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Elios4you: A Personal Guide

Solar Photovoltaic (PV) technology provides free electricity. In a simple installation this electricity will partly or fully power the household, and any excess solar PV power will be exported to the Grid. Some Grids pay good economic returns for exported electricity, but most do not or will soon not do so. In that case solar PV only makes economic sense with a smart installation that maximises the use of the solar electricity. There are a number of suppliers of suitable smart technology, including the Italian company 4-noks SRL, who make the *Elios4you* smart controller [1], *Power Reducer* diverter [2], and ZigBee *Smartsockets* [3] used in the author's installation. These are impressive products that can be made better, and as yet their documentation is limited, hence this guide, which also proposes firmware-only solutions to:

(1) control more Smartsockets
(2) add smart environment control
(3) combat Legionaires disease
(4) reduce hot water temperature
(5) avoid the diverter ever being idle
(6) consume <u>all</u> excess solar energy

All great marketing features that would save costs and the environment.

Figs.2-3 show the author's installation. The *Elios4you* measures the solar & mains electricity and provides two paths to soak up excess solar electricity: via the *Power Reducer* diverter, and via the ZigBee *Smartsockets*.

The author's policy is the great majority of excess solar electricity is self-consumed, with a different strategy for Summer and Winter:

(1) In Winter the ambient air and water temperatures are very low, and very little solar electricity is available until 10am, so the gas-fired central heating is on to heat the house (solar electricity could not anyway) and also heat the hot cylinder to provide hot water. Therefore any excess solar electricity is self-consumed in electric radiators. These serve two purposes, firstly to reduce the central heating demand (i.e. to save gas) and secondly to protect the house from frost when the central heating is off (e.g. when on holiday).
(2) In Summer the ambient air and water temperatures are warm, and solar electricity is available well before 8am, so the central heating is off, and any excess solar electricity is self-consumed firstly to heat the hot cylinder to provide hot water, and after that to warm the house via electric radiators.

An IOS/Andoid smartphone/tablet App is used both to monitor and control these devices, either locally via the house WiFi or remotely via 4-nok's *4-Cloud* [4]. The setup of the App is well explained in 4-noks guides, but neither the control of devices nor the *4-Cloud* is explained. There are three main devices, each conditionally activated:

(1) The *Onboard Relay*, see further below.
(2) The *Power Reducer* diverter, a device that can soak up a variable quantity of excess solar electricity.
(3) The ZigBee *Smartsockets*, devices that can soak up fixed quantities of excess solar electricity.

The App supports conditions for device activation that are broadly similar:

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(1) *Off:* deactivate.
(2) *On:* activate.
(3) *Auto:* conditionally activate/deactivate devices:
  (i) *Acivate* if over a defined switch-on delay the export power is greater than or import power is less than a threshold; a minimum activation time can be set.
  (i) *Deactivate* if over a defined switch-off delay the export power is less than or import power is greater than a threshold.
(4) *Timer:* set to *Off*, *On* ("*Boost*") or *Auto* according to a 7-day schedule, defined in 30 minute intervals. Qualifying *Auto* with a schedule is a very useful feature.
(5) *Rename:* rename the device and/or change its icon.

Self-consuming excess solar electricity using only *Power Reducer*:
The *Power Reducer diverter* is turned on when its conditions are satisfied. The *Elios4you* controls the *Power Reducer* to vary its output voltage in proportion to the excess solar electricity, so between them they can track the excess and consume it all. In most simple installations the *Power Reducer* powers the hot cylinder immersion heater, the majority of which include a thermostat that trips at about 65°C. After that the *Power Reducer* becomes idle. The disadvantage of this approach is the subsequent unused excess solar electricity.

Self-consuming excess solar electricity using only *Smartsockets*:
For the *Smartsockets*, the order (left-to-right or top-to-bottom) in which they appear in the App defines the priority for evaluation of their activation conditions. The highest priority *Smartsocket* is turned on when its conditions are satisfied and becomes part of the base load for subsequent evaluations for the lower-priority *Smartsockets*. In effect there is a bucket of excess solar electricity and each *Smartsocket* subtracts from that when it is activated.

In the author's installation these are used to power 240W electric tube radiators [5] that are placed directly above the central heating radiators, so for example, let us assume the *Smartsockets* power 240W loads, their threshold is 250W, with a 5min turn-on delay, the house load is 500W, and the excess is 1000W:
(1) After 5min the highest priority *Smartsocket* is turned on. The base load is now 740W and the excess is now 760W.
(2) After another 5min the next priority *Smartsocket* is turned on. The base load is now 980W and the excess is now 520W.
(3) After another 5min the next priority *Smartsocket* is turned on. The base load is now 1220W and the excess is now 280W.
(4) After another 5min the lowest priority *Smartsocket* is turned on. The base load is now 1460W and the excess is now 40W.
All the *Smartsockets* power thresholds are set to the same 250W and 5min turn-on delay; some may consider this to be counter-intuitive. They can only consume fixed quantities of excess solar electricity, so the disadvantage of this approach is that there will always be an unused remnant of excess solar electricity, see Fig.1.

Self-consuming excess solar electricity using *Power Reducer* <u>and</u> *Smartsockets*:
There are two possibilities for prioritising these devices:
(1) *Power Reducer* has highest priority, so it will consume all the excess solar electricity until its load deactivates (e.g. its thermostat trips), then *Smartsockets*

turn on and consume all but an unused remnant of excess solar electricity. This is the default setting. The disadvantage is the unused remnant.

(2) *Power Reducer* priority is modified so *Smartsockets* turn on and consume all but an unused remnant of excess solar electricity, and the *Power Reducer* consumes that unused remnant until its load deactivates. This is not supported as yet.

In the author's installation the *Power Reducer* output is switchable:

(1) Winter: the *Power Reducer* powers a 3kW heater, and its priority is modified as above so *Smartsockets* turn on and consume all but an unused remnant of excess solar electricity, and the *Power Reducer* consumes all that unused remnant of excess solar electricity. Its load will never deactivate as it is a standard oil-filled electric radiator. But as stated above this modified priority is not supported yet.

(2) Summer: the *Power Reducer* powers the 3kW hot cylinder immersion heater, so it must have highest priority in order to produce hot water, and will consume all the excess solar electricity until the thermostat trips. After that the *Power Reducer* becomes idle and *Smartsockets* turn on to consume all but an unused remnant of excess solar electricity. The disadvantage is the unused remnant.

***Onboard Relay* usage:**

This facility was announced as follows:

"The Elios4you update allows you to control another source (at circuit level 10Amp) wired to the onboard relay. If you have been looking for a solution that allows you to connect Heat Pumps and Electric Heating to work with Solar PV Generated Energy, this is the answer you've been waiting for!

This software upgrade will enable users to control the amount of energy diverted to the second source connected to the relay without ever having to import energy from the grid unless required. You will have the option to choose to divert all surplus energy automatically with set parameters or manually configure times by the hour 7 days a week!"

Note: there also appears to be a relay in the *Power Reducer* but this is not explained.

***Elios4you* priority management:**

There is a *Priority Management* tickbox in the *Power Reducer* settings:

"If activated, the Power Reducer is turned on only when the relay is switched on. It works only if the relay is in Auto mode and the [Onboard Relay] export energy thresholds are set."

The *Onboard Relay* has priority, then the *Power Reducer*. This enables, for example, a heat pump to be activated by the *Onboard Relay* then any excess to be consumed by the *Power Reducer*.

Export management:

Export management is not yet explained.

***4-Cloud*:**

A very nice feature of the App is that it may be used on a tablet or a smartphone, either locally via *Elios4you* over the house WiFi, or remotely via *4-Cloud* over the web on a remote WiFi or GSM data connection. Once outside the house, the App receives its data from the *4-Cloud* servers, and does not communicate directly with the *Elios4you*, so inbound access to the house WiFi is not required. When receiving

data via the *4-Cloud*, the App shows a small cloud symbol at the top right. But to use *4-Cloud* one must first register the *Elios4you* device in what appear to be four steps:

(1) Navigate to Preferences → ConnectionMode, set Automatic *4-Cloud* connection.
(2) Navigate to Preferences → SecurityPIN, set *4-Cloud* security PIN.
(3) Go to http://www.4-cloud.org/ and register as a user.
(4) Log onto http://www.4-cloud.org/ and select Settings → JoinDevice. The prompt for "Username on Label" relates to the *Elios4you* install guide, which says that "before installing *Elios4you*, remove the label with device credentials ... with USER: xxxxxxxx". However the author's label only gives a Device ID, bar code and 12-character MAC address; USER is the last 8 characters of the latter.

Running the App on more than one tablet/mobile:

Another very nice feature of the App is that more than one tablet/mobile can run the App at any one time (despite general advice that this cannot be done). Completely close down any other tablets/mobiles the App is on, then install and run the App on the target tablet/mobile and invoke 'Wizard Configuration'. Select 'Direct' mode (at the beginning of the Android process, afterwards for iOS). When it says 'press the button on the device', firstly 'device' means the *Elios4you*, and secondly do that for about 10 seconds (use a toothpick, and be careful to feel where the button is; it is quite small, maybe 2cm inside). Press it for about 10 seconds, and on release the *Elios4you* LEDs should 'follow-the-leader' in rotation; otherwise you have not actually pressed the button. This step in the Wizard process switches the *Elios4you* into 'Direct' mode, activating an internal WiFi access point with SSID of "E4U-*****", where '****' is the USER ID explained in the section above. It is only by doing this that a new tablet/mobile can be recognised by *Elios4you*. Then when it says 'enter the device recognition code', delete any previously entered digits, and be sure to enter any leading zeroes. The further steps should then recognise the new tablet/mobile; occasionally this fails and the Wizard must be run again.

Once the Wizard has completed, close the App, then run it again and again invoke 'Wizard Configuration'. Select 'Indirect' mode and the *Elios4you* should then recognise the new tablet/mobile via the domestic WiFi access point (router). Then restart the other tablets/mobiles and run the App on them too. Only one tablet/mobile will be connected via the domestic WiFi access point (indicated by the WiFi symbol on top right corner of its screen); the others will connect via the *4-Cloud* (indicated by the cloud symbol on top right corner of their screen) after about 20 to 30 seconds.

To propagate previously collected data to the newly recognised tablets/mobiles do 'Backup to Cloud' on the original tablet/mobile, then 'Restore from Cloud' on the newly recognised tablets/mobiles.

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Wish List:

(1) To be able to control more *Smartsockets*.
(2) To add smart environment control to the *Elios4you*, using a sensor to monitor ambient temperature (communicated wirelessly by ZigBee), and controlling the central heating boiler via a *Smartsocket*. A very nice extra feature would be a related *frost-detection* setting.
(3) To combat Legionaires disease, once a week the *Power Reducer* could be either activated at highest priority, or *Boosted* as needed if there had not been sufficient excess over the week.
(4) Given automatic support for (3), the opportunity could safely be taken to reduce the temperature to which the central heating boiler heats water, e.g. to 50°C (fine for showers and domestic use), simply by adjusting its hot cylinder thermostat. The advantage would be the saving in gas, costs, and the environment.
(5) To add a modified *Power Reducer* priority so *Smartsockets* turn on and consume all but an unused remnant of excess solar electricity, and the *Power Reducer* consumes that unused remnant until its load deactivates. The *Power Reducer* still would have highest priority but its power consumption could be used to decide when to activate a *Smartsocket* (which is activated when its conditional variable exceeds its threshold). If 'power reduced' was added to the existing 'power purchased' and 'power sold' conditional variables, then a *Smartsocket* could be activated whenever 'power reduced' exceeded its threshold, after which the *Power Reducer* would consume the remaining (decreased) excess.
(6) Given automatic support for (3) and (5), the opportunity could safely be taken to avoid the *Power Reducer* becoming idle <u>and</u> reduce the temperature to which the immersion heats water [similarly to (4)]. This could be achieved by automatically modifying the *Power Reducer* priority once the hot water is "hot enough" (say 50°C), so then *Smartsockets* turn on to consume all but an unused remnant, and the *Power Reducer* consumes <u>all</u> that unused remnant. A 50°C limit would provide 15°C "headroom" that would ensure the immersion 65°C thermostat would be unlikely to trip (which if it did occur would cause the *Power Reducer* to become idle and thereby prevent it from consuming <u>all</u> that unused remnant). This would require a ZigBee hot cylinder temperature sensor, independent of the immersion thermostat and central heating hot cylinder thermostat.
(7) To add automatic propagation of previously collected data to newly recognised tablets/mobiles.

This wish list only requires *Elios4you* firmware upgrades. As stated, temperature sensing could be done using the existing *Elios4you* ZigBee communications.

References:

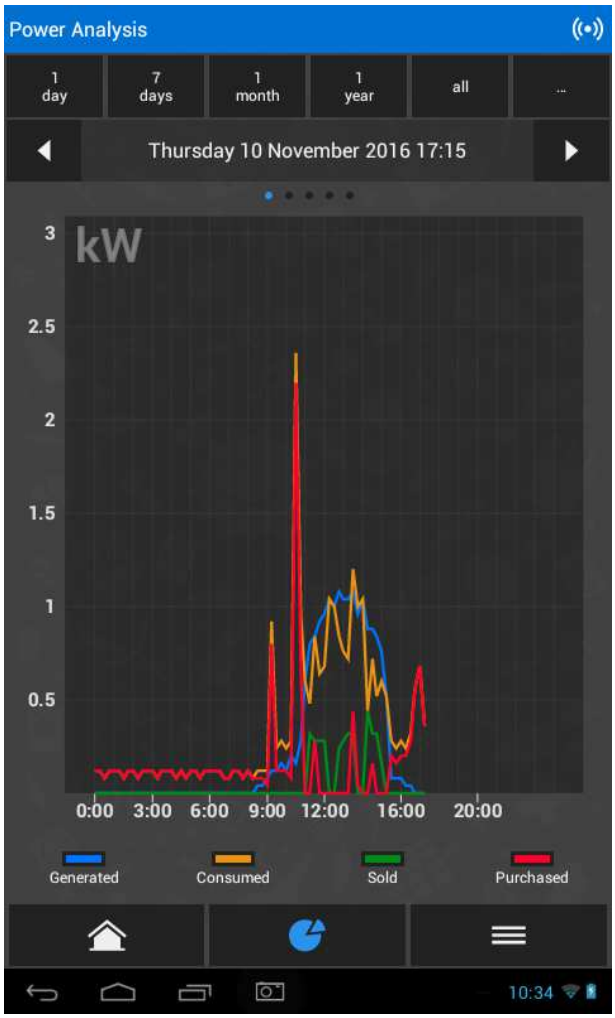
1. 4-noks, *Elios4you*, 4-noks SRL, 2016.
   http://www.4-noks.com/shop/elios4you-en/elios4you/?lang=en
   http://www.4-noks.com/shop/self-consumption/red-cap/?lang=en
   Last browsed to on 5-Nov-2016.

2. 4-noks, *Power Reducer*, 4-noks SRL, 2016.
   http://www.4-noks.com/shop/self-consumption/power-reducer/?lang=en
   Last browsed to on 5-Nov-2016.

3. 4-noks, *Smartsockets*, 4-noks SRL, 2016.
   http://www.4-noks.com/shop/elios4you-accessories/smart-plug/?lang=en
   Last browsed to on 5-Nov-2016.

4. 4-noks, *4-Cloud*, 4-noks SRL, 2016.
   http://www.4-noks.com/product-categories/4-cloud-en/?lang=en
   Last browsed to on 5-Nov-2016.

5. Hausen, *Electric Tubular Heater*, 2016.
   http://www.outdoorvalue.co.uk/99640-hausen-electric-tubular-heater.html
   https://www.amazon.co.uk/Hausen-Electric-Tubular-Heater-Greenhouse/dp/B01BPA08P0
   Last browsed to on 5-Nov-2016.



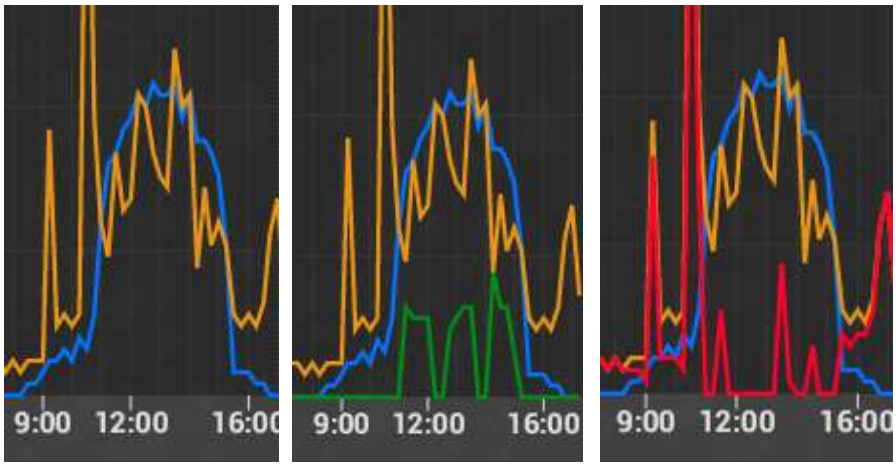


Figure 1: Author's solar PV smart home installation
Left: Screenshot
Top left: (PV-)Generated (blue) & (self-)Consumed power (yellow)
Smartsocket activations are clearly visible
Top middle: with Exported power (green)
This represents unused (remnant) excess solar electricity
Top right: with Imported power (red)

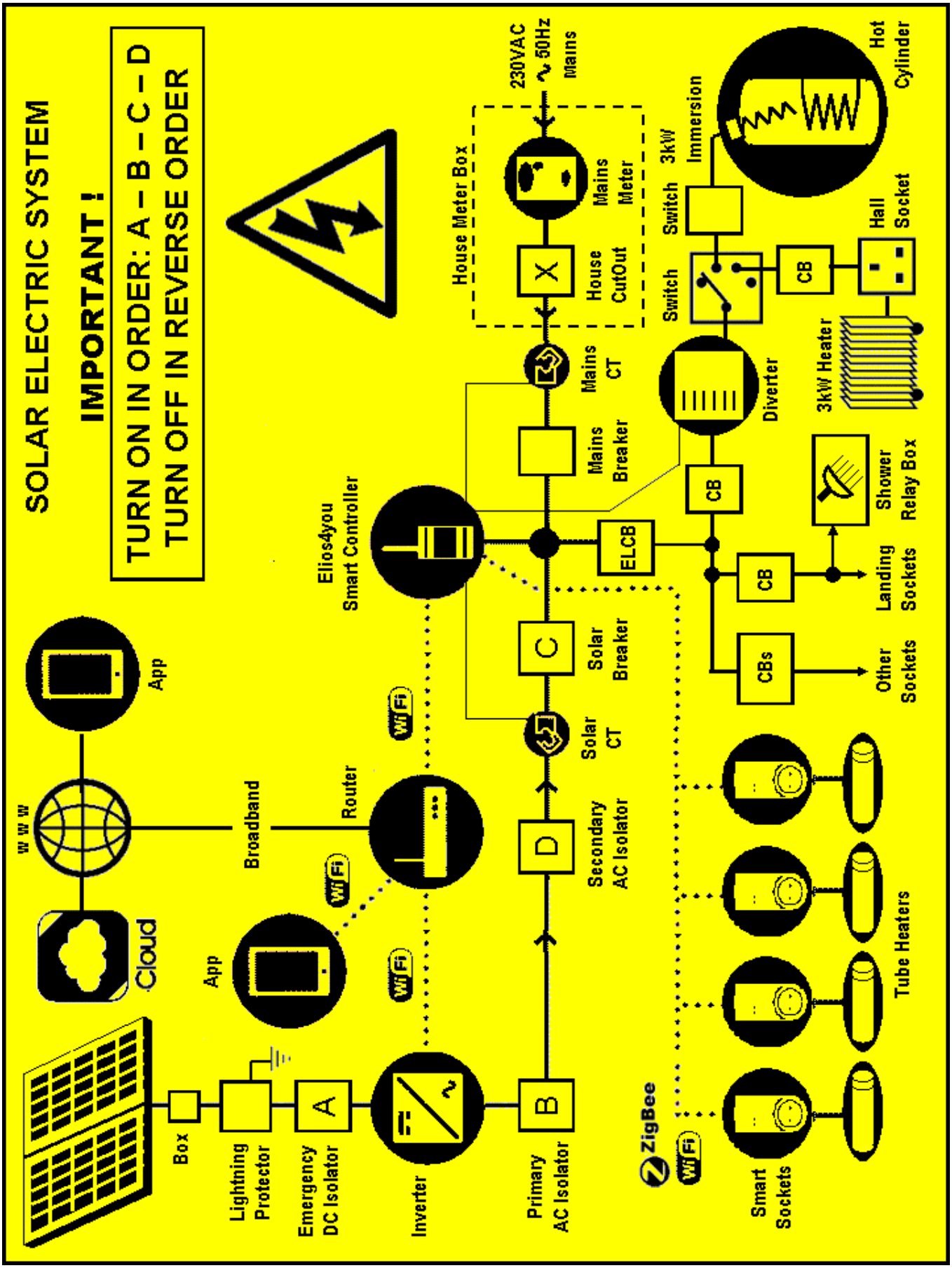


Figure 2: Author's solar PV smart home installation

Figure 3: Author's solar PV smart home installation
Top: PV panels
Lower Left: DC Isolator, Inverter, AC Isolator, Lightning Protector
Lower Right: Fusebox, AC Isolator, Smart Control, Power Reducer