

# **Design and Evaluation of PV Rooftop system in Thailand**

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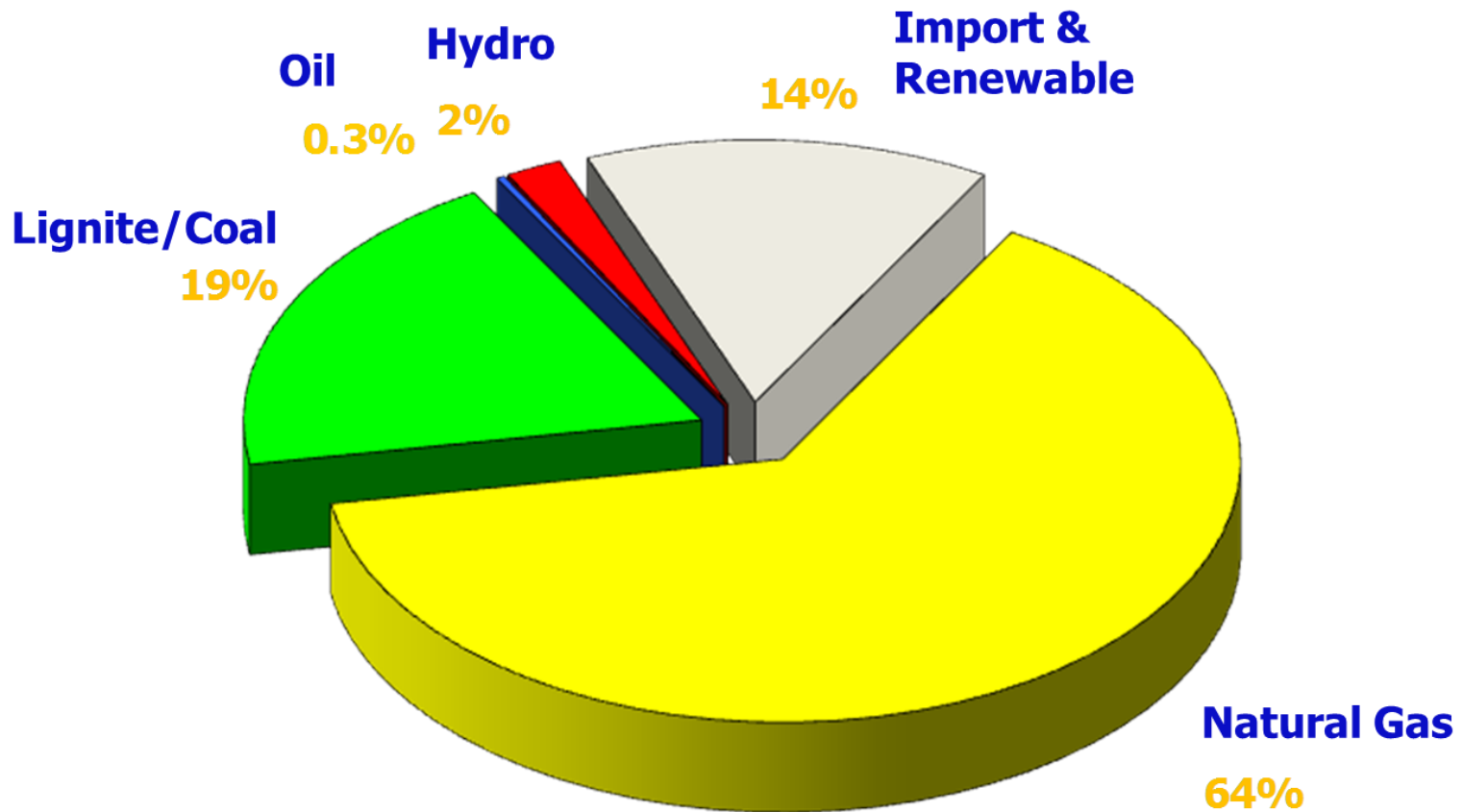
# Outline

- **Introduction**
- **Standard**
- **Implementation**
- **Results**
- **Conclusions**



# Introduction

Share of Power Generation by Fuel Type February 2016



Remark : on EGAT system



# Introduction

**PV system installation capacity >1,058 MW**

**North 164 MW**



**Northeast 379 MW**

**Middle 515 MW**

**Southern 0.2 MW**

**June 2015: Ministry of Energy**



# Introduction

Thai Government launched a Feed-in Program PV rooftop system 200 MW<sub>p</sub>

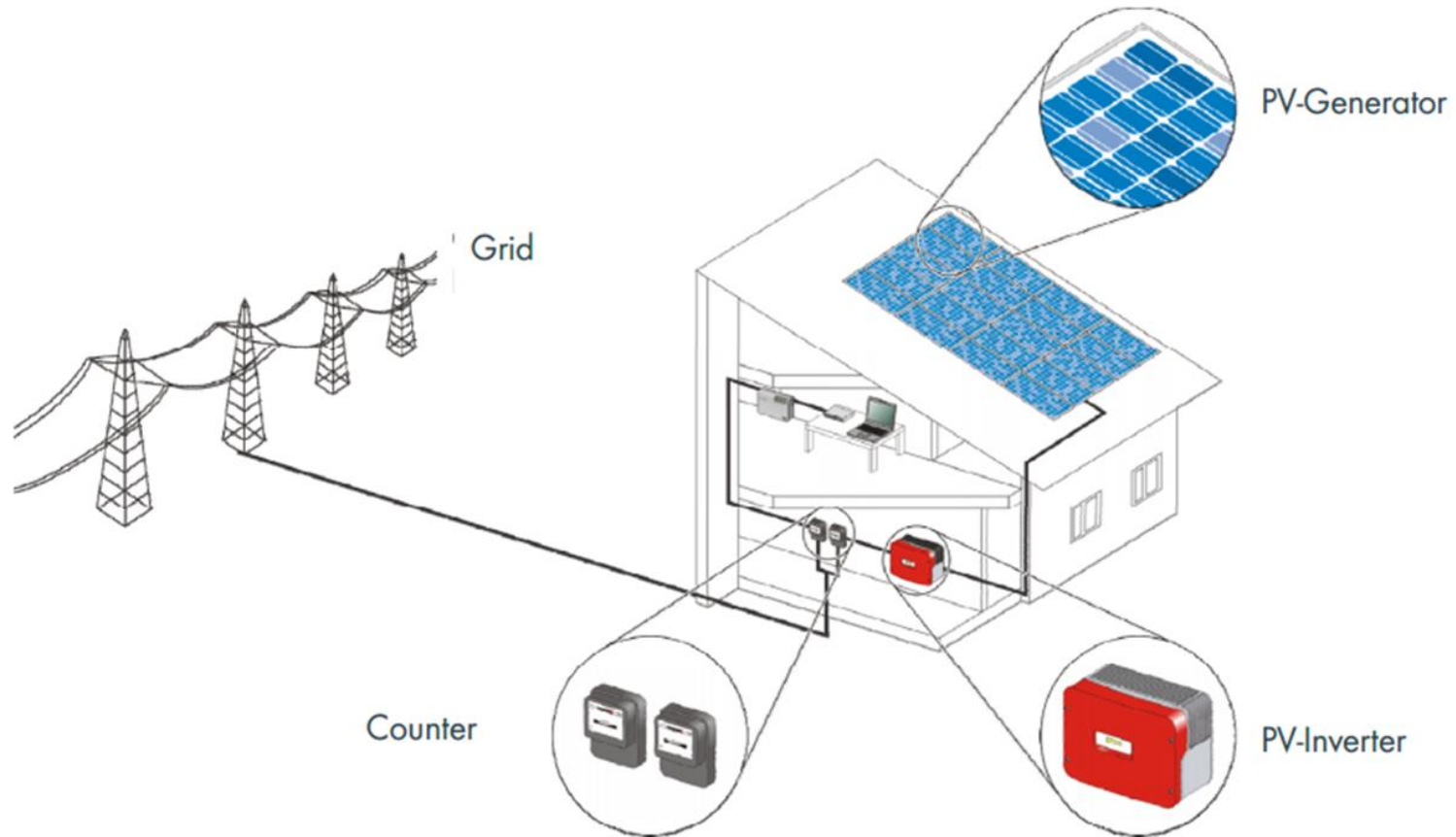
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Type of Building	Capacity	Total Capacity
Households	$< 10 \text{ kW}_p$	100 MW <sub>p</sub>
Small Business	$10 < 250 \text{ kW}_p$	
Medium and Bigger	$250 < 1,000 \text{ kW}_p$	100 MW <sub>p</sub>

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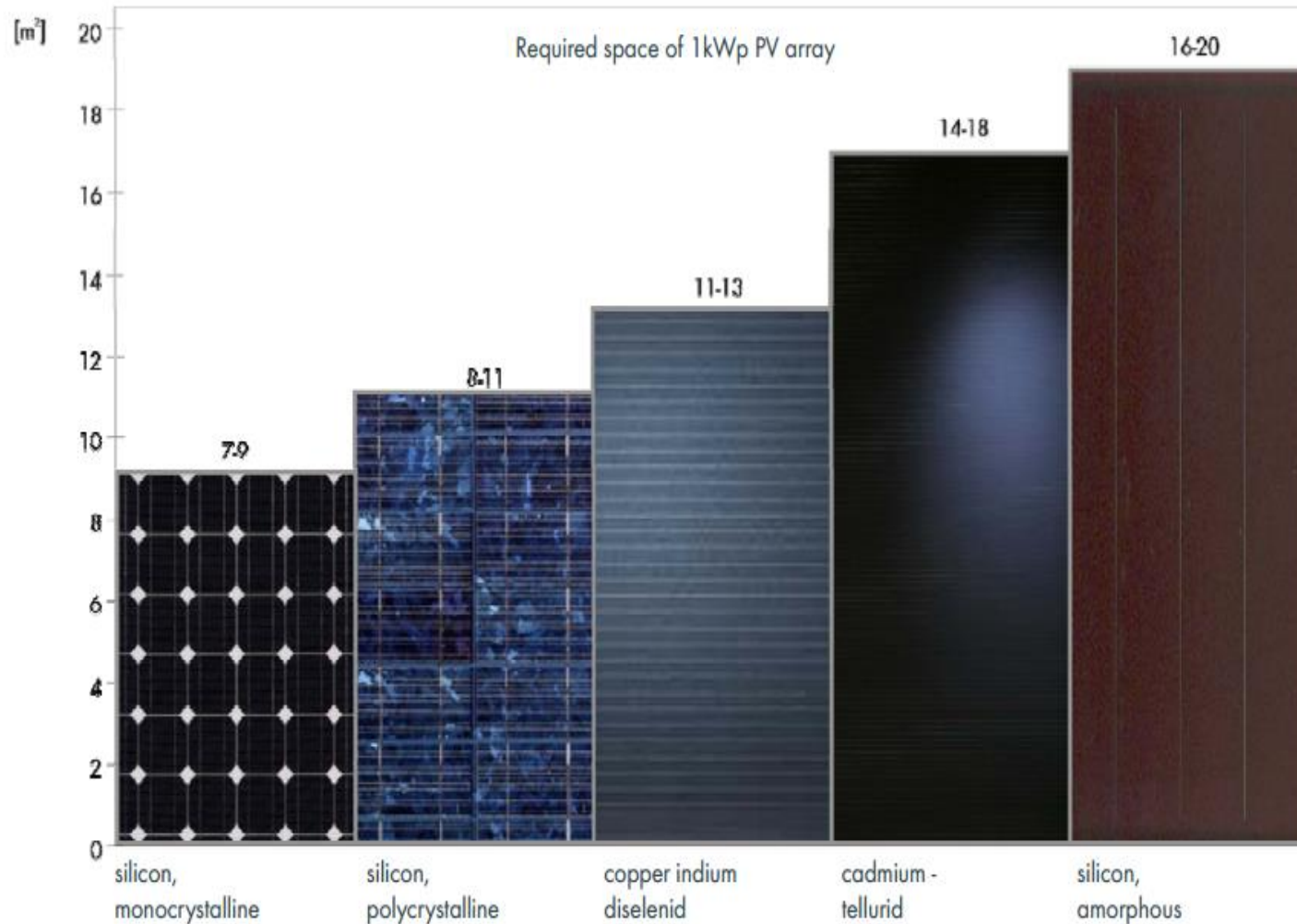
# Introduction

## Grid Connected System

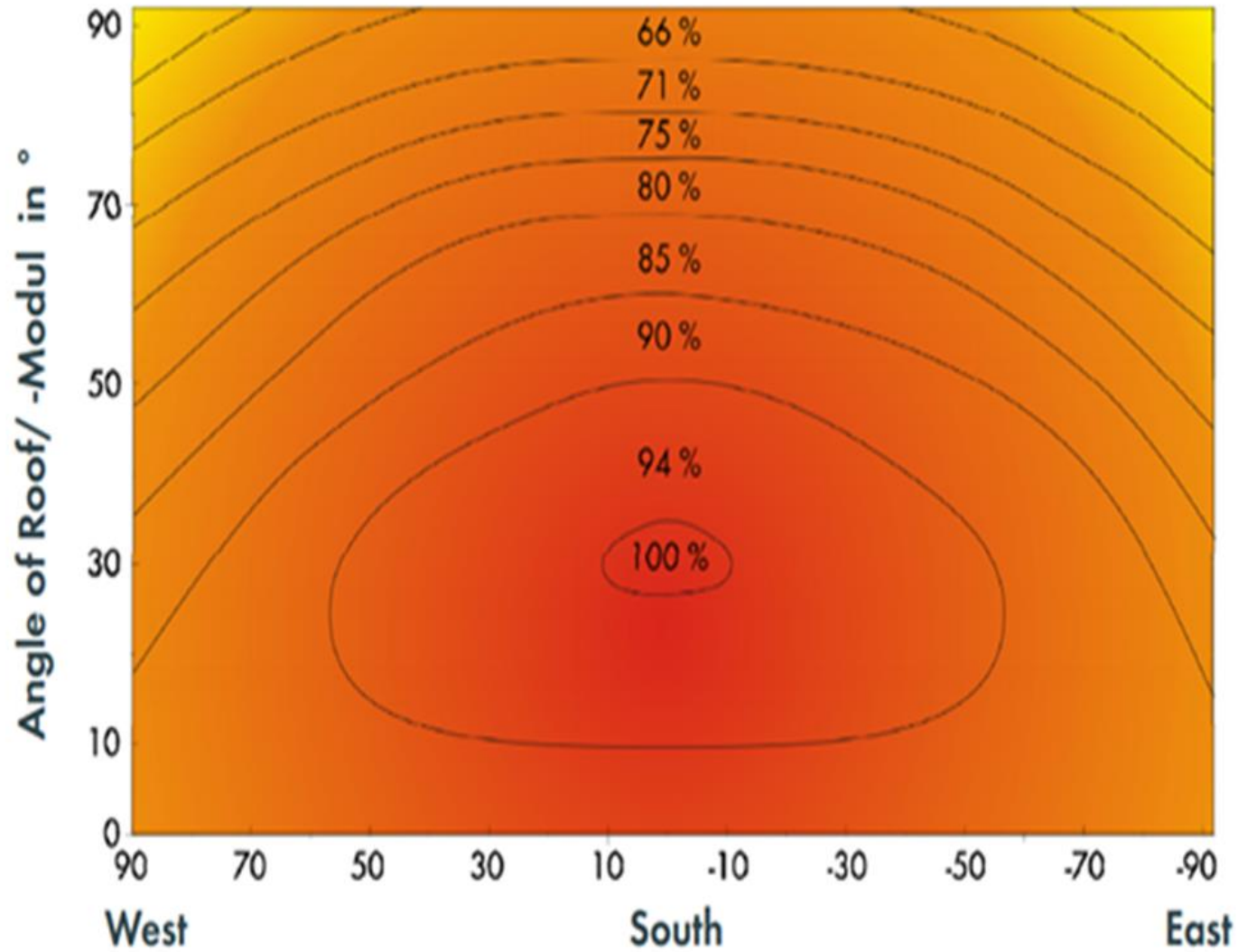


# Introduction

## Surface requirements of different module types



# Introduction







Equipment to consider Add/Remove...

Resources Other

- Solar resource
- Economics
- System control
- Emissions
- Constraints

Document

Author

Notes

### Solar Resource Inputs

File Edit Help

HOMER uses the solar resource inputs to calculate the PV array power for each hour of the year. Enter the latitude, and either an average daily radiation value or an average clearness index for each month. HOMER uses the latitude value to calculate the average daily radiation from the clearness index and vice-versa.

Hold the pointer over an element or click Help for more information.

Location

Latitude  ?  '  North  South Time zone

Longitude  ?  '  East  West

Data source:  Enter monthly averages  Import time series data file Get Data Via Internet

Baseline data

Month	Clearness Index	Daily Radiation (kWh/m <sup>2</sup> /d)
January	0.621	5.190
February	0.594	5.439
March	0.606	6.079
April	0.611	6.455
May	0.527	5.618
June	0.485	5.130
July	0.486	5.135
August	0.483	5.085
September	0.509	5.167
October	0.532	4.990
November	0.583	4.960
December	0.647	5.220
Average:	0.553	5.371

Global Horizontal Radiation

Plot... Export...  
Help Cancel OK

Scaled annual average (kWh/m<sup>2</sup>/d)  {..}

## Homer Simulation



# Introduction

## Standard of Power Quality

Voltage RMS



Power Frequency



Harmonics



Voltage Unbalance

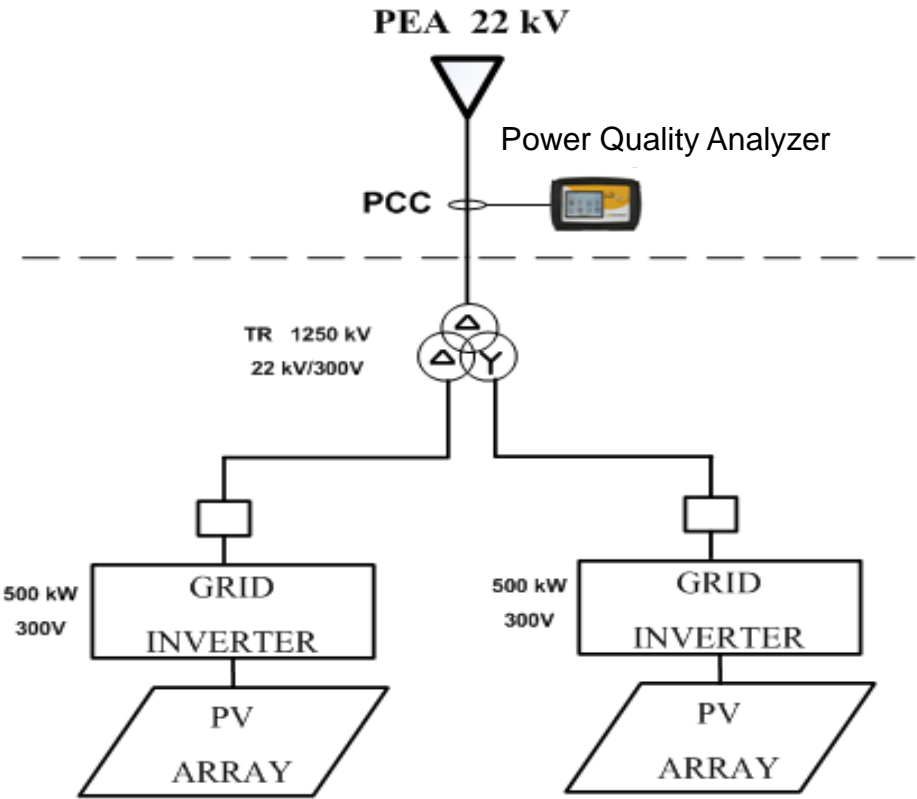


Voltage Fluctuation



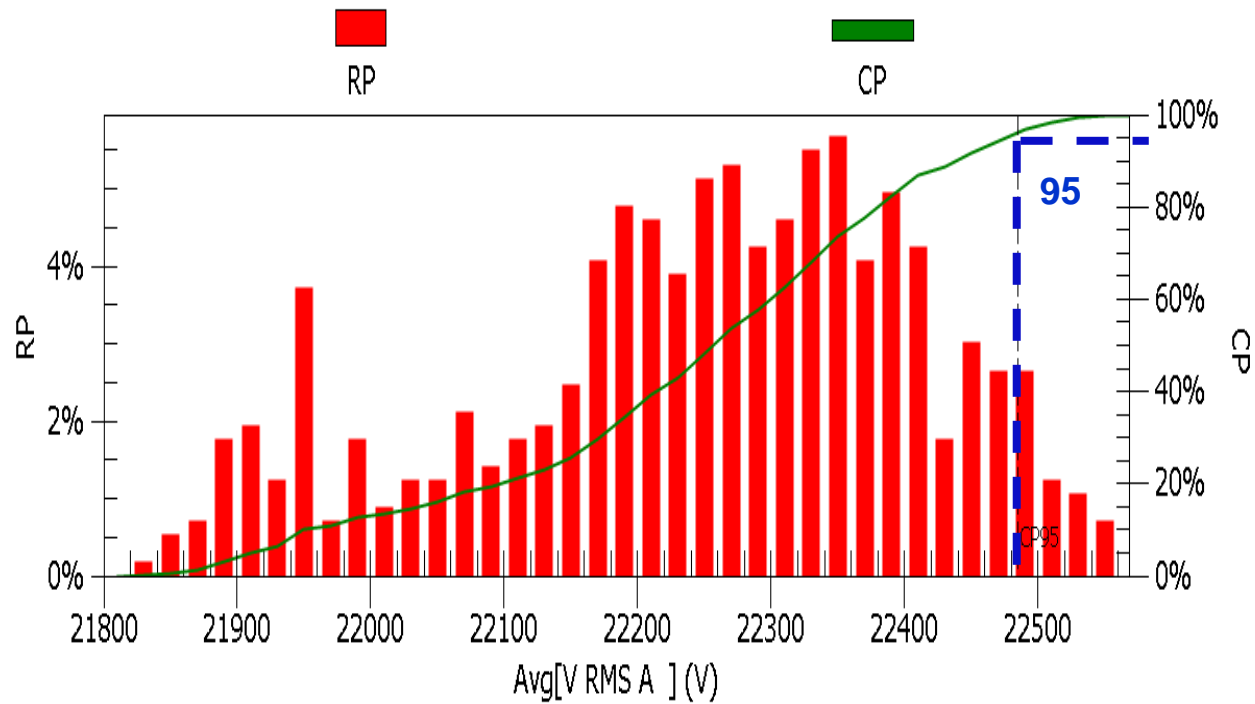
# Power Quality Analyzer Measurement

Period of Measurement: 7+ 1 Days





# Analysis CP95 of PCC



**Standard EN 50160**

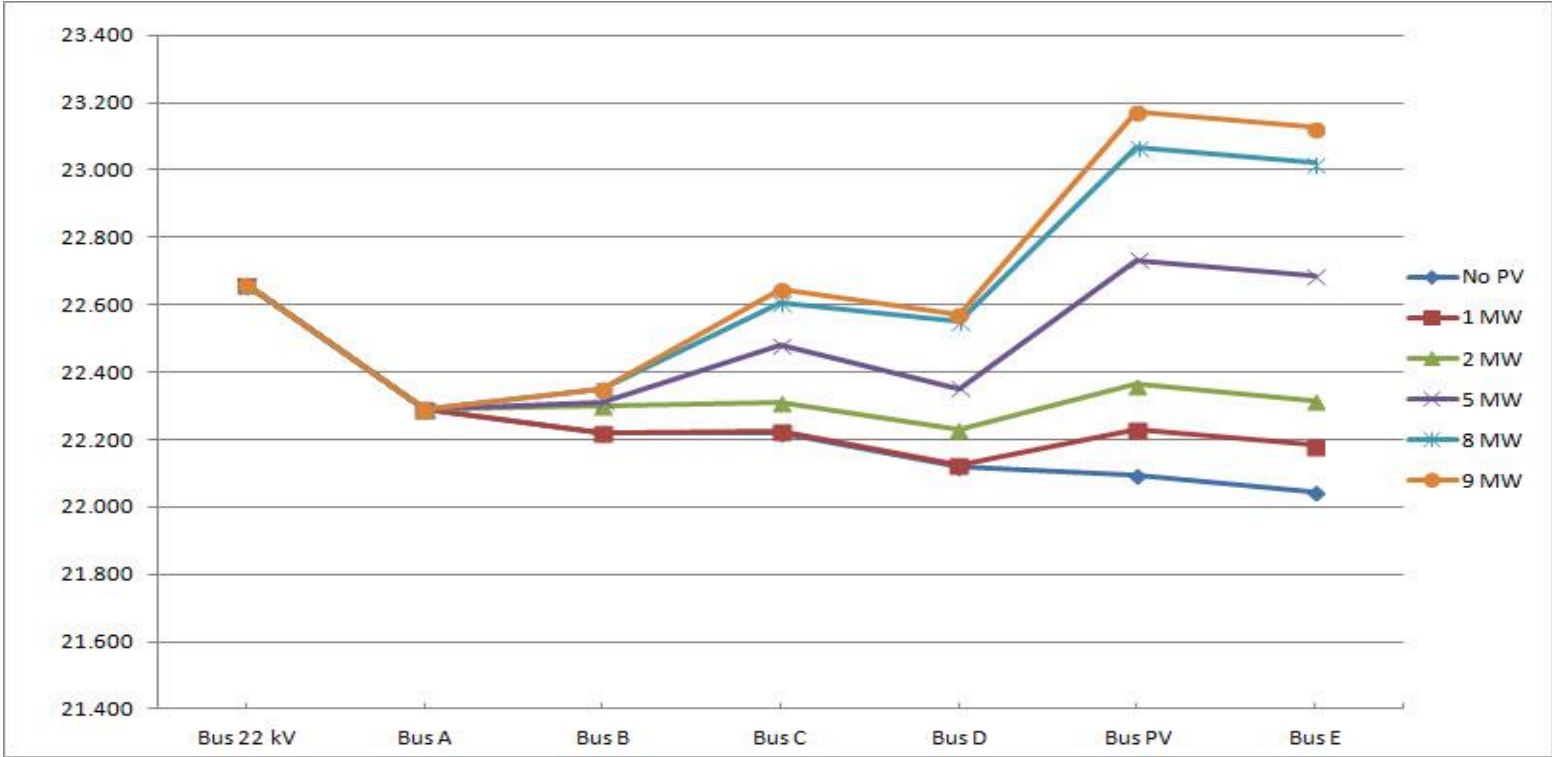


## Standard must be considered : PEA

Parameters	Phase	Standard	Measured	
Voltage	A	22±5% (21.9-23.1 kV)	22.613	Pass
	B		-	-
	C		22.793	Pass
Frequency		50±1% (49.5-50.5 Hz)	50.05	Pass
THD <sub>V</sub>	A	THD <sub>V</sub> < 4 %	1.631	Pass
	B		-	-
	C		1.347	Pass
Voltage Fluctuation: Plt	A	Pst < 0.8	0.467	Pass
	B		-	-
	C		0.657	Pass



# Grid Connected Capacity

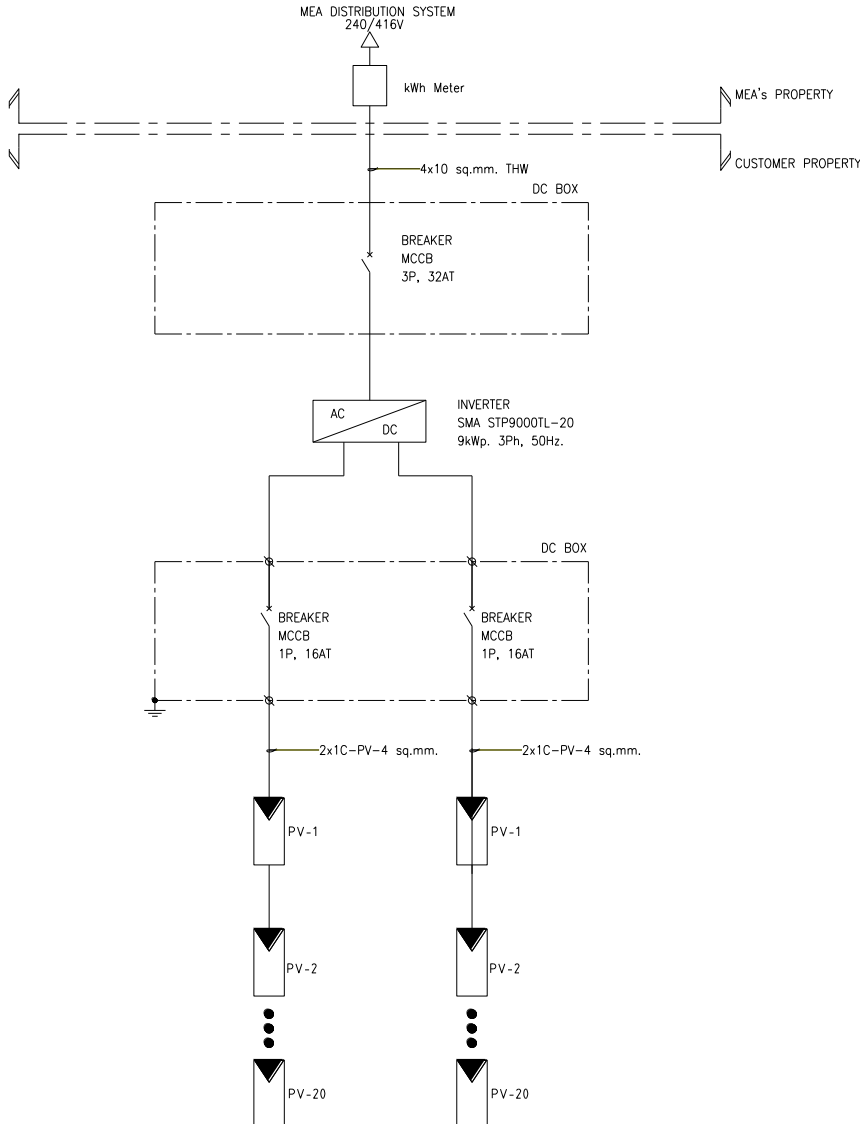


DlgSILENT Simulation

# **PV Rooftop System**

**1 Phase or 3 phase inverter??**

# 3 Phase inverter

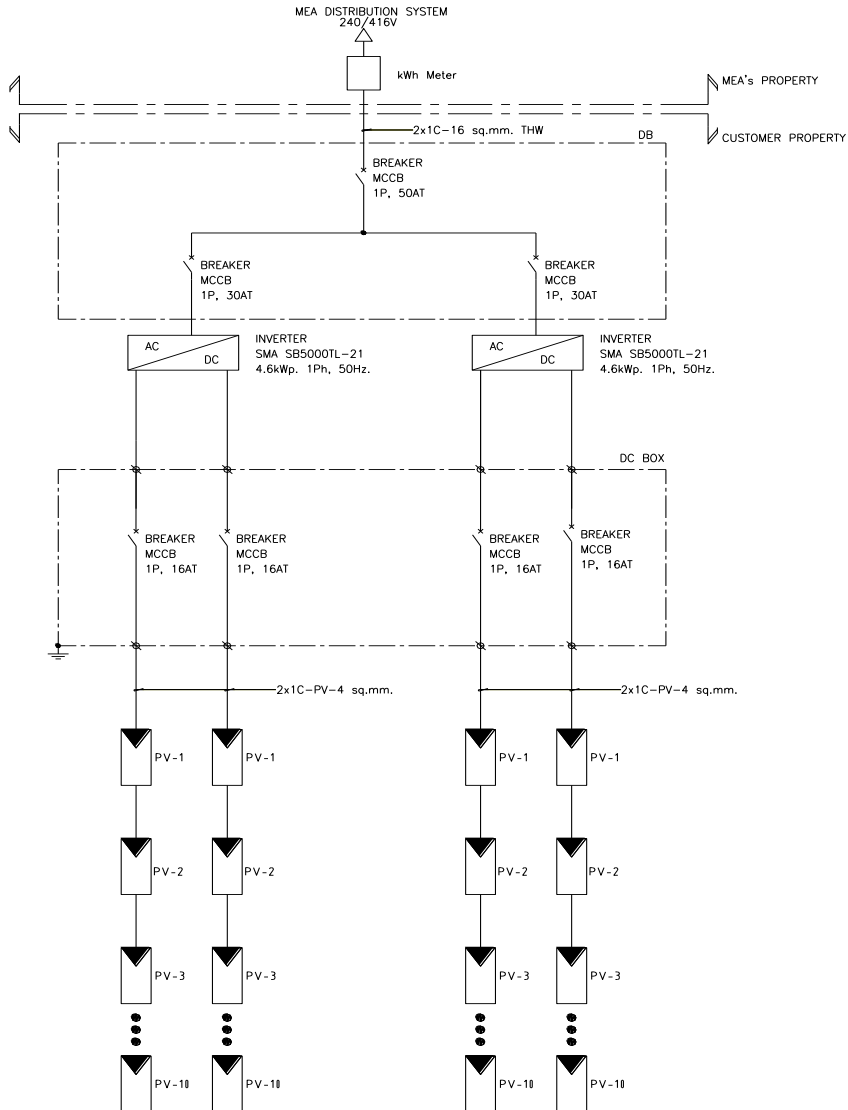




# Installation



# 1 Phase inverter





# Installation





# Installation



# Energy Yield from 3 Phase Inverter



SN: 304989812

Day yield **43.20 kWh**

Condition **Ok**

Power **2,693 W**

Total yield **10.231 MWh**

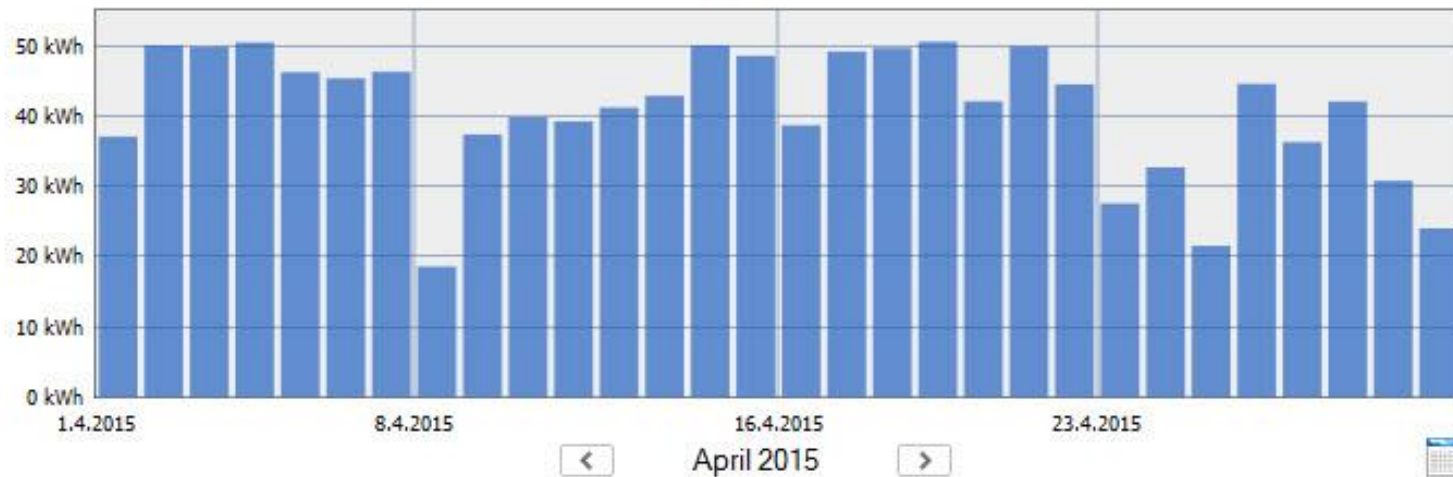
Day

**Month**

Year

Total

Yield



# Energy Yield from 1 Phase Inverter



**SN: 2130294874**

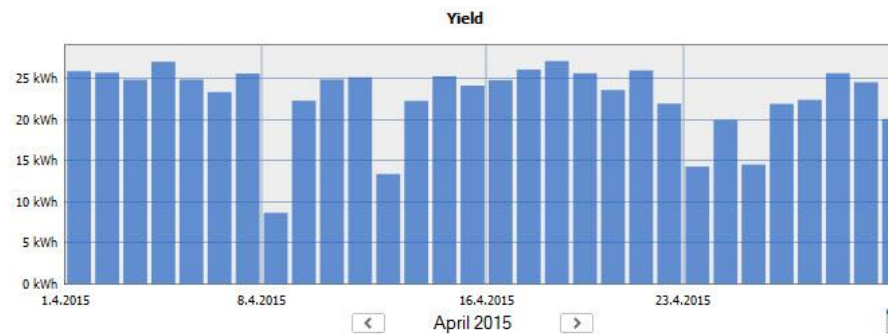
Day yield	<b>12.99 kWh</b>
Condition	<b>Ok</b>
Power	<b>3,508 W</b>
Total yield	<b>5,276.51 kWh</b>



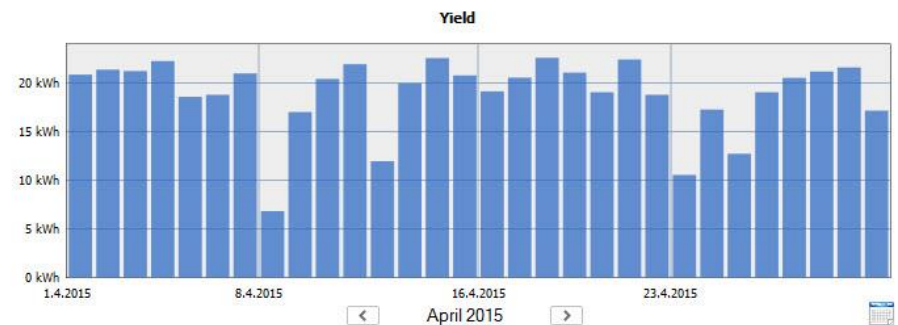
**SN: 2130294877**

Day yield	<b>14.89 kWh</b>
Condition	<b>Ok</b>
Power	<b>2,559 W</b>
Total yield	<b>4,485.24 kWh</b>

Day **Month** Year Total



Day **Month** Year Total



# Measurement Result of Energy Yield

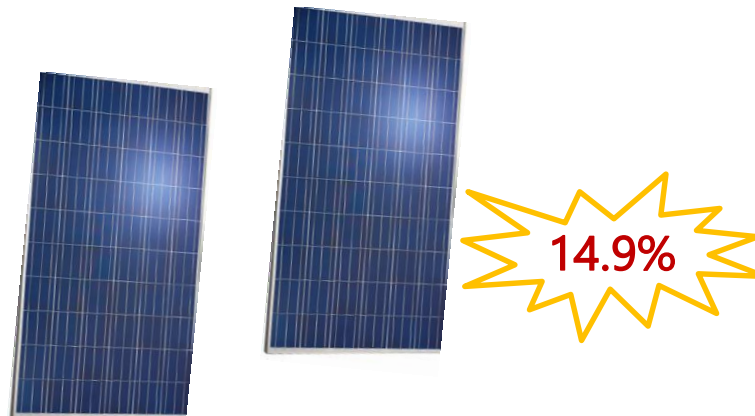
Day	Energy (kWh/day)		Day	Energy (kWh/day)		Day	Energy (kWh/day)	
	3 Ph	1 Ph		3 Ph	1 Ph		3 Ph	1 Ph
1	37.08	49.29	11	39.21	48.36	21	49.87	48.71
2	50.02	49.26	12	41.18	25.82	22	44.49	41.39
3	49.82	47.86	13	42.85	43.15	23	27.54	27.29
4	50.44	51.32	14	50.05	48.08	24	32.70	37.60
5	46.21	47.06	15	48.54	45.89	25	21.53	28.15
6	45.33	45.82	16	38.65	48.34	26	44.54	40.87
7	46.26	49.97	17	49.15	50.19	27	36.27	42.33
8	18.59	16.82	18	49.64	51.24	28	42.06	48.02
9	37.35	43.15	19	50.54	48.58	29	30.77	46.25
10	39.82	47.75	20	42.06	44.49	30	24.01	38.07
Annual							1,227	1,301



# PV Efficiency from selected System

ประสิทธิภาพของแผงเซลล์แสงอาทิตย์ (  $\eta$  : Total Efficiency)

$$\begin{aligned}\eta &= \frac{E_{tot}}{H_i \times A_A} \\ &= \frac{3,858.71}{5.32 \times 7,000} \\ &= 10.36 \%\end{aligned}$$







# Economics calculation from selected System

## Annuity Method

$$a = NPV \cdot \frac{i \cdot (1+i)^n}{(1+i)^n - 1}$$

**a** = annuity [currency]  
**NPV** = net present value [currency]  
**i** = fictitious interest  
**n** = planning horizon [a]

**n** = 9.34 Years

**FIT = 6.16  
THB/UNIT**

# Conclusions

- ❖ **Meet the Standards**
- ❖ **Rooftop has a difficulty for installation**
- ❖ **Roof has different Tile angles in one system**
- ❖ **Group all PVs in one inverter: lower yields**
- ❖ **Rooftop gains lower than ground system**
- ❖ **Difficulty for Cleaning**



**Thank you**

**Khob-Khun-Krabb**

**ขอบคุณครับ**