

# Planning, Simulation and Yield Calculation of Solar Power Plants

Dr. Gerhard Valentin  
**Valentin Software**  
Berlin, Germany

```
    set | m_DesignTemplate = value; |  
    get | return m_DesignTemplate; |  
    |  
    /// <summary>  
    /// Fill the variables  
    /// </summary>  
    /// <returns></returns>  
    public string PreviewPrint()  
    (  
        ReadXML();  
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    )  
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    /// Sets the language for the Preview Editor (Modinary)  
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    public string Language { set; get; }  
    |  
    public IntPtr Handle { set; get; }  
    |  
    /// <summary>  
    |  
    |
```



# Agenda

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

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# 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](http://www.valentin.de)

**Valentin Software Inc.**

Temecula CA, **USA**

[www.valentin-software.com](http://www.valentin-software.com)

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# 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

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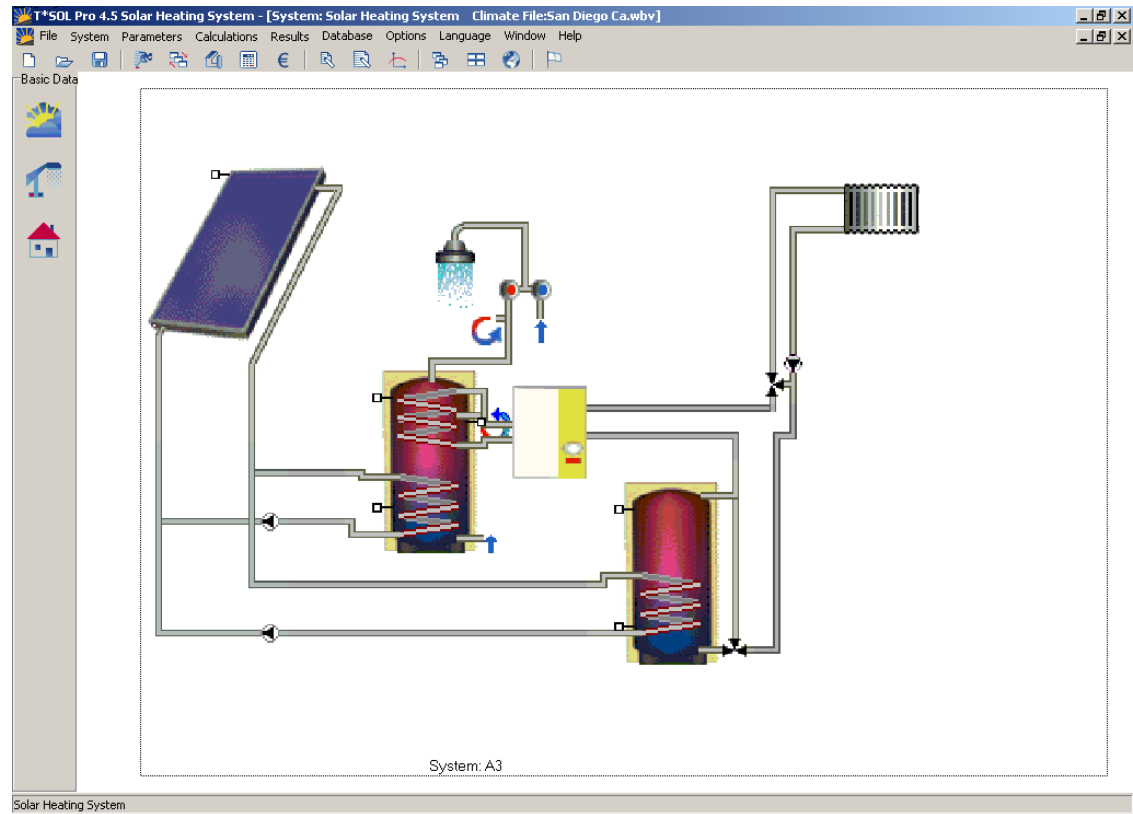
public IntPtr Handle | set; get; |

/// <summary>
```



# T\*SOL Pro

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



```
set | m_DesignTemplate = value; |
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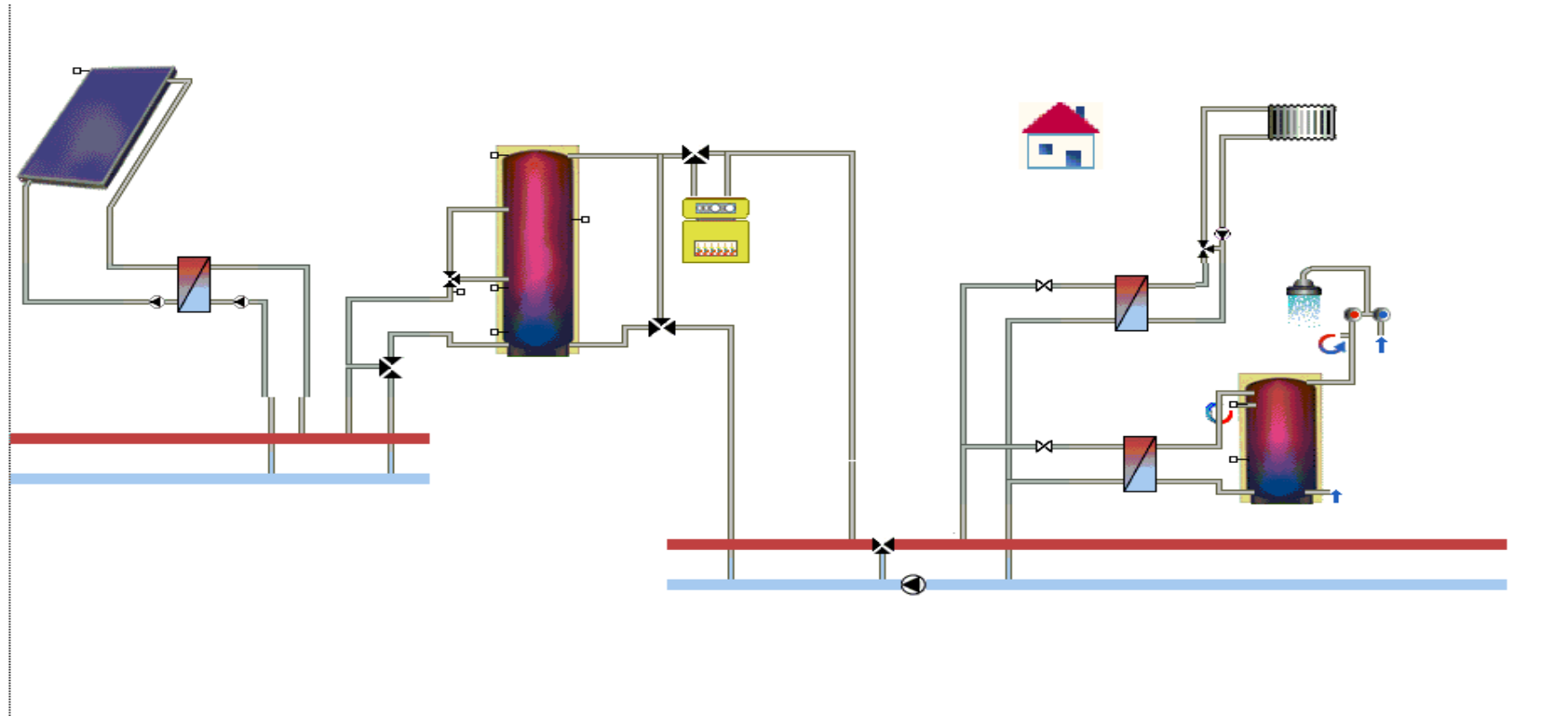
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/// <summary>
/// Sets the language for the Preview Editor (Ordinary)
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```



# Select a System District Heating Systems



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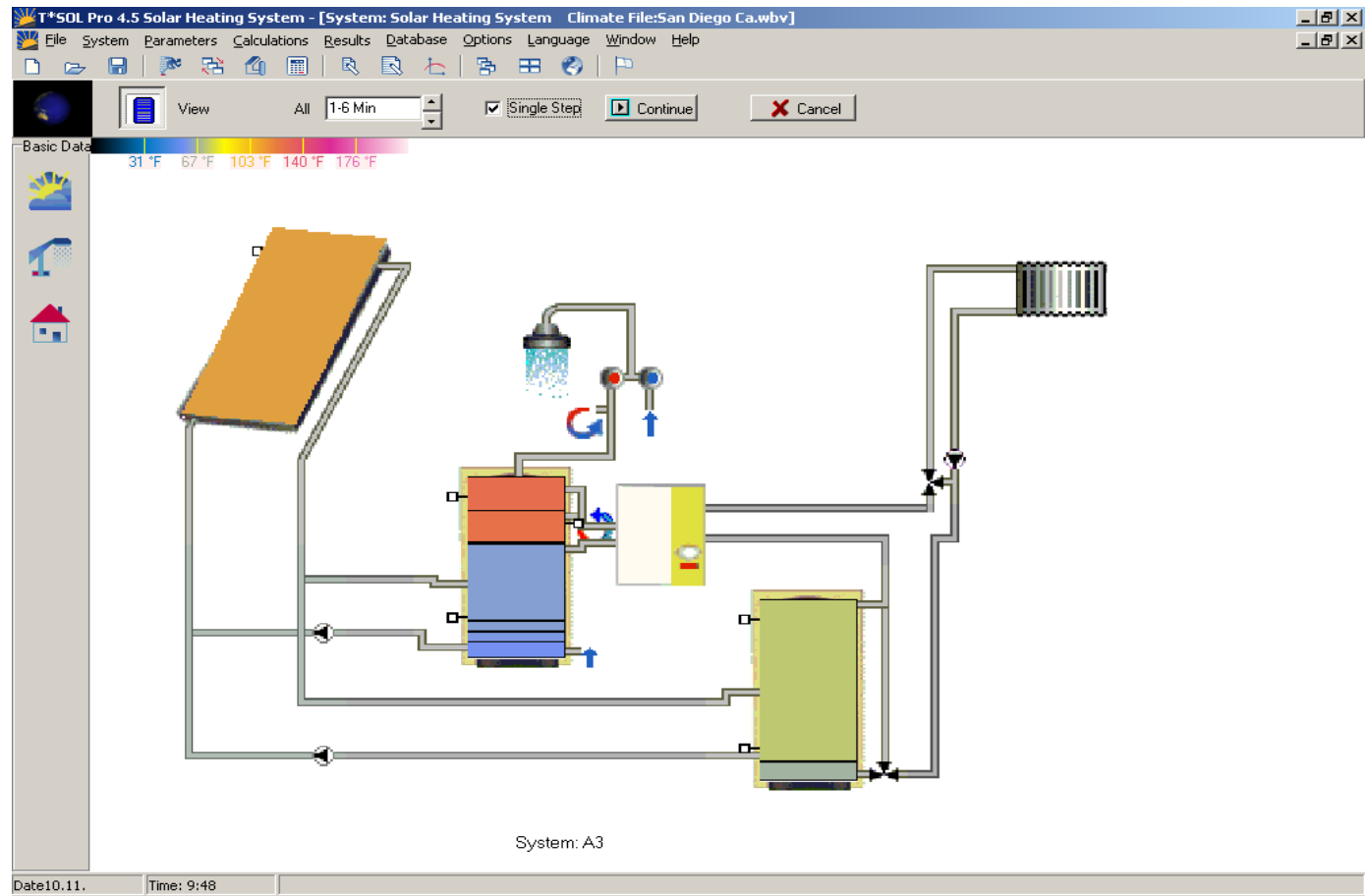
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# Simulation





```

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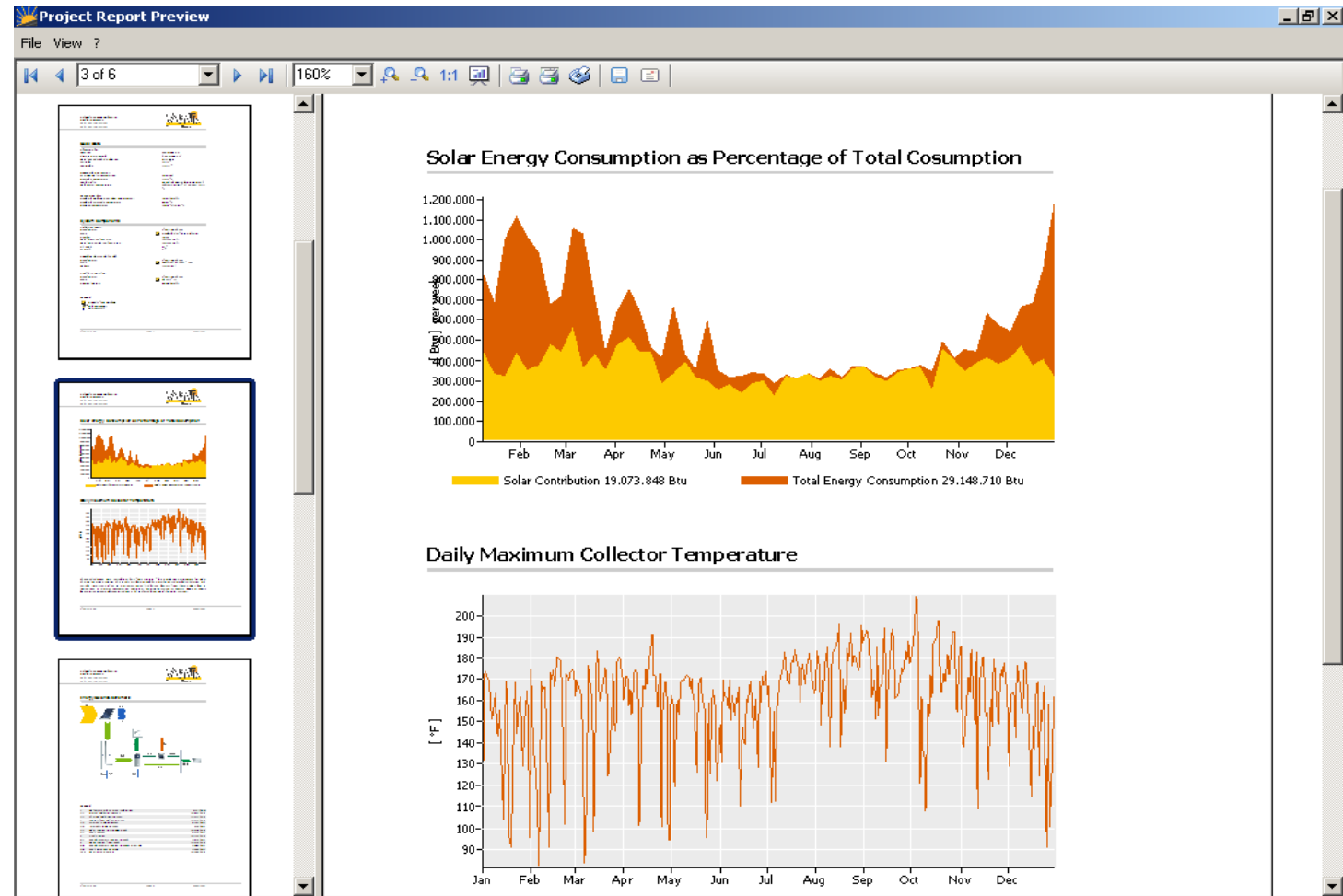
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# Results





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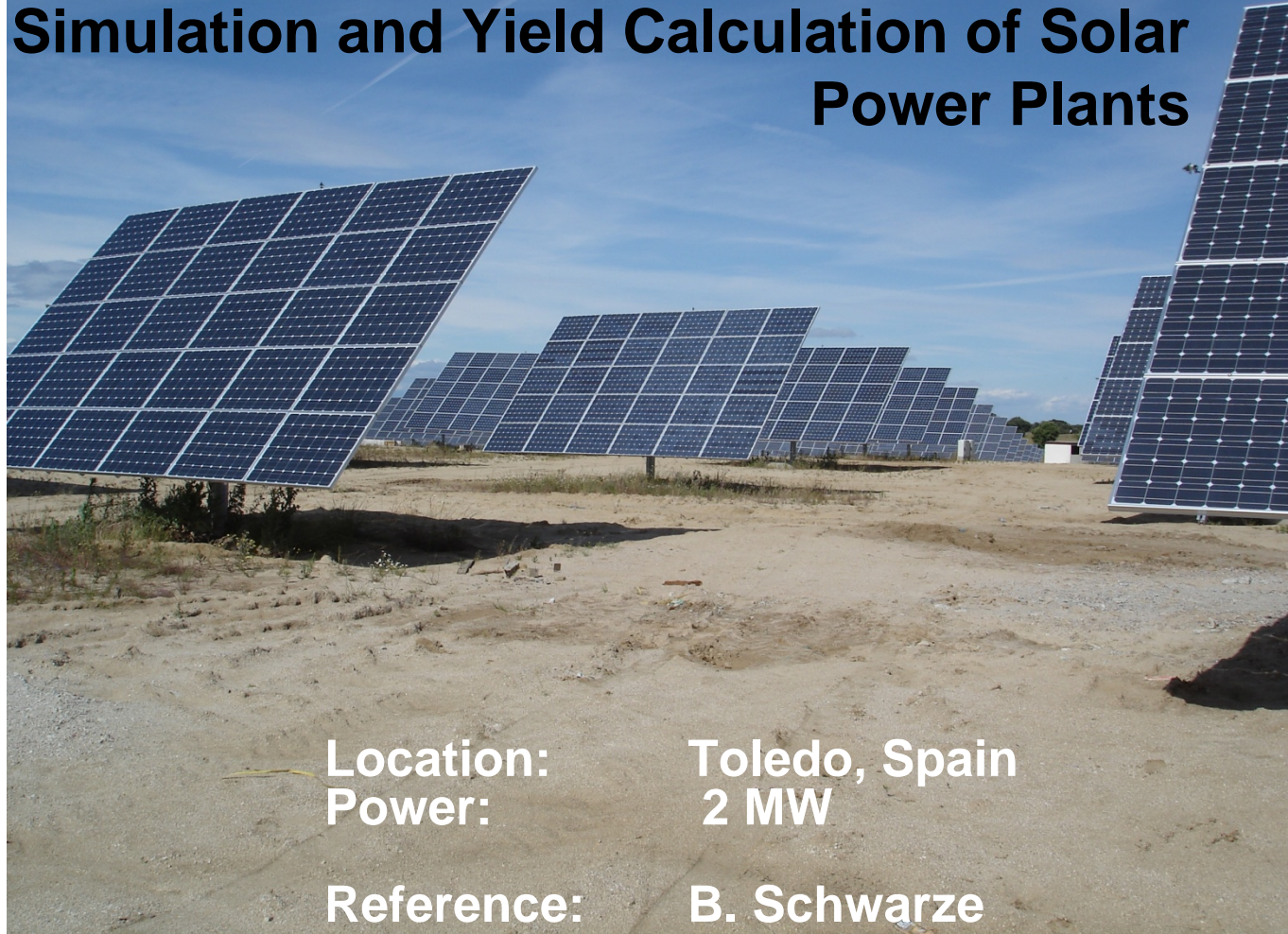
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# Simulation and Yield Calculation of Solar Power Plants



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

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set | m_DesignTemplate = value; |
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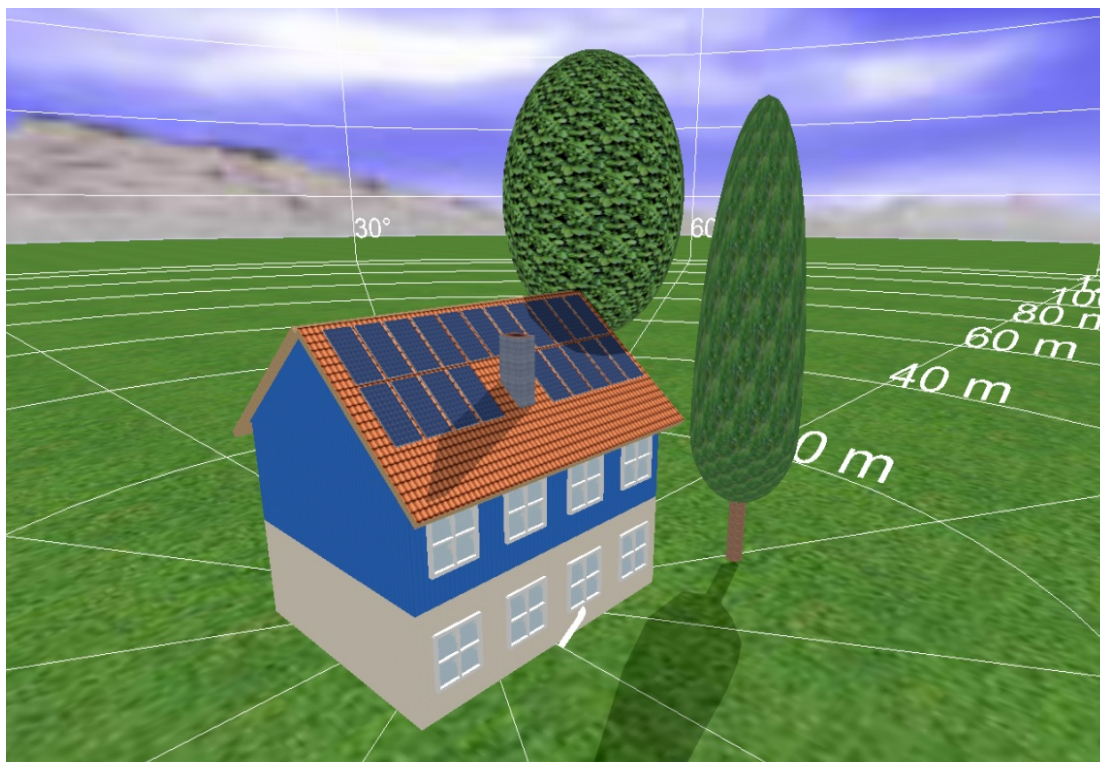
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# PV\*SOL Pro



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





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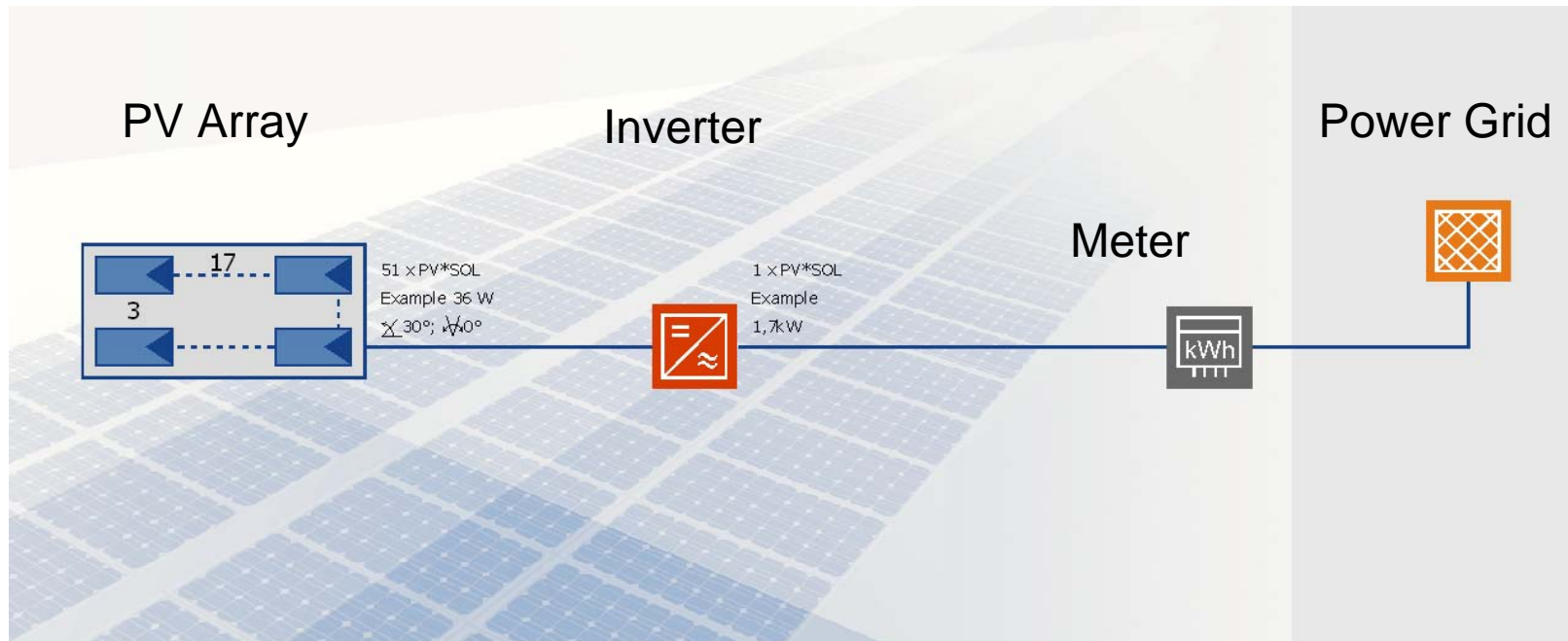
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```



# PV\*SOL Full Feed-In System



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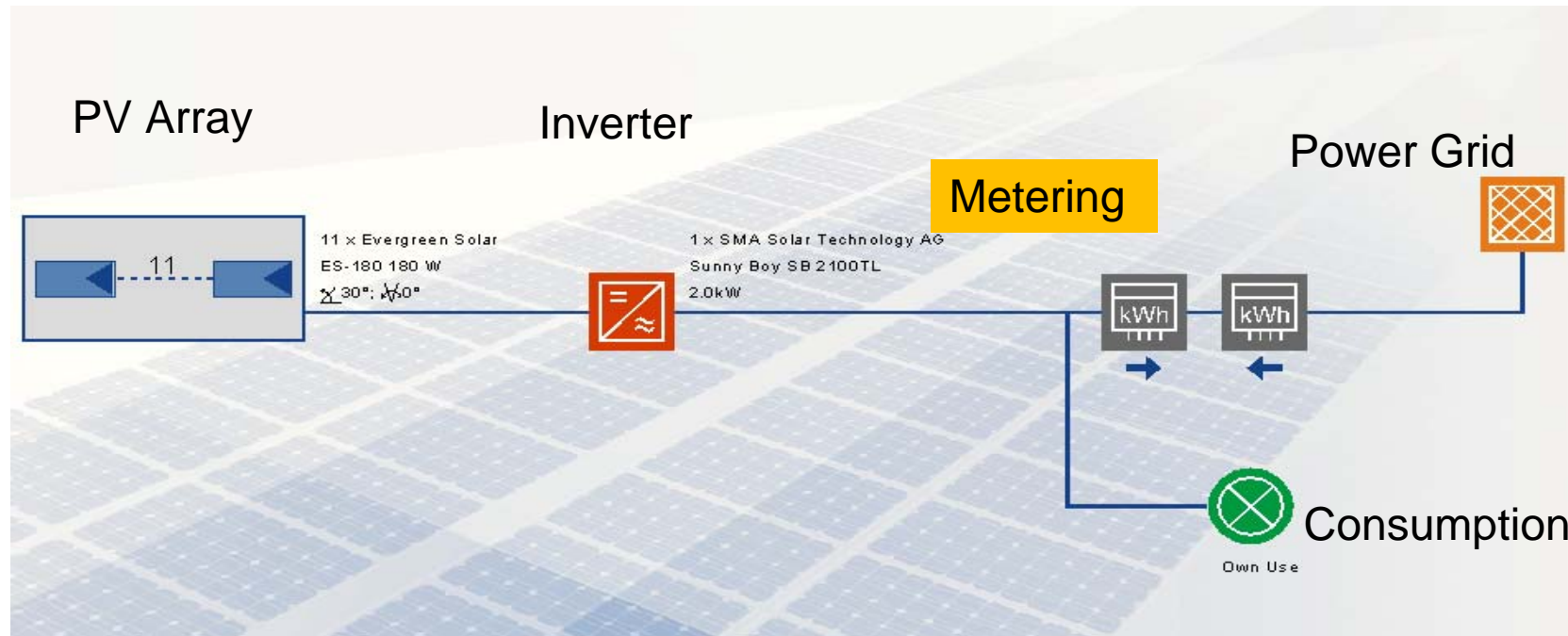
public IntPtr Handle | set; get; |

/// <summary>

```



# PV\*SOL Net Metering System



```

/// <summary>
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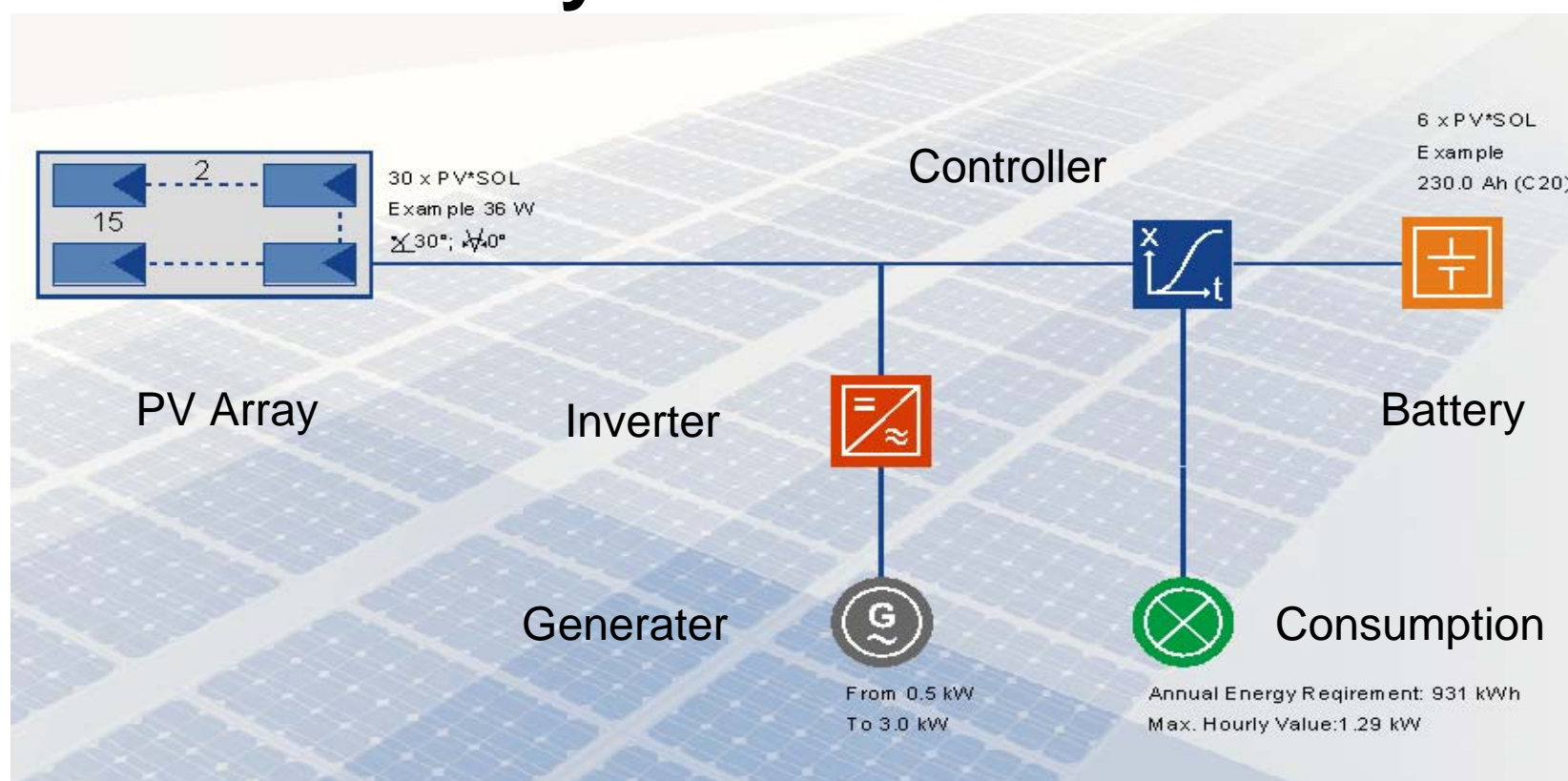
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```



# PV\*SOL Stand Alone System





```
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/// <returns></returns>
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public IntPtr Handle { set; get; }

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```

## Why is Simulation Software needed



**Location:** Barcelona, Spain  
**Power:** 2.5 MW

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# 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



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# 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.

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# 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

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# Input



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

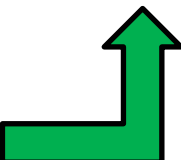


Simulation

# Output



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



```
set | m_DesignTemplate = value; |
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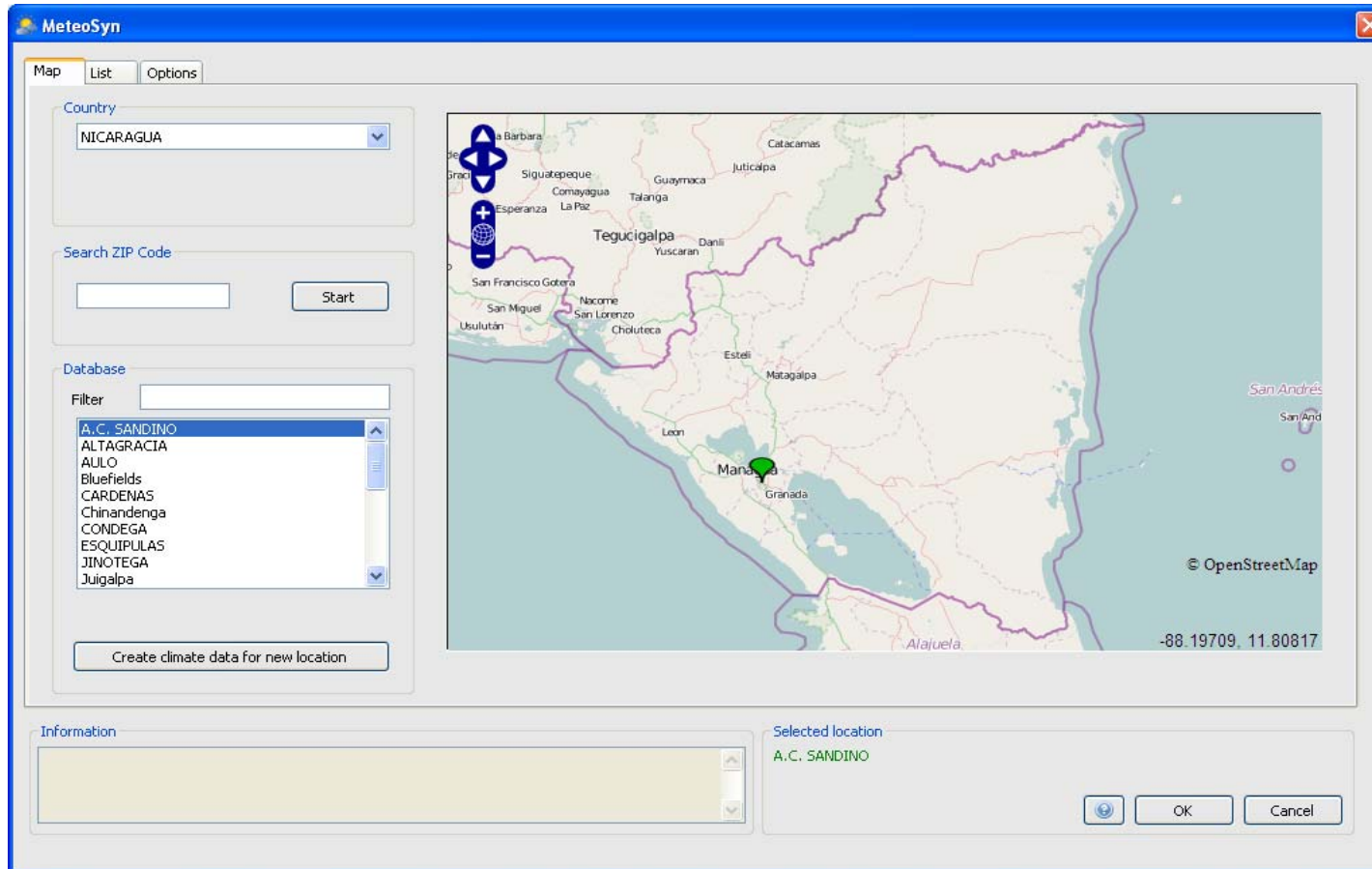
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# Meteorological Data



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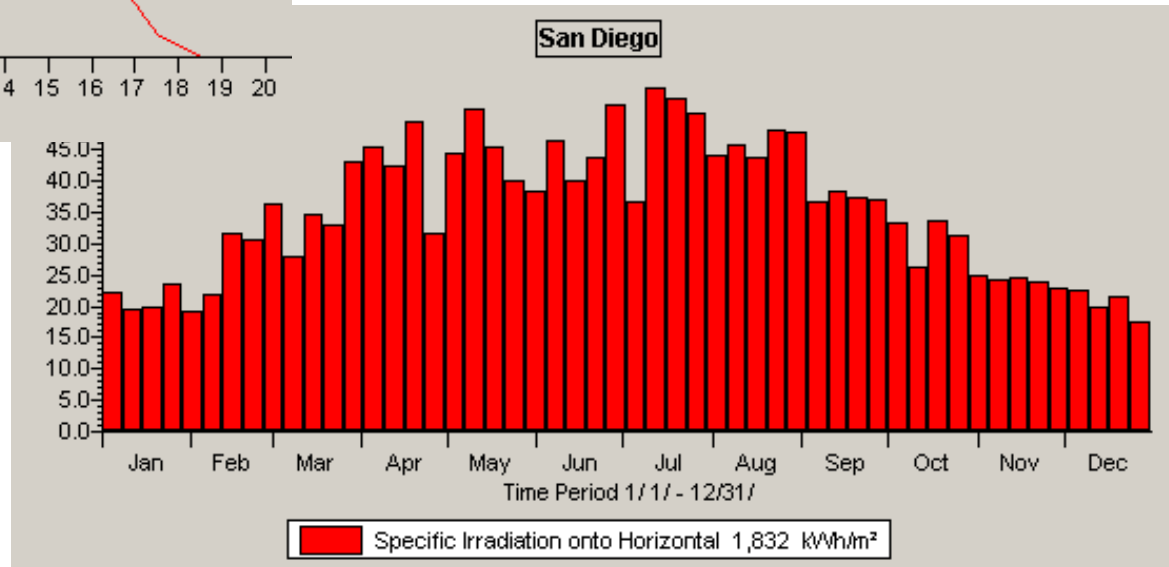
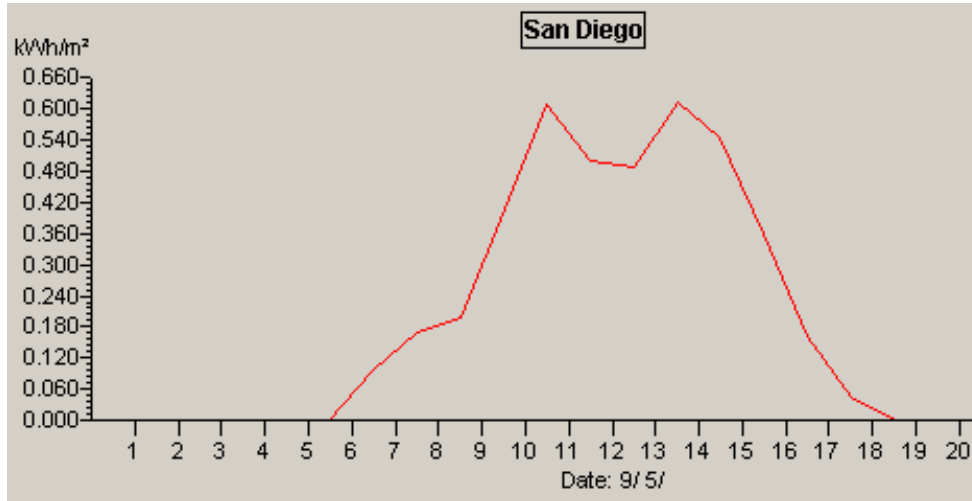
```



# Irradiation

Hourly Values for

- Irradiation
- Outside Temperature
- Wind Velocity



8760 Values per Year  
Loaded from a Database

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```



# Orientation of the Modul Area

**Module Data**

Tilt Angle of PV Modules:  °

Orientation of PV Modules:  °

Installation Type:

Determine PV System DC Output from:

**Model: Example**  
Output: 36 W

-90° = East  
0° = South  
90° = West  
180° = North

Selection

Input

PV Generator Output: 1,73 kWp

Number of PV Modules: 48

1,73 kWp



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# PV\*SOL Calculates Shade

**Row Distance**
[-] [x]

**Settings**

Reference	Value	Unit
Module Width b	0,40	m
Mounting Height h	0,20	m
Module Inclination $\beta$	30,00	°
Roof Angle $\beta_1$	0,00	°
Position of Sun $\gamma$	14,02	°
Solar Altitude Valid for	21.12. 12:00	-

**Results**

Reference	Value	Unit
Row Distance d	1,15	m
Frame Distance d1	0,80	m
Projected Module Width	0,35	m

**Minimum distance is calculated for azimuth = 0**  
(Northern Hemisphere: Module Orientation South)  
(Southern Hemisphere: Module Orientation North)



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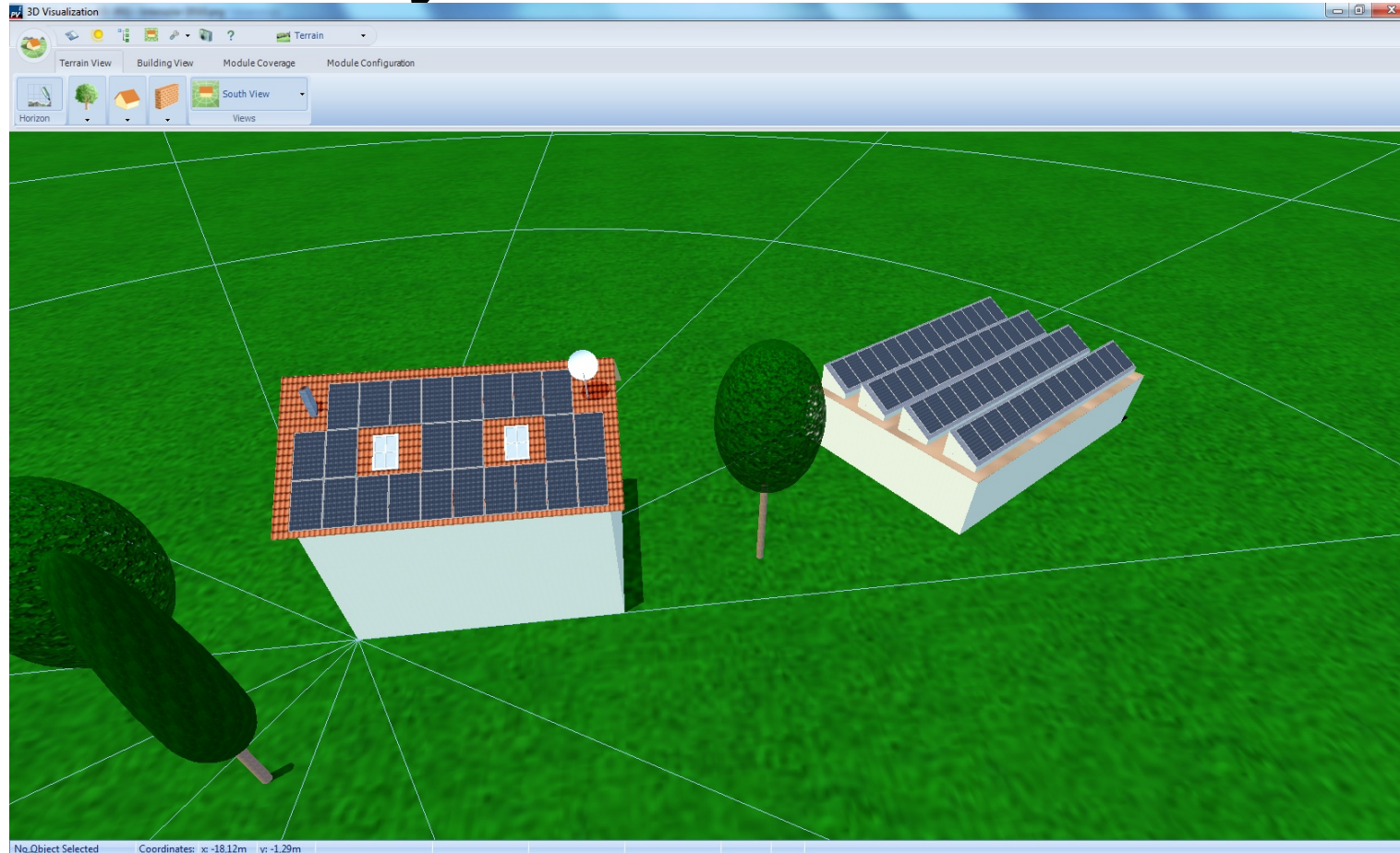
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```



# Roof based Systems



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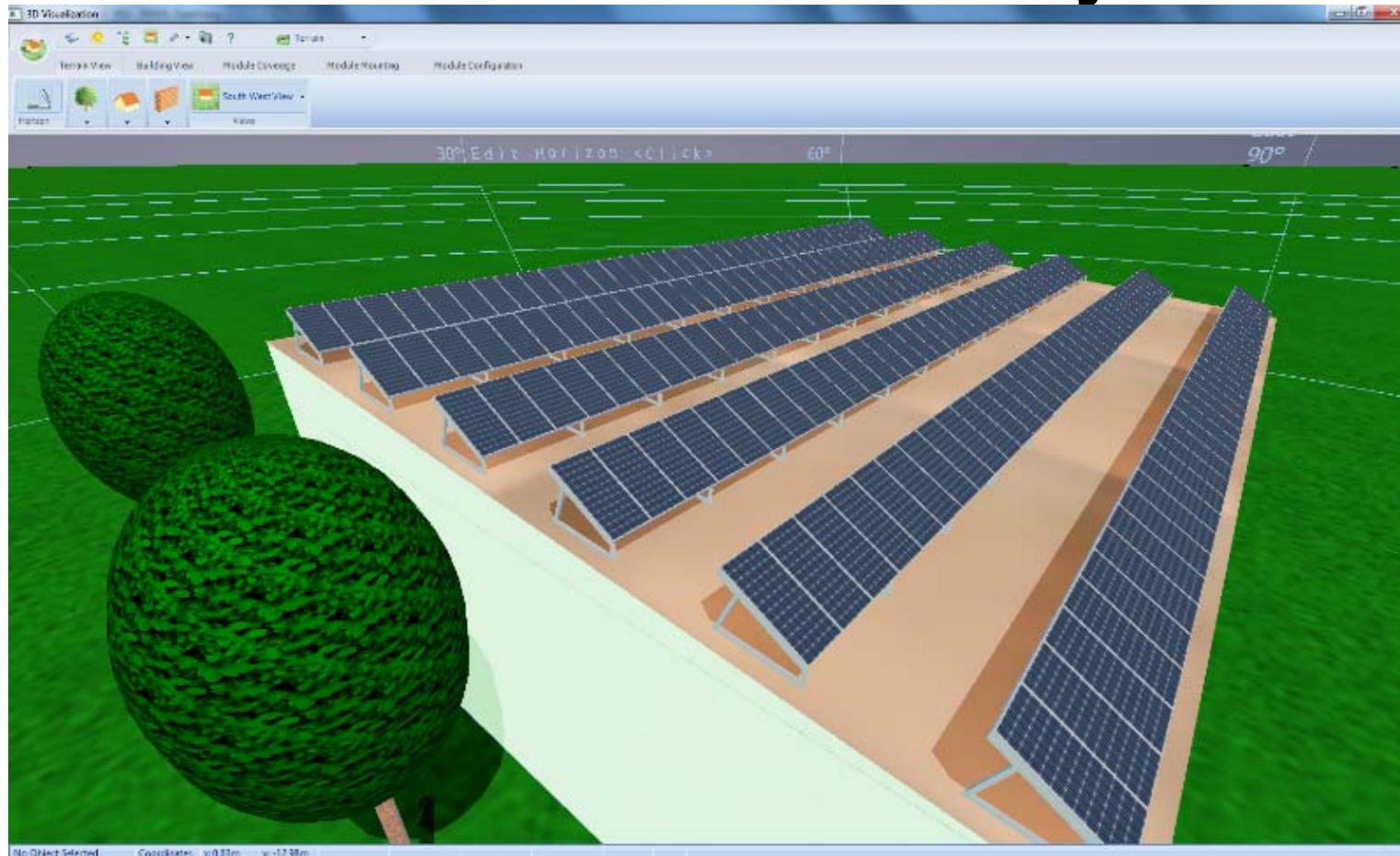
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# Flat Roof or Ground Mounted System





```

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```

# Module Database

**Load File**

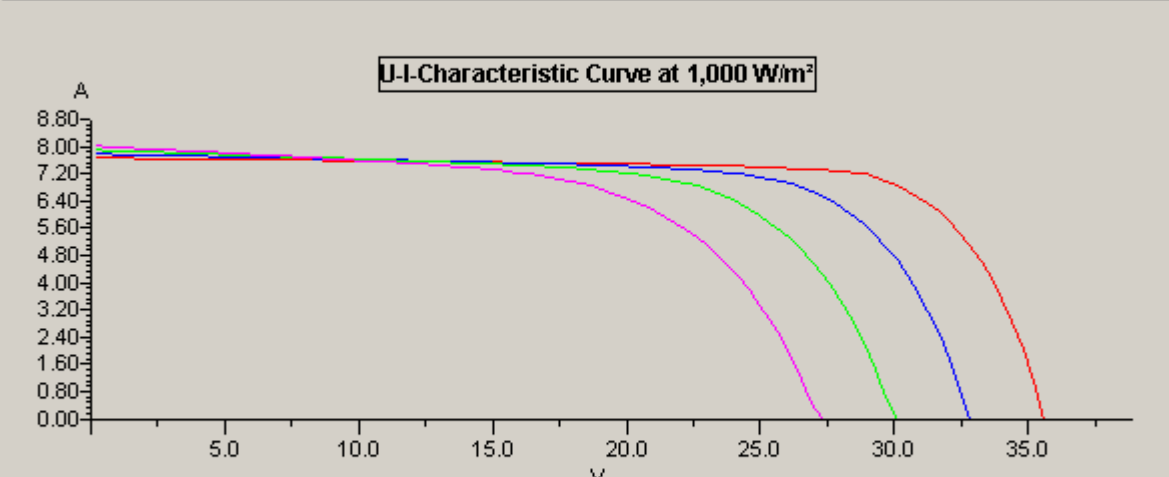
Show Only User-Created Data Records   
  Show Products that are Not Available

	Manufacturer	Type
Atlantis Solar Systeme AG	BP Solar	BP 7180N
Axitec/Krannich Solartechn.	BP Solar	BP 7175N
Azur Solar GmbH	BP Solar	BP 380S
Bekaert ECD Solar	BP Solar	BP 3160N
Bharat Electronics Limited	BP Solar	BP 3150S
Bharat Heavy Electricals	BP Solar	BP 3125S
BIC	BP Solar	BP 7185N
Biohaus	BP Solar	BP 7190N
BP Solar	BP Solar	BP 3165N
Buderus Heiztechnik GmbH	BP Solar	BP 3170N
Canadian Solar Inc.	BP Solar	BP 3165Q
Chauri	BP Solar	BP 3170Q
CNPV Power	BP Solar	BP 3170Q
Conergy AG	BP Solar	BP 3210N
Corus Bausysteme GmbH	BP Solar	BP 3220N
Creton AG	BP Solar	BP 3230N
CSG Solar		
Dachziegelwerke Pfeleiderer		
DAY4 SYSTEMS GmbH		
Dunasolar Photovoltaics Inc		
EBARA SOLAR, INC.		
ecoTec Energy		
EGing		
Emmvee Solar		
Energetica Energietechnik G		

**Graph**

File Curve Axes Options Table

Arial
⏪ ⏩



— 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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# 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

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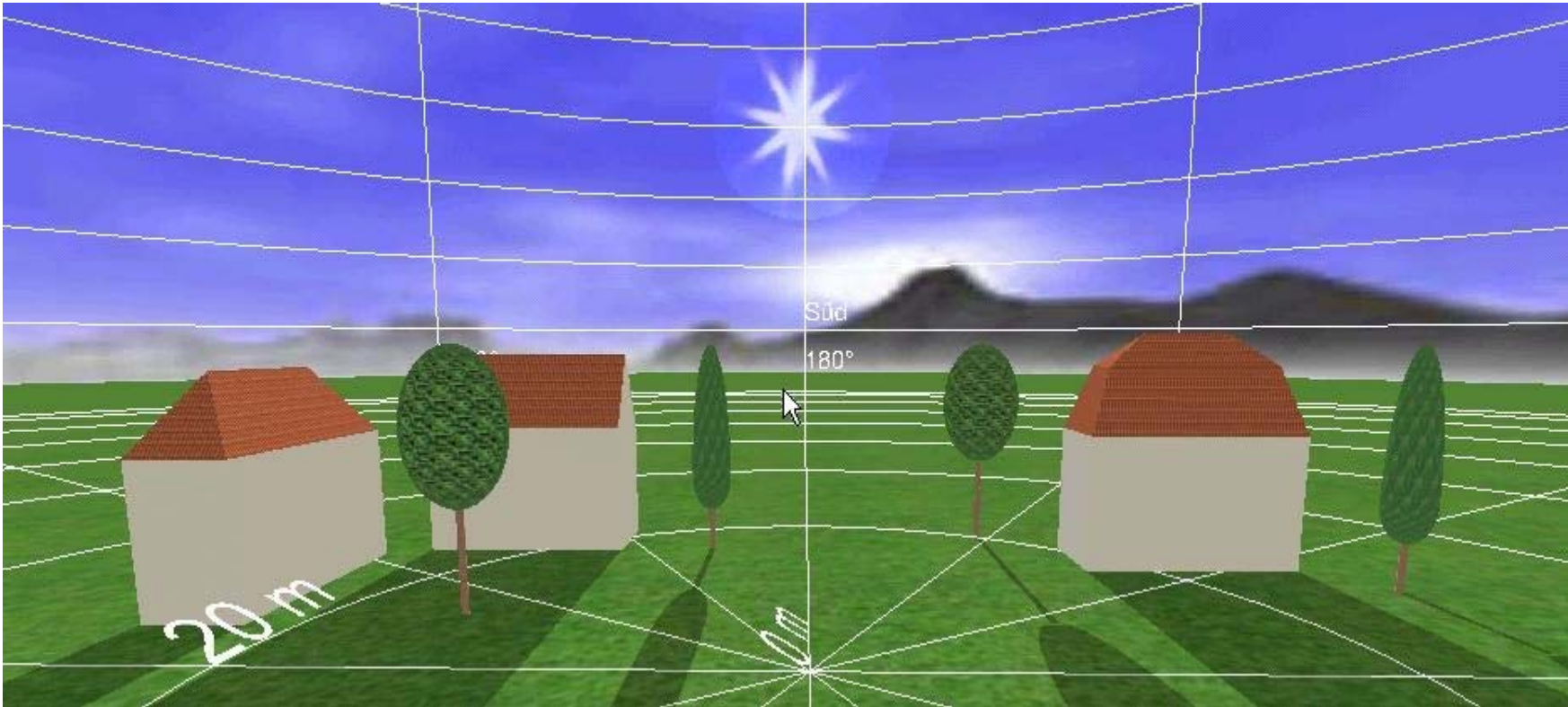
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# Simulation



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# Input

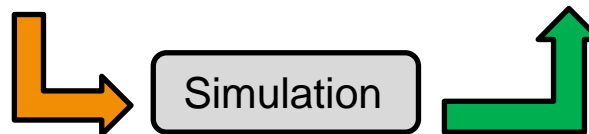


- Meteorological Data
- Consumption Profile
- Module Modeling
- Inverter Modeling
- Tariffs
- Others

# Output



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



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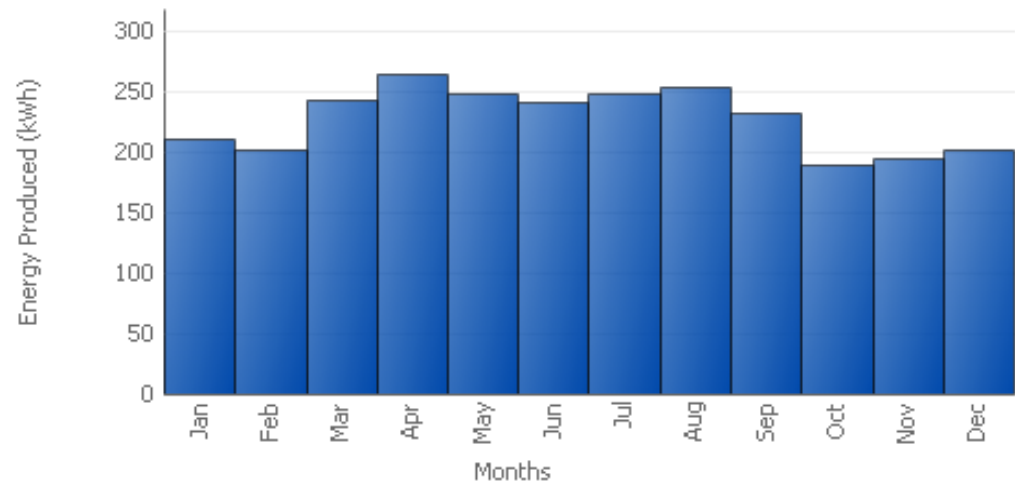


# Energy Yield

## Simulation

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

Production Forecast





```

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```



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)

Year	Cash Value [€]
1	-28000
2	-26000
3	-24000
4	-22000
5	-20000
6	-18000
7	-16000
8	-14000
9	-12000
10	-10000
11	-8000
12	-6000
13	-4000
14	-2000
15	0
16	2000
17	4000
18	6000
19	8000
20	10000

<< Back
>> Continue
Close >>
Help

```
set | m_DesignTemplate = value; |  
get | return m_DesignTemplate; |  
  
/// <summary>  
/// Fill the variables  
/// </summary>  
/// <returns></returns>  
public string PreviewPrint()  
{  
    ReadXML();  
    IsPreviewNotRTF = true;  
    String sz = GetLLFile();  
    Print();  
  
    set | m_DesignTemplate = value; |  
    get | return m_DesignTemplate; |  
  
/// <summary>  
/// Sets the language for the Preview Editor (Modiary)  
/// </summary>  
public String Language { set; get; }  
  
public IntPtr Handle { set; get; }  
  
/// <summary>
```

# Impact of Environmental Factors with Regard to the Yield



Location: Extremadura, Spain  
Power: 3.0 MW  
Reference: [www.geosol.com](http://www.geosol.com)

```
set | m_DesignTemplate = value; |
get | return m_DesignTemplate; |

/// <summary>
/// Fill the variables
/// </summary>
/// <returns></returns>
public string PreviewPrint()
{
    ReadXML();
    IsPreviewNotRTF = true;
    String sz = GetLLFile();
    Print();
}

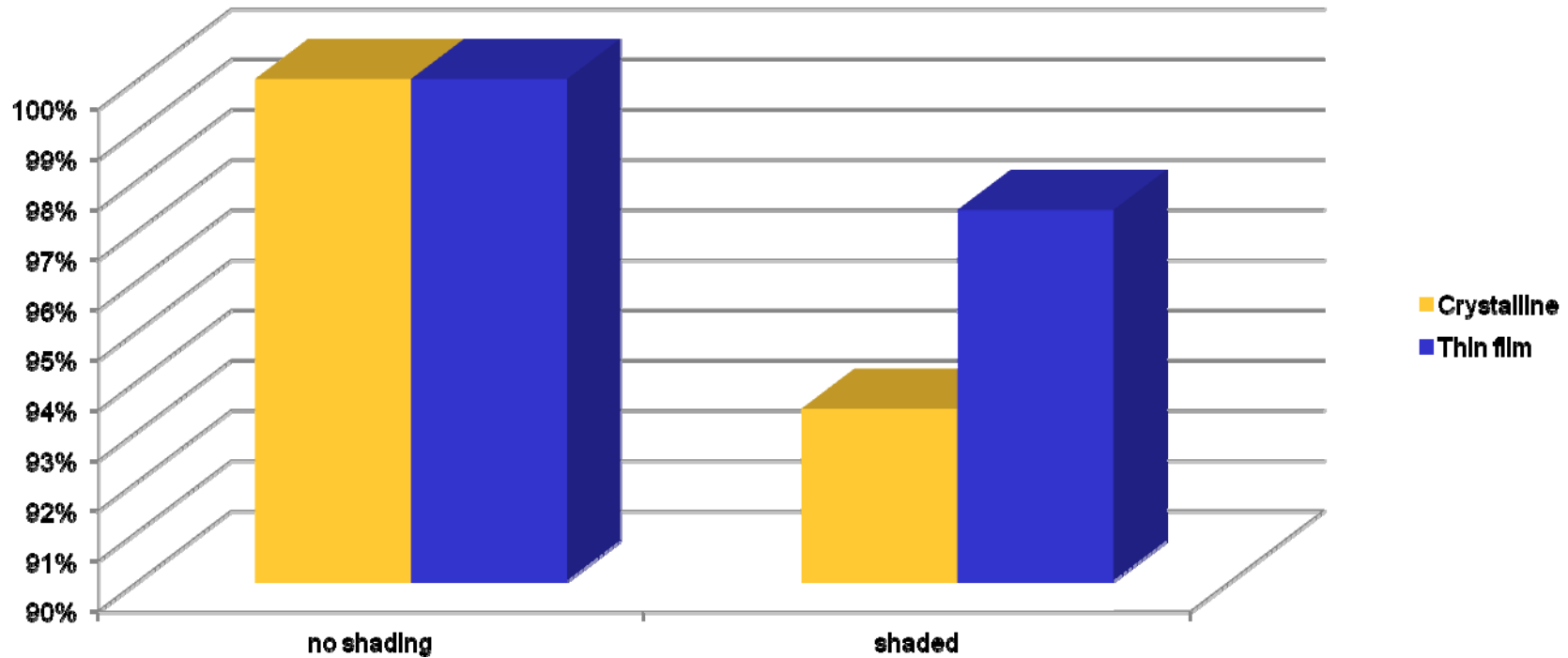
/// <summary>
/// Sets the language for the Preview Editor (Modular)
/// </summary>
public String Language { set; get; }

public IntPtr Handle { set; get; }
/// <summary>
```



# Partial Shading Impact on Crystalline and Thin Film Modules

For Las Vegas

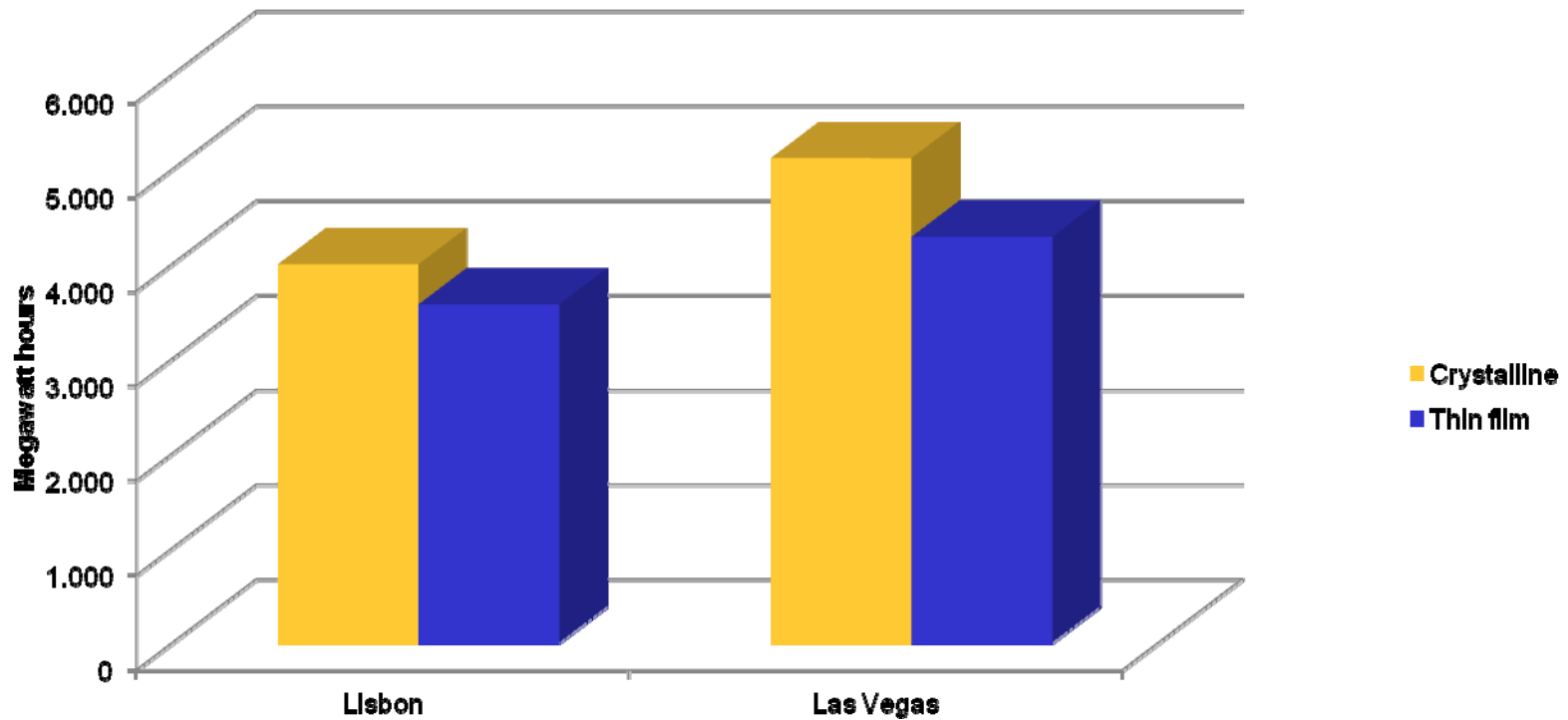




```
set | m_DesignTemplate = value; |
get | return m_DesignTemplate; |
/// <summary>
/// Fill the variables
/// </summary>
/// <returns></returns>
public string PreviewPrint()
{
    ReadXML();
    IsPreviewNotRTF = true;
    String sz = GetLLFile();
    Print();
}
/// <summary>
/// Sets the language for the Preview Editor (Ordinary)
/// </summary>
public String Language { set; get; }
public IntPtr Handle { set; get; }
/// <summary>
```



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



```
set | m_DesignTemplate = value; |
get | return m_DesignTemplate; |

/// <summary>
/// Fill the variables
/// </summary>
/// <returns></returns>
public string PreviewPrint()
{
    ReadXML();
    IsPreviewNotRTF = true;
    String sz = GetLLFile();
    Print();
}

/// <summary>
/// Sets the language for the Preview Editor (Toolbar)
/// </summary>
public string Language { set; get; }

public IntPtr Handle { set; get; }

/// <summary>
```



# Design and Simulation Program for Off-Grid Systems



## SMA OFF-GRID CONFIGURATOR

SMA Off-Grid Configurator 1.0 (R2)

```
set | m_DesignTemplate = value; |
get | return m_DesignTemplate; |

/// <summary>
/// Fill the variables
/// </summary>
/// <returns></returns>
public string PreviewPrint()
{
    ReadXML();
    IsPreviewNotRTF = true;
    String sz = GetLLFile();
    Print();
}

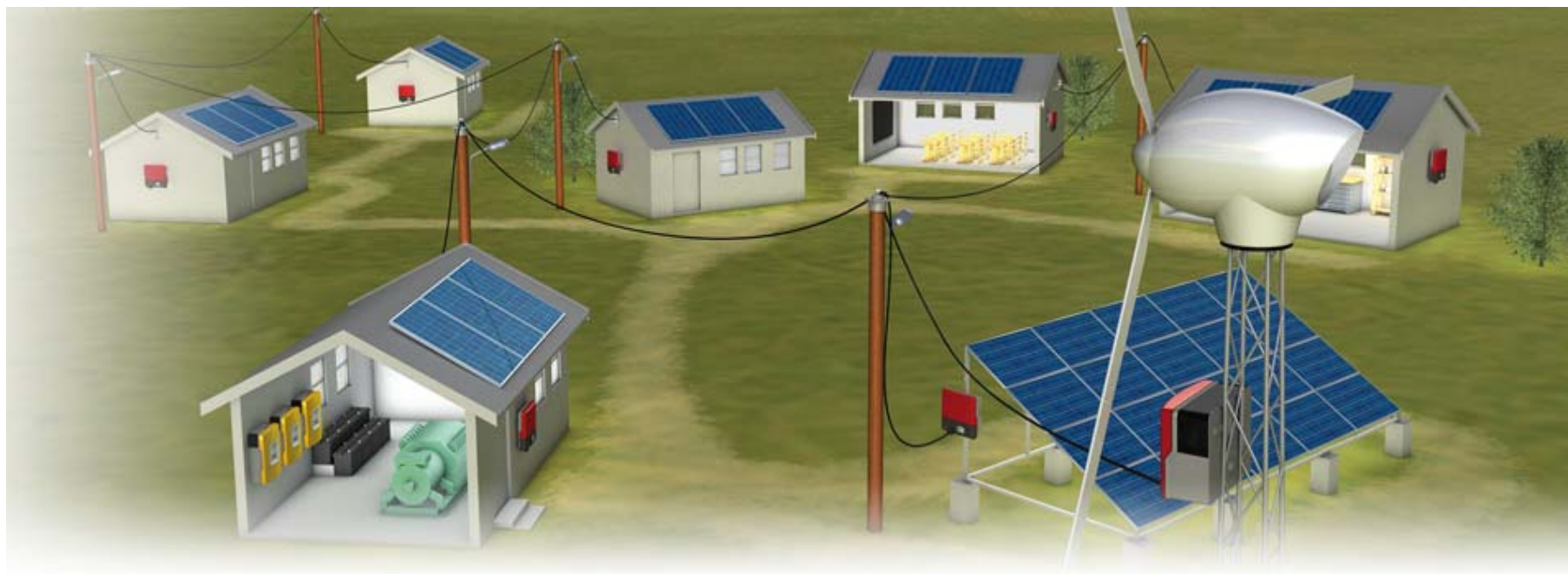
/// <summary>
/// Sets the language for the Preview Editor (Modinary)
/// </summary>
public String Language | set; get; |

public IntPtr Handle | set; get; |

/// <summary>
```



# SMA Off – Grid Configurator



```

set | m_DesignTemplate = value; |
get | return m_DesignTemplate; |
}
}
/// <summary>
/// Fill the variables
/// </summary>
/// <returns></returns>
public string PreviewPrint()
{
    ReadXML();
    IsPreviewNotRTF = true;
    String sz = GetLLFile();
    Print();
}
}
}
/// <summary>
/// Sets the language for the Preview Editor (Modiary)
/// </summary>
public String Language { _set; get; }
}
public IntPtr Handle { set; get; }
}
/// <summary>

```



- 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**



```

set | m_DesignTemplate = value; |
get | return m_DesignTemplate; |

/// <summary>
/// Fill the variables
/// </summary>
/// <returns></returns>
public string PreviewPrint()
{
    ReadXML();
    IsPreviewNotRTF = true;
    String sz = GetLLFile();
    Print();
}

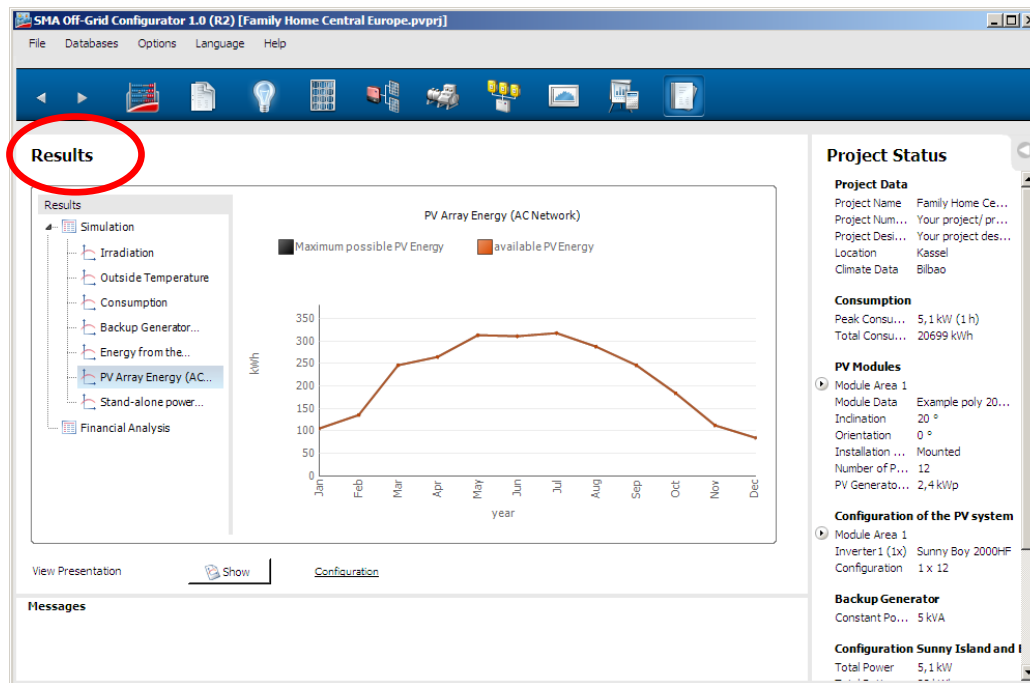
/// <summary>
/// Sets the language for the Preview Editor (Modular)
/// </summary>
public String Language { set; get; }

public IntPtr Handle { set; get; }
/// <summary>

```

# 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



```

/// <summary>
/// Fill the variables
/// </summary>
/// <returns></returns>
public string PreviewPrint()
{
    ReadXML();
    IsPreviewNotRTF = true;
    String sz = GetLLFile();
    Print();
}

```

```

set | m_DesignTemplate = value; |
get | return m_DesignTemplate; |

```

```

/// <summary>
/// Sets the language for the Preview Editor (Modiary)
/// </summary>
public String Language | set; get; |
public IntPtr Handle | set; get; |
/// <summary>

```



**SMA Off-Grid Configurator 1.0 (R2)**

File Databases Options Language Help

**Financial Analysis**

Assessment Period:  Years Interest on Capital:  %

Components	Model	Installed Elements	Unit Price	Installation Costs	Service Life	Number of	Cost over Assesme
Modules	Example poly 200 W	24	0,00 €	0,00 €	25,00	24	0,00 €
Inverter	Sunny Boy 5000TL-20	1	0,00 €	0,00 €	25,00	1	0,00 €
						2	0,00 €
						48	0,00 €
						1	0,00 €

**Project Status**

**Project Data**

Project Name Your Project Name  
Project Num... Your Project/Pr...  
Project Desi... Your Project De...  
Location City of the Insta...  
Climate Data Kassel

**Consumption**

Peak Consu... 3,1 kW (1h)  
Total Consu... 5000 kWh

Cable Costs   
Work Costs   
Other Costs

**Messages**

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

```
/// <summary>
/// Fill the variables
/// </summary>
/// <returns></returns>
public string PreviewPrint()
{
    ReadXML();
    IsPreviewNotRTF = true;
    String sz = GetLLFile();
    Print();
}

set | m_DesignTemplate = value; |
get | return m_DesignTemplate; |

/// <summary>
/// Sets the language for the Preview Editor (Modular)
/// </summary>
public String Language | set; get; |

public IntPtr Handle | set; get; |
/// <summary>
```



# Thank You for Your Attention



Stand Alone System in Nepal  
Designed by PV\*SOL