Sunsafe-II
System Documentation

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CAUTION – THIS IS A WORK-IN-PROGRESS. ANYTHING IN THIS DOCUMENT MAY CHANGE BEFORE RELEASE!

1 Introduction

SunSafe-II is a dedicated software system for configuring standalone Solar Home Systems. (In this, it is a subset of Evonet Energy Ltd's more general eSafr compatibility assessment system.)

It assumes that the objective is to assemble an optimally-sized Solar Home System, for a particular range of load appliances. The system will comprise:

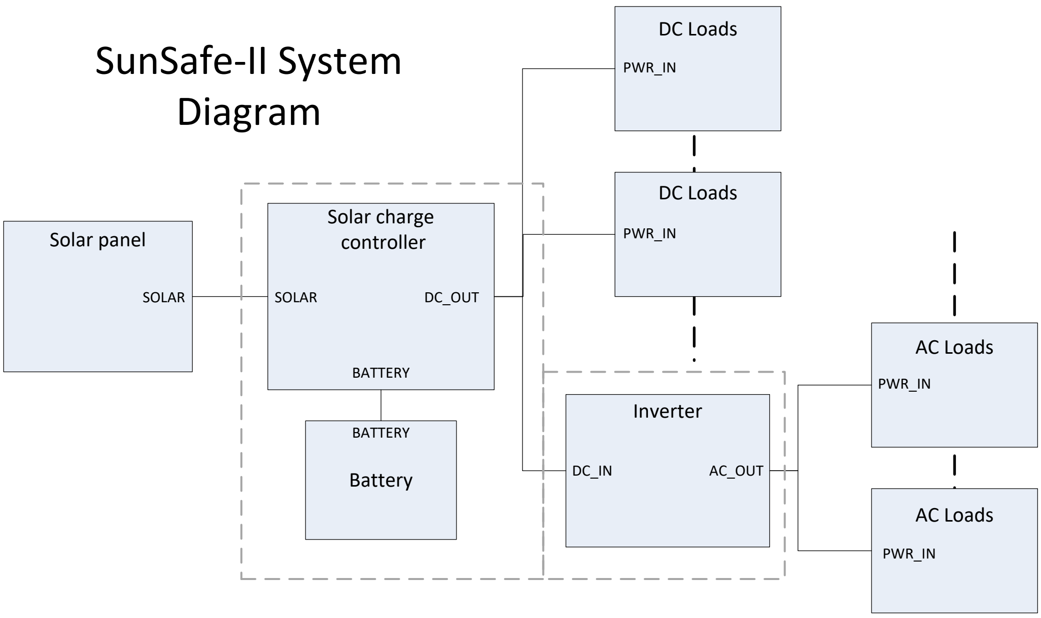

Figure 1 SunSafe-II System Diagram

A partial system may be defined, in which case a list of what's missing will be produced. A partial system can be saved, for additional components to be added later.

There are two phases to the operation of the system.

In **Phase 1 – Label Creation**, a QR-code label is created for an item of electrical equipment, containing as much information as is available on the electrical and connector characteristics of the equipment. This is printed, and applied to the equipment in question.

In normal circumstances, there will be one QR-code label per item of equipment, containing all the relevant information about the equipment.

The amount of information available to put in the label will vary – with no product documentation of any kind and no test equipment, the best that can be done is to record what is printed on the rating plate on the equipment, and to attempt to identify the provided connector(s). With excellent technical documentation and a report from a test house, much, much more will be known, and a much more detailed (and consequently larger) label may be produced.

It may be that absolutely nothing is known about the component – the customer may say, "I already have a (whatever) that I want to be part of the system". In this case, a card is provided containing a selection of QR-codes for typical items of this type of equipment. However, users must understand that relying on these 'generic' QR-codes will be MUCH less satisfactory, and produce a very uncertain result.

Clearly, the more specific information it is possible to incorporate in the label, the less likely it will be that some unusual form of incompatibility goes unnoticed and subsequently causes the user a problem.

In **Phase 2 – Compatibility Assessment**, the labels on possible components of a solar home system are read using a smartphone with a camera, and for each interconnection, an electrical and connector compatibility report is given. When the labels for all the components for a complete system have been read, an energy assessment of the whole system is given.

It is intended that the skill level needed for Phase 2 should be low – no understanding of volts, amps etc should be required. However, the more skill that can be applied to Phase 1, the more comprehensive and thorough the compatibility checking can be.

2 The Parameters on the Label

The first parameters on the label are:

- The text string "SunSafe-II" to identify that this QR-code has been created as part of the SunSafe-II system,
- A text string identifying the equipment. This should be kept as short as possible (to keep the QR-code small), whilst still uniquely identifying the equipment. This is to ensure that the correct label is affixed to the correct product. A product or stock code could be used.

These first two text strings are printed in human-readable text above the QR-code, and also incorporated into the QR-code itself.

2.1 Equipment types

The next parameter identifies which of the building blocks in Figure 1is being described. The choices are:

- **Power_source** – perhaps a grid connection,
- **Intermittent_power_source** – a power source which will require to be sustained by a battery,
- **Solar_panel,**

- **Solar_charge_controller** – a product connecting a solar panel to a battery in such a way as to extract as much solar power as possible, whilst not overcharging the battery. This product may also incorporate other components of the system.
- **Battery,**
- **Inverter,**
- **AC_load** – any mains-voltage AC load, which must be powered by an inverter,
- **DC_load** – any low-voltage DC-powered appliance.

The format for further data input is a function of the type of port.

2.2 Ports

To form part of an electrical system, a component must be connected to other components. These connections are known in the SunSafe-II system as 'ports'. A port will always comprise at least two electrical contacts, perhaps with additional contacts for carrying signalling information.

A solar panel will have just one port – the output port where the generated electricity is offered. A battery will normally have just one (bidirectional) port. A solar charge controller will have ports to connect the solar panel, a battery port (if the battery isn't integral) and a number of output ports, perhaps at a range of voltages.

In SunSafe-II, the port names are pre-defined:

Component	Port Function	Predefined port name
(Intermittent) Power Source	Power output	OUT
Solar Panel	Power output	SOLAR
Solar Charge Controller[+]	Solar input Other power input Battery connection AC output(s) DC output(s)	SOLAR PWR_IN BATTERY AC_OUT DC_OUT
Battery	Battery power terminals	BATTERY
Inverter	DC input AC output	DC_IN AC_OUT
AC/DC load	Power input	PWR_IN

[+] If the Solar Charge Controller contains other components, some of these ports may be absent – for example an integral battery will usually mean that there is no BATTERY port.

Where several output ports are connected in parallel (that is to say, they share a voltage and a current limit), this is considered as a single port, with a "number_of_ways" greater than one. This is the case even when connectors may be switched individually – the essential feature is that when turned on, they share the same terminal voltage, and the current limit applies to the TOTAL current through all the ways.

2.3 Linking equipment together

The software will generally automatically know which ports connect to which:

Connect…	…with
Solar Panel/SOLAR	Solar Charge Controller/SOLAR
(Intermittent) Power Source/OUT	Solar Charge Controller/PWR_IN
Solar charge controller/BATTERY	Battery/BATTERY
Solar charge controller/DC_OUTn*	Inverter/DC_IN
Solar charge controller/DC_OUTn*	DC Load/PWR_IN
Inverter/AC_OUT	AC Load/PWR_IN

* Where equipment has several ports of a particular kind, single digits may be added to each port name to make it unique. If it is not obvious, it may be necessary to state which output port a load is to be connected to.)

Note that although technically possible, and apparently functional in the short term, connections between solar panels and batteries without an intervening charge controller, and connections between a battery and loads or inverters without intervening electronics, are considered bad practice, and not supported by this software.

2.4 Entering Data – Solar Panel

2.5 Entering Data – Solar Charge Controller

2.5.1 SOLAR - Solar input

2.5.2 PWR_IN

2.5.3 BATTERY

2.5.4 DC_OUT

2.6 Entering Data – Battery

2.7 Entering Data – Inverter

2.8 Entering Data – DC Load

2.9 Entering Data – AC Load

3 Entering Energy Information

There are a lot of unknowns in estimating energy generated and required. Any determination is likely to be quite approximate. It is recommended that the total energy generated should exceed the total energy requirement by a factor of two (more if more loads are anticipated), and likewise the night-time energy storage requirement.

The duration of use of each appliance is critical to estimating energy consumption, but this is generally not known in advance of the system being in operation.

The entered energy information is also used to check instantaneous power limitations.

3.1 Energy Transfer Efficiency

Devices that have more than one port or a bidirectional port will have an efficiency figure which expresses the amount of energy lost as heat within the equipment in the process of moving the energy from the input port to the output port. Between each pair of ports, this figure may not be known (it is rarely on the rating plate though it may be in the printed Technical Specification), in which case a figure of 85% efficiency (ie 15% lost as heat) will be assumed.

In the case of a battery with a single bi-directional port, this will be the round-trip efficiency of the battery (the ratio of the energy returned when discharging from fully-charged to as flat as is permitted to the amount of energy required to charge from flat to fully-charged).

3.2 Energy generated

This figure is the number of watt-hours to be expected from a renewable or non-renewable energy source in a 24-hour period. Where this figure is seasonally-dependent, the lowest figure should be used. ***For solar panels, local information will be required.***

3.3 Energy Consumed

The energy consumed by a domestic electrical appliance is highly dependent on the way it is used. In sizing a Solar Home System, we cannot know this (we may ask the intending user, but the answer may not be useful. The following methodology is proposed:

3.3.1 Continuously-powered appliances

For a product that is powered 24/7, for example a fridge or freezer, the energy consumption is deemed to be:

$$Daily\ energy\ E_{day} = (Rating\ plate\ volts) * (Rating\ plate\ amps) * x * 24 \quad (watt - hours)$$

where $\boldsymbol{x}$ is some value less than one. ***This value will need to be determined from what is considered best practice in the off-grid industry.*** This gives the energy consumed in a day by the appliance, but energy used at night has first to be stored in the battery, so half the energy needs to have round-trip losses added. If the round trip efficiency is 85%, this gives:

$$Additional\ total\ energy\ E_{add} = E_{day} * \frac{24}{12 * (1 + 0.85)}$$

..and

$$Additional\ stored\ energy\ E_{store\_add} = E_{day} * \frac{12}{(24 * 0.85)}$$

3.3.2 Appliances at user discretion

This general method may also be used for appliances controlled at user discretion – but note that $\boldsymbol{x}$ is likely to be ***a different value for different types of appliance***. For a television or radio, it is legitimate to ask the prospective user how many hours during the day and how many hours at night they expect it to be on (they should be warned that if they leave it on much longer, it's likely the battery will run out before the morning). In the absence of this information, it is reasonable to assume that a radio will be on for 7 hours/day and 5 hours/night and a television for 5 hours/night.

The general formulae are:

Hourly energy consumption: $E_{hour} = (Rating\ plate\ volts) * (Rating\ plate\ amps) * x\ (wh)$

Additional stored energy: $E_{store\_add} = E_{hour} * (night\_hours/0.85)$

..and additional total energy: $E_{add} = E_{hour} * \left(\frac{night_{hours}}{0.85}\right) + day\_hours$

This method may also be used for lights (assume 5 hours/night, zero day hours if no better information is available).

3.3.3 Handheld appliances

This group includes any appliance that needs constant supervision while in use – for example a food blender or mixer, a steam iron or a toaster. Whilst these appliances may use considerable amounts of power, they are likely to only be used for relatively short periods of time, and there will be days when they aren't used at all.

The user should be asked how long they would have each appliance running during the day and the night. If the appliance is only used for a minute or two at a time (like a blender), it will be important to ask the user whether they would every use it several times in a day, and multiply the total duration accordingly.

These appliances can use the same formulae as above (though you might want to make the daytime and night-time hours expressed in minutes) …BUT when all the energy and stored energy requirements of all the handheld devices have been calculated, only the two MOST ENERGY-HUNGRY appliances will be added to the total energy requirement and the two most night-time energy-hungry devices added to the stored energy requirement. This is exploiting the assumption that on any given day, only two hand-held devices will be used.