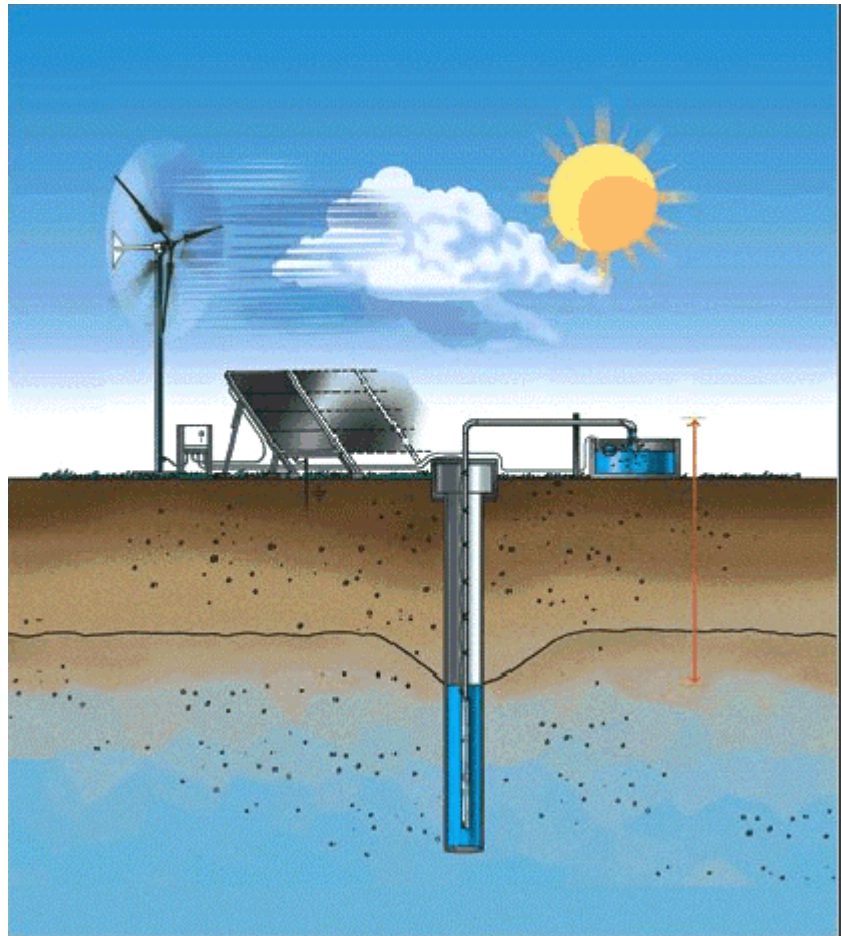

A Guide Using

SQ Flex Sizing in WinCAPS



Selection of Grundfos Renewable Energy Systems in WinCAPS 7.4

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Introduction

The sizing tool for renewable energy systems

The sizing tool for renewable-energy based water supply systems is a guide on how to size SQFlex Solar, SQFlex Wind and SQFlex Combi systems. Select the desired application type by clicking the 'Solar system', 'Wind system' or 'Combi system' button, depending on whether you want your SQFlex system to be powered by solar energy, wind energy or a combination of both.

The sizing tool allows you to size *'from water to system'* (you need a specific volume of water and want to size an appropriate SQFlex system) or *'from system to water'* (you have a specific SQFlex system in mind and want an estimate of the volume of water it can supply).

In short, the sizing calculation in the SQFlex sizing tool works in such a way that, based on the location on earth, solar and/or wind data are found.

Based on information about the installation conditions, of the wind turbine and/or solar modules and product data, - and cable losses - we calculate how much power is delivered to the pump. Based on pump characteristics, head and pipe losses, we calculate how much water is supplied by the pump.

All pump types are investigated. This is held against the requirements (water to system) and more panels are added (for solar and combi) if not enough water is supplied.

Pump curves:

The performance curves for the SQFlex pumps are based on the following guidelines:

All curves show mean values.

The curves must not be used as guarantee curves.

Typical deviation: +/-15%.

The measurements were made at a water temperature of 20°C.

The curves apply to a kinematic viscosity of 1 mm²/s (1 cSt). If the pump is used for liquids with a viscosity higher than that of water, this will reduce the head and increase the power consumption.

The performance curves are inclusive of inlet and valve losses at the actual speed.

Supply to pump: 120 VDC.

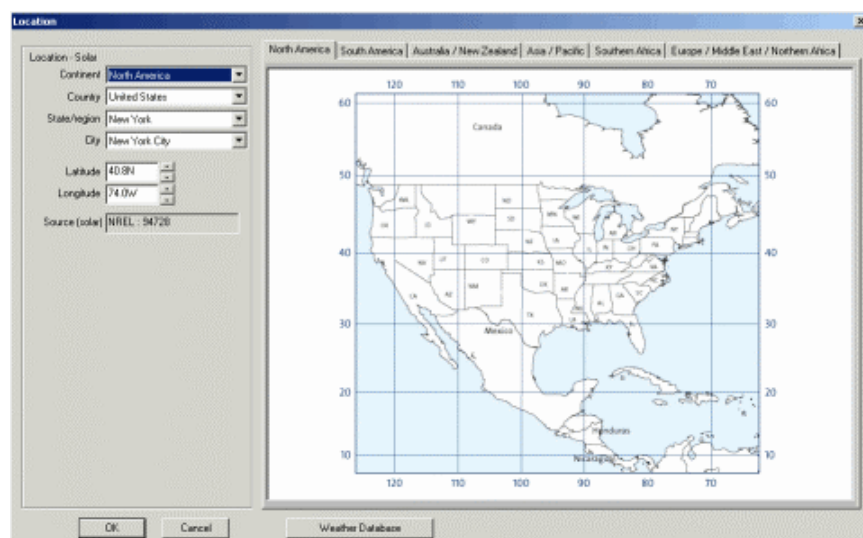
Selection of a Renewable Energy System

The General Section

Location

Data on solar radiation and wind speed are used in the sizing calculations to estimate the power available to the pump and thus the volume of water supplied. As solar radiation and wind speed depend on the installation location, input about the location are required in order to size an SQFlex system.

Solar data (*radiation and temperature*) for more than 2000 locations are included in the sizing tool solar database. The wind database includes global wind data measurements (*wind speeds and Weibull k factors* at 10 m height and standard terrain conditions). Based on interpolations, an estimate of wind data can be found for any location in the world. The average temperature and altitude used for wind calculations are taken from the solar database. For a wind location, different from any of the solar data locations, average temperature is set to 25 °C (77 °F) as default and altitude from the last selected solar data location is maintained.

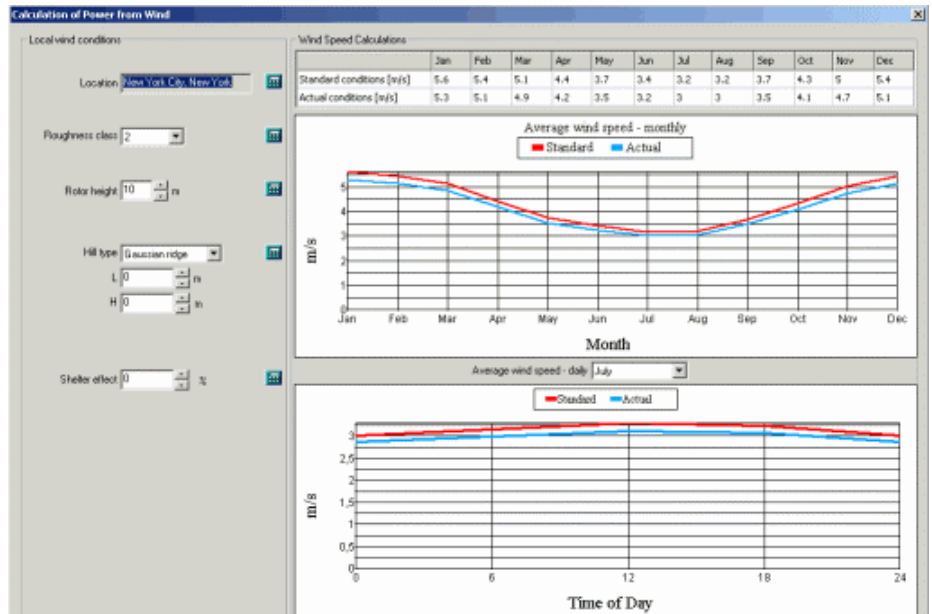


Click the calculator button next to 'Location' and, for solar and combi systems, select a solar data location, near the application site, via 'Continent', 'Country', 'State/region' and 'City'. If the database does not include solar data for the application site, enter a new set of solar data into the database via the "Weather database" button on the Location screen.

		Jan	Feb	Mar
Radiation horizontal	kWh/m ² day	1.9	2.7	3.8
Temperature	°C	-0.3	0.9	5.8
Temp. Variation	K	5.0	5.0	5.0
Avg. wind speed	m/s	5.6	5.4	5.1
Wind speed at 00:00	m/s	5.5	5.4	5.1
Wind speed at 06:00	m/s	5.7	5.5	5.3
Wind speed at 12:00	m/s	5.6	5.4	5.1
Wind speed at 18:00	m/s	5.6	5.5	5.1
k factor at 00:00		2.1	2.0	1.9
k factor at 06:00		2.1	2.0	1.9
k factor at 12:00		2.1	2.0	1.9
k factor at 18:00		2.1	2.0	1.9

Access to the weather database

For wind systems select the location, either by selecting among the cities existing for the solar database, or by simply entering the degrees of latitude and longitude. You can adjust altitude directly and temperature via the weather database to improve the calculation results.



Access to data on wind conditions

For combi systems wind data will be found for the same location as the solar weather station, unless you enter a different wind location by

selecting the 'Edit location – wind' checkbox. We recommend you do this if the wind turbine is not sited near the solar data location. Simply enter the degrees of longitude and latitude (and adjust altitude and temperature when required).

Water Volume (max)

The SQFlex system will be sized to meet the water volume requirement per day for a particular month (often the peak month during which the largest volume of water is required). Enter the water volume per day of the peak month.

If you size 'from system to water', turn the input field blank and, for solar and combi systems, enter value in the 'Number of solar modules' field instead.

Peak Month

Select the month related to your water volume requirement.

If you size 'from system to water', the peak month has no influence on the sizing.

Head

Enter the head. By head is meant the total dynamic water level: The difference in height between the (lowered) water level in the borehole and the water level in the tank/reservoir. If you want more accurate calculations of cable and friction losses, click the calculator button.

The screenshot shows a software dialog box titled "Calculation of Total Head and Cable losses". The dialog contains several input sections:

- Head:** Dynamic water level (input field) m, Static lift above ground (input field) m.
- Piping System:** Pipe Length (input field) 25 m, Pipe diameter (dropdown menu).
- Cables:** Three sets of inputs for wind, solar, and pump:
 - Wind: Cable length (input field) 15 m, Cable size (dropdown menu) Any (mm²), Cable loss (dropdown menu) 2 %.
 - Solar: Cable length (input field) 5 m, Cable size (dropdown menu) Any (mm²), Cable loss (dropdown menu) 2 %.
 - Pump: Cable length (input field) 25 m, Cable size (dropdown menu) Any (mm²), Cable loss (dropdown menu) 2 %.

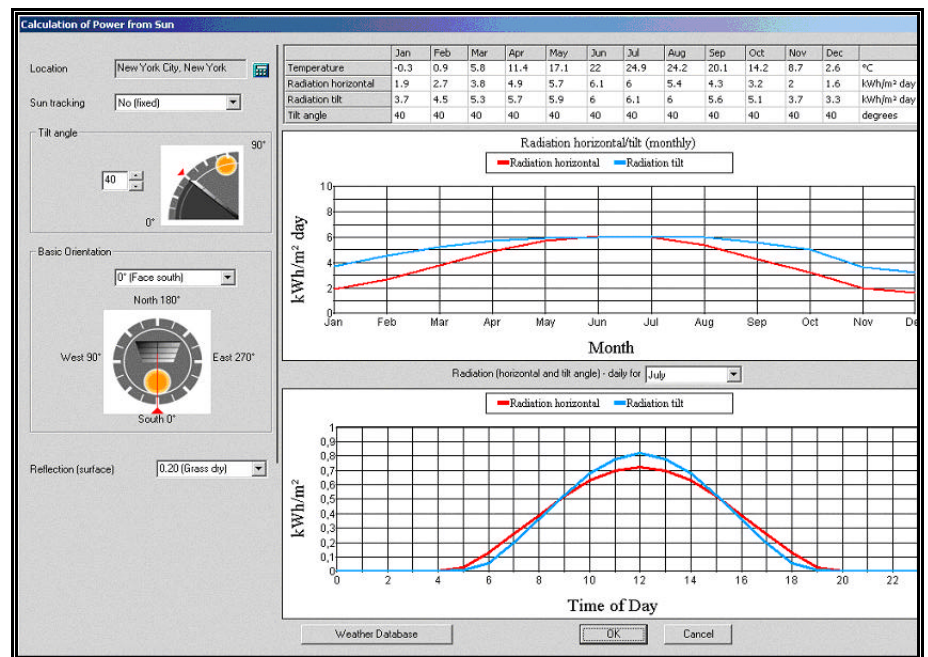
On the right side of the dialog is a diagram illustrating a renewable energy system. It shows a wind turbine, solar panels, and a borehole with a pump. A red arrow indicates the static lift from the ground level to the water level in the tank/reservoir. The borehole shows a lowered water level, and a blue arrow indicates the dynamic water level.

More detailed input about head and cable losses can be entered in the 'Calculation of Total Head and Cable losses' window

Sun tracking (Solar and Combi systems).

Select mounting of modules: Fixed or with either single (polar) axis or double axis (full) sun tracking. The sizing tool will automatically select a basic orientation of the solar modules facing directly south/north, a tilt angle equal to the latitude as well as a reflection (surface) of 0.2 (grass dry).

Via the calculator button, you can adjust the default settings and investigate how the adjustment affects the solar radiation available at the surface of a solar module. Irrelevant inputs will be removed or dimmed when you select tracking. If you have selected fixed mounting, you can adjust the tilt angles for individual months via the table, if required. You can also see the solar radiation variation through the day of a specific month. To investigate the database further and/or enter your own data, access the database by clicking the 'Weather database' button.



Input to "Calculation of Power from Sun"

Solar modules (Solar and Combi systems)

Select type of solar module. To enter new solar modules in the database or see the performance characteristics of the existing module(s), click the calculator button.

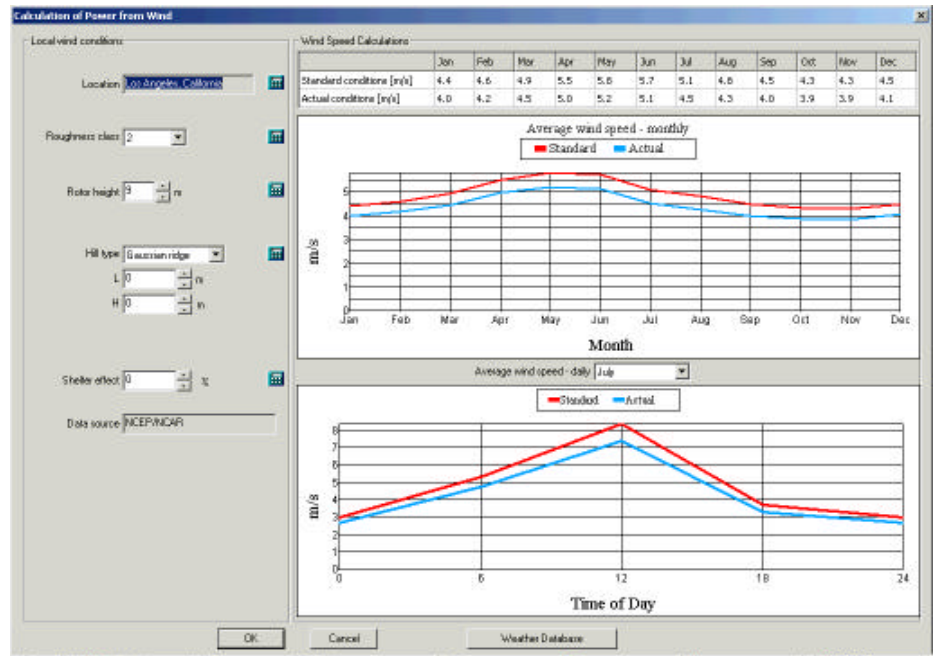
Number of solar modules

When you use the 'from water to system' approach, do not enter any value here. The sizing tool will suggest the required number of modules for you.

If you size 'from system to water', enter the required number of solar modules. The SQFlex pumps require a minimum of 120 W and 36 V. If the number of solar modules is too low to provide this you will receive an error message when you click 'Start sizing'. When activating 'Number of solar modules' another input field will occur: 'Number of solar modules in series'. Leave this input field blank unless you want a particular layout of the modules.

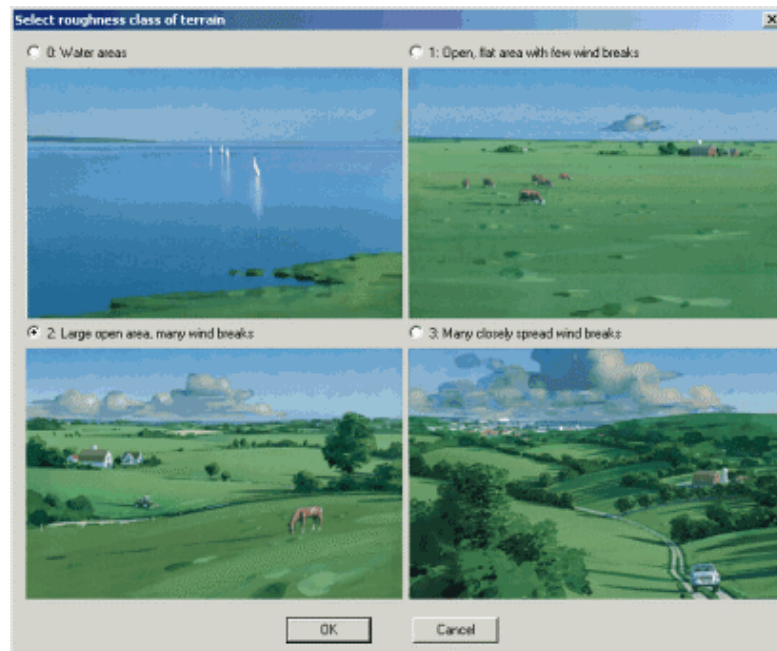
Roughness of terrain (Wind and Combi systems)

Click the calculator button (necessary), as details about the terrain in which the wind turbine is sited are important in order to estimate the actual wind speed at the wind turbine rotor. On the 'Calculation of Power from Wind' screen, make your inputs about the terrain roughness, rotor height, hill type and shelter effect.



Detailed information about the wind turbine terrain is entered in "Calculation of power from Wind"

The 10 metres standard terrain wind speed values available in the database are shown. You will also see how the actual terrain conditions adjust the database values to the actual wind speed. Moreover, you can see the wind speed variation through the day of any specific month. To investigate the database further and/or edit it, access the database by clicking the 'Weather database' button.



Selection of Roughness of Terrain

Wind turbine (Wind and Combi systems).

Select type of wind turbine.

Pump outlet

Select pump outlet (Rp or NPT). If you leave this blank, the program will include both types of pumps in the result grid.

Pre-select pump type.

You do not need to enter any value here, as the sizing tool automatically selects one or more appropriate pumps. If you prefer a specific pump type, select the pump by entering the name of the pump in the input field direct or by clicking the calculator button. If you click the calculator button, a number of pre-selected pumps will be displayed; the pumps have been pre-selected according to your head and water volume inputs.

The system configuration section

In order for the accessories to appear on the printouts and in the price calculation, select them via the 'System Configuration' folder. The inputs will not affect the sizing of the system.

Solar array support structure (Solar and Combi systems)

Grundfos offers support structures for the GF solar module. If you do not require any support structures, deselect them here.

Row closures and wire kits

To mount the solar array support structures you need row closures and wire kits. The sizing program will automatically calculate how many you need and show it in the results and printouts. If you do not want any row closures or wire kits shown in the results deselect them here.

Box

Select control unit/switch box.

Level switch

If you require a level switch in your system, select it here. The use of level switch requires a CU 200 control unit.

The User-defined Day section

The results calculated on the basis of average values for solar radiation and wind speed may show that no water will be supplied during a specific (winter) month. The 'User-defined Day' function enables you to show your customer how much water the sized system will provide on a particular day of the specified month with a certain solar radiation and/or wind speed (higher than the average values). Activate the 'User-defined Day' function by selecting the check box in the 'User-defined Day' folder. The inputs required for the calculation are solar radiation, month, temperatures and/or wind speed.

Solar radiation (Solar and Combi systems)

Enter the daily solar radiation value (on a horizontal surface) for the user-defined day. The solar radiation on the solar module surface is calculated on basis of input about sun tracking, tilt angle, basic orientation and reflection (surface) in the General section.

Month (Solar and Combi systems)

Select the month concerned. (When you do so, the number of sun hours and the sun's movement pattern will automatically be found in the calculations).

Temperature (Solar and Combi systems)

Enter the average daily temperature for the user-defined day at the location. The default value is taken from the database for the selected location and month of the user-defined day.

Temperature variation (Solar and Combi systems)

Enter the temperature variation (the average number of degrees between the average temperature and high or low temperature.). If you have a maximum value for the temperature you can take the max. temperature and subtract it by the average temperature.

Wind speed (Wind and Combi systems)

Enter the average (actual) wind speed value at the height of the rotor, you want for the user-defined day. (The entered value will not be adjusted for roughness, hill and shelter effects.)

Results and printouts

Start sizing

You have now finished entering the data required in order to size the system. Click the 'Start sizing' button to initiate the sizing calculations.

Result grid

After a few seconds, the sizing tool will display one or more appropriate SQFlex systems in the field at the bottom of the screen. Systems with the fewest solar modules (lowest price) will head the result list. Systems with the same amount of solar modules (and wind systems) will be ordered with the system supplying most water first. The selected system is indicated by grey. Select another system by clicking on the system line.

You can check whether you get the required water volume for all months by checking the water supply for January, April, July, October and the user-defined day, if it has been activated. If you do not get the required water volume all year round, increase the 'water volume (max)' value until you get the required volume of water all year. Alternatively, you can change the (peak) month.

Product details windows

More detailed information about the products of the SQFlex system and the sizing results is available in the 'Product details windows'. Click on a highlighted (blue) product number. Depending on which product number you have clicked on the 'Product picture', 'Dimensional Drawing', and 'Wiring Diagram' of the product details windows will be concerning pump, solar modules, or wind turbine. If you want to change this you simply click on another (blue) product number in the result grid at the bottom of the screen.

Print

You can print your selection of printouts via the print icon at the bottom of the screen, or via 'File' at the top of the screen.

The product details windows and the printouts include a graph showing water production daily for a particular month. Select month via the windows appearing when clicking on the 'Sun tracking' or 'Roughness of terrain' calculator buttons. Default is July/ January for the Northern/ Southern hemisphere.

Templates

Save as/ Open

Often several of the inputs will be similar for you, e.g. location may be similar for your projects. WinCAPS does not save your last entered information automatically but you can create your own template(s) via the 'Save as' button with the inputs you want as default. Via the 'Open' button you can then later access your template(s) and only enter the inputs that differ from project to project.

The Databases

User-defined database

Part of the database is the 'user-defined database'. It contains the weather data and/or solar module data entered by you in the sizing tool. You can hand over your 'user-defined database' to another WinCAPS user in this way:

- Find your ' GPIUser.mdb ' file via your Explorer and copy it. Send this file to the other WinCAPS user and advice him to:
- Install his WinCAPS CD
- Start up WinCAPS and close it again.
- Via Windows Explorer find the existing (empty) 'GPIUser.mdb' file on the computer.
- Copy the 'GPIUser.mdb' file sent by you and paste it in the same folder as the existing 'GPIUser.mdb' file. Overwrite the existing file.

This way the other WinCAPS user will have access to the same user-defined solar modules and weather data as you do.

Weather database

You can access the weather database via the windows appearing when clicking on the calculator button for 'Location', 'Sun tracking' or 'Roughness of terrain'. Click on the 'Weather Database' button.

The weather database includes, for more than 2000 solar weather station locations, solar data (radiation horizontal and average temperature) and altitude data. You can investigate these locations by the selection fields: 'Continent', 'Country', 'State/Region', and 'City'. Outside USA the average temperature is set to 25 °C (77 °F) as default, and temperature variation, which is also used in the solar calculations, is for all locations set to a default value of 5 °C (5 °K) for each month. As the performance of the solar module and wind turbine depends on the temperature you can increase the exactness of the calculations by entering more exact temperature data in the database for relevant locations.

The database also includes more than 18.000 wind data measurements (wind speeds and Weibull k-factors). The database wind speed and k factor values are for 10 m height and a standard roughness of 5 cm. A k-factor is a Weibull shape parameter. It tells something about the distribution of the wind. If the k factor is relatively high the wind will be relatively unpredictable (wide range of wind speeds). If the k factor is relatively low the wind will be relatively predictable (narrow range of wind speeds).

Based on interpolations between the database values an estimate of wind data can be found for any location (latitude/ longitude values) in the world. To investigate wind data for a location, different from any of the solar weather station locations, select the required latitude and longitude values in 'Location' and enter the weather database. The average temperature and altitude, which are also used in the wind calculations, is here as default set to respectively 25 °C (77 °F) and the altitude given for the last selected solar weather station location.

Via the 'New' and 'Copy' buttons you can enter your own set of solar and/or wind data in the database. (Enter wind speed and k factor values for 10 m height and a standard roughness of 5 cm at 0, 6, 12, 18 hours local time.)

If you adjust the latitude or longitude after having clicked 'New' or 'Copy' you can update the wind data for the new latitude and longitude values by clicking 'Update wind data'. Dataset entered by you can also be edited and deleted by clicking on the 'Edit' and 'Delete' buttons. Your own set of weather data will be saved when updating WinCAPS.

Solar modules (the database)

The solar module database is accessed via the solar modules calculator button. Here you can enter new modules and/or investigate performance parameters of the existing solar modules. Only crystalline modules can be entered. As for weather data your solar module data will be saved when updating WinCAPS.

The Solar Module dialog allows for new data entry

An example of data for a crystalline module is here shown for the BP Solar SX-120 module. The parameters are explained in the 'Solar modules' window in the SQFlex sizing program.

Pmax: 120 Wp
 Vmp: 33.7 V
 Imp: 3.56 A
 Voc: 42.1 V
 Isc: 3.87
 μ Voc: - 0.16 V/°C
 μ Isc: 0.00065 A/°C (0.065 %/°C)
 Ns: 72
 ACELL: 130
 Rsh: 3000 Ohm
 NOCT: 47 °C (117 °F)
 ITNOCT: 0.8 kW/m²
 Tcref: 25 °C (77 °F)
 Icref: 1 kW/m²

Print Simplified Sizing Tables

Simplified paper-based sizing tables for solar and wind systems can be printed via the sizing tool. Click on the 'Sizing table (solar)' and/or 'Sizing table (wind)'.

How the calculation model works

General

The calculation program utilised for sizing SQFlex systems consist of a range of calculation procedures using database data and input from the user interface to size an SQFlex system and give a water supply estimate. Here you find a brief description of how the SQFlex sizing tool sizes a system.

The Weather Database (Solar)

The solar database contains data, for an average day in each month, for solar radiation on a horizontal surface (kWh/m²), average temperature and temperature variation. More than 2000 locations are included.

The SQFlex weather database includes solar data from the NREL database (for United States of America) and from the U Lowell database created by the University of Lowell (for the rest of the world). Besides this you can enter your own solar data.

The U Lowell database does not contain information about temperature (25 °C (77 °F) is default), and for both databases the temperature variation is set to a default value of 5 °K (5 °C) for each month. As the performance of the solar module and wind turbine depends on the temperature you can increase the exactness of the calculations by entering more exact temperature data in the database for relevant locations.

More information about the databases can be found on the internet:

<http://www.eng.uml.edu/Dept/Energy/>

<http://www.nrel.gov/>

<http://rredc.nrel.gov/solar/>

The solar energy calculation

To calculate the solar energy available at the (tilted) solar module surface we use the model described in the book, '**Solar Engineering and Thermal Processes**' by John A. Duffie (ISBN 0-471-51056-4). The calculation requires input about solar radiation on a horizontal surface (in kWh/m²day) taken

from the weather database, and user or default input about the installation of the solar module (tilt angle, basic orientation (azimuth angle), tracking and reflection of the surrounding ground).

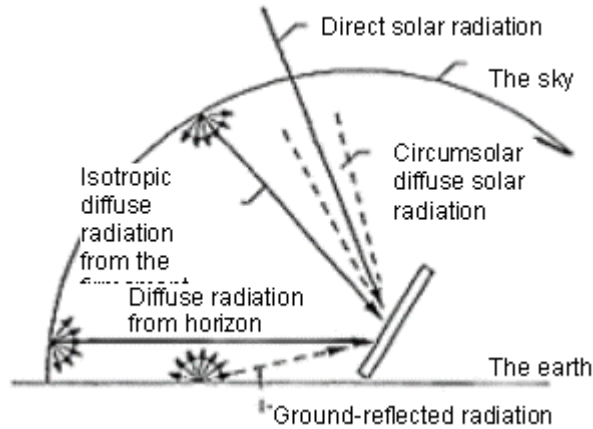


Figure 1: The three instantaneous energy components

Taking the movement pattern of the sun, as well as of the solar module (sun tracking), into account the total instantaneous energy on the tilted surface for every hour of the day (in kW/m²) is calculated. The so-called KT method (Liu and Jordan and modified by Erbs et al) is used to transform the total instantaneous energy on the horizontal surface to the instantaneous energy on a tilted surface. The daily energy is split up in three instantaneous energy components one for instantaneous beam energy one for instantaneous diffuse energy and one for instantaneous reflected energy. After the calculation to the tilted surface these three instantaneous energy components are added to a total instantaneous energy (figure 1 and 2).

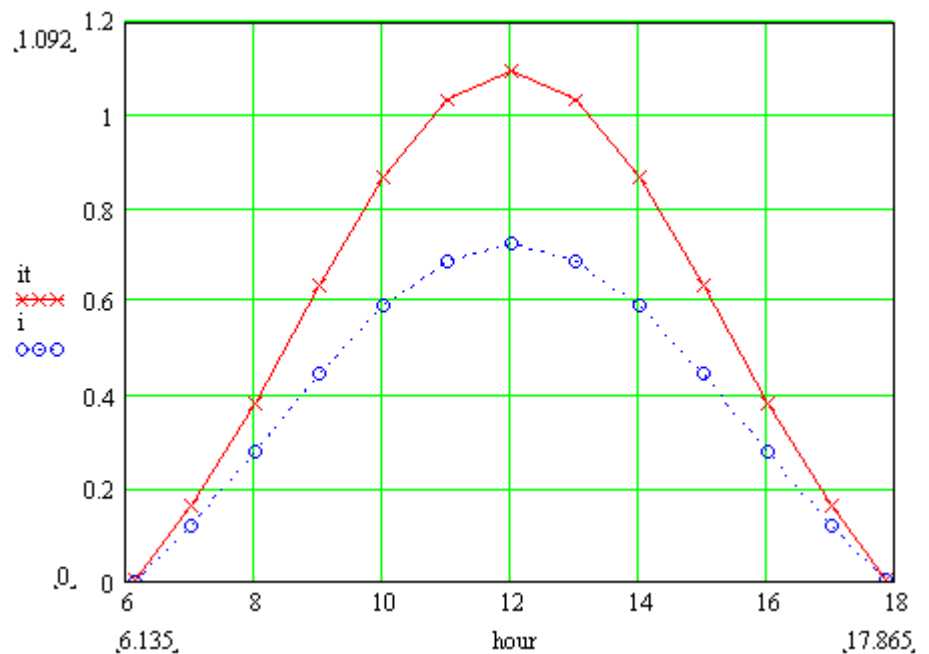


Figure 2: Instantaneous energy on horizontal and tilted surface.

The Solar Module Database

The solar module database includes parameters that characterise respectively performance of a solar module and the test conditions.

You can add solar modules to the database, but only crystalline modules, as no standard algorithm exists to describe amorphous modules.

An example of data for a crystalline module is here shown for the BP Solar SX-120 module. The parameters are explained in the 'Solar modules' window in the SQFlex sizing program.

Pmax: 120 Wp

Vmp: 33.7 V

Imp: 3.56 A

Voc: 42.1 V

Isc: 3.87

μ Voc: - 0.16 V/°C

μ Isc: 0.0025 A/°C (0.065 %/°C)

Ns: 72

ACELL: 130

Rsh: 1500 Ohm

NOCT: 47 °C (117 °F)

ITNOCT: 0.8 kW/m²

Tcref: 25 °C (77 °F)

Itref: 1 kW/m²

Power produced by a solar module - calculation

An IV (current, voltage) curve is calculated for every hour (of an average day for each month) for the solar module (figure 3). This calculation requires input about instantaneous energy on the solar module surface (from the 'Solar energy on a solar module surface' calculation), solar module parameters from the solar module database, and the solar cell temperature.

The solar cell temperature is a function of instantaneous energy on the solar module surface, average temperature and temperature variation (taken from the weather database), and material parameters for the solar modules (taken from the solar module database).

The IV curve calculation model for crystalline modules is based on the model described in the book, Solar Engineering and Thermal Processes by John A. Duffie. ISBN 0-471-51056-4.

The IV curve calculation model, developed for the amorphous solar module in particular, also follows the overall approach described above, but includes some curve fittings.

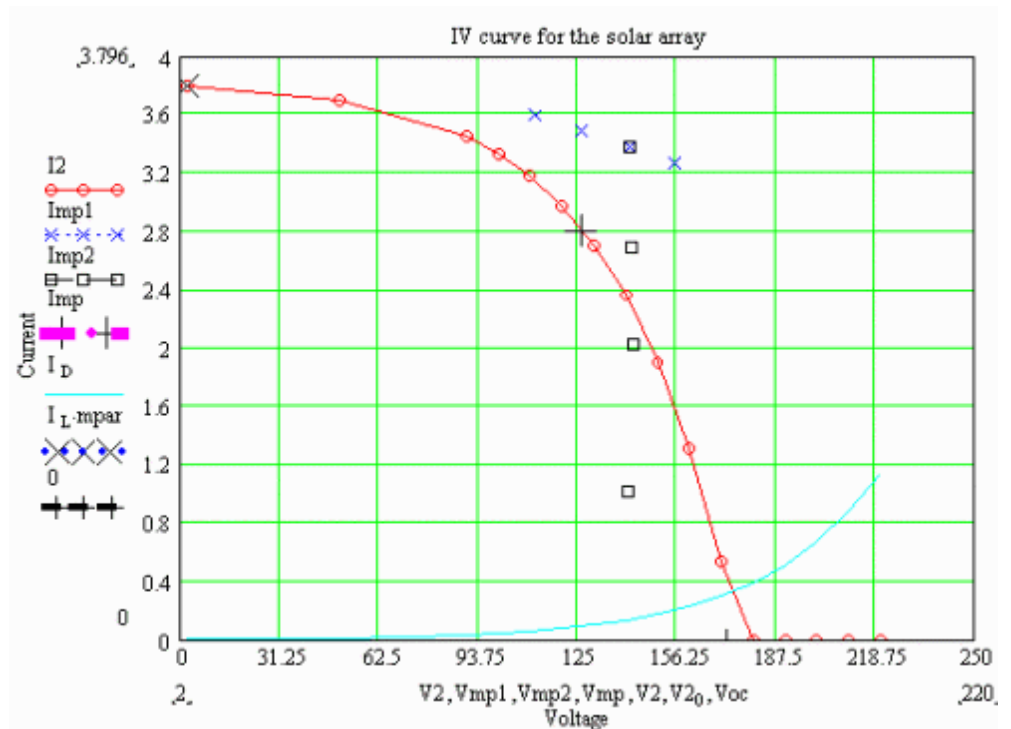


Figure 3: Solar module IV curve

The Weather database, wind

The wind database contains data, for 0, 6, 12, 18 UTC (Coordinated universal time) at an average day of each month, about the mean wind speed and shape parameters, k , of the Weibull distribution.

The wind speed and k factor values are for 10 m height above ground and a standard roughness of 5 cm. The k factor tells something about the distribution of the wind. If the k factor is relatively high the wind will be relatively unpredictable (wide range of wind speeds). If the k factor is relatively low the wind will be relatively predictable (narrow range of wind speeds).

The database contains global wind data for 192 x 94 grid points (a grid point for every 1.9 degree longitude and latitude). By a spatial interpolation and estimate of the wind speeds and k factors are found for any location (figure 4). It should though be mentioned that in areas with high mountains (like the Andes) the data are particularly uncertain.

The wind data are adjusted from UTC time to local time, by a time of day interpolation, before they are shown in the weather database in the SQFlex sizing tool. You can enter your own wind speed and k factor data in the database (at 0, 6, 12, 18 hours local time for each month). Wind data from a nearby weather station is likely to be more accurate than the data found in the wind database.

The wind data are extracted from the NCAR/NCEP (National Centers for Environmental Prediction and National Center for Atmospheric Research in the United States of America) global reanalysis data set covering the period 1948-2000.

Link: www.cdc.noaa.gov (NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado, USA)

The average temperature and altitude values, which are used in the wind calculations, exist in the Weather database for the solar weather station locations. For a location, different from any of the solar weather station locations, a default value is set to respectively 25 °C (77 °F) and the altitude given for the last selected solar weather station location.

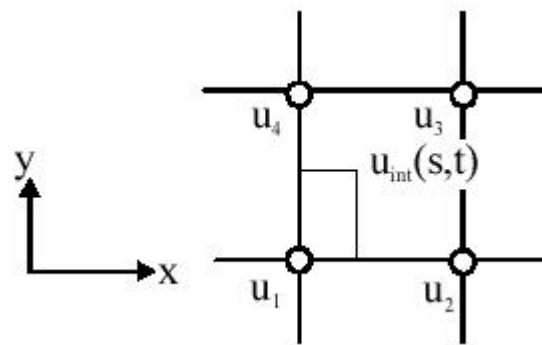


Figure 4 :Data for any location ($U_{int}(s,t)$) is found by spatial interpolation between data for four surrounding grid points (u_1, u_2, u_3 and u_4).

Wind energy at the wind turbine rotor – calculation

The local wind speed is influenced by surface roughness, shelter effects (due to obstacles) and terrain-induced speed up (due to hill effect). The calculation model adjusting for this influence is a simplified version of the Risø Wind Atlas Method, (original works: Troen and Petersen, 1989; Jensen et al., 1984). The simplification involves that directional information about the wind and changes in roughness class through the year are left out, and the speed-up and shelter effect models are crude. We have made this simplification to decrease the complexity of required user input.

Input about average temperature and altitude (taken from the solar data base, default values, or user input) is used to calculate the air density, which influence the power of the wind at a certain wind speed. The higher altitude and temperature the lower is the air density and thereby power of wind.

The Weibull distribution k factor is used in calculation of the distribution of the wind over six hours for the four time intervals between 0, 6, 12, and 18 hours. The wind distribution indicates the likelihood of a wind speed of respectively 1 m/s, 2 m/s, etc. This information is important because a wind distribution where there for example is 100% likelihood of a 5 m/s wind speed (relatively low k factor) involves less wind power than a wind distribution where there is 50% likelihood of a 2 m/s wind speed and 50 % likelihood of a 8 m/s wind speed (relatively high k factor). The reason is that the power of the wind is very non-linear. In both situations the mean wind speed is 5 m/s, but the wind power at 8 m/s is more than four times

the wind power at 2 m/s as would be the case if the power of the wind was linear.

The wind turbine database

The wind turbine is defined in the database with a reference rotor power as a function of an RPM curve at a given wind speed. The generator of the wind turbine is defined by four performance parameters.

Power produced by a wind turbine - calculation

The output to the shaft, that runs the generator of the wind turbine, is calculated from the RPM curve taken from the wind turbine database. The RPM curve is calculated according to input about the actual wind speed from the 'wind energy at the wind turbine rotor calculation'.

The wind turbine will automatically limit the speed of the rotor at very high wind speeds. The calculations are adjusted for this characteristic.

The generator is modelled with a simple standard DC generator model and together with the four performance parameters of the generator found in the wind turbine database the model can generate an IV (current, voltage) curve as a function of the shaft speed (RPM).

Power available to the pump - calculation

From the calculations described above we know how much power the solar module and/or wind turbine produce.

For solar and wind (single source) systems the voltage drop in the cables are calculated and the result is checked for overload of current or power to the pump. If the pump will be overloaded the voltage will be adjusted to the maximum load. If the power from the solar module or the wind generator is under the max overload values, then the voltage will be adjusted to give the max power to the pump (max power point tracking is a feature of the motor controller in the pump).

For combi systems the IV curve from the solar module will be added to the IV curve from the wind generator after reduction of voltage equal to the voltage drop in the cables connecting the source and the switch box. After reduction of voltage equal to the voltage drop in the cable, connecting the switch box and the pump, the electrical output will be checked for overload of current or power to the pump. If the pump will be overloaded the voltage will be adjusted to the maximum load. If the power from the solar module and the wind generator is under the max overload values, then the voltage will be adjusted to give the maximum power to the pump.

Pump database

The SQFlex pumps are defined with polynomials from which it can be calculated how much water will be produced at a certain power input and head (QP curves).

Water volume supplied by the pump - calculation

The power available to the pump (adjusted for cable loss and overload) combined with the QP curve at the given head allows calculation of how much water is produced by the SQFlex system.

Optimising routine

To select the appropriate SQFlex systems to show in the result grid of the sizing tool the pumps are first pre-selected according to user input about required water volume and head. The pumps unable to supply the required water volume at the given head even at constant max power input will be deselected.

Then it is calculated for solar systems, for each remaining pump, whether the required water volume can be supplied by use of a minimum number of solar modules. The minimum number of modules depends on how many modules are required to provide the minimum voltage and power required by the SQFlex pumps. If this system does not supply enough water the number of modules is increased until the required water volume is reached (or the max limit of solar modules is reached)

For wind systems it is calculated for each remaining pump whether the required water volume can be supplied by use of one wind turbine. If not the pump is deselected.

For combi systems it is calculated, for each remaining pump, whether the required water volume can be supplied by use of a wind turbine and a minimum number of solar modules. If this system does not supply enough water the number of modules is increased until the required water volume is reached (or the max limit of solar modules is reached)

In the result grid of the sizing tool SQFlex systems with the lowest number of solar modules (lowest price) will head the result list. Systems with the same amount of solar modules (and wind systems) will be ordered with the system supplying most water first

Important Internet Information

Important Links

The following links supply more information on this subject

<http://www.eng.uml.edu/Dept/Energy/>

<http://www.nrel.gov/>

<http://rredc.nrel.gov/solar/>

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