

PV System Design with PVsyst



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“Training on Renewable Energy Policy Tools
and Energy Technologies Best Practices”

CES Solar Cells Testing Center (CSSC)
King Mongkut’s University of Technology Thonburi (KMUTT)
November 23, 2018

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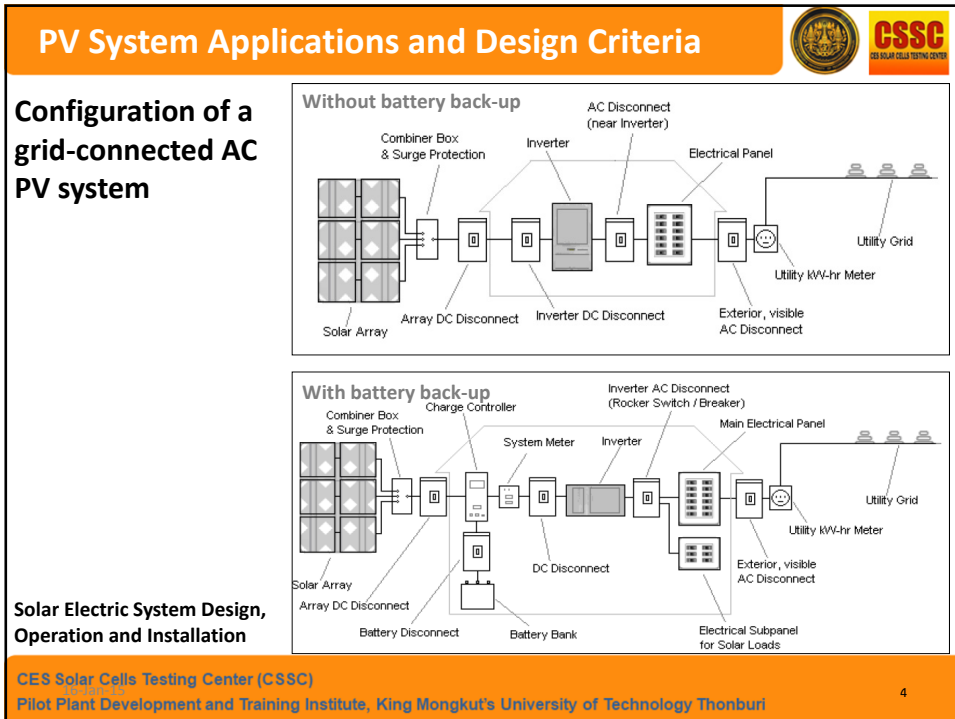
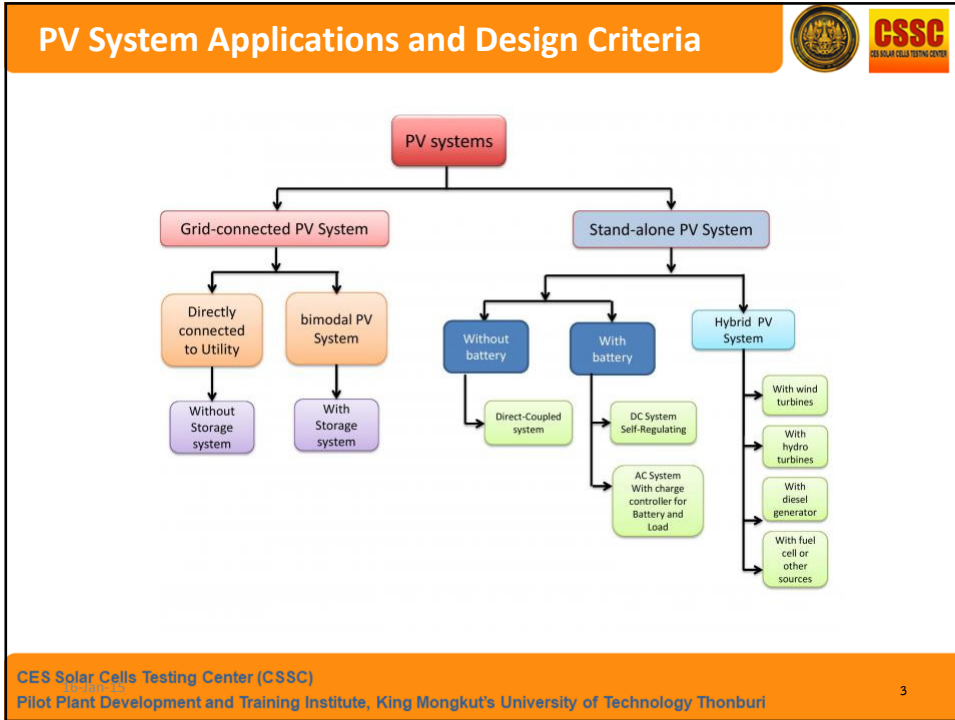


TOPICS



- PV System Applications and Design Criteria
- Software for PV System Design
- Concepts of PV System Design with PVsyst
- Exercises with PVsyst

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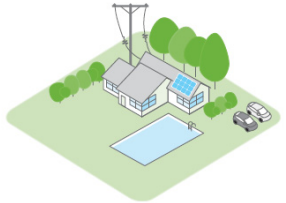
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PV System Applications and Design Criteria

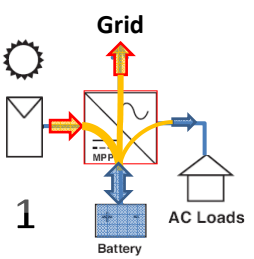
Grid-connected PV System with Battery Back-up



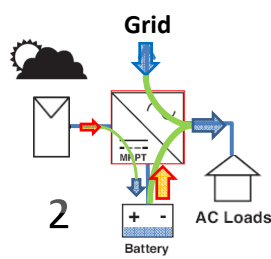
Case	Solar	Load	Bat.	Grid
1	High	Low	Full	Export
2	Low	High	Discharge	Import
3*	No	Low	Discharge	Export

*Case 3 is when export energy to the grid during network peak (20:00 – 22:00)

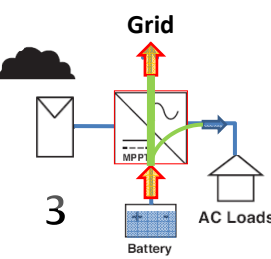
➤ Residential grid-interactive solar with battery backup



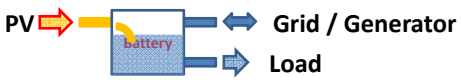
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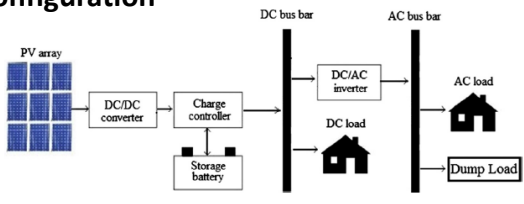
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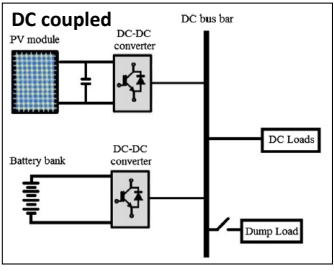
PV System Applications and Design Criteria

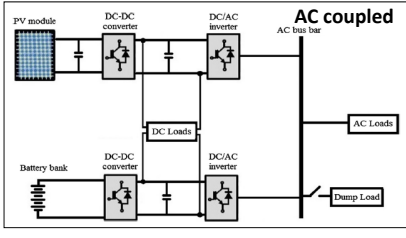
Standalone (off-grid) PV system Configuration



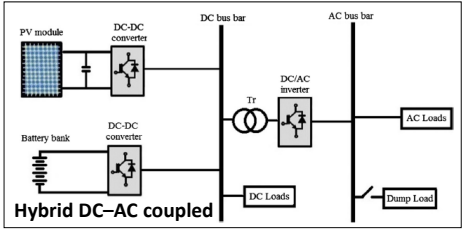
DC coupled



AC coupled



Hybrid DC-AC coupled





Tamer Khatib et. al., A review on sizing methodologies of photovoltaic array and storage battery in a standalone photovoltaic system

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PV System Applications and Design Criteria






Ambient temp.
Module temp.

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PV System Applications and Design Criteria

Solar Irradiation

PV plane of 14 degrees incline angle which is the optimum tilt angle in Bangkok.

Daily solar radiation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total (kWh/m ² /day)	5.63	5.93	5.95	5.71	4.98	4.75	4.61	4.78	4.97	5.19	5.37	5.41
Global (kWh/m ² /day)	4.9	5.44	5.78	5.89	5.41	5.28	5.07	5.03	4.92	4.81	4.71	4.62



— Total solar radiation (kWh/m²/day) — Global solar radiation (kWh/m²/day)

Data from Department of Alternative Energy Development and Efficiency (DEDE)

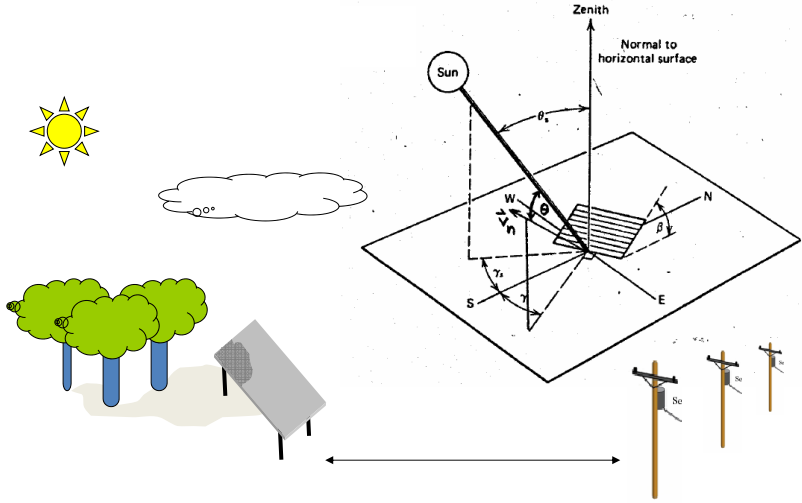
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PV System Applications and Design Criteria



Site and Building factors




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PV System Applications and Design Criteria


Site and Building factors




On or in a gently sloped roof



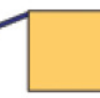
On a flat roof



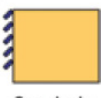
In a flat roof




Glazed roof



Canopy




Sun shade




Steep sloped roof

Options less suitable for Singapore:



In front of façade



Cold/warm façade




Figure A.1.1. Building exterior




Figure A.1.2. PV array view (PV Sunshade)




Figure A.1.3. PV array view (PV Main Roof)






Figure A.1.4. PV array view (PV Staircase Facade)

Handbook for Solar Photovoltaic (PV) Systems, The Building and Construction Authority (BCA), Singapore

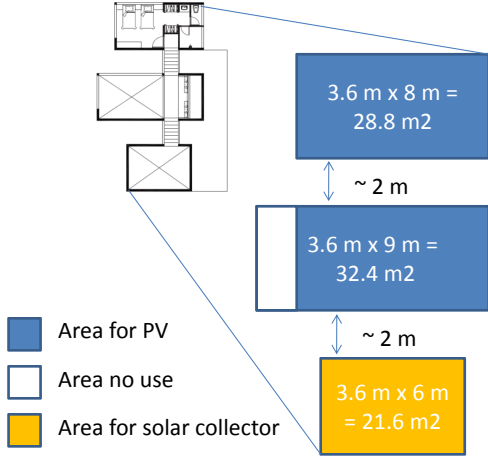
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PV System Applications and Design Criteria

Available Area for PV Installation



Roof No.1	28.8 m2
Roof No.2	32.4 m2
Roof No.3	21.6 m2
Total	82.8 m2
Area for others	25.2 m2
Area for PV	57.6 m2

■ Area for PV



□ Area no use

■ Area for solar collector

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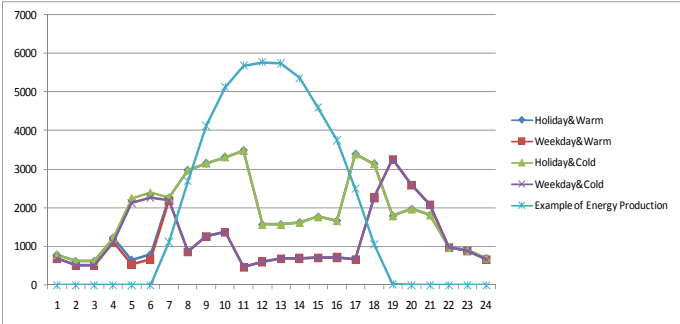
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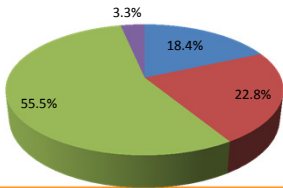
PV System Applications and Design Criteria

Load Consumption

Hourly Power production and consumption (Watts)







- Holiday load
- Weekday load
- Everyday load
- Additional load for cold day

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PV System Applications and Design Criteria



Load Consumption

System	Appliances	Q'ty	Power (W)	Operating hours/day	Energy use (kWh / day)	Day use (days/year)	Energy use (kWh / year)
House Functioning	Refrigerator	1	60	24.00	1.44	365	525.60
	Freezer	1	120	24.00	2.88	52	150.17
	Washing Machine	1	2000	2.00	4.00	52	208.57
	Clothes dryer	1	2000	1.00	2.00	52	104.29
	Dishwasher	1	600	1.00	0.60	209	125.14
	Television	1	65	7.00	0.46	365	166.08
	Computer	1	170	4.00	0.68	261	177.29
	DVD Player	1	20	3.00	0.06	261	15.64
	Loudspeaker	1	30	3.00	0.09	261	23.46
	Oven	1	2500	1.00	2.50	104	260.71
	Stove (cooking)	1	1400	2.00	2.80	365	1022.00
Lighting System	Light bulbs	8	20	8.00	1.28	365	467.20
Air Handling System	*Air conditioner	2	2000	8.00	32.00	150	4800.00
	Ventilation Fan	3	30	8.00	0.72	180	129.60
Plumbing System	Electric pump	1	125	2.00	0.25	365	91.25
Monitoring System	Display unit	1	50	4.00	0.20	365	73.00
	Power&Energy meters	20	1	24.00	0.48	365	175.20
	Measuring Data Center	1	10	24.00	0.24	365	87.60
Others	Electric Fan	4	50	8.00	1.60	365	584.00
	Computer Notebook	1	70	8.00	0.56	365	204.40
Total					25.73	365	9391.2

*For stand alone PV system, load is 3694.4 kWh/year if 2 air conditioners are not operated.

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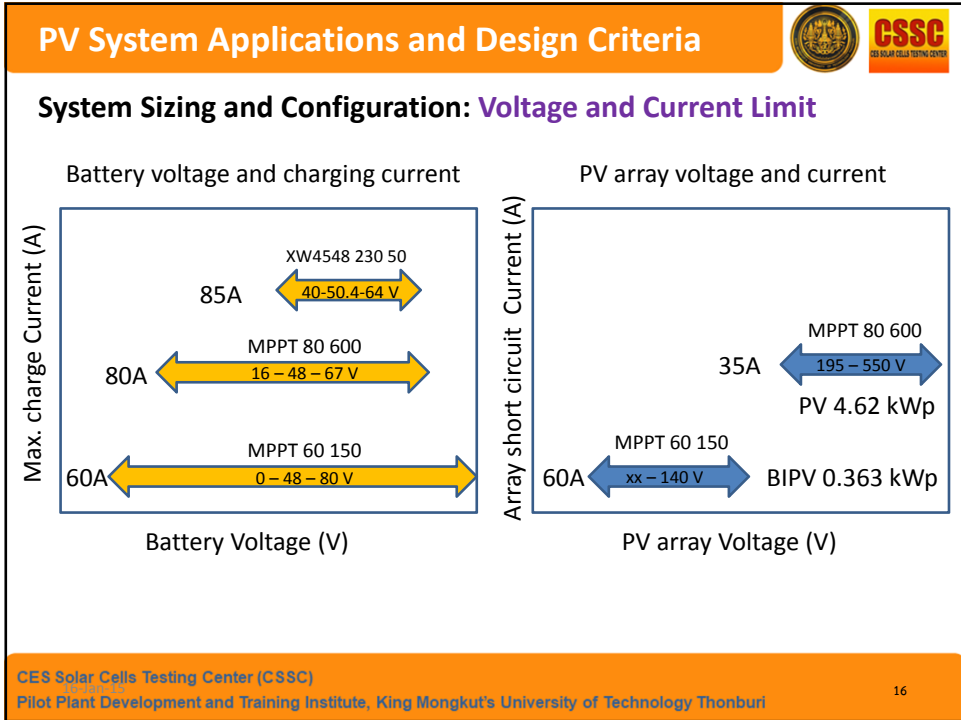
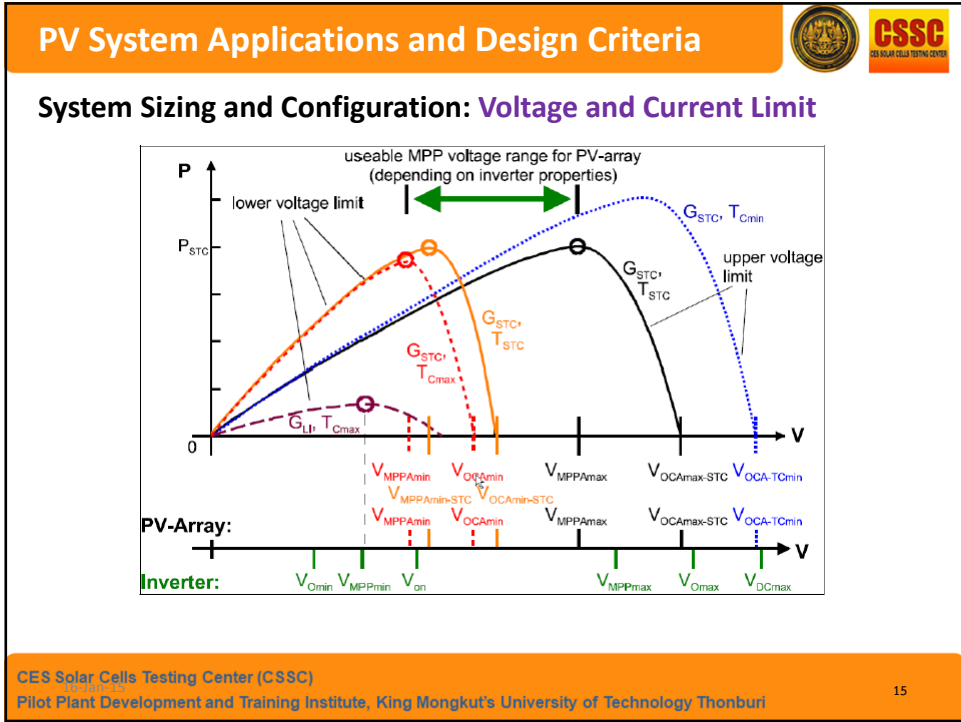
PV System Applications and Design Criteria

Criteria for components selection

Items	PV modules	Inverters	Batteries
Capacity	Consider load, size and inverter (should be >180 W)	~ 5kW , 50Hz, 230 V	For 3 days off-grid load
Limited capacity	PV array rated <= 1.5 inverter rated power	<= 5kW with >=2 MPPT or 1 MPPT & charge controllers	Depend on voltage , total size, and cost
Voltage	System voltage 1000V	PV string voltage	2V x 6, 12, 24
Efficiency	>=14 %	> 90%	> 70%
Warranty	>= 20 years	>= 5 years	>= 5 years
Life time	>= 25 years	>= 10 years	>= 10 years
Availability	Local agent or manufacturer	Local agent or manufacturer	Local agent or manufacturer
Cost	Reasonable	Reasonable	Reasonable
Size	Consider roof area and maximum installed power	Depend on capacity	Depend on capacity
Standard	IEC61215	IEC61727-2004 and IEC 62116	Safety standard TISI, IEC, UL
Reliability	High	High	High

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PV System Applications and Design Criteria

Criteria Parameters for PV System Design and Evaluation

Technical parameters (Off-grid)*

- Loss of power supply probability (LOSP)
- Loss of load probability (LOLP)
- Loss of load expected (LOLE)
- Equivalent loss factor (ELF)
- Total energy loss (TEL)
- State of charge (SOC)
- Level of autonomy (LA)

Economic parameters*

- Net present value (NPV)
- Annualized cost of a system (ACS)
- Total life cycle cost (TLCC)
- Capital recovery factor (CRF)
- Generation cost of energy (GCOE)
- Levelized cost of energy (LCOE)

Technical parameters (Grid)

- Reference Incident Energy in coll. Plane or Reference yield (Yr)
- Ya : Normalized Array Production or Array yield (Ya)
- Yf : Normalized System Production or System yield (Yf)
- PR : Performance Ratio (PR = Yf / Yr)

* Tamer Khatib et. al., A review on sizing methodologies of photovoltaic array and storage battery in a standalone photovoltaic system, *Energy Conversion and Management*, 2016

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PV System Applications and Design Criteria

Limitation of different sizing methods

Sizing method	Input data*			Limitation
	H	D	M	
Intuitive (simplified) methods		•	•	Simple calculations used based on daily or monthly meteorological data may lead to over/under sizing of system design, low reliability and increase system capital, and maintenance and operation costs
Numerical methods	•	•	•	Suboptimal solutions are reached as computation involves linear changes of the decision variables
Analytical methods	•	•	•	Less flexible in designing a standalone PV system as performance is estimated by the computational models
Software tools	•	•	•	Unable to improve system components and limited ability to change the component specifications
AI methods	•	•	•	Complexity in designing system components
Hybrid methods	•	•	•	Complexity in designing system components which are based on complex algorithm functions

Remark: *Input data are the Hourly (H), Daily (D) and Monthly (M) average meteorological data.



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Software for PV System Design

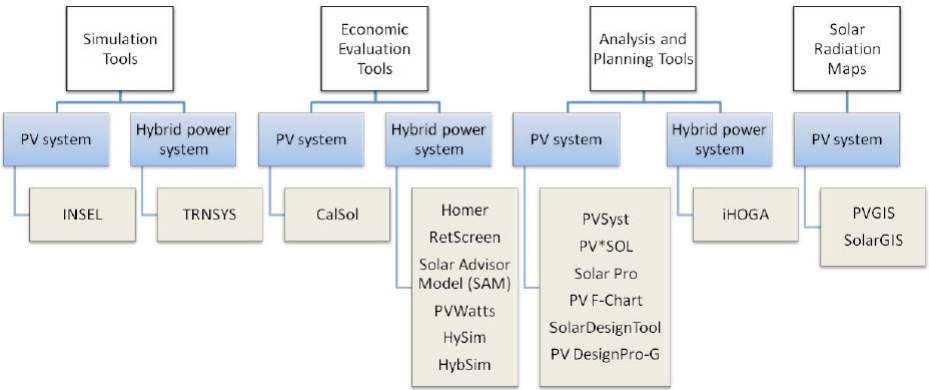
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Software for PV System Design

Classification of PV system design tools based on application



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    graph TD
      ST[Simulation Tools] --> ST_PV[PV system]
      ST --> ST_HPS[Hybrid power system]
      ST_PV --> INSEL[INSEL]
      ST_HPS --> TRNSYS[TRNSYS]
      
      EET[Economic Evaluation Tools] --> EET_PV[PV system]
      EET --> EET_HPS[Hybrid power system]
      EET_PV --> CalSol[CalSol]
      EET_HPS --> Homer[Homer]
      EET_HPS --> RetScreen[RetScreen]
      EET_HPS --> SAM[Solar Advisor Model (SAM)]
      EET_HPS --> PVWatts[PVWatts]
      EET_HPS --> HySim[HySim]
      EET_HPS --> HybSim[HybSim]
      
      ATP[Analysis and Planning Tools] --> ATP_PV[PV system]
      ATP --> ATP_HPS[Hybrid power system]
      ATP_PV --> PVsyst[PVsyst]
      ATP_PV --> PV_SOL[PV*SOL]
      ATP_PV --> SolarPro[Solar Pro]
      ATP_PV --> PV_FChart[PV F-Chart]
      ATP_PV --> SolarDesignTool[SolarDesignTool]
      ATP_PV --> PV_DesignProG[PV DesignPro-G]
      ATP_HPS --> iHOGA[iHOGA]
      
      SRM[Solar Radiation Maps] --> SRM_PV[PV system]
      SRM_PV --> PVGIS[PVGIS]
      SRM_PV --> SolarGIS[SolarGIS]
  
```

Samer Alsadi and Tamer Khatib, Photovoltaic Power Systems Optimization Research Status: A Review of Criteria, Constraints, Models, Techniques, and Software Tools, Appl. Sci. 2018, 8, 1761; doi:10.3390

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Software for PV System Design



Software	Developed by	Type of Analysis	Advantages	Disadvantages	Availability
SAM	National Renewable Energy Laboratory (NREL), USA. 2007	Performance analysis; Economic analysis	user friendly; easy to understand; graphical representation of results; Manually add custom modules and inverters	3D shade modeling is not supported; No available weather data for other locations of the world	Free
PV Syst	Institute of Environmental Sciences (ISE), University of Geneva, Switzerland	Performance analysis; Financial estimation used for both grid-connected, stand-alone, pumping and DC-grid PV systems,	Extensive meteorological and PV systems components databases; Has ability to identify the weaknesses of the system design through Loss Diagram; Results include several dozens of simulation variables	Program screen cannot be maximized to enable user to see all parameters if using a small monitor; Inability to handle shadow analysis; No single line diagram	priced, 30-day trial version is free
HOMER	National Renewable Energy Laboratory (NREL), USA	Optimization and Sensitivity analysis; Technical analysis; Financial analysis	Determines the possible combinations of a list of different technologies and its size; Very detailed results for analysis and evaluation; Has optimization algorithms used for feasibility and economic analysis	Inability to guess missing values or size; Sophisticated and time consuming; Detailed input data is needed	priced, 21-day free trial is available
PV*SOL	Valentine Energy Software, Germany	Shading analysis and 3D visualization; Performance analysis; Economic analysis	Vast meteorological database with over 8000 climatic location worldwide; Strong module and inverter database with over 13000 modules and 3100 inverters; Manually add custom modules and inverters	Sensitivity analysis is not supported; Complexity in building and site modeling; Error in the presentation of circuit diagram; Advanced scientific calculation is not supported	priced, 30-day trial version is free
RETScreen	Natural Resources Canada	Benchmark analysis; Feasibility analysis; Performance analysis; Portfolio analysis	Strong meteorological and product database; Contains extensive integrated training material; High strength in financial analysis	Inability to save, print and export files when using free view mode version; Data sharing problem; No option for time series data files Import; Does not support advanced calculations.	priced, Viewer mode is available free-of-charge

Najibhamisu Umar et. al., Comparison of different PV power simulation softwares: case study on performance analysis of 1 MW grid-connected PV solar power plant

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Software for PV System Design



Software	Developed by	Type of Analysis	Advantages	Disadvantages	Availability
Solaris PV	ACCA software, Italy	Technical analysis; Economic analysis; Shading analysis	Extensive meteorological database; Numerical and graphical results can be easily exported; Has photographic simulation feature	Less user-friendly as compared to other softwares Advanced feasibility analysis is not supported; Internet connection is required for installation	priced, 30-day free trial version is available
HelioScope	Folsom Lab, San Francisco, USA	Technical analysis; shading analysis	User-friendly; Is a web-based tool, so there is no software to download; Provides a detailed wiring diagram; Has 3D model design	Does not support financial analysis; Does not support feasibility analysis; Does not support advance scientific calculation	30-day trial version is available
Solar Pro	Laplace Systems Company, Japan	Technical analysis; shading analysis; Economic analysis; Performance modeling	Strong meteorological database; Advanced 3D shading analyses; Provides system layouts; Provides detailed and customized reports which can be exported	Sophisticated software as compared to other softwares; Advanced feasibility study is not supported	Priced, 30-day trial is available
SOLARGIS	Solargis, Slovakia. 2010	Technical analysis; Planning and optimization	User-friendly; is a web-based tool, so there is no software to download; Provides a detailed output with graphs and tables	Not suitable for financial analysis; Less technical parameters; Feasibility analysis is not supported; Internet is needed to run the simulation.	30-day trial version is available

Najibhamisu Umar et. al., Comparison of different PV power simulation softwares: case study on performance analysis of 1 MW grid-connected PV solar power plant

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Software for PV System Design

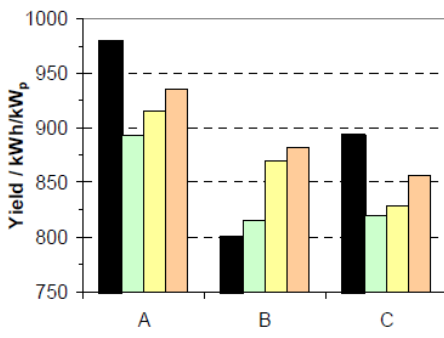


Table 1: Basic data of the systems investigated



Sys.	Location	Rated power	Azi-muth	Tilt	Start-Up
A	Munich	1,1 kW _p	190°	30°/45°	1996
B	70 km south of Munich	1,1 kW _p	160°	60°	24.06.1996
C	20 km east of Munich	1,1 kW _p	180°	60°	19.12.1995

Figure 3: Comparison of real and simulated data

Gerd Becker et. al., Energy Yields of PV Systems - Comparison of Simulation and Reality

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Software for PV System Design





Photovoltaic Software

www.pvresources.com/en/softw

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<http://www.pvresources.com/>

PV Software

Modular Simulation Tools

INSEL - is software for planning, monitoring and visualising energy systems. For this purpose INSEL provides state-of-the-art functions in the form of blocks that can be linked to a concrete solution, for example for simulating meteorological data, electrical and thermal energy components etc.

TRNSYS - (TRAnsient System Simulation Program) is an energy simulation program whose modular system approach makes it one of the most flexible tools available. It includes a graphical interface, a simulation engine, and a library of components that range from various building models to standard HVAC equipment to renewable energy and emerging technologies. TRNSYS also includes a method for creating new components that do not exist in the standard package. A special library of components is available to simulate renewable energy-based power generation: PV systems, batteries, wind turbines, fuel cells.

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Software for PV System Design

<http://www.pvsyst.com/en/>

The screenshot shows the PVsyst website interface. At the top, there's a navigation bar with 'Home' and 'Forum' links. Below that, a 'Software' section highlights a 'full package for the study of your photovoltaic systems' with a 'DOWNLOAD PVsyst' button. A 'News' section mentions 'New version 6.70!' and 'New training in September 2016'. A 'A powerful software for your photovolta' section features an image of solar panels and text describing the software's design for engineers and researchers. On the right, a 'New Features in PVsyst6' section lists seven key updates:

- Meteorology included:** Direct search for a location using Google Maps; Full Meteorology interpolation program for any location on earth.
- Detailed electrical shading losses:** Defines the position of all modules of the system in the 3D field; Computes the electrical circuit at the input of each inverter; Outputs: "irradiance shading loss" and "electrical shading loss".
- Improved shading calculations:** Direct shading calculation during the simulation (avoids interpolation uncertainties); Big plants: optimized calculation of the shading factor; Plants following the terrain (Holoos 3D): orientation analysis and management.
- New simulation process:** Improved project management, parameter access, copy, templates; New organization of the losses; New losses like LID, unreliability, and light-soiling gain for CIG.
- PV modules and model management:** Sandia model implementation and comparison with PVsyst model; Tools for parameter optimization (low-light, IV curve); New parameters (tolerance, VM profile, Vmax UL).
- Inverters:** New parameters (Transfer, CEC efficiency); Multi-MPPT with asymmetric inputs; Improvement of choice by manufacturer.
- Batch model for parametric studies.**

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Software for PV System Design



PVsyst: Photovoltaic Systems Software

Advantage

- Large database: PV component, meteorological sites
- Many systems: Grid-connected, Stand alone, Pumping, DC grid
- Parameters allowing fine effects analysis, including thermal behavior, wiring and mismatch losses, real module quality loss, incidence angle losses
- A [3-D CAO](#) tool for "near shading", animation
- [economic evaluation](#) performed using real component prices, additional costs and investment conditions, in any currency

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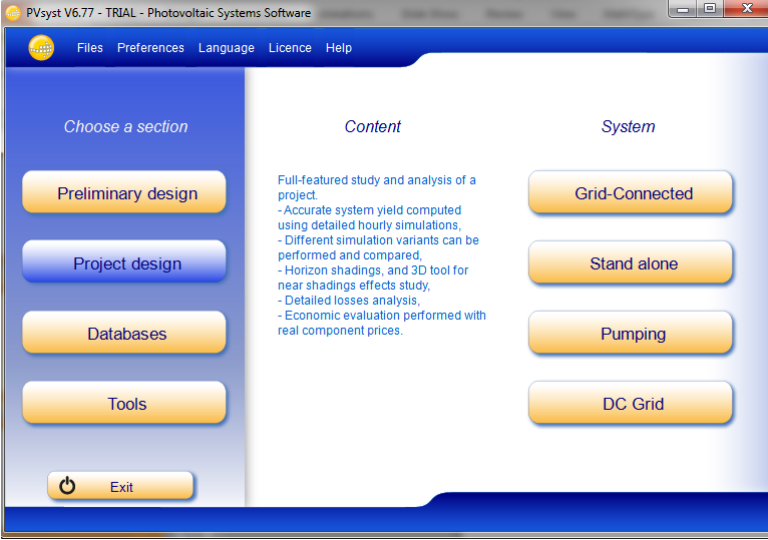
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Concepts of PV System Design with PVsyst

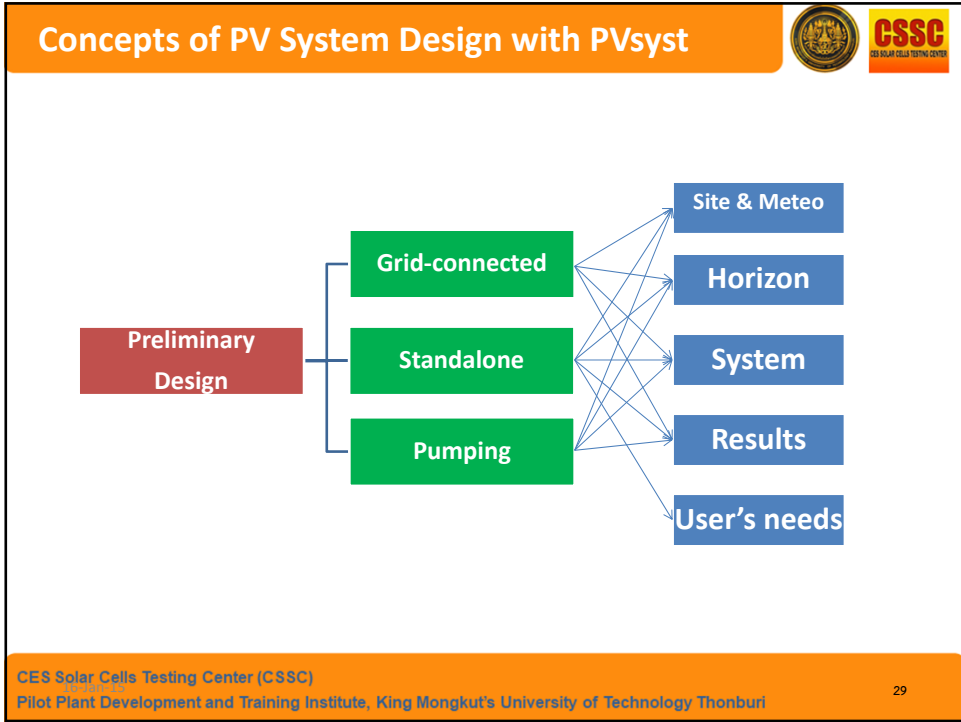


The screenshot shows the PVsyst V6.77 software interface. The window title is "PVsyst V6.77 - TRIAL - Photovoltaic Systems Software". The menu bar includes "Files", "Preferences", "Language", "Licence", and "Help". The main interface is divided into three columns: "Choose a section", "Content", and "System".

- Choose a section:** Preliminary design, Project design, Databases, Tools, Exit.
- Content:** Full-featured study and analysis of a project. - Accurate system yield computed using detailed hourly simulations. - Different simulation variants can be performed and compared. - Horizon shadings, and 3D tool for near shadings effects study. - Detailed losses analysis. - Economic evaluation performed with real component prices.
- System:** Grid-Connected, Stand alone, Pumping, DC Grid.

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Concepts of PV System Design with PVsyst

The screenshot shows the PVsyst V6.66 software interface. The main window is titled 'Project's location' and contains the following information:

- Project name:** Grid system presizing at Bangkok.
- Location:** Country: Thailand, Site: Bangkok - MeteoNom 7.1 station.
- Buttons:** 'Open site' (circled in red), 'Grid-Connected', 'Stand alone', and 'Pumping' (circled in red).

Below the main window, there is a 'Geographic site parameters for Bangkok (PVsyst original database)' window showing monthly and yearly data:



	Global Inrad	Diffuse	Temper.	Wind Vel.
	kWh/m ² .mth	kWh/m ² .mth	°C	m/s
January	145.0	64.8	27.5	1.11
February	143.7	69.9	28.7	1.30
March	174.4	95.3	29.8	1.60
April	174.6	92.6	30.5	1.60
May	163.4	84.8	29.9	1.40
June	152.0	81.4	29.2	1.40
July	148.9	80.3	29.4	1.39
August	138.7	79.6	29.2	1.40
September	130.0	82.3	28.4	1.19
October	137.7	78.6	28.8	0.79
November	129.9	68.7	28.0	0.69
December	141.9	55.2	27.6	0.90
Year	1790.1	920.5	28.9	1.2

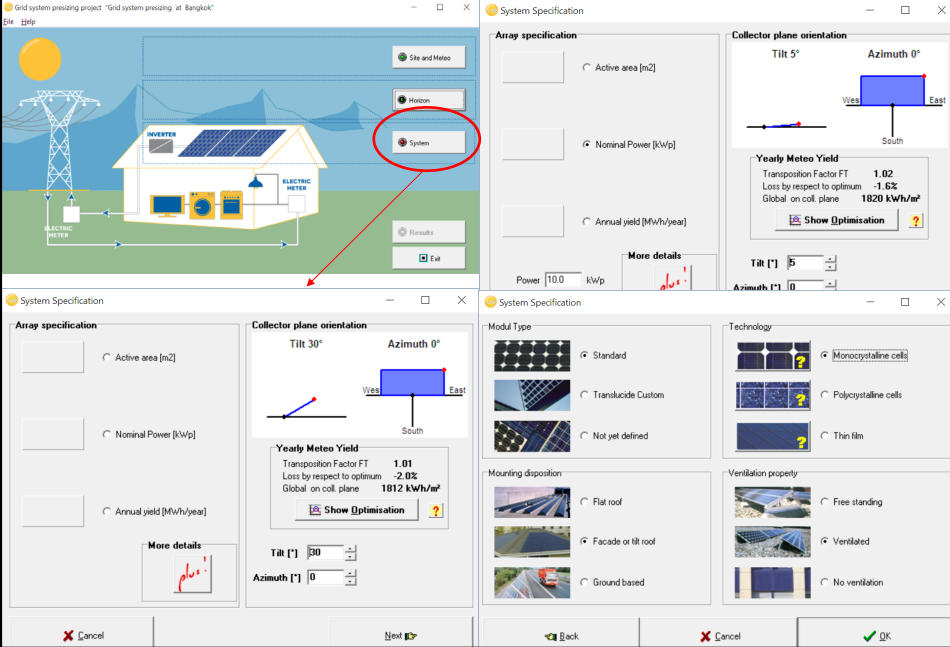
Additional features include a 'Content' sidebar with 'Preliminary design' selected, and a 'Required Data' section with checkboxes for 'Vertical global irradiation', 'Average Ext. Temperature', 'Horizontal diffuse irradiation', and 'Wind velocity'. The bottom of the interface shows the CSSC logo and contact information.

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Concepts of PV System Design with PVsyst








The image displays the PVsyst software interface for system specification. It includes a 3D house model with solar panels, an inverter, and an electric meter. The 'System Specification' window is open, showing various configuration options:

- Array specification:** Active area [m²], Nominal Power [kWp], Annual yield [kWh/year].
- Collector plane orientation:** Tilt 5°, Azimuth 0°. Yearly Metro Yield: Transposition Factor FT 1.02, Loss by respect to optimum -1.6%, Global on coll. plane 1820 kWh/m².
- System configuration:** Modul Type (Standard, Translucide Custom, Not yet defined), Technology (Monocrystalline cells, Polycrystalline cells, Thin film), Mounting disposition (Flat roof, Facade or tilt roof, Ground based), and Ventilation property (Free standing, Ventilated, No ventilation).

Concepts of PV System Design with PVsyst



Preliminary Design





The image displays the PVsyst software interface for preliminary design. It includes a 3D house model with solar panels, an inverter, a controller, and a battery. The 'Results' window is open, showing input data and results:

- Input Data:** Bangkok, Plane tilt 5°, azimuth 0°, Nominal power 10.0 kW, Module Cost 24.25 THB/kWp, Technology Monocrystalline.
- Results:** Area 63 m², Annual Yield 15.3 MWh/yr, Investment 137,2548 THB, Energy cost 9.03 THB/kWh.

The 'Definition of Daily Household consumptions for Summer (Jun-Aug)' window is also visible, showing a table of appliance consumption and various charts for energy distribution and global consumption.

Number	Appliance	Power	Daily use	Hourly distrib.	Daily energy
[1]	[Lamp] LED or halid	[5] W/kw	[5] h/day	OK	500 Wh
[2]	[TV] LCD / Plasma	[100] W/kw	[5] h/day	OK	1000 Wh
[3]	[Refrigerator]	[100] W/kw	[24] h/day	OK	2400 Wh
[4]	[Washing Machine]	[1000] W/kw	[1] h/day	OK	1000 Wh
[5]	[Dryer]	[1000] W/kw	[1] h/day	OK	1000 Wh
[6]	[Iron]	[1000] W/kw	[1] h/day	OK	1000 Wh
[7]	[Air conditioning]	[1000] W/kw	[5] h/day	OK	3000 Wh
[8]	[Standby consumers]	[5] W/kw	[24] h/day	OK	144 Wh

Concepts of PV System Design with PVsyst



Project Design

Project Design	Input								Optional				Simulation			
	Site & Metro.	Orientation	User's needs	Water needs	System	Detailed losses	Self-consumption	Storage	Horizon	Near shading	Module Layout	Energy Manage	Economic Evaluation	Advance Simulation	Report	Detail Results
Grid-connected	•	•			•	•	•	•	•	•	•	•	•	•	•	•
Standalone	•	•	•		•	•			•	•			•	•	•	•
Pumping	•	•		•	•	•			•	•			•	•	•	•
DC Grid	•	•	•		•	•			•	•			•	•	•	•

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Concepts of PV System Design with PVsyst

Project Design

```

    graph TD
      A[Site and Location Determination] --> B[Define Meteorological Data]
      B --> C[Input: Orientation]
      C --> D[Input: User's needs]
      D --> E[Input: System Info.]
      E --> F[Input: Detailed losses]
      F --> G[Optional: Horizon & Near Shading]
      G --> H[Setting and Run Simulation]
      H --> I[Results Analysis]
    
```

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Concepts of PV System Design with PVsyst

Site and Location Determination

The screenshot shows the PVsyst V6.66 TRIAL interface. The 'Databases' menu is open, showing options like 'Geographical sites', 'Synthetic hourly data generation', 'Meteo tables and graphs', 'Compare Meteo Data', 'Import meteo data', and 'Import ASCII meteo file'. The 'Component choice' dialog is also open, showing a search for 'Thailand' and a table of geographical sites. The 'New' button in the dialog is highlighted with a red circle.

Filename	Town	Country	Data source
Bangkok	Bangkok	Thailand	MeteoNom 7.1 station
Mueang Chiang Mai	Mueang Chiang Mai	Thailand	MeteoNom 7.1 station

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Concepts of PV System Design with PVsyst

Site and Location Determination → **Define Meteorological Data**

The screenshot shows the 'Define Meteorological Data' dialog in PVsyst. The 'Site' is set to 'Nakhon Ratchasima (Thailand)'. The 'Global Inrad' table is visible, and the 'Required Data' section is highlighted with a red circle. The 'Meteo data import' section is also visible.

Month	Global Inrad (kWh/m ² .day)	Temper. (°C)
January	0.00	0.0
February	0.00	0.0
March	0.00	0.0
April	0.00	0.0
May	0.00	0.0
June	0.00	0.0
July	0.00	0.0
August	0.00	0.0
September	0.00	0.0
October	0.00	0.0
November	0.00	0.0
December	0.00	0.0
Year	0.00	0.0

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Concepts of PV System Design with PVsyst

Define Meteorological Data

ข้อมูลพลังงานแสงอาทิตย์ จังหวัด: นครราชสีมา - ภาค: เมืองนครราชสีมา - ตำบล: ใบเมือง

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Global Irradiation (kWh/m ² /day)	4.80	5.25	5.53	5.65	5.35	5.23	4.96	4.87	4.77	4.81	4.62	4.53	5.03

	A	B	C	D	E
1	เดือน	อุณหภูมิ ต่ำสุด (°C)	อุณหภูมิ สูงสุด (°C)	ปริมาณฝน (mm)	จำนวนวัน มีแดด(วัน)
2	มกราคม	18.5	30.7	8.2	-
3	กุมภาพันธ์	21	33.6	16.1	-
4	มีนาคม	23.2	35.6	37.1	-
5	เมษายน	24.9	36.5	72.2	-
6	พฤษภาคม	25	35	154.1	-
7	มิถุนายน	25.1	34.4	104.5	-
8	กรกฎาคม	24.7	33.8	120.9	-
9	สิงหาคม	24.5	33.2	157.2	-
10	กันยายน	24	32.2	228.3	-
11	ตุลาคม	23.2	31	146.3	-
12	พฤศจิกายน	21.1	30.1	23.9	-
13	ธันวาคม	18.3	29.3	2.7	-

Copy & Paste

Concepts of PV System Design with PVsyst

Define Meteorological Data

Filename	Town	County	Data source
Bandok	Bandok	Thailand	MeteoNom 7.1 station
Mueang Chang Mai	Mueang Chang Mai	Thailand	MeteoNom 7.1 station
Mueang Chiang Mai	Mueang Chiang Mai	Thailand	MeteoNom 7.1 station



Save

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Concepts of PV System Design with PVsyst






Define Meteorological Data: Synthetic Hourly data generation

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Meteorological Data

Global Solar Radiation (Surface Measurement) Database		
World Radiation Data Center (WRDC)	WMO, Main Geophysical Observatory in St. Petersburg, Russia	1964 – present, >1000 stations, daily sums and monthly mean data
Baseline Surface Radiation Network (BSRN)	World Climate Research Program	~40 stations, high time resolution (1-3 minutes)
Integrated Information System		
Photovoltaic Geographical Information System (PVGIS)	Joint Research Center of the European Commission (JRC)	~566 stations, 1 km grid, 1981–1990 in Europe, HelioClim-1 in Africa
METEONORM	www.meteonorm.com	1961–1990 and 1981–2000, 1325 stations with irr, very high resolution (0.1–1 km)

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Concepts of PV System Design with PVsyst



Meteorological Data

Online Satellite Database		
Satel-Light	European Union	Heliosat model, 1996 to 2000, Monthly average data
SoDa	MINES ParisTech	long-term time series of daily irradiation
SMSE or SSE	Surface Meteorology and Solar Energy (NASA)	200 satellite-derived meteorological parameters, 1 x 1°, 64800 regions from GOES
ABM	Australian Bureau of Meteorology	daily global solar irradiation from GMS-5, GOES-9, MTSAT-1R, MTSAT-2
SolarGIS	http://solargis.info/ by GEO Model SOLAR	Satellite data from Mateosat, GOES

http://re.jrc.ec.europa.eu/pvg_tools/en/tools.html

<https://sam.nrel.gov/weather>

<https://nsrdb.nrel.gov/nsrdb-viewer>



Concepts of PV System Design with PVsyst



Summary of sources in Hourly values

Database	Region	Values	Source	Period	Variables	Availability	PVsyst import
3Tier-Vaisala	Worldwide	Hourly	Satellites Spectroradiometer MODIS	1998 - today	GHI, DHI, DNI available no temper.	For pay	Direct (file) .csv PVsyst format
Canada EPW	Canada	Hourly	CWEC, 80 stations Typical Meteo Years	1953-1995 (samples)	GHI, DHI, TA WindVel	Web free	Direct (file) EPW format
Explorador Solar	Chile	Hourly	Satellites Interp. 90x90 m²	2004-2016 and TMY	GHI, DHI, TA WindVel	Web free	Direct (file) .csv PVsyst format .csv SAM CSV format
Meteonorm	Worldwide	Hourly	Synthetic generation	Reference	GHI, DHI, TA Wind, RH	Included in PVsyst V 6	At site creation and available for sites from other sources
NREL TMY2/3 (NSRDB)	USA + Hawaii	Hourly	NREL, 1693 stations Typical Meteo Years	1991-2005	GHI, DHI, TA WindVel	Web free	Direct (file) TMY2&TMY3 format
NREL NSRDB Viewer	America 175°W to 25°W 20°S to 50°N India and around 67°E to 98°E 5°N to 38°N	Hourly	Satellites 4x4 km² PSM3 model	1998-2016 and TMY	GHI, DHI, TA WindVel	Web free	Direct (file) .csv SAM CSV format
		Hourly	Satellites 10x10 km² SUNY model	2000-2014 and TMY	GHI, DHI, TA WindVel	Included in PVsyst V 6.76	TMY at site creation (requires internet access)
PVGIS v5	Worldwide	Hourly	Satellites CM, SAF, SARAII or NSRDB	Reference TMY	GHI, DHI, TA Wind, RH	Web Included in PVsyst V 6.76	TMY at site creation (requires internet access)
SatelliteLight	Europe	Hourly	Meteosat Any pixel of about 5x7 km²	1996-2000 5 years only	GlobH no temper.	Web free	Direct (file) tsv format
Soda-Helioclim3	Europe Africa	Hourly	Meteosat	2004 - today	GlobH no temper.	Web For pay 2004/5 free	Direct by copy/paste or .csv PVsyst format
Solar Anywhere (SUNY model)	USA + Hawaii	Hourly	Satellites 10x8 km²	1998 - today	GlobH, DiffH Temp. for pay Wind for pay	Web 2010 - today for pay	Direct (file) native + PVsyst format
Solar Solargis	Worldwide	Hourly	Meteosat, ERA	1994 - today	GHI, DHI, TA	For pay	Direct (file) native + PVsyst format
Solar Prospector (SUNY Model)	USA	Hourly	Satellites	1998 - 2009	GHI, DHI, DNI TA, WindVel	Web No more available	Direct (file) TMY2 format
Vortex Solar	Worldwide	Hourly	Satellites	1997 - today	GHI, DHI, TA	For pay	Direct (file) .csv PVsyst format

Concepts of PV System Design with PVsyst






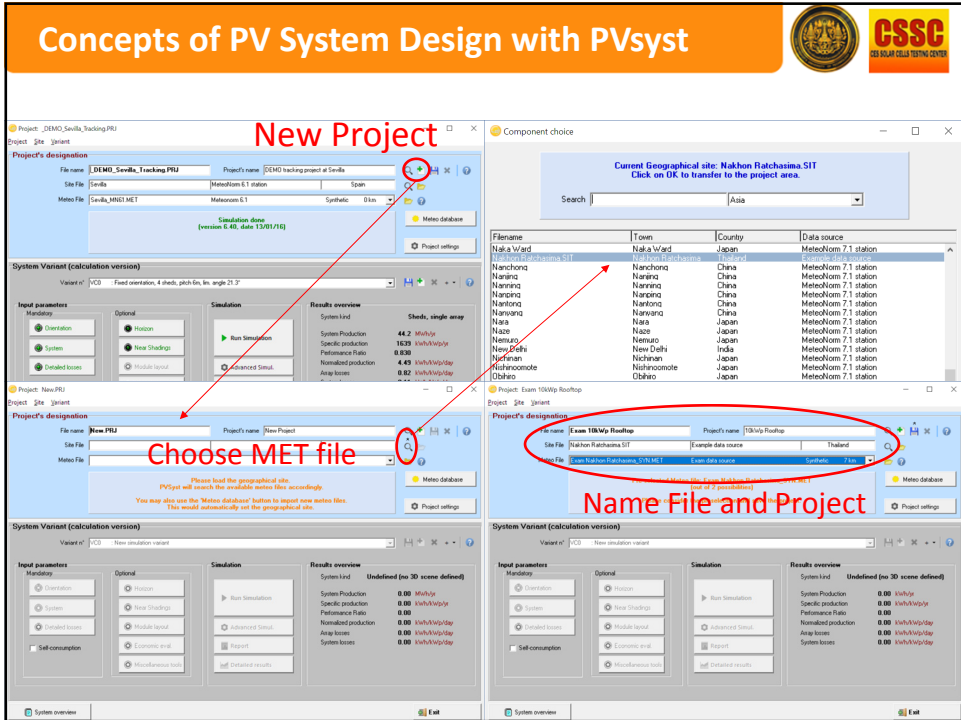
Meteorological Data (Monthly Data)

Database	Region	Values	Source	Period	Variables	Availability	PVsyst import
Meteonorm	Worldwide	Monthly	1'200 Terrestrial stations (+ complement satellite) Interpolations	1960-1991 averages V 6.1; 1995-2005 (optional)	GlobH Temp, Wind, Others	Included in PVsyst V 6 Software	Direct by site choice Direct by hourly file
Meteonorm 7.2	Worldwide	Monthly	2'500 Terrestrial stations (+ complement satellite)	1961 - up to 2015 for some countries	GHI, DHI, TA, Wind, RH, Linke turbidity	Software, for pay Included since PVsyst V6.7.3	Direct import - hourly file Included stations or at site creation
NASA-SSE (old data)	Worldwide	Monthly	Satellites 1°x1° cells (111 km)	1983-2005 averages	GlobH Temp	Web, free Included in PVsyst	At site creation
RETScreen	Worldwide	Monthly	Compil. 20 sources incl. WRDC - NASA	1961-1990 (averages)	GlobH, TA, WindVel	Software, free	Direct by copy/paste
SolarGIS	Worldwide	Monthly	Meteosat, ERA	1994 - today	GHI, DHI, TA	For pay	Direct (file) .csv native format
WRDC (old database)	Worldwide	Hourly Daily Monthly	1195 stations	1964-1993 (each)	GlobH no temper.	Web free	Direct by copy/paste

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Concepts of PV System Design with PVsyst



New Project

Current Geographical site: Nakhon Ratchasima SIT
Click on OK to transfer to the project area.



Filename	Town	Country	Data source
Nakhon Ratchasima SIT	Nakhon Ratchasima	Thailand	MeteoNorm 7.1 station
Nanchong	Nanchong	China	MeteoNorm 7.1 station
Nanning	Nanning	China	MeteoNorm 7.1 station
Nansong	Nansong	China	MeteoNorm 7.1 station
Nankong	Nankong	China	MeteoNorm 7.1 station
Naravong	Naravong	China	MeteoNorm 7.1 station
Nara	Nara	Japan	MeteoNorm 7.1 station
Naze	Naze	Japan	MeteoNorm 7.1 station
Nemuro	Nemuro	Japan	MeteoNorm 7.1 station
New Delhi	New Delhi	India	MeteoNorm 7.1 station
Nishan	Nishan	Japan	MeteoNorm 7.1 station
Nishinomiya	Nishinomiya	Japan	MeteoNorm 7.1 station
Osaka	Osaka	Japan	MeteoNorm 7.1 station

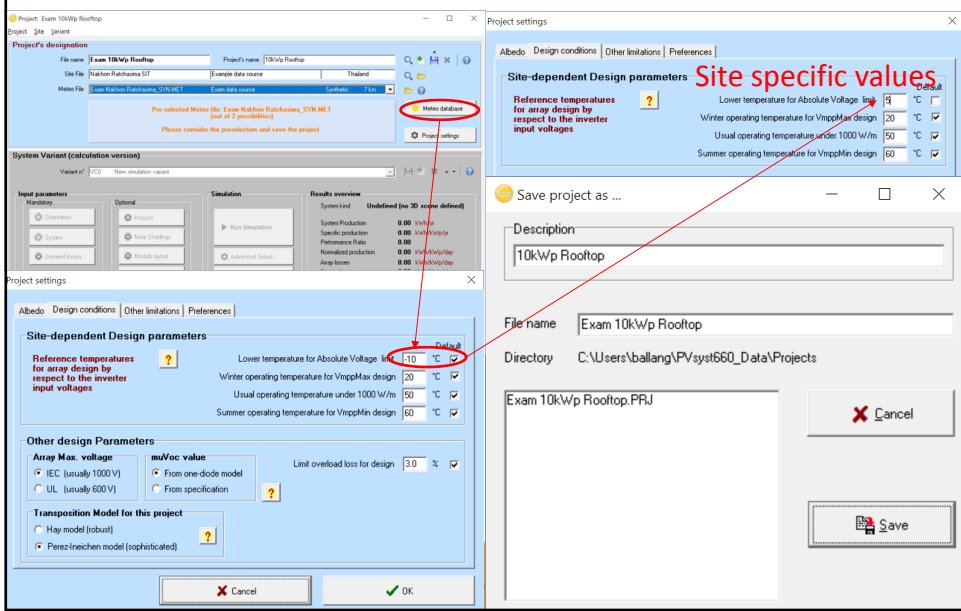
Choose MET file

Example data source

Name File and Project

Concepts of PV System Design with PVsyst





Site specific values

Reference temperatures for array design by respect to the inverter input voltages

- Lower temperature for Absolute Voltage: 10 °C
- Winter operating temperature for VmpMax design: 20 °C
- Usual operating temperature under 1000 W/m: 50 °C
- Summer operating temperature for VmpMin design: 60 °C

Save project as ...

Description: 10kWp Rooftop



File name: Exam 10kWp Rooftop

Directory: C:\Users\ballang\PVsyst660_Data\Projects

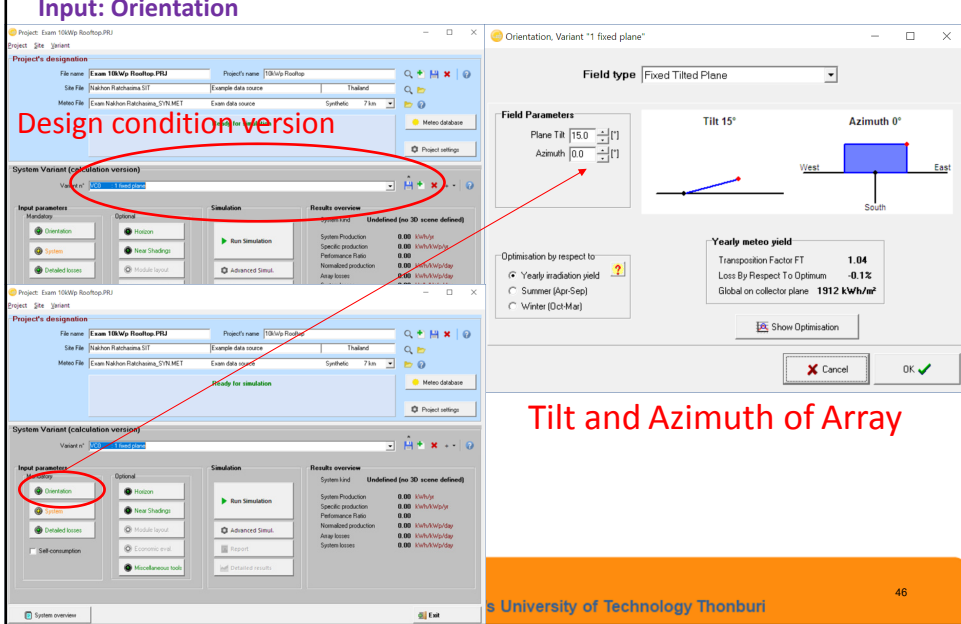
Exam 10kWp Rooftop.PRJ

Cancel Save

Concepts of PV System Design with PVsyst



Input: Orientation



Design condition version

Orientation, Variant "1 fixed plane"

Field type: Fixed Tilted Plane

Field Parameters

- Plane Tilt: 15.0 °
- Azimuth: 0.0 °

Tilt 15° Azimuth 0°

Yearly meteo yield

- Transposition Factor FT: 1.04
- Loss By Respect To Optimum: -0.1%
- Global on collector plane: 1912 kWh/m²

Optimisation by respect to

- Yearly irradiation yield
- Summer (Apr-Sep)
- Winter (Oct-Mar)

Show Optimisation



Cancel OK

Tilt and Azimuth of Array

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Concepts of PV System Design with PVsyst

Input: Orientation

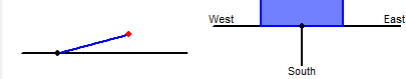
Field type: **Fixed Tilted Plane**

Field parameters

Plane Tilt: [°]

Azimuth: [°]

Tilt 15° Azimuth 0°



Optimisation by respect to:

Yearly irradiation yield

Summer (Apr-Sep)

Winter (Oct-Mar)

Yearly meteo yield

Transposition Factor FT: **1.04**

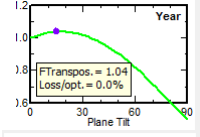
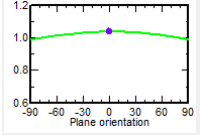
Loss By Respect To Optimum: **0.0%**

Global on collector plane: **1947 kWh/m²**

[Show Optimisation](#)

Fixed orientation planes

- Fixed Tilted Plane
- Seasonal tilt adjustment
- Unlimited sheds
- Unlimited sun-shields
- One-axis tracking planes
- Horiz. axis, unlimited trackers
- Tracking tilted or horiz. N-S axis
- Tracking, horizontal axis E-W
- Tracking, vertical axis
- Tracking sun-shields
- Two-axis tracking planes
- Tracking two axis, frame N-S
- Tracking two axis, frame E-W






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Concepts of PV System Design with PVsyst

Input: System Info. (Grid-connected)

Project: Exam 10kWp Rooftop PV1

Project's designation: Exam 10kWp Rooftop PV1

Site File: Nakhon-Ratchasima_S1

Meteo File: Exam Nakhon-Ratchasima_SYNMET

Ready for simulation

System Variant (calculation version)

Variant: **Calculation version**

Input parameters: **System** (highlighted)

Simulation: Run Simulation

Results overview: System kind: Disabled (no 3D scene defined)

Global system configuration

Global system summary:

Nb. of modules	36	Normal PV Power	9.0 kWp
Module area	59 m²	Maximum PV Power	8.7 kWdc
Nb. of inverters	1	Normal AC Power	9.9 kWac

Sub-array name and Orientation

Name: #1

Client: **Fixed Tilted Plane**

Tilt: 15°

Azimuth: 0°

Select the PV module

Available Now: **Tiara Solar**

String voltage: Vmp (STC): 25.5 V

Voc (STC): 41.7 V

Select the inverter

Available Now: **SMA**

Nb. of inverters: 1

Operating Voltage: 300-500 V

Global inverter's power: 9.9 kWac

Design the array

Number of modules and strings:

Mod in series: 12

Nb. strings: 3

Nb. modules: 36

Area: 59 m²

Operating conditions:

Vmp (STC): 306 V

Vmp (50°C): 264 V

Voc (STC): 500 V

Plane irradiance: 1000 W/m²

Imp (STC): 25.3 A

Isc (STC): 26.9 A

Max. operating power: 8.1 kW

Array nom. Power (STC): 9.0 kWp



System configuration, Array details, PV Module, Inverter

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Concepts of PV System Design with PVsyst

Input: System Info. (Grid-connected)

Grid system definition, Variant "1 fixed plane"

Global System configuration		Global system summary	
1 Number of kinds of sub-arrays		Nb. of modules	36
Simplified Schema		Module area	59 m ²
		Nb. of inverters	1
		Nominal PV Power	9.0 kWp
		Maximum PV Power	8.7 kWdc
		Nominal AC Power	9.9 kWac

Sub-array name and Orientation

Name: #1
Orient: Fixed Tilted Plane
Tilt: 15°
Azimuth: 0°

Select the PV module

Available Now: Tripe Solar
250 Wp 25V Si-poly TSM-310PD14 Since 2015 Manufacturer DNV

Sizing voltages: Vmp (60°C) 25.5 V
Voc (-10°C) 41.7 V

Approx. needed modules: 40

Select the inverter

Available Now: SMA
3.9 kW 300 - 530 V TL 50/60 Hz Sunny Tripower 10000TLEE JP-11 Since 2014

Nb. of inverters: 1
Operating Voltage: 300-590 V Global Inverter's power: 3.9 kWac
Input maximum voltage: 600 V

Design the array

Mod. in series: 12 (between 12 and 14)
Nb. strings: 3 (only possibility 3)
Overload loss: 0.0 %
Phom ratio: 0.91

Operating conditions:
Vmp (60°C) 306 V
Vmp (20°C) 364 V
Voc (-10°C) 500 V

Plane irradiance: 1000 W/m²
Isc (STC) 26.9 A
Isc (at STC) 26.9 A

The inverter power is slightly oversized.

Max. in data at 1000 W/m² and 50°C: 8.1 kW
Array nom. Power (STC): 9.0 kWp

Number of Array

Array Name

Tilt & Azimuth of Array

kWp or Available Area

PV module



Inverter

Number of inverter

Array configuration

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Concepts of PV System Design with PVsyst

Input: System Info. (Standalone)

Stand-alone system definition, Variant "New simulation variant", Variant "New simulation variant"

Specified User's needs: Pre-sizing suggestions | System summary

Av. daily needs: 11.0 kWh/day
Enter accepted FULC: 6.0 %
Enter requested autonomy: 4.0 days

Battery (user) voltage: 48 V
Suggested capacity: 1239 Ah
Suggested PV power: 3.16 kWp (nom.)

Storage: PV Array | Back-Up | Simplified Schema

Procedure

- Pre-sizing: Define the desired Pre-sizing conditions (LDL, Autonomy, Battery voltage)
- Storage: Define the battery pack (default checkboxes will approach the pre-sizing)
- PV Array design: Design the PV array (PV module) and the control mode. You are advised to begin with a universal controller.
- Back-Up: Define an eventual Genset

Specify the Battery set

Sort batteries by: voltage (Lead-acid)
Generic: 12 V 100Ah Pb Open Plates Open 12V / 100Ah

4 batteries in series: Number of batteries: 48
12 batteries in parallel: Number of elements: 288

Battery pack voltage: 48 V
Global capacity: 1200 Ah
Stored energy (80% DOD): 46.1 kWh
Total weight: 2285 kg
Nb. cycles at 80% DOD: 1200
Total stored energy during the battery life: 61.0 MWh

Operating battery temperature: Fixed (tempered local)
Fixed temperature: 20 °C

The battery temperature is important for the aging of the battery. An increase of 10 °C divides the "static" battery life by a factor of two.

Storage: PV Array | Back-Up | Simplified Schema

Sub-array name and Orientation

Name: PV Array
Orient: Fixed Tilted Plane
Tilt: 15°
Azimuth: 0°

Select the PV module

Generic: 136 Wp 28V a-Si:H tripol a-Si:H tripole junction Since 2015 Typical

Sizing voltages: Vmp (60°C) 31.0 V
Voc (-10°C) 51.4 V

Select the control mode and the controller

Universal controller: All manufacturers
MPPT power converter: MPPT 300W 48 V 75 A 45A Universal controller with MPPT conv.

PV Array design

Number of modules and strings: should be 24
Mod. in series: 2 (No constraint)
Nb. strings: 12 (between 10 and 14)



Operating conditions:
Vmp (60°C) 62 V
Vmp (20°C) 74 V
Voc (-10°C) 103 V

Plane irradiance: 1000 W/m²
Isc (STC) 48.9 A
Isc (STC) 62.6 A
Isc (at STC) 62.6 A

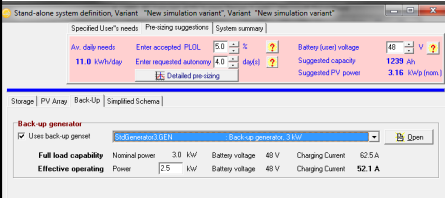
Max. operating power at 1000 W/m² and 50°C: 3.2 kW
Array nom. Power (STC): 3.3 kWp

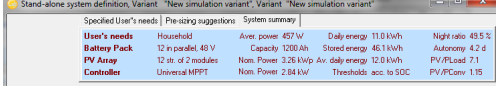
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Concepts of PV System Design with PVsyst

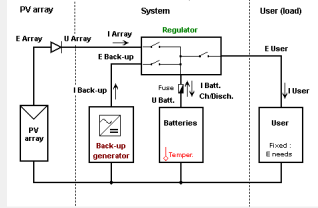



Input: System Info. (Standalone)







Typical layout of a stand-alone system

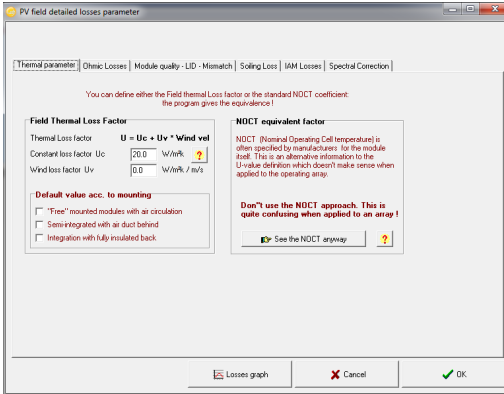


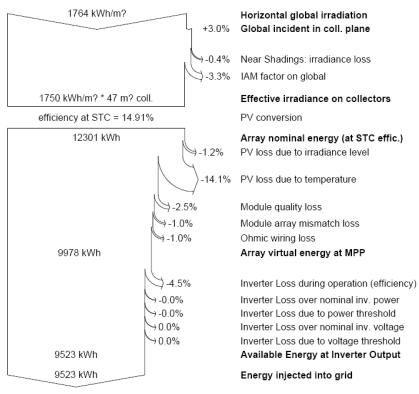
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Input: Detailed losses





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Run Simulation

Project: Exam 10kWp Rooftop PVU

Project Site Variant

Project's designation

File name: Exam 10kWp Rooftop PVU
 Site File: Nakhon Ratchasima SIT
 Metro File: Nakhon Ratchasima_SYN.MET

Simulation date: version 6.7.6, date 22/08/18

Run Simulation

System Variant (calculation version): VCB 1 fixed plane

Input parameters

Mandatory: Orientation (Horizontal), System (System), Detailed losses (Detailed losses)

Optional: Horizon, Near Shadings, Module layout, Economic eval, Miscellaneous

Simulation

Run Simulation

Hourly Simulation Progress

Status: **Simulation ended successfully** 1.6 sec

Attenuation factors for Diffuse

	IAM	Shading	IAM*Shading
Diffuse	0.042	0.000	0.042
Albedo	0.195	0.000	0.195

Display daily values: Simulation 31/12/90

Meteo: Global, Diffuse, Tairm4.48, 2.20kWh/m² day, 31.1°C, 0.0 m/s

On coll: Global, Diffuse, Glob.5.18, 2.40, 0.02, 5.02 kWh/m² day

System: EMex, ENet, EUUse 38.4, 38.4, 37.24kWh/day

Load: ELoad, EUUse, EOverUnlimited, 0.0, 0.0 kWh/day

Automatically close when simulation ends success

Project: Exam 10kWp Rooftop PVU

Project Site Variant

Project's designation

File name: Exam 10kWp Rooftop PVU
 Site File: Nakhon Ratchasima SIT
 Metro File: Nakhon Ratchasima_SYN.MET

Simulation date: version 6.7.6, date 22/08/18

Run Simulation

System Variant (calculation version): VCB 1 fixed plane

Input parameters

Mandatory: Orientation (Horizontal), System (System), Detailed losses (Detailed losses)

Optional: Horizon, Near Shadings, Module layout, Economic eval, Miscellaneous

Simulation

Run Simulation

Advanced Simul

Final report

Results overview

System kind: No 3D scene defined

System Production: 13332 kWh/yr

Specific production: 1481 kWh/kWp/yr


Performance Ratio: 0.782

Normalized production: 4.86 kWh/kWp/day

Array losses: 1.08 kWh/kWp/day



System losses: 0.14 kWh/kWp/day

System overview



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Concepts of PV System Design with PVsyst

Results Analysis

PVSYST V6.75 | 22/08/18 | Page 1/3

Grid-Connected System: Simulation parameters

Project: 10kWp Rooftop

Geographical Site: Nakhon Ratchasima, Thailand

Latitude: 14.58° N, Longitude: 102.00° E

Legal Time zone: UT+7, Altitude: 165 m

Meteo data: Nakhon Ratchasima, Synthetic

Simulation variant: 1 fixed plane

Simulation date: 22/08/18 22h52

System type: No 3D scene defined

Collector Plane Orientation: Tilt 15°, Azimuth 0°

Models used: Transposition Perez, Diffuse Perez, Meteonom

Near Shadings: No Shadings

PV Array Characteristics

Si-poly	Model	TSM-316FD14
Manufacturer	Trina Solar	
Series	in series	12 modules
No. modules	36	Unit Nom. Power
Array global power	9.90 kWp	AI operating cond.
Array operating characteristics (50°C)	U mpp 320 V	I mpp 25 A
Total area	Module area 69.2 m ²	Cell area 52.6 m ²

Inverter: Sunny Tripower 10000TLEE-JP-11

Manufacturer	SMA	Unit Nom. Power	9.90 kWac
Operating Voltage	300-550 V	Total Power	9.9 kWac
No. of inverters	1 units	Prism ratio	0.91

PV Array loss factors

Thermal Loss factor	Uc (const): 20.0 W/mK	Uv (wind): 0.0 W/mK / m/s
Wiring Ohmic Loss	Global array res.: 212 mOhm	Loss Fraction: 1.5 % at STC
Module Quality Loss		Loss Fraction: -0.5 %
Module Mismatch Losses		Loss Fraction: 1.0 % at MPP
String Mismatch loss		Loss Fraction: 0.15 %
Incidence effect, ASHRAE parameterization	IAM = 1 - bo (1/cos(i - i _o))	bo Param: 0.05

User's needs: Unlimited load (grid)

Main simulation results

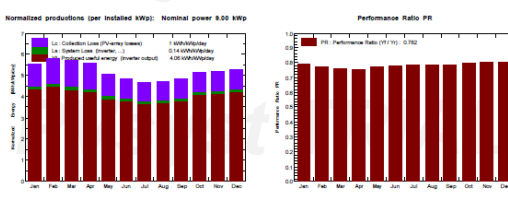
System Production: 13.33 MWh/year

Produced Energy: 13.33 MWh/year

Performance Ratio PR: 78.18 %

Specific prod.: 1481 kWh/kWp/year

Normalized production (per installed kWp): Nominal power 9.90 kWp



1 fixed plane Balances and main results

	GlobHor kWh/m ²	DiffHor kWh/m ²	T Amb °C	GlobInc kWh/m ²	GlobEff kWh/m ²	EArray MWh	E_Grid MWh	PR
January	145.8	60.45	30.70	171.5	186.4	1.280	1.222	0.791
February	147.0	65.40	33.60	161.9	157.0	1.162	1.128	0.774
March	171.4	80.38	35.60	177.8	172.1	1.251	1.212	0.759
April	168.5	78.33	36.50	167.3	162.0	1.177	1.150	0.756
May	165.9	83.32	35.00	156.8	150.9	1.131	1.091	0.774
June	156.9	81.58	34.40	145.6	140.1	1.061	1.023	0.781
July	153.8	86.53	33.80	144.3	138.9	1.058	1.019	0.785
August	151.0	82.98	33.20	145.8	140.7	1.067	1.026	0.763
September	143.1	74.10	32.20	145.1	140.5	1.061	1.024	0.784
October	149.1	75.60	31.00	150.9	155.1	1.180	1.142	0.794
November	138.6	62.54	30.10	155.9	151.1	1.156	1.121	0.790
December	140.4	59.33	29.30	163.6	156.6	1.216	1.162	0.803
Year	1635.5	560.02	32.94	1866.2	1833.5	13.762	13.332	0.762



Legends:

- GlobHor: Horizontal global irradiation
- DiffHor: Horizontal diffuse irradiation
- T Amb: Ambient Temperature
- GlobInc: Global incident in coll. plane
- GlobEff: Effective Global, corr. for IAM and shadings
- EArray: Effective energy at the output of the array
- E_Grid: Energy injected into grid
- PR: Performance Ratio

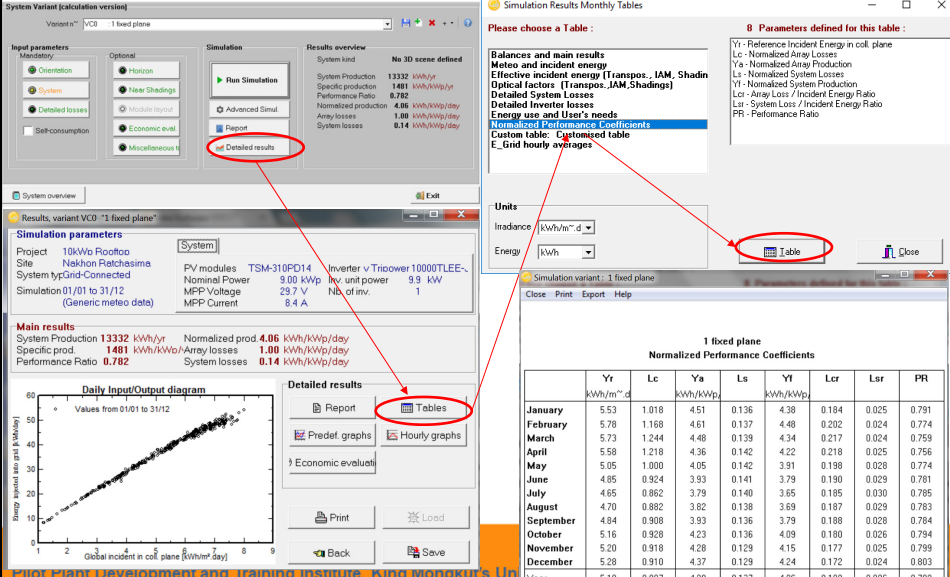
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Results Analysis



The screenshot shows the PVsyst software interface with several windows open. The 'Simulation Results Monthly Tables' window is the primary focus, displaying a list of tables to choose from. A red circle highlights the 'Tables' button in the 'Detailed results' window. Another red circle highlights the 'Tables' button in the 'Simulation Results Monthly Tables' window. A third red circle highlights the 'Tables' button in the 'Simulation Results Monthly Tables' window's 'Units' section. The 'Simulation Results Monthly Tables' window shows a table of 'Normalized Performance Coefficients' for a '1 fixed plane' system.

	Yr	Lc	Ya	Ls	Yf	Lcr	Lsr	PR
	kWh/m ² .d		kWh/kWp _a		kWh/kWp _a			
January	5.53	1.018	4.51	0.136	4.38	0.184	0.025	0.791
February	5.78	1.168	4.61	0.137	4.48	0.202	0.024	0.774
March	5.73	1.244	4.48	0.139	4.34	0.217	0.024	0.759
April	5.58	1.218	4.36	0.142	4.22	0.218	0.025	0.756
May	5.05	1.000	4.05	0.142	3.91	0.198	0.028	0.774
June	4.85	0.924	3.93	0.141	3.79	0.190	0.029	0.781
July	4.65	0.862	3.79	0.140	3.65	0.185	0.030	0.785
August	4.70	0.882	3.82	0.138	3.69	0.187	0.029	0.783
September	4.84	0.908	3.93	0.136	3.79	0.188	0.028	0.784
October	5.16	0.928	4.23	0.136	4.09	0.180	0.026	0.794
November	5.20	0.918	4.28	0.129	4.15	0.177	0.025	0.799
December	5.28	0.910	4.37	0.129	4.24	0.172	0.024	0.803
Year	5.19	0.997	4.20	0.137	4.06	0.192	0.026	0.782

Concepts of PV System Design with PVsyst






Results Analysis

	Yr	Lc	Ya	Ls	Yf	Lcr	Lsr	PR
	kWh/m ² .d		kWh/kWp _a		kWh/kWp _a			
January	5.53	1.018	4.51	0.136	4.38	0.184	0.025	0.791
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August	4.70	0.882	3.82	0.138	3.69	0.187	0.029	0.783
September	4.84	0.908	3.93	0.136	3.79	0.188	0.028	0.784
October	5.16	0.928	4.23	0.136	4.09	0.180	0.026	0.794
November	5.20	0.918	4.28	0.129	4.15	0.177	0.025	0.799
December	5.28	0.910	4.37	0.129	4.24	0.172	0.024	0.803
Year	5.19	0.997	4.20	0.137	4.06	0.192	0.026	0.782

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Results Analysis

Performance Parameters in PVsyst

- Yr : Reference Incident Energy in coll. Plane
- Lc : Normalized Array Losses
 - ✓ Thermal losses
 - ✓ Ohmic wiring losses
 - ✓ Module quality losses
 - ✓ Incidence angle losses
- Ya : Normalized Array Production
- Ls : Normalized System Losses
- Yf : Normalized System Production
- Lcr : Array Loss/ Incident Energy ratio
- Lsr : System Loss/ Incident Energy ratio
- PR : Performance Ratio

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Concepts of PV System Design with PVsyst

IEC 61724 ed2-2017 : Photovoltaic system performance monitoring-Part1: Monitoring

- Yr : Reference yield
 meaning : Total in-plane irradiation (H_i) divided by module's reference plane of array irradiance ($G_{i,ref}$)
- Ya : PV array energy yield
 meaning : Array DC energy output (E_A) divided by installed PV array (P_o)

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Concepts of PV System Design with PVsyst



IEC 61724 ed2-2017 : Photovoltaic system performance monitoring-Part1: Monitoring

- Y_f : Final system yield
 meaning (For grid-tied): net AC energy output (E_{out}) of entire PV system divided by the installed PV array power (P_o)
- PR : Performance ratio
 meaning : The over all effect of losses on the system output due to the array temperature, system loss, failure etc.

$$PR = Y_f/Y_r$$



Concepts of PV System Design with PVsyst



Results Analysis: Economic Evaluation



The screenshot displays the PVsyst software interface for economic evaluation. It is divided into several sections:

- Simulation parameters:**
 - Project: KMUTT PR01-21Nov
 - Site: KMUTT BKT
 - System type: Stand alone
 - Simulation: 01/01 to 31/12 (Generic meteo data)
 - System: PV modules: a-SiH, tripple junction; Nominal Power: 3.26 kWp; MPP Voltage: 36.2 V; MPP Current: 3.9 A; Battery voltage; Total capacity
- Main results:**
 - System Production: 5156 kWh/yr
 - Specific prod.: 1580 kWh/kWp/yr
 - Performance Ratio: 0.634
 - Normalized prod.: 3.36 kWh/kWp/day
 - Array losses: 1.56 kWh/kWp/day
 - System losses: 0.38 kWh/kWp/day
- Daily Input/Output diagram:** A scatter plot showing the relationship between global incident radiation in the collector plane (kWh/m²/day) on the x-axis and the electrical energy output of the array (kWh/day) on the y-axis. The data points show a strong positive correlation, indicating that as incident radiation increases, the energy output also increases.
- Economic evaluation:**
 - Project and Simulation variant: KMUTT PR01-21Nov, New simulation variant
 - PV Array, Prom = 3.3 kWp
 - PV module: a-SiH, tripple junction
 - System: Stand alone system
 - Investment: PV modules (24 units of 136 Wp), Supports / Integration, Batteries (48 of 12 V / 100 Ah), Controller, Settings, wiring, Others, miscellaneous, Substitution underworth.
 - Gross investment, (excl. taxes): 0 EUR
 - Financing: Taxes (15.00%), Subsidies.
 - Net investment: 0 EUR
 - Annulities: 0 EUR / yr
 - Running Costs: 0 EUR / yr
 - Total yearly cost: 0 EUR / yr
 - Loan: Duration (20 Years), Rate (5.0%), Ann. factor (8.02 %cap./yr)
 - Energy cost: Used solar energy (4001 kWh / year), Excess energy (960 kWh / year), Yearly cost (0 EUR / year), Used energy cost (0.00 EUR / kWh)

Exercises with PVsyst

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Exercises with PVsyst

Load consumption

Use example: template household 12kWh/d

Definition of Daily Household consumptions for Summer (Jun-Aug)

Number	Appliance	Power	Daily use	Hourly distrib.	Daily energy
10	Lamps (LED or fluo)	10	W/lamp 5.0 h/day	OK	500 Wh
2	TV / PC / Mobile	100	W/app 5.0 h/day	OK	1000 Wh
1	Domestic appliances	500	W/app 4.0 h/day	OK	2000 Wh
2	Fridge / Deep-freeze	1500	W/h/day 24.0 h/day	OK	1500 Wh
1	Dish- & Cloth-washers	1000.0	W/aver. 2.0 h/day	OK	2000 Wh
1	Ventilation	100	W/app 24.0 h/day	OK	2400 Wh
1	Air conditioning	1000	W/app 3.0 h/day	OK	3000 Wh
	Stand-by consumers	6	W tot 24 h/day		144 Wh
Total daily energy					12642 Wh/day
Total monthly energy					379.3 kWh/month

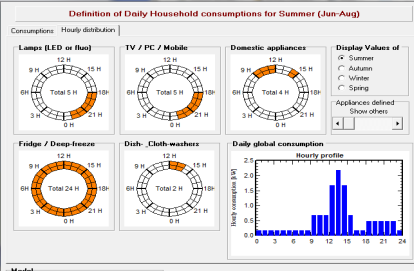
Consumption definition by: Year Seasons Months

Week-end or Weekly use: Use only during [7] days in a week

Display Values of: Summer Autumn Winter Spring

Model: [Load] [Save]

Definition of Daily Household consumptions for Summer (Jun-Aug)



Model: [Load] [Save]

- Design standalone PV system over the limited roof area.
 Lead Acid Batt. LOL 5%, Autonomy 4 days, Battery voltage 48V
 PV Array Operation mode: MPPT
 Generator Back-up 3kW Effective 2.5kW
 Location: at home!

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Exercises with PVsyst

Available Area for PV Installation

Roof	Area	Tilt/Azimuth
Roof No.1	28.8 m ²	10/0
Roof No.2	32.4 m ²	0/0
Roof No.3	21.6 m ²	0/0
Total	82.8 m²	
Area for PV	57.6 m²	

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Exercises with PVsyst

2. Design Grid-connected PV system on full area over the same roof and same place.
No storage, Not self-consumption
Horizon: Azimuth/Height 120/10 , -40/15
Without near shading

Report the Balance and Main results

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