POWERFACTORY

PowerFactory 2021

Technical Reference

PV System

ElmPvsys, TypPvpanel

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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Contents

1 General Description

The Photovoltaic System element (*ElmPvsys*) is an easy-to-use model based on the Static Generator element (*ElmGenstat*). The PV System element models an array of photovoltaic panels, connected to the grid through a single inverter. The main difference with the static generator, is that the PV System provides an option to automatically estimate the active power setpoint, given the geographical location, date and time.

The description of the following functions supported by *PowerFactory* can be found in the Technical Reference of the Static Generator:

- Load Flow Analysis
- Short Circuit Analysis
- Optimal Power Flow
- Harmonics Analysis
- Stability/Electromagnetic Transients Analysis

1.1 Basic Data

1.1.1 Model for Active Power Calculation

The active power value can be specified directly by the user through the option **Active Power Input**, or it can be automatically calculated, given the data of the solar panel type, the arrangement of the solar array, the local time and date, and optionally irradiance data, with the option **Solar Calculation**.

When the option **Solar Calculation** is used, the active power is calculated according to the Section 2.

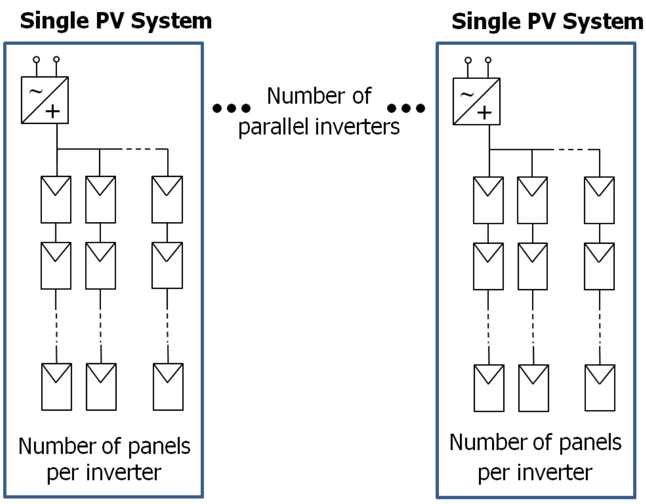

Figure 1.1: Photovoltaic System

1.1.2 Number of Parallel Inverters

The number of parallel inverters can be entered, as well as the MVA rating of a single inverter. In general, the total MW and Mvar outputs of the PV System will be the rating of a single PV Array multiplied by the number of parallel inverters specified.

1.1.3 Number of Panels Per Inverter

For each PV System, which contains a single inverter, a number of panels can be entered. The panels can be connected either in parallel, series or in series-parallel combination. The PV System models the solar array viewed from the grid side.

2 Solar Calculation

The active power output of a single PV System, i.e. an array of panels connected to the grid through a single inverter is calculated based on irradiance input data and the local time and date.

The following equations for the panel and system output are proposed in [5].

$$P_{panel} = \frac{E_{g,pv} \cdot P_{pk,panel} \cdot \eta_{rel} \cdot \eta_{inv}}{E_{STD}} \tag{1}$$

and

$$P_{system} = P_{panel} \cdot num_{panels} \tag{2}$$

Where:

- P_{panel} is the active power output of the panel in kW
- P_{system} is the single system active power output in kW
- num_{panels} is the number of panels per inverter
- $E_{g,pv}$ is the global irradiance on the plane of the array in W/m^2. See Sections 2.1 to 2.5
- E_{STD} is the standard irradiance value of 1000 W/m^2
- $P_{pk,panel}$ is the total rated peak power of the solar panel in kW
- η_{rel} is the relative efficiency of the panel, unit-less. See Section 2.6
- η_{inv} is the efficiency factor of the inverter, unit-less

The geometrical calculation of the global irradiance on an inclined surface is proposed in [1] and [3].

2.1 Angle of Incidence

The first step in the process of calculating the irradiance on the surface of the PV panel ($E_{g,pv}$), is to calculate the angle of incidence of the solar irradiance ($\nu(\beta,\alpha)$), which can be defined as the angle between the solar rays and the line perpendicular to the surface of the solar panel.

This angle of incidence of the irradiance is calculated as follows:

$$J'_{rad} = \frac{J \cdot 2\pi}{365.25} \tag{3}$$

$$J'_{deg} = \frac{J \cdot 360}{365.25} \tag{4}$$

$$\delta = sin^{-1}0.3978 \cdot sin[J'_{rad} - 1400 + 0.0355 \cdot sin(J'_{rad} - 0.0489)] \tag{5}$$

$$EOT = -0.128 \cdot sin(J'_{deg} - 2.8^{\circ}) - 0.165 \cdot sin(2J'_{deg} + 19.7^{\circ}) \tag{6}$$

$$t_{LAT} = t_{LMT} + \frac{(\lambda - \lambda_R)}{15} + EOT - c \tag{7}$$

$$\omega = 15 \cdot (t_{LAT} - 12) \tag{8}$$

$$sin\gamma_s = sin\phi \cdot sin\delta + cos\phi \cdot cos\delta \cdot cos\omega \tag{9}$$

$$cos\alpha_s = \frac{sin\phi \cdot sin\gamma_s - sin\delta}{cos\phi \cdot cos\gamma_s} \tag{10}$$

$$sin\alpha_s = \frac{cos\delta \cdot sin\omega}{cos\gamma_s} \tag{11}$$

$$\alpha_s = \begin{cases} -cos^{-1}(cos\alpha_s) & if\ sin\alpha_s < 0 \\ cos^{-1}(cos\alpha_s) & if\ sin\alpha_s > 0 \end{cases} \tag{12}$$

$$\alpha_F = \alpha_s - \alpha \tag{13}$$

$$\nu(\beta,\alpha) = cos^{-1}(cos\gamma_s \cdot cos\alpha_F \cdot sin\beta + sin\gamma_s \cdot cos\beta) \tag{14}$$

Where:

- α_F is the Julian day number (1 to 366)
- J'_{rad} is the day angle in radians
- J'_{deg} is the day angle in degrees
- δ is the declination angle in radians

- EOT is the Equation of Time in hours
- λ is the longitude of the site in degrees, with east being positive
- λ_R is the longitude of the local time zone, in degrees, east positive
- c is the correction for summer time in hours
- t_{LMT} is the Local Mean Time in hours
- t_{LAT} is the solar time in hours
- ω is the hour angle in degrees
- ϕ is the latitude of the location in degrees
- γ_s is the solar altitude angle in degrees
- α is the azimuth angle of the surface in degrees
  - Measured from due south in the northern hemisphere and from due north in the southern hemisphere, i.e. facing equator is always zero degrees
  - Directions to the west of north-south are positive, east is negative (for both hemispheres)
- α_s is the solar azimuth angle in degrees
- α_F is the wall solar azimuth angle in degrees
  - If $\alpha_F > 180°$, then $\alpha_F = \alpha_F - 360°$
  - If $\alpha_F < 180°$, then $\alpha_F = \alpha_F + 360°$
- β is the surface tilt angle from the horizontal plane in degrees
- $\nu(\beta,\alpha)$ is the angle of incidence of the solar irradiance

2.2 Tilt and Orientation Angle for Tracking Systems

It is possible to specify whether or not the panels have a fixed mounting or a tracking system. When the panels are fixed, the user must specify the orientation and/or the tilt angles. If a tracking system is used, it is assumed that the angles are optimized. The optimization is calculated according to the sections below.

Essentially, the most realistic way to find the angle optimization, is to maximize the direct irradiance beam, as many sensors of solar panels work this way. If we look at the equation 42, we can note that the values depend proportionally on the cosinus of the incidence angle. The solar altitude can be disregarded since it does not depend on the tilt nor on the orientation. Therefore, the tilt and the orientation must be found such that:

$$\text{maximize } f(\beta,\alpha) = (cos\gamma_s \cdot cos\alpha_F \cdot sin\beta + sin\gamma_s \cdot cos\beta) \tag{15}$$

subject to:

$$-90° \leq \beta \leq 90°$$
$$-90° \leq \alpha \leq 90°$$

Derivating, in order to find the local maximum:

$$\frac{\partial f}{\partial \beta} = k_1 \cdot cos\beta - sin\beta = 0 \tag{16}$$

$$\frac{\partial f}{\partial \alpha} = k_2 \cdot sin(\alpha_s - \alpha) = 0 \tag{17}$$

Where the constants k_1 and k_2 are defined as:

- $k_1 = \frac{cos\gamma_s \cdot cos\alpha_F}{sin\gamma_s}$
- $k_2 = -\alpha \cdot cos\gamma_s \cdot sin\beta$

2.2.1 Dual Axis Tracking System

For this type of tracking system, both equations in 16 and 17 must be satisfied. Therefore,

$$\beta = \beta_{tracking} = 90° - \gamma_s \tag{18}$$

$$\alpha = \alpha_{tracking} = \alpha_s \tag{19}$$

2.2.2 Horizontal Single Axis Tracking System

For the horizontal tracking system, the equation 16 must be satisfied, and this can only be done iteratively.

2.2.3 Vertical Single Axis Tracking System

For the vertical tracking system, the equation 17 must be satisfied. Thus,

$$\alpha = \alpha_{tracking} = \alpha_s \tag{20}$$

2.3 Extraterrestrial Irradiance on the Horizontal Plane

The extraterrestrial irradiance value incident on a horizontal surface corrected by the day of the year, $E_0(J)$, is given by

$$I_0 = 1367w/m^2 \tag{21}$$

$$\epsilon = 1 + 0.03344 \cdot cos(J'_{rad} - 0.048869) \tag{22}$$

$$E_0 = I_0 \cdot sin(\gamma_s) \tag{23}$$

$$E_0(J) = I_0 \cdot \epsilon \cdot sin\gamma_s \tag{24}$$

Where:

- I_0 is the solar constant, equal to $1367W/m^2$
- ϵ is the correction of the variation of the sun-earth distance from its mean value
- E_0 is the extraterrestrial irradiance on the horizontal plane
- $E_0(J)$ is the extraterrestrial irradiance on the horizontal plane corrected by the day of the year

2.4 Global Irradiance on the Horizontal Plane

The global irradiance is the sum of two components: direct or beam irradiance ($E_{b,hor}$), diffuse irradiance ($E_{d,hor}$). Since the values of the global irradiance and its two components are necessary to calculate the global irradiance on the inclined surface of the solar panels, the value of two components will be needed as an input from the user.

$$E_{g,hor} = E_{b,hor} + E_{d,hor} \tag{25}$$

Where:

- $E_{g,hor}$ is the global irradiance at the surface falling on a horizontal plane in W/m^2
- $E_{b,hor}$ is the direct or beam irradiance on the horizontal plane in W/m^2
- $E_{d,hor}$ is the diffuse irradiance on the horizontal plane in W/m^2

The values of these irradiance components can be in the form of historical or forecasted data, or they can be estimated through simple or complex models. The simple ones use only geometrical methods, whereas the complex models include atmospheric factors. Implemented here are **only the simple methods**, which are described in Sections 2.4.1, 2.4.2 and 2.4.3.

2.4.1 Estimation of Global Irradiance on the Horizontal Plane

The following models are referenced in [3] and [4].

Kasten-Czeplak Model

$$E_{g,hor} = 910 \cdot sin\gamma_s - 30 \tag{26}$$

Haurwitz Model

$$E_{g,hor} = 1098 \cdot sin\gamma_s \cdot exp(\frac{-0.057}{sin\gamma_s}) \tag{27}$$

Berges-Duffie Model

$$E_{g,hor} = I_0 \cdot 0.70 \cdot sin\gamma_s \tag{28}$$

Adnot-Bourges-Campana-Gicquel Model

$$E_{g,hor} = 951.39 \cdot (sin\gamma_s)^{1.15} \tag{29}$$

Robledo-Soler Model

$$E_{g,hor} = 1159.24 \cdot (sin\gamma_s)^{1.179} \cdot exp(-0.0019 \cdot gamma_s) \tag{30}$$

Hourly Clearness Index Value
The Hourly Clearness Index values can be entered through a characteristic object. From the clearness index, KT, the horizontal irradiance is calculated by

$$E_{g,hor} = E_0(J) \cdot KT \tag{31}$$

Where:

- KT is the clearness index. Daily values vary around 0.68 to 0.72 under cloudless conditions, with lower values at high latitudes in winter.

Inversely, the clearness index factor can be calculated from estimated or given irradiance data:

$$KT = \frac{E_{g,hor}}{E_0(J)} \tag{32}$$

Hourly Data, GHI

Normally given as Global Horizontal Irradiance (GHI) data. In the dialog, the data can be entered with a characteristic object.

2.4.2 Estimation of Diffuse Irradiance on the Horizontal Plane

The following models are referenced in [2] and [6].

Bugler Model

$$E_{d,hor} = 16 \cdot \sqrt{\gamma_s} - 0.4 \cdot \gamma_s \tag{33}$$

Erbs et al. Model

$$E_{d,hor} = \begin{cases} Eg{,}hor \cdot (1.0 - 0.09 \cdot KT) & for\ KT \leq 0.22 \\ Eg{,}hor \cdot (0.9511 - 0.1604 \cdot KT - 4.388 \cdot KT^2 - \\ \quad 16.638 \cdot KT^3 + 12.336 \cdot KT^4) & for\ 0.22 < KT < 0.8 \\ Eg{,}hor \cdot (0.165) & for\ KT \geq 0.8 \end{cases} \tag{34}$$

Reindl et al. Model

$$E_{d,hor} = \begin{cases} Eg{,}hor \cdot (1.02 - 0.254 \cdot KT + 0.0123 \cdot sin\gamma_s) & for\ KT \leq 0.3 \\ Eg{,}hor \cdot (1.4 - 1.749 \cdot KT + 0.177 \cdot sin\gamma_s) & for\ 0.3 < KT < 0.78 \\ Eg{,}hor \cdot (0.468 \cdot KT - 0.182 \cdot sin\gamma_s) & for\ KT \geq 0.78 \end{cases} \tag{35}$$

Liu and Jordan Model

$$E_{d,hor} = \frac{E_{g,hor}}{KT} \cdot (0.384 - 0.416 \cdot KT) \tag{36}$$

Orgill and Holands Model

$$E_{d,hor} = \begin{cases} Eg{,}hor \cdot (1.0 - 0.249 \cdot KT) & for\ KT < 0.35 \\ Eg{,}hor \cdot (1.577 - 1.84 \cdot KT) & for\ 0.35 \leq KT \leq 0.75 \\ Eg{,}hor \cdot (0.177) & for\ KT > 0.75 \end{cases} \tag{37}$$

Spencer Model

$$E_{d,hor} = \begin{cases} E_{g,hor} \cdot (0.94 + 0.0118 \cdot |\phi| - (0.41475 + 0.004725 \cdot |\phi|)) & for\ 0.35 < KT \\ E_{g,hor} \cdot (0.94 + 0.0118 \cdot |\phi| - (1.185 + 0.0135 \cdot |\phi|) \cdot KT) & for\ 0.35 \leq KT \leq 0.75 \\ E_{g,hor} \cdot (0.94 + 0.0118 \cdot |\phi| - (0.88875 + 0.010125 \cdot |\phi|)) & for\ KT > 0.75 \end{cases} \tag{38}$$

Where:

- ϕ is the latitude of the site in degrees

Lam and Liu Model

$$E_{d,hor} = \begin{cases} Eg{,}hor \cdot (0.977) & for\ KT \leq 0.15 \\ Eg{,}hor \cdot (1.237 - 1.361 \cdot KT) & for\ 0.15 < KT \leq 0.7 \\ Eg{,}hor \cdot (0.273) & for\ KT > 0.7 \end{cases} \tag{39}$$

Louche et al. Model

$$E_{d,hor} = E_{g,hor}(1 - \frac{1}{KT} \cdot (-10.627 \cdot KT^5 + 15.307 \cdot KT^4 - 5.205 \cdot KT^3 + 0.994 \cdot KT^2 - 0.059 \cdot KT + 0.002)) \tag{40}$$

2.4.3 Direct (Beam) Irradiance on Horizontal Plane

Hourly Data, Horizontal (DHI)

In the dialog, the data can be entered with a characteristic object.

Hourly Data, Normal (DNI)

In the dialog, the normal direct irradiance data can be entered with a characteristic object.

From the normal direct irradiance, the direct horizontal irradiance can be calculated by

$$E_{b,hor} = E_{b,norm} * sin\gamma_s \tag{41}$$

Where

- $E_{b,norm}$ is the normal solar irradiance in W/m^2

2.5 Global Irradiance on Inclined Surface

Finally, the global irradiance on an inclined surface, $E_{g,pv}$, is the sum of the direct (beam), the diffuse and the ground reflected irradiance values, all of them on the plane of the inclined surface, and affected by respective overshading factors.

$$E_{g,pv} = E_{b,pv} \cdot (1 - S_{dir}) + E_{d,pv} \cdot (1 - S_{diff}) + E_{r,pv} \tag{42}$$

Where:

- $E_{g,pv}$ is the global solar irradiance at the surface on the inclined plane in W/m^2
- $E_{b,pv}$ is the slope direct or beam component in W/m^2
- $E_{d,pv}$ is the slope sky diffuse component in W/m^2
- $E_{r,pv}$ is the slope ground reflected component in W/m^2
- S_{dir} is the direct Irradiance shading factor, unit-less
- S_{diff} is the diffuse Irradiance shading factor, unit-less

2.5.1 Direct (Beam) Irradiance on Inclined Surface

The direct or beam component $E_{b,pv}$ can be calculated very easily with some of the values calculated above in the following way

$$E_{b,pv} = \begin{cases} \frac{E_{b,hor} \cdot cos\nu(\beta,\alpha)}{sin\gamma_s} & for \ \cos\nu(\beta,\alpha) > 0 \\ 0 & otherwise \end{cases} \tag{43}$$

Where:

- $E_{b,hor}$ is the direct (beam) irradiance on a horizontal plane
- $\nu(\beta,\alpha)$ is the angle of incidence in degrees
- γ_s is the solar altitude in degrees

2.5.2 Sky Diffuse Irradiance on Inclined Surface

The diffuse component $E_{d,hor}$ can also be computed straight forward with

$$E_{d,PV} = \begin{cases} E_{d,hor} \cdot \left(\frac{1+cos(\beta)}{2}\right) & for \ \frac{1+cos(\beta)}{2} > 0 \\ 0 & otherwise \end{cases} \tag{44}$$

Where:

- β is the surface tilt angle from the horizontal plane in degrees

2.5.3 Ground Reflect Irradiance on Inclined Surface

The ground reflected irradiance can be computed as a fraction of the global horizontal irradiance with the following

$$E_{r,pv} = \begin{cases} E_{g,hor} \cdot \rho_g \cdot \left(\dfrac{1 - cos(\beta)}{2}\right) & for\ \dfrac{1 - cos(\beta)}{2} > 0 \\ \\ 0 & otherwise \end{cases} \tag{45}$$

Where:

- ρ_g is the ground albedo, unit-less
- β is the surface tilt angle from the horizontal plane in degrees

2.6 Relative Efficiency of Solar Panel

The relative efficiency is calculated according to [5].

$$\eta_{rel} = (1 + c_T \cdot 0.01 \cdot (T_c - T_r)) \cdot \left(1 + k_1 \cdot ln\left(\frac{E_{g,pv}}{E_{STD}}\right) - k_2 \cdot \left(\frac{E_{g,pv}}{E_{STD}} - 1\right)\right) \tag{46}$$

Where:

- η_{rel} is the relative efficiency of the solar panel, unit-less
- c_T is the temperature coefficient for module efficiency, in $\%\backslash°C$
- T_c is the average module temperature in $°C$
- T_r is the reference temperature = 25$°C$
- k_1 and k_2 are efficiency coefficients

2.6.1 Average Module Temperature

$$T_c = T_a + \Delta T \cdot 0.01 \cdot E_{g,pv} \tag{47}$$

$$\Delta T = \frac{NOCT - 20}{0.8 \cdot E_{STD}} \tag{48}$$

Where:

- T_a is the ambient temperature in $°C$
- $NOCT$ is the Nominal Operating Cell Temperature in $°C$

2.6.2 Efficiency Coefficients

For the efficiency coefficients, the single-diode model is considered:

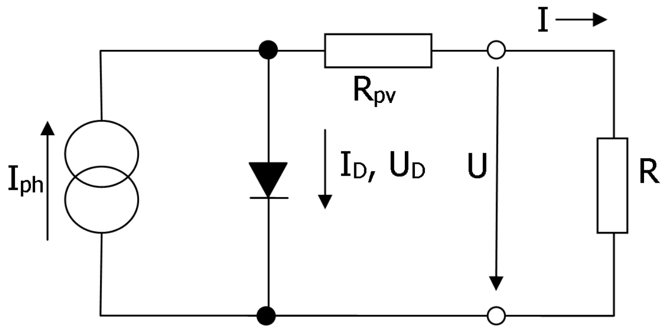

Figure 2.1: Solar Cell Model

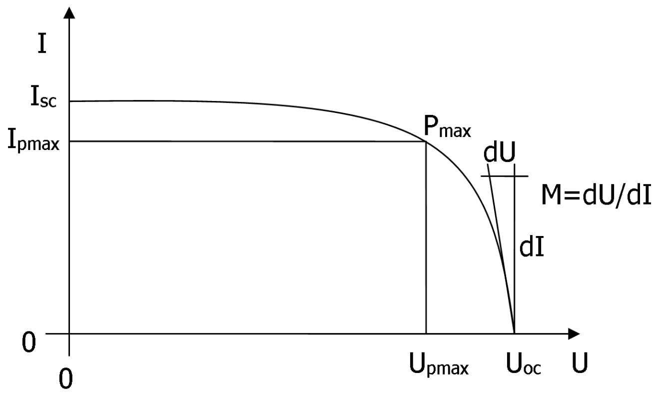

Figure 2.2: Solar Cell Curve

The efficiency coefficients are calculated as follows:

$$k_1 = \frac{U_{T0}}{U_{pmax0}} \tag{49}$$

$$k_2 = \frac{R_{pv} \cdot I_{pmax0}}{U_{pmax0}} \tag{50}$$

$$M = \frac{U_{oc}}{I_{sc}} \cdot \left(-5.411 \cdot \frac{I_{pmax} \cdot U_{pmax}}{I_{sc} \cdot U_{oc}} + 6.450 \cdot \frac{U_{pmax}}{U_{oc}} + 3.417 \cdot \frac{I_{pmax}}{I_{sc}} - 4.422 \right) \tag{51}$$

$$R_{pv} = -M \cdot \frac{I_{sc}}{I_{pmax}} + \frac{U_{pmax}}{I_{pmax}} \cdot \left(1 - \frac{I_{sc}}{I_{pmax}} \right) \tag{52}$$

$$U_T = -(M + R_{pv}) \cdot I_{sc} \tag{53}$$

$$U_{T0} = U_T \cdot \frac{T_r}{T_c} \tag{54}$$

$$I_{pmax0} = I_{pmax} \cdot \frac{E_{STD}}{E_{g,eff}} \tag{55}$$

$$U_{pmax0} = \frac{U_{pmax}}{1 + c_T \cdot 0.01 \cdot (T_c - T_r)} + U_{T0} \cdot ln\left(\frac{E_{STD}}{E_{g,eff}}\right) - I_{pmax} \cdot R_{pv} \cdot \left(\frac{E_{STD}}{E_{g,eff}} - 1\right) \tag{56}$$

Where:

- k_1 is first coefficient, unit-less
- k_2 is second coefficient, unit-less
- U_{pmax} is the rated voltage at maximum power point in V
- I_{pmax} is the rated current at maximum power point in A
- U_{oc} is the open circuit voltage in V
- I_{sc} is the short-circuit current in A
- U_T is the temperature voltage
- U_{T0} is the temperature voltage proportional to temperature
- U_{pmax0} is the voltage at maximum power point proportional to irradiance in V
- I_{pmax0} is the current at maximum power point proportional to irradiance in A
- M is the slope of the IV curve at $I = 0$
- R_{pv} is the photovoltaic resistance in Ohm
- $E_{g,eff}$ is the effective irradiance, in W/m^2. See Section 2.6.3 below.

2.6.3 Effective Irradiance

The effective irradiance is the irradiance measured at AM 1.5-conditions.

AM 1.5 applies, when for the solar altitude angle applies

$$sin(\gamma_s) = \frac{1}{AM} = \frac{1}{1.5} \tag{57}$$

Therefore, the effective irradiance is calculated as the global horizontal irradiance (as calculated in Section 2.4 with the following conditions:

$$\gamma_s = asin\left(\frac{1}{1.5}\right) \tag{58}$$

$$\omega = -acos\left(\frac{\left(\frac{1}{1.5}\right) - sin\phi \cdot sin\delta}{cos\phi \cdot cos\delta}\right) \tag{59}$$

These values will be used in equations 3 to 14 in order to calculate:

$$E_{g,eff} = E_{g,hor} \tag{60}$$

2.7 Required Input Parameters

The required parameters to calculate the active power setpoint of the solar system are shown in the following tables.

2.7.1 In Basic Data Page

The parameters in the Basic Data page are shown in Table 2.1.

Table 2.1: Input parameters in Basic Data Page (*ElmPvsys*)

Parameter	**Unit**	**Default Value**	**Description**	**Range**	**Symbol**
			General Tab		
typ_id			Type		
nnum		1	No.of Parallel Inverters		
npnum		1	No.of Panels per Inverter		num_{panels}
			System Configuration Tab		
cGPSLat	deg		Latitude		ϕ
cGPSLon	deg		Longitude		λ
timezone			Local Time Zone		λ_R
mount		0	Mounting System		
orient	deg	0	Orientation Angle		α
tilt	deg	30	Tilt Angle		β
inveff	%	95	Efficiency Factor		η_{inv}

2.7.2 In Load Flow Page

The parameters in the Load Flow page are shown in Table 2.2.

Table 2.2: Input parameters in Load Flow Page (*ElmPvsys*)

Parameter	Unit	Default	Description	Range	Symbol
Environment Factors Tab					
iopt_rad		1	Specified Components option		
iopt_glo		0	Global Irradiance option		
kt		0.6	Clearness Index	$0 \leq KT \leq 1$	KT
ghi	W/m^2	600	Global Horizontal Irradiance		$E_{g,hor}$
iopt_dir			Direct Irradiance option		
dhi	W/m^2	400	Direct Horizontal Irradiance		$E_{b,hor}$
dni	W/m^2	400	Direct Normal Irradiance		$E_{b,norm}$
iopt_dif			Diffuse Irradiance option		
Tamb	$°C$	25	Ambient Temperature		T_a
shfdir		0	Shadowing Factor (Direct)	$0 \leq S_{dir} \leq 1$	S_{dir}
shfdif		0	Shadowing Factor (Diffuse)	$0 \leq S_{diff} \leq 1$	S_{diff}
albedo		0.31	Albedo		ρ_g

2.7.3 In *TypPvpanel*

The parameters in the *TypPvpanel* dialog are shown in Table 2.3.

Table 2.3: Input parameters in Type (*TypPvpanel*)

Parameter	Unit	Default	Description	Range	Symbol
Ppk	W	500	Rated Power of the Panel		$P_{pk,panel}$
Umpp	V	80	Rated Voltage at MPP		U_{pmax}
Impp	A	6	Rated Current at MPP		I_{pmax}
Uoc	V	90	Open Circuit Voltage		U_{oc}
Isc	A	7	Short-Circuit Current		I_{sc}
material		0	Material		
iusetval		1	Use default values		
dcT	$\%/°C$	-0.4	Temperature coefficient	$-100 \leq \beta_c \leq 0$	β_c
dnoct	$°C$	45	Nominal Operating Cell Temperature		$NOCT$

2.7.4 In *SetTime*

The parameters in the object *SetTime* are shown in Table 2.4.

Table 2.4: Input parameters in Type (*TypPvpanel*)

Parameter	Unit	Default	Description	Range	Symbol
cTime			Local Time		t_{LMT}
dayofyear			Day of Year		J

3 References

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