Planning, Simulation and Yield Calculation of Solar Power Plants

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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
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Berlin, Germany
www.valentin.de

Valentin Software Inc.
Temecula, CA, USA
www.valentin-software.com
Main Software Products

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

- 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
Results – Project Report

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**Solar Energy Consumption as Percentage of Total Consumption**

- **Solar Contribution:** 15,183,140 Btu
- **Total Energy Consumption:** 29,140,730 Btu

**Daily Maximum Collector Temperature**

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17.01.2012

International Conference RIO 12
Granada, Nicaragua
Simulation and Yield Calculation of Solar Power Plants

Location: Toledo, Spain
Power: 2 MW
Reference: B. Schwarze

International Conference RIO 12 Granada, Nicaragua
PV*SOL Pro / Expert

Dynamic Simulation Program for the Design and Yield Calculation of Grid-Connected and Off-Grid Photovoltaic Systems
PV*SOL Pro / Expert
Full Feed-In System
PV*SOL Pro / Expert Net Metering System

PV Array

Inverter

Metering

Power Grid

Consumption

11 x Evergreen Solar ES-160-130 Wp

1 x SMA Solar Technology AG Sunny Boy SB 100 TL

Consumption

17.01.2012

International Conference RIO 12 Granada, Nicaragua
PV*SOL Pro / Expert Off-Grid System

PV Array

Inverter

Controller

Generator

Battery

Consumption

30 x PV*SOL
Example 36 W
× 30°, AP'

5 x PV*SOL
Example
230.0 Ah (C20)

From 0.5 kW
To 3.0 kW
Annual Energy Requirement 931 kWh
Max. Hourly Value 1.29 kW
Why is Simulation Software needed?

Location: Barcelona, Spain
Power: 2.5 MW
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

Output

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

Simulation
Meteorological Data – Climate Data Generator “MeteoSyn”
Irradiation

Hourly Values for:
- Irradiation
- Outside Temperature
- Wind Velocity

8760 Values per Year
Loaded from a Database
Orientation of the Modul Area

Module Data

Model: Example
Output: 36 W

Tilt Angle of PV Modules
30°

Orientation of PV Modules

installation Type
Mounted

Determine PV System DC Output from
Roof Mounting

PV Generator Output
1,73 kWp

Number of PV Modules
48

1,73 kWp
PV*SOL Calculates Shade
Roof Top Systems
Flat Roof or Ground Mounted Systems
### Module Database

**Load File**

- Show Only User-Created Data Records
- Show Products that are Not Available

<table>
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<tr>
<th>Manufacturer</th>
<th>Type</th>
<th>Output [W]</th>
<th>MPP Voltage [V]</th>
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**Graph**

**U-I Characteristic Curve at 1,000 W/m²**

- U-I Characteristic Curve 0 °C
- U-I Characteristic Curve 25 °C
- U-I Characteristic Curve 50 °C
- U-I Characteristic Curve 75 °C

Current X Value: 18.5 V

12.14 A

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17.01.2012  International Conference RIO 12 Granada, Nicaragua
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
• Meteorological Data
• Consumption Profile
• Module Modeling
• Inverter Modeling
• Tariffs
• Others

Input

Simulation

Output

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

Simulation

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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<tr>
<td>Annual Electricity Production</td>
<td>2737 kWh</td>
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<tr>
<td>Performance Ratio</td>
<td>73.80%</td>
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<tr>
<td>Spec. Annual Yield</td>
<td>1582 kWh/kWp/yr</td>
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Production Forecast

- Energy Produced (kWh)
- Months: Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
Economic Efficiency Results

Net Present Value: 21.632 €
Payback Period: 13.6 years
Yield: 5.1% 
Electricity Production Costs: 0.35 €/kWh

Cash Balance (Accrued Cash Flow)
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

For Las Vegas

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no shading shaded
Impact of the Location of a Crystalline and a Thin Film Module
Design and Simulation Program for Off-Grid Systems
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 array
Thank You for Your Attention

Off-Grid System in Nepal
Designed with PV*SOL