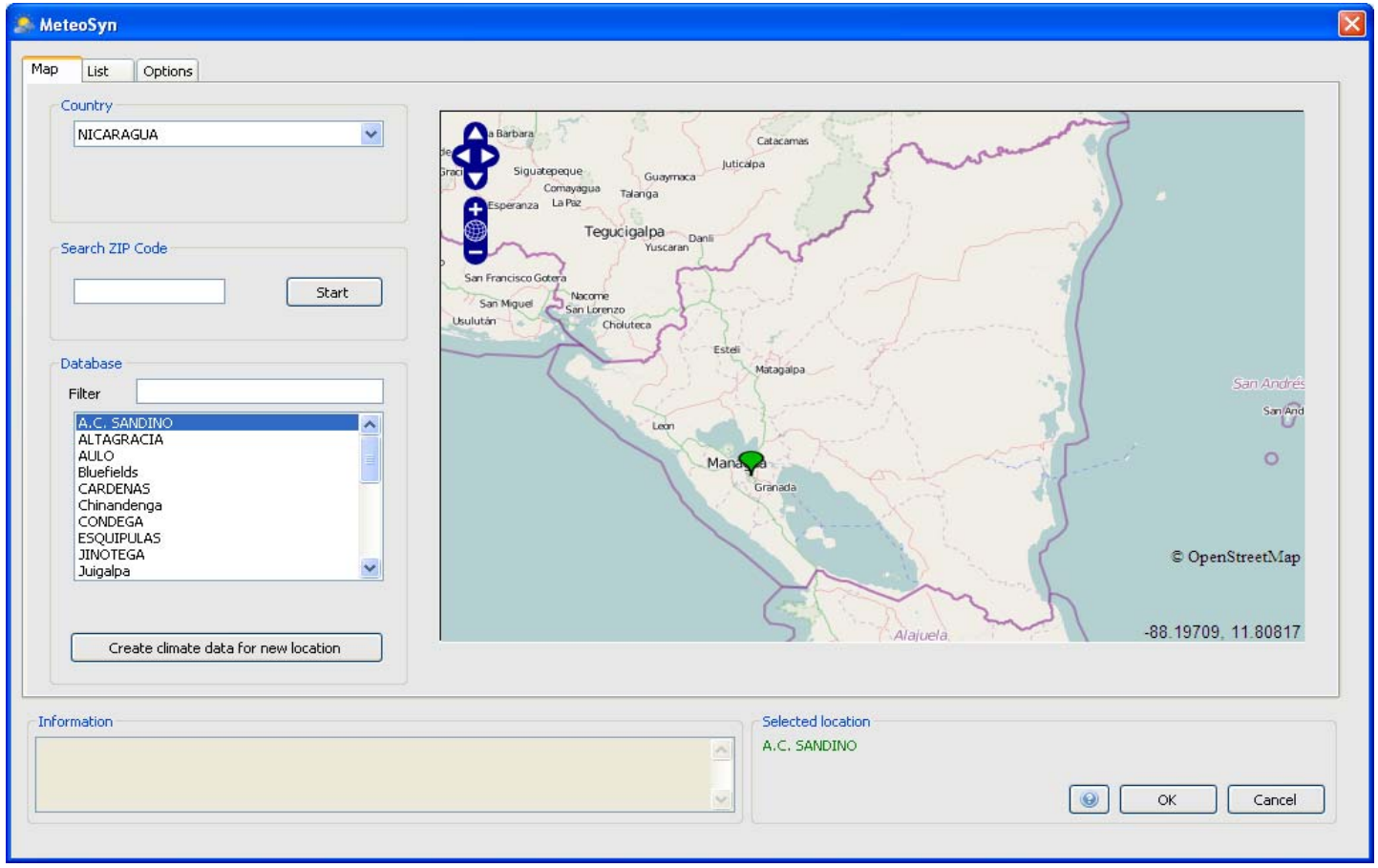
- Meteorological Data
- Consumption Profile
- Module Modeling
- Inverter Modeling
- Tariffs
- Others

Simulation

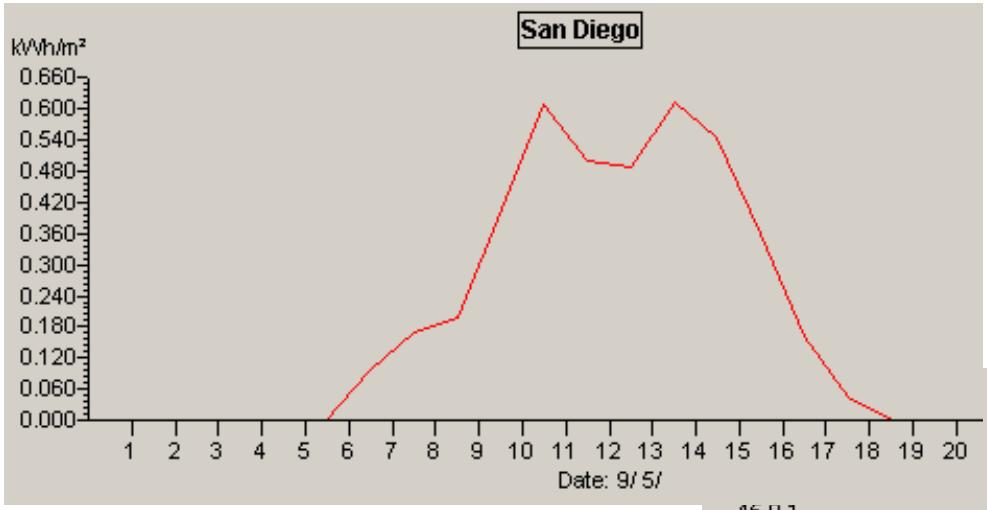
Output

- Energy Balance
- Final Yield
- Efficiency
- Economic Balance
- Return of Investment

Meteorological Data

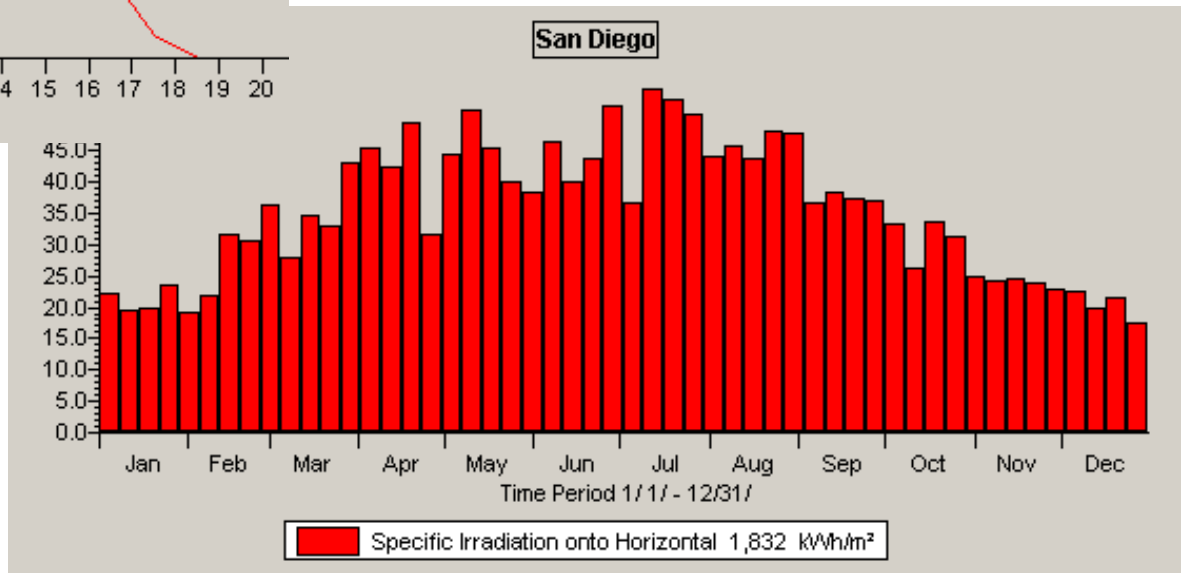


Irradiation



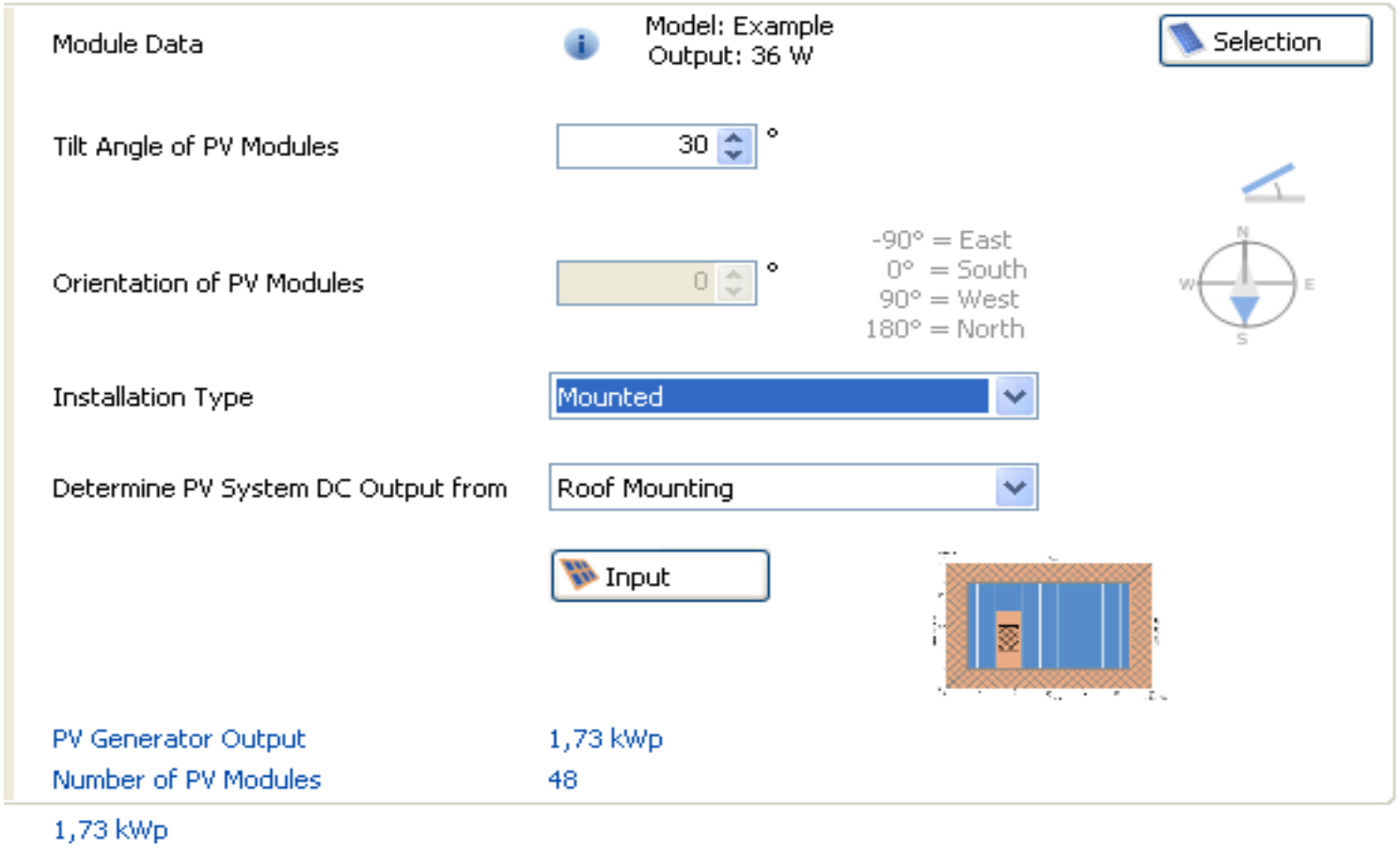
Hourly Values for

- **Irradiation**
- **Outside Temperature**
- **Wind Velocity**

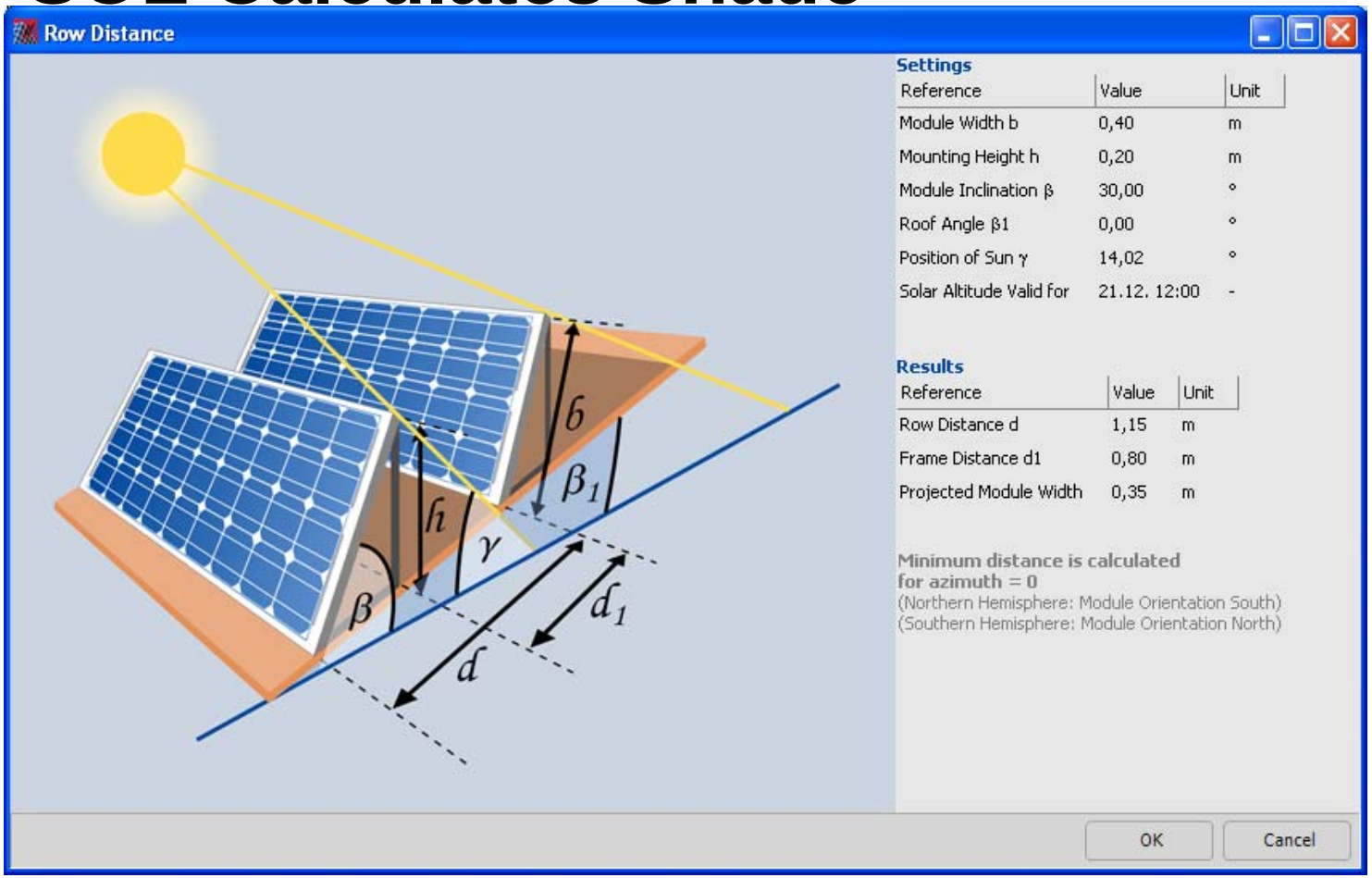


8760 Values per Year
Loaded from a Database

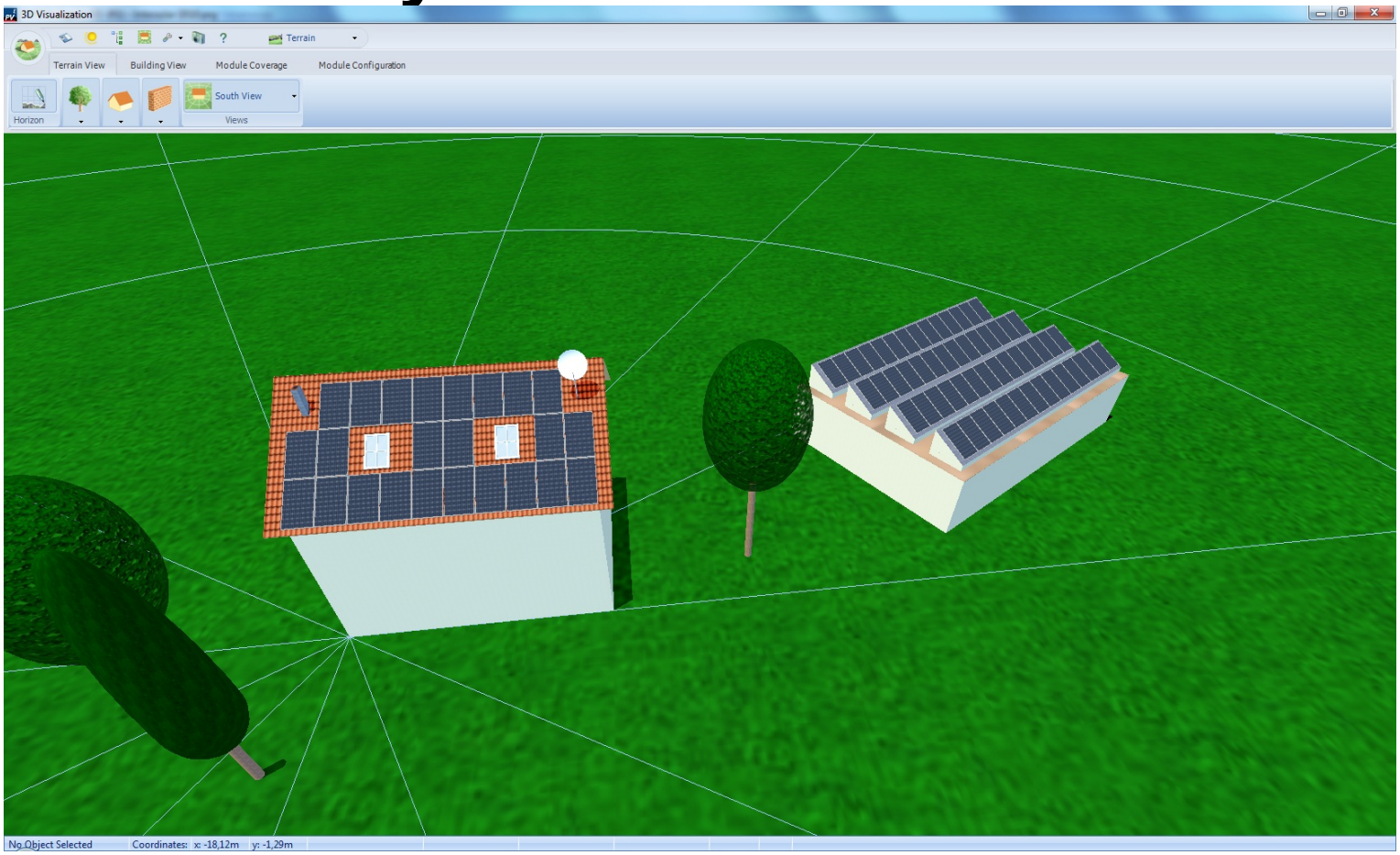
Orientation of the Modul Area



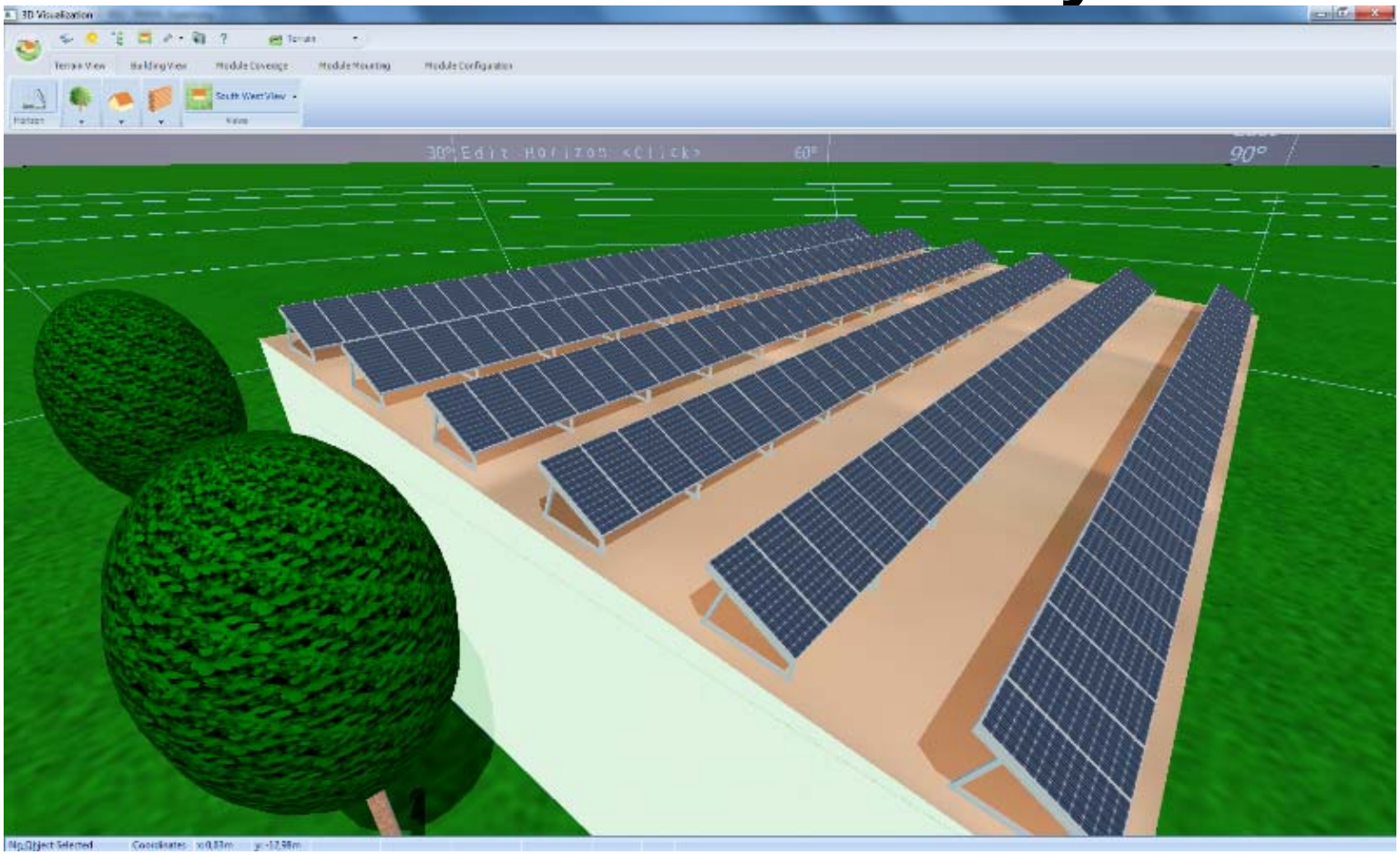
PV*SOL Calculates Shade



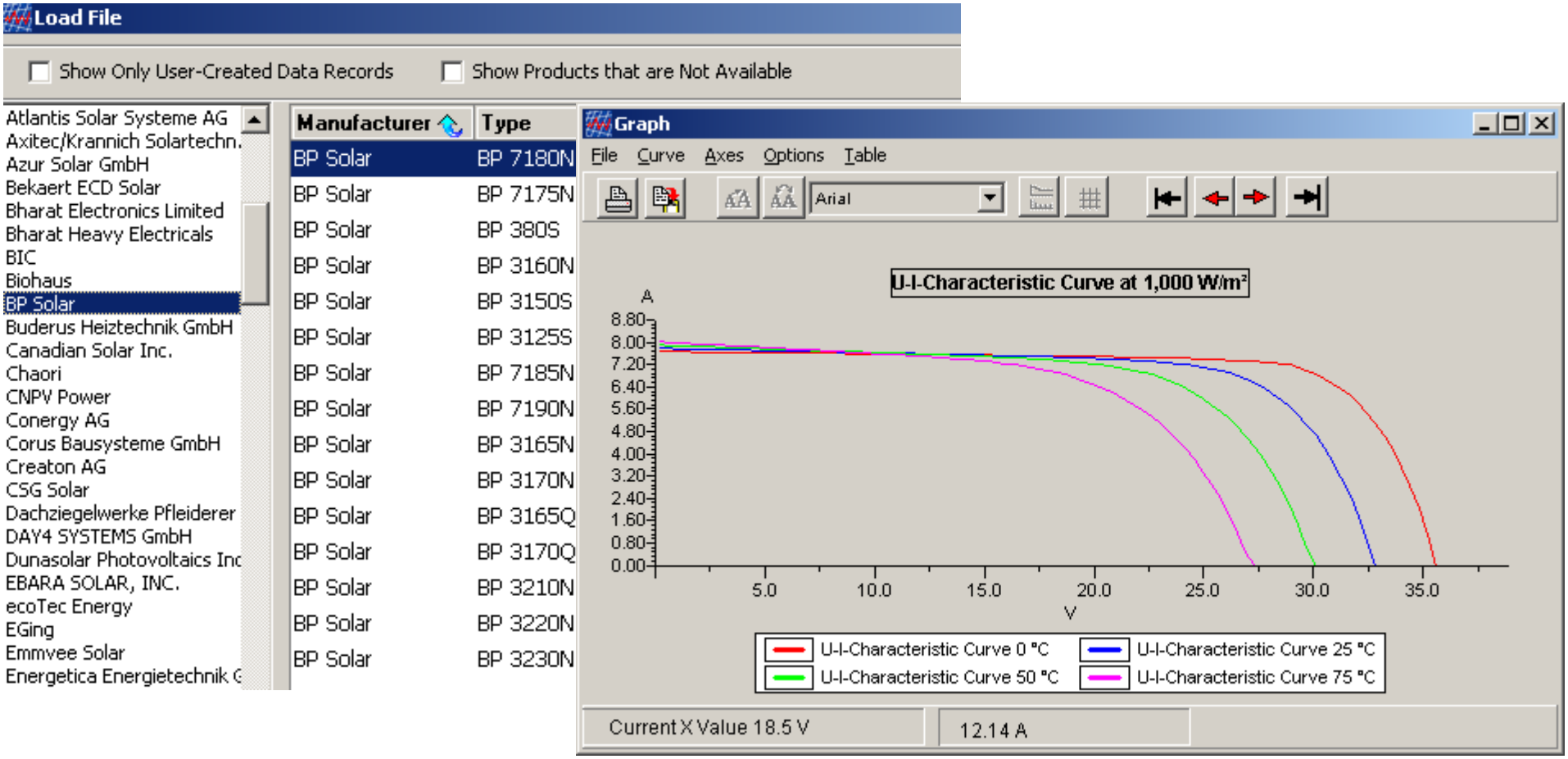
Roof based Systems



Flat Roof or Ground Mounted System



Module Database

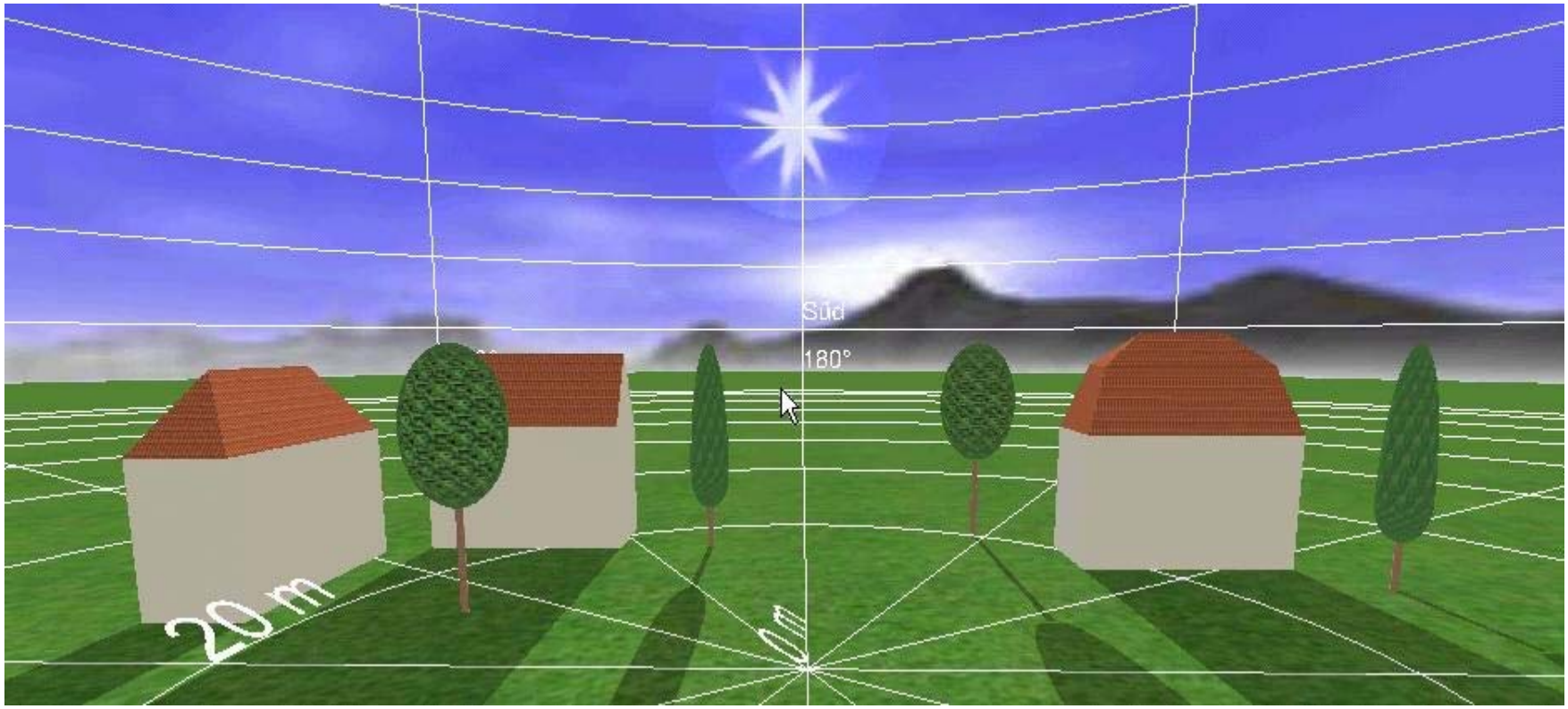


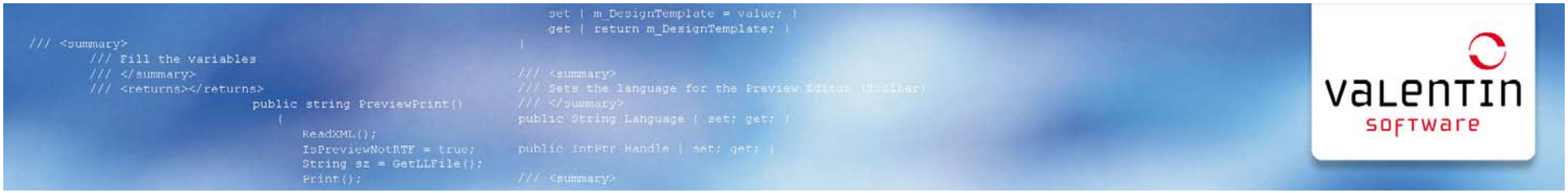
How does PV*SOL evaluate different components of a system

Simulation based on I-V Efficiency Curves:

- Calculation of Module Temperature using hourly Irradiation and wind velocity
- Current and voltage per Module are calculated by using the MPP in respect to the chosen Inverter

Simulation





Input

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Output

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- Final Yield
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- Economic Balance
- Return of Investment

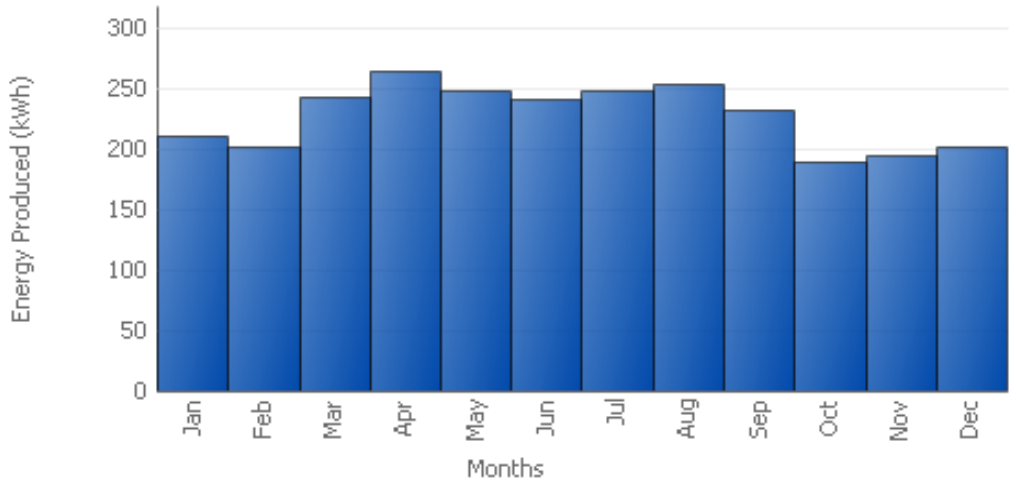
Simulation

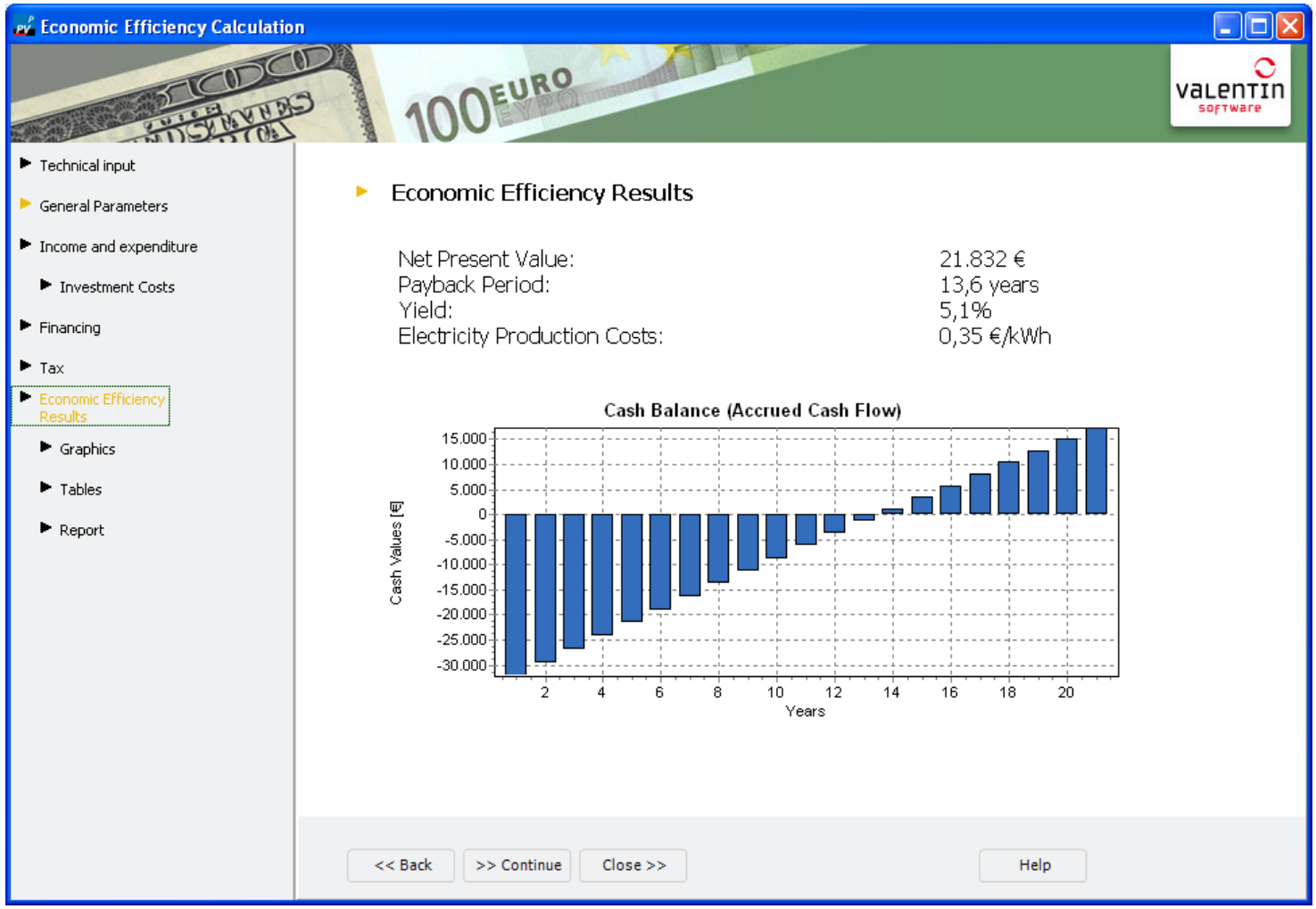
Energy Yield

Simulation

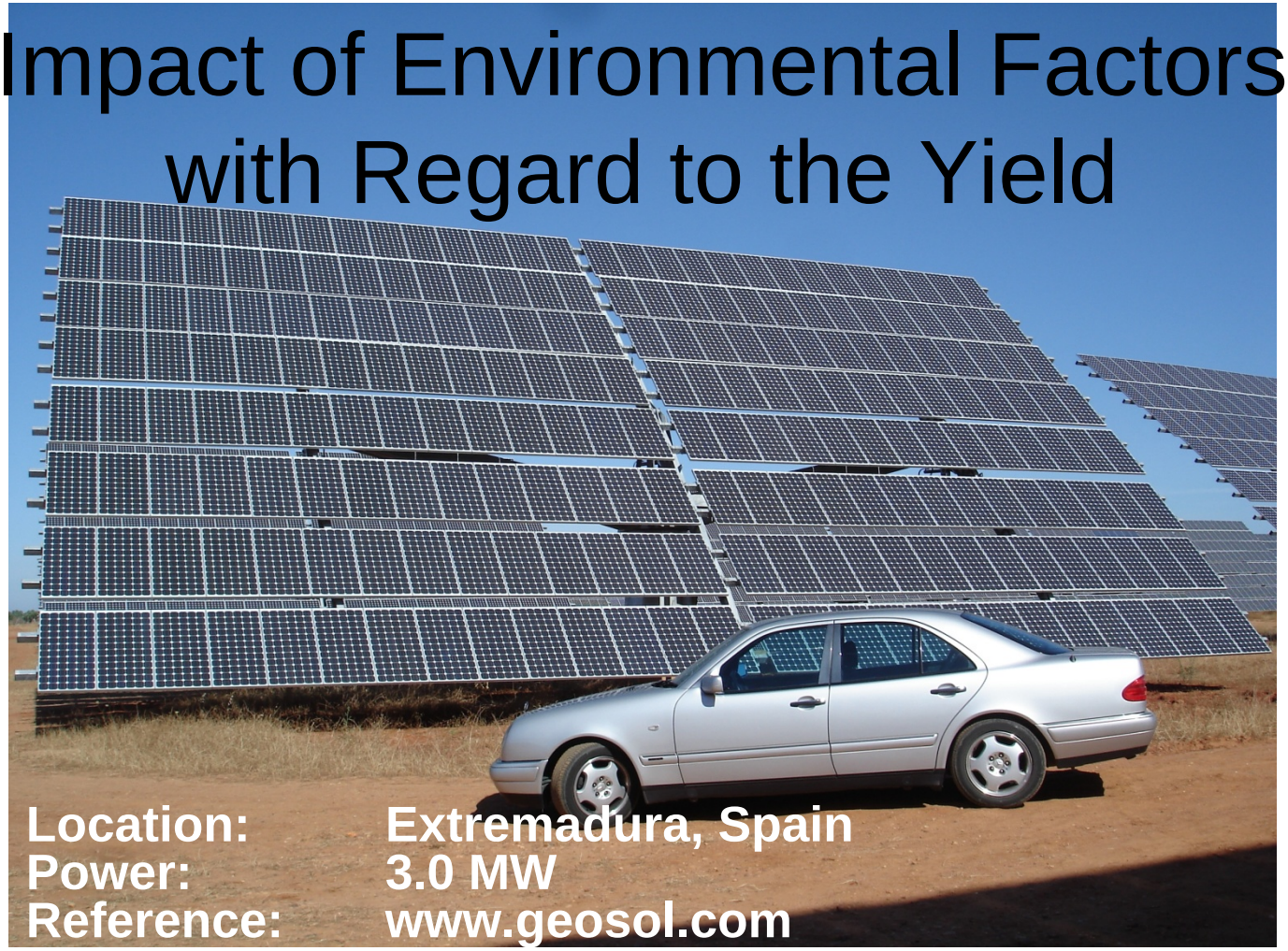
Annual Electricity Production	2737 kWh
Performance Ratio	73,80 %
Spec. Annual Yield	1582 kWh/kWp*year

Production Forecast



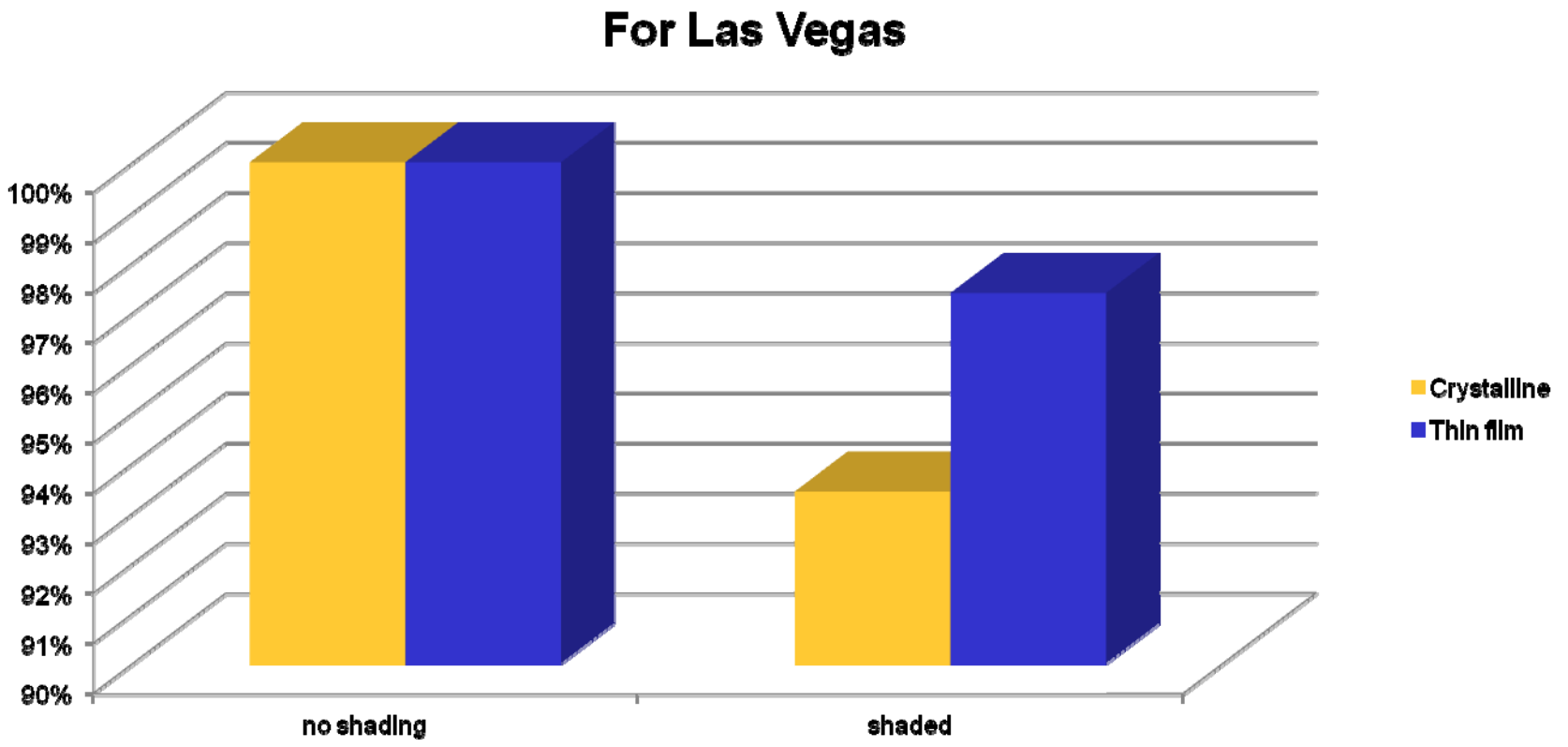

Economic Efficiency Calculation
Technical input
General Parameters
Income and expenditure
Investment Costs
Financing
Tax
Economic Efficiency Results
Graphics
Tables
Report
Economic Efficiency Results
Net Present Value: 21.832 €
Payback Period: 13,6 years
Yield: 5,1%
Electricity Production Costs: 0,35 €/kWh
Cash Balance (Accrued Cash Flow)
Cash Values [€]
15.000
10.000
5.000
0
-5.000
-10.000
-15.000
-20.000
-25.000
-30.000
2
4
6
8
10
12
14
16
18
20
Years
<< Back
>> Continue
Close >>
Help

Impact of Environmental Factors with Regard to the Yield

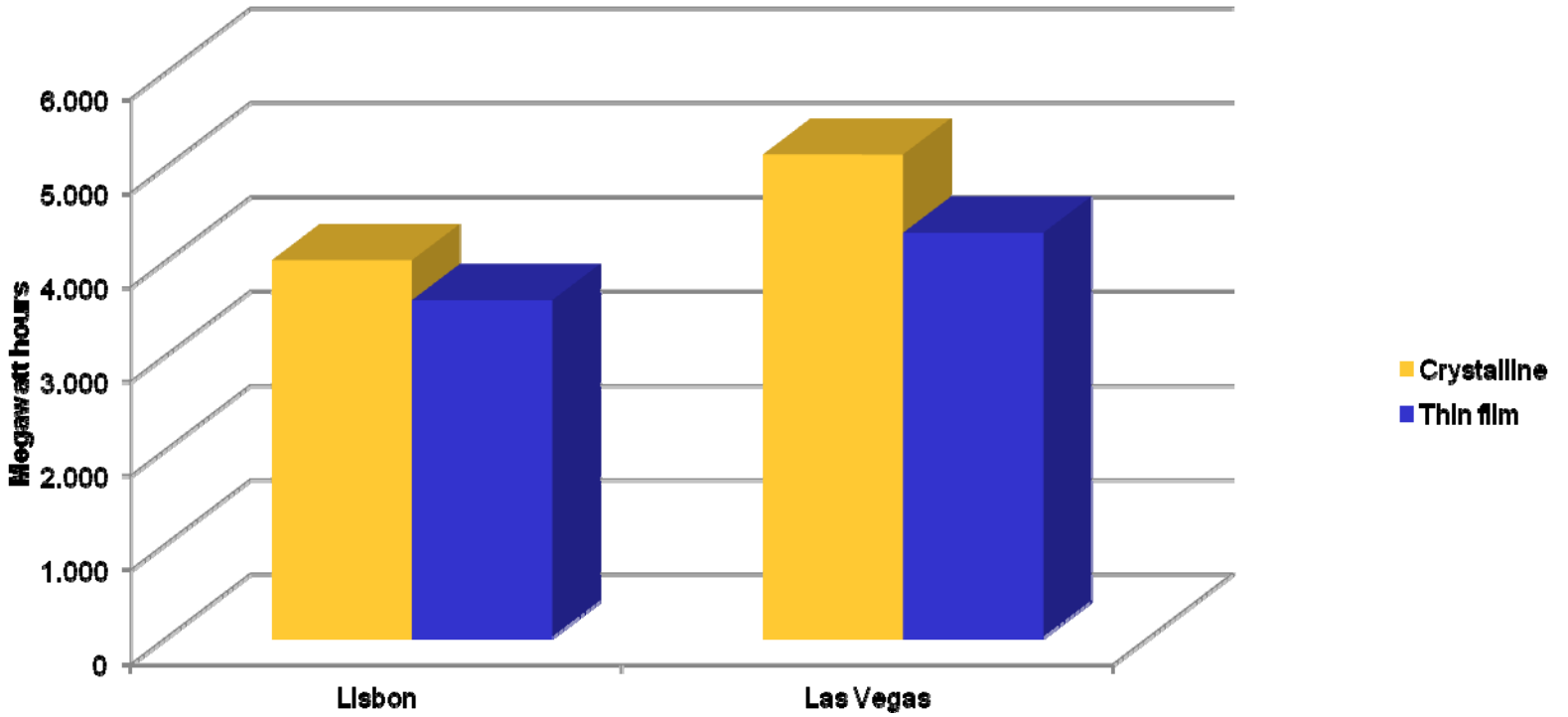


Location: Extremadura, Spain
Power: 3.0 MW
Reference: www.geosol.com

Partial Shading Impact on Crystalline and Thin Film Modules



Impact of the Location of a Crystalline and a Thin Film Module



VALENTIN SOFTWARE

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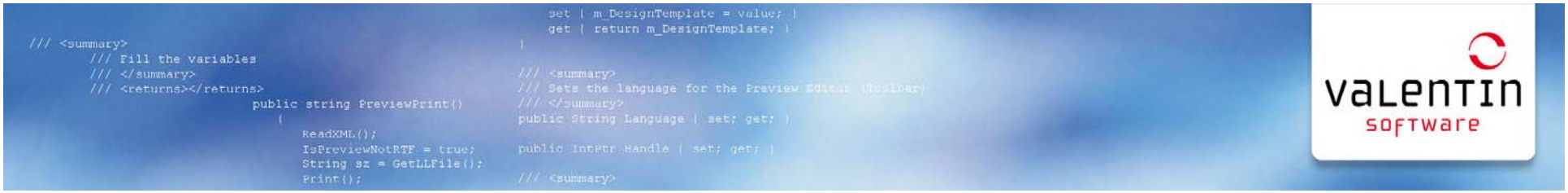
SMA

Design and Simulation Program for Off-Grid Systems

SMA OFF-GRID CONFIGURATOR

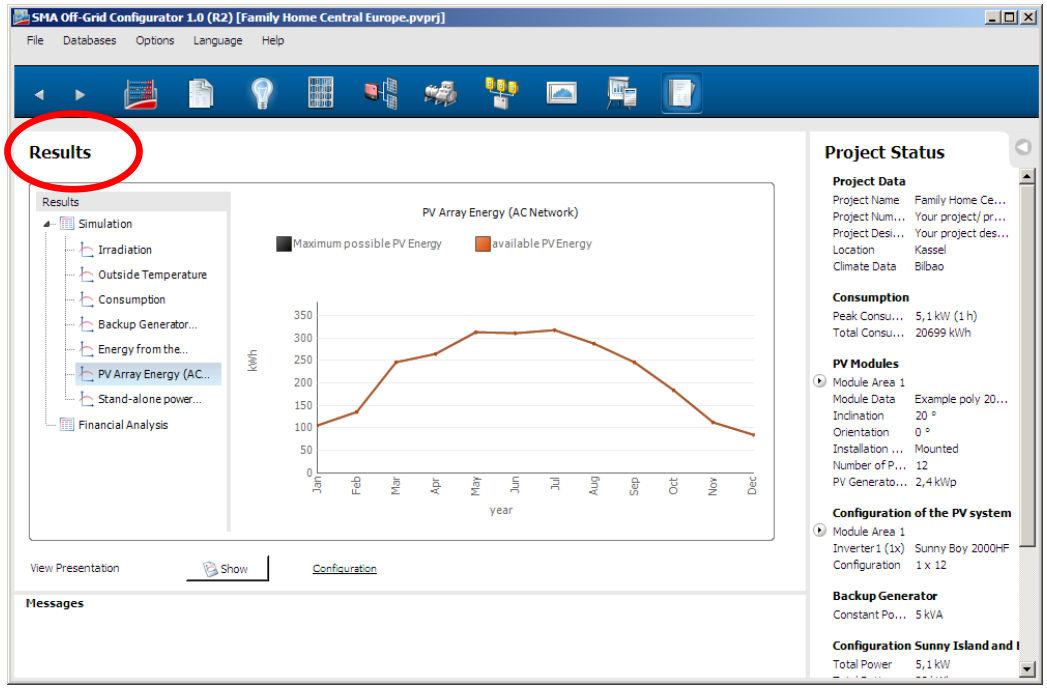
SMA Off-Grid Configurator 1.0 (R2)

SMA Off – Grid Configurator

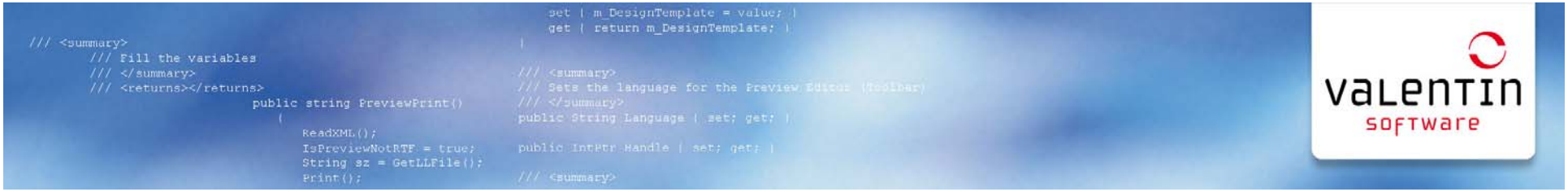


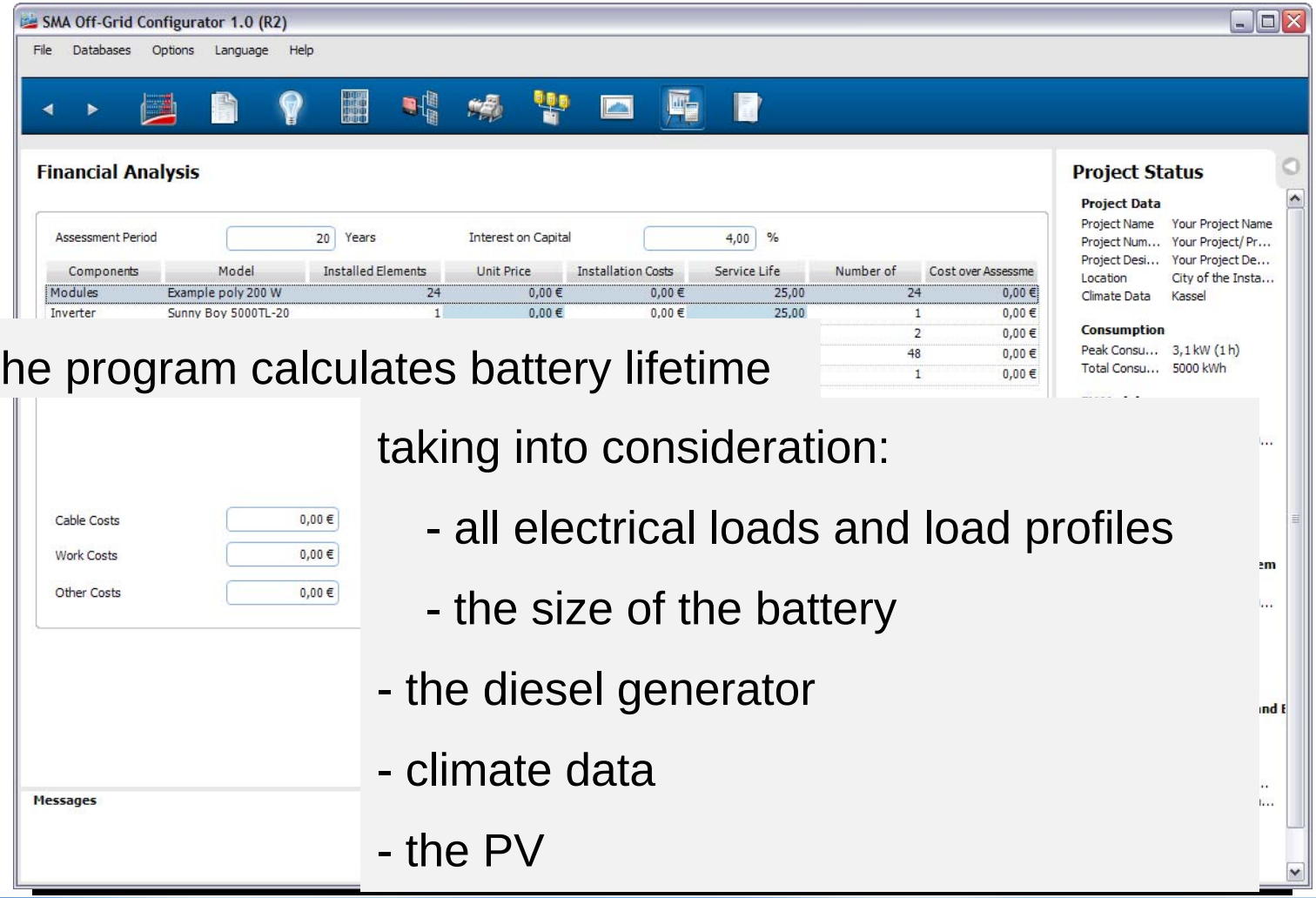
- Design 2 to 300 kW plants in a flexible manner
- Calculate an optimized system based on the loads
- Simulate the load, inverter, modules, battery, and diesel generator
- Calculate the plant's profitability
- Clearly present the results in a project folder
- **Professional system design**
- **The SMA Configurator will save you planning time**

SMA Off-Grid Configurator
Results in 9 steps



1. Enter project data and select climate data
2. Enter electrical loads
3. Select PV modules
4. Configure the PV plant
5. Enter the backup generator
6. Calculate or enter the Sunny Island and batteries
7. Simulate the plant
8. Calculate profitability
9. Display results





The program calculates battery lifetime

taking into consideration:

- all electrical loads and load profiles
- the size of the battery
- the diesel generator
- climate data
- the PV

Thank Your for Your Attention

Stand Alone System in Nepal

Designed by PV*SOL