Contact addresses

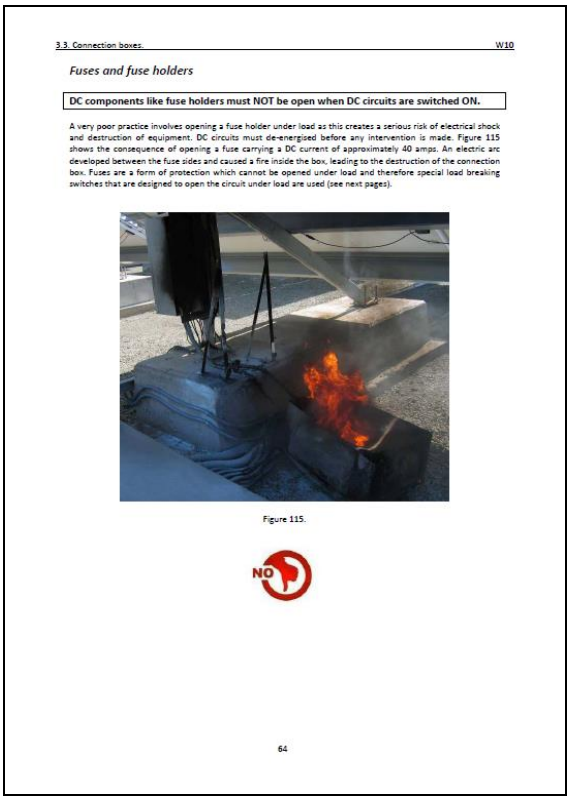
The following table summarizes the name and email of the main contacts of PVCROPS consortium and the two spin-offs implemented in the framework of the project:

Partner	Name	e-mail
Project coordinator (Universidad Politécnica de Madrid)	Luis Narvarte	navarte@ies-def.upm.es
Universidad Pública de Navarra	Luis Marroyo	luisma@unavarra.es
Universidade de Evora	Manuel Collares Pereira	collarespereira@uevora.pt
Central Laboratory of Solar Energy and New Energy Sources of the Bulgarian Academy of Sciences	Nikolay Tyutyundzhiev	pv-jet@phys.bas.bg
Dublin Institute of Technology	Michael Conlon	Michael.conlon@dit.ie
Office National de l'Electricité	Nour Eddin Bouzzan	bouzzan@onee.ma
Acciona Energía S.A.	Eugenio Guelbenzu	Eugenio.guelbenzu.michelena@acciona.com
Ingeteam Power Technology S.A.	Roberto González	Roberto.gonzalez@ingeteam.com
Rtone SARL	Adrien Desportes	Adrien.desportes@rtone.fr
Renewable Energy Dynamics Technology LTD	Gary Simmonds	gary@redtenergy.com
Association pour la Promotion des Energies Renouvelables	Benjamin Wilkin	bwilkin@apere.org

PVCROPS LOGO

Pictures to promote the work

Picture 1. Cover of "Good and bad practices. Manual to improve the quality and reduce the cost of PV systems" (English version).



3.3. Connection boxes. W10

Fuses and fuse holders

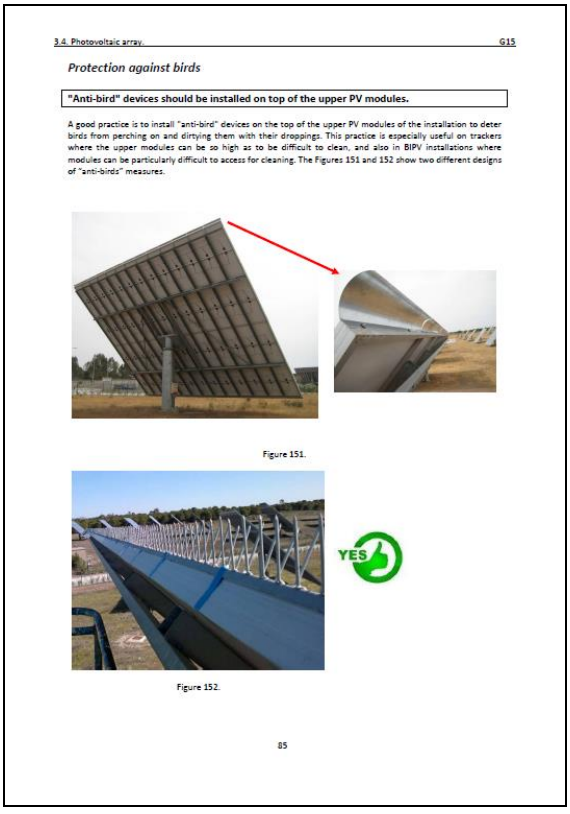
DC components like fuse holders must NOT be open when DC circuits are switched ON.

A very poor practice involves opening a fuse holder under load as this creates a serious risk of electrical shock and destruction of equipment. DC circuits must de-energised before any intervention is made. Figure 115 shows the consequence of opening a fuse carrying a DC current of approximately 40 amps. An electric arc developed between the fuse sides and caused a fire inside the box, leading to the destruction of the connection box. Fuses are a form of protection which cannot be opened under load and therefore special load breaking switches that are designed to open the circuit under load are used (see next pages).

Figure 115.

64

Picture 2. Example of bad practice in the "Good and bad practices. Manual to improve the quality and reduce the cost of PV systems".



3.4. Photovoltaic array. G15

Protection against birds

"Anti-bird" devices should be installed on top of the upper PV modules.

A good practice is to install "anti-bird" devices on the top of the upper PV modules of the installation to deter birds from perching on and dirtying them with their droppings. This practice is especially useful on trackers where the upper modules can be so high as to be difficult to clean, and also in BIPV installations where modules can be particularly difficult to access for cleaning. The Figures 151 and 152 show two different designs of "anti-birds" measures.

Figure 151.

Figure 152.

85

Picture 3. Example of good practice in the "Good and bad practices. Manual to improve the quality and reduce the cost of PV systems".

Figure 4. Home page of SISIFO, the free and open-source simulation tool developed in PVCROPS and available at www.sisifo.info

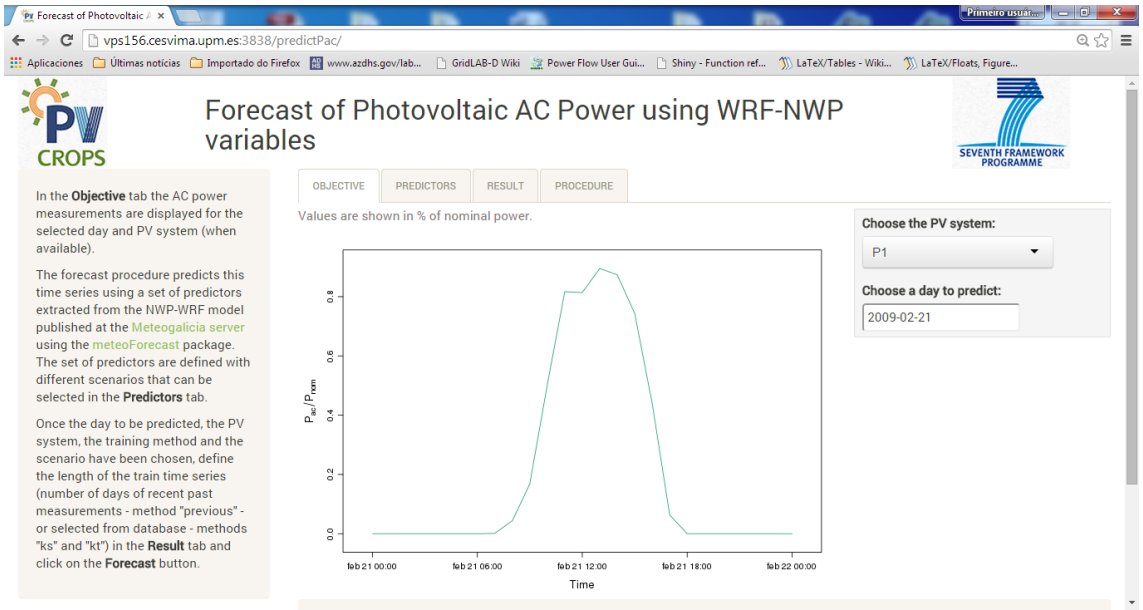


Figure 5. Home page of PROPHET – prediction of PV production, the free and open-source simulation tool developed in PVCROPS and available at http://vps156.cesvima.upm.es:3838/predictPac/

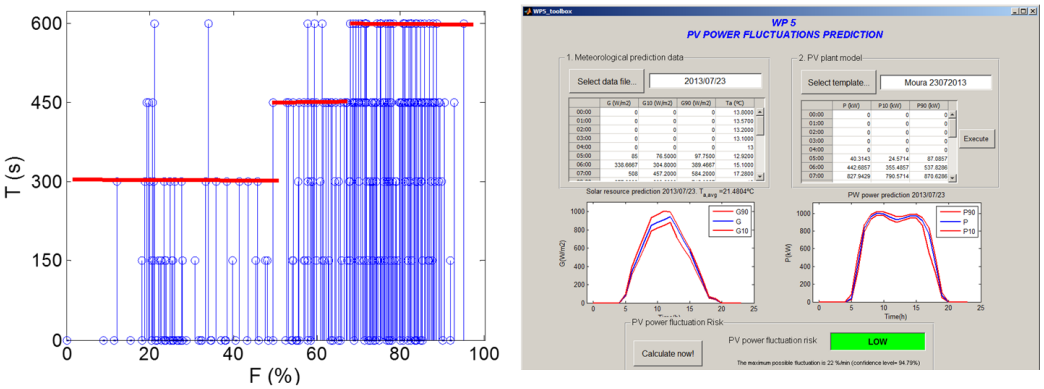


Figure 6. Toolbox to simulate the variability in the power generated by a group of large dispersed PV plants.

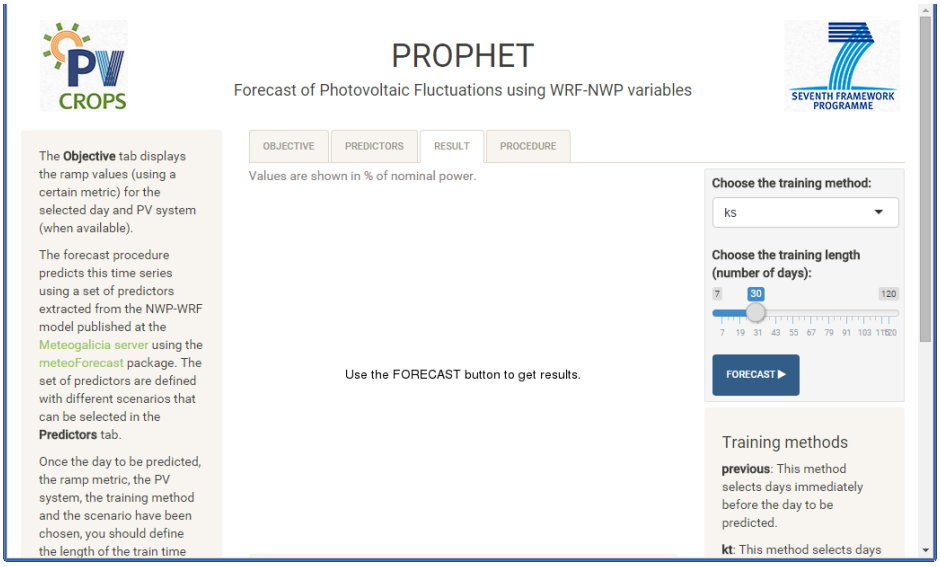


Figure 7. Home page of PROPHET – prediction of PV power fluctuations, the free and open-source simulation tool available at http://vps156.cesvima.upm.es:3838/predictRamps/

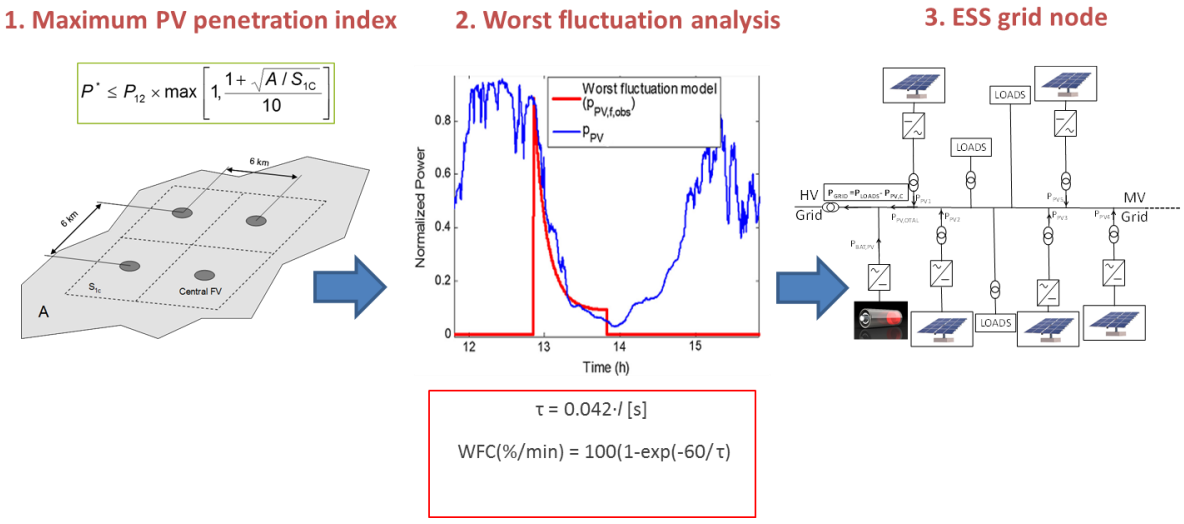


Figure 8. Toolbox providing guidelines for the integration of PV plants into the grid.

Figure 9. Lithium ion energy storage system installed at Tudela PV plant

Figure 10. VRB system installed at Évora's university.

Figure 11. Li-ion demonstrator at University of Évora. Ingeteam's power inverters on the right and lithium-ion battery on the left.

Figure 12. EMS Tools screenshot.

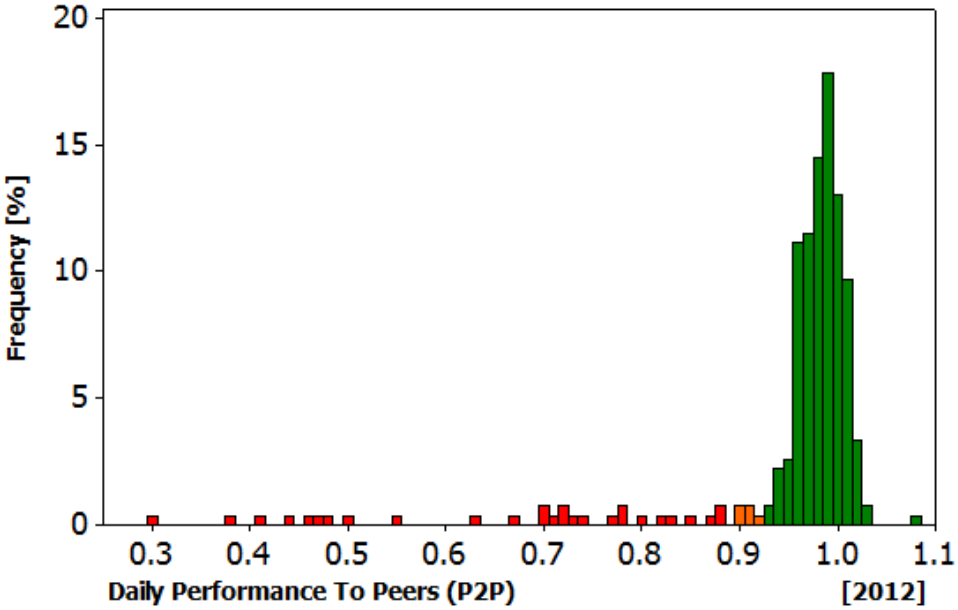


Figure 13. Histogram of daily *P2P* on a BIPV system during the whole year 2012. The green bars are representative of the normal operation of the PV system. The red bars are probably due to performance problems. The orange bars correspond to an intermediate zone where there is an overlap between the two populations.

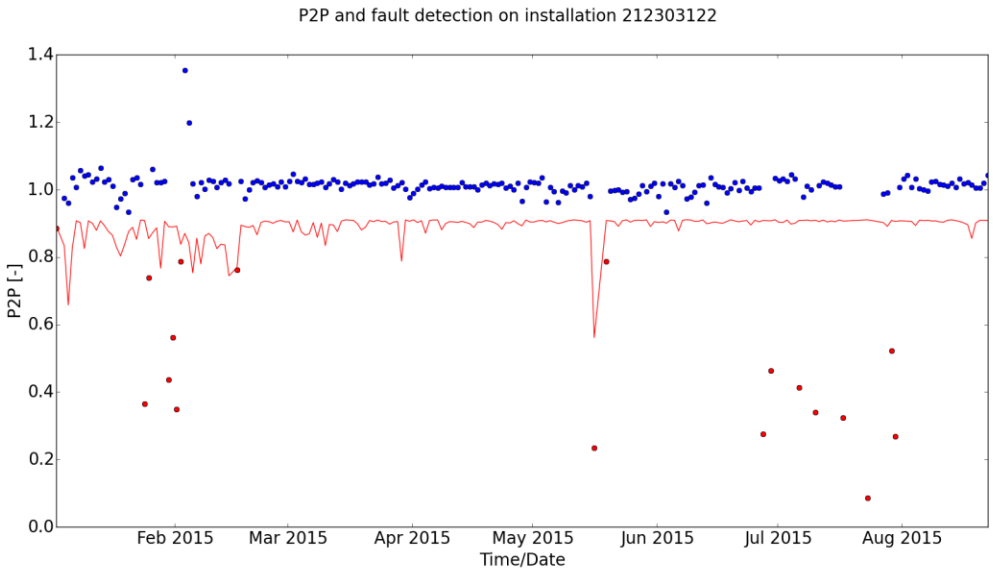


Figure 14. Daily P2P of one PV installation located in Belgium from January to August 2015. The P2P values corresponding to days that were free of faults (blue points) are generally stable over the year. The variability is generally higher during the winter. The fault detection threshold (red line) is high overall, but decreases during the days whose sky conditions are more unstable. The red points correspond to P2P values that are below the threshold and that were attributed to faults.

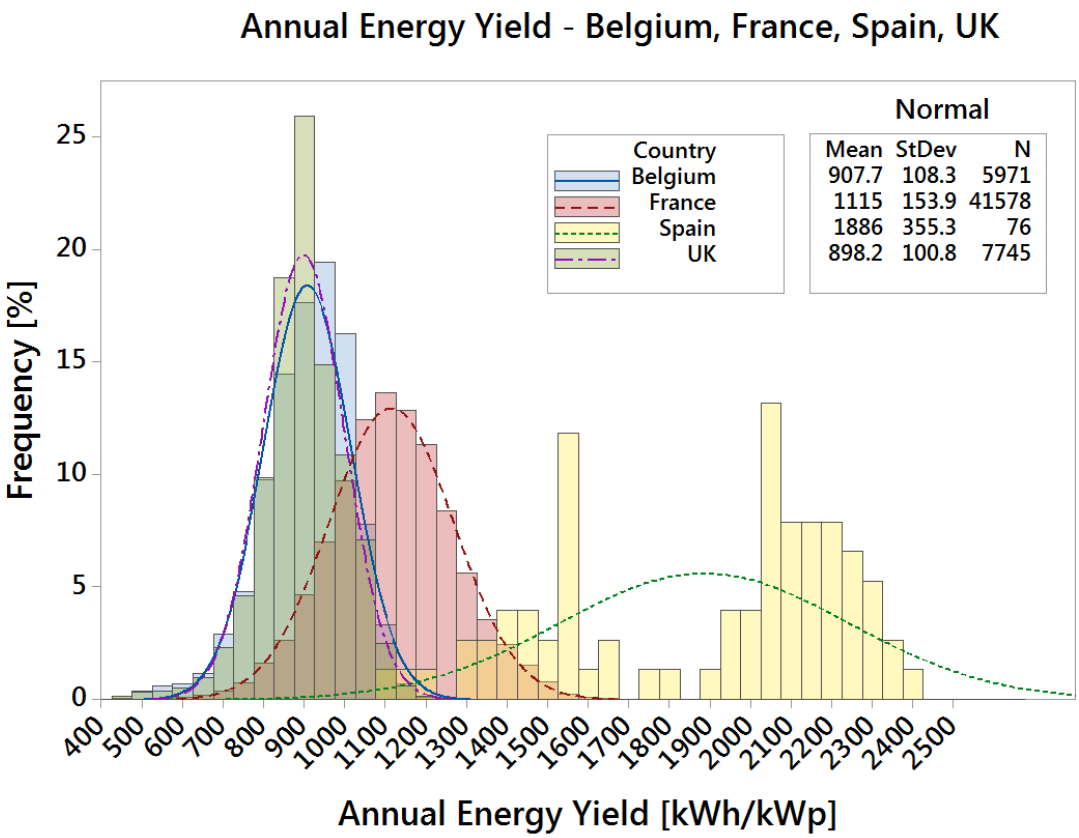


Figure 15. Annual Energy Yield obtained on the data analysed from four key countries of Europe: Belgium, France, Spain, and the UK.

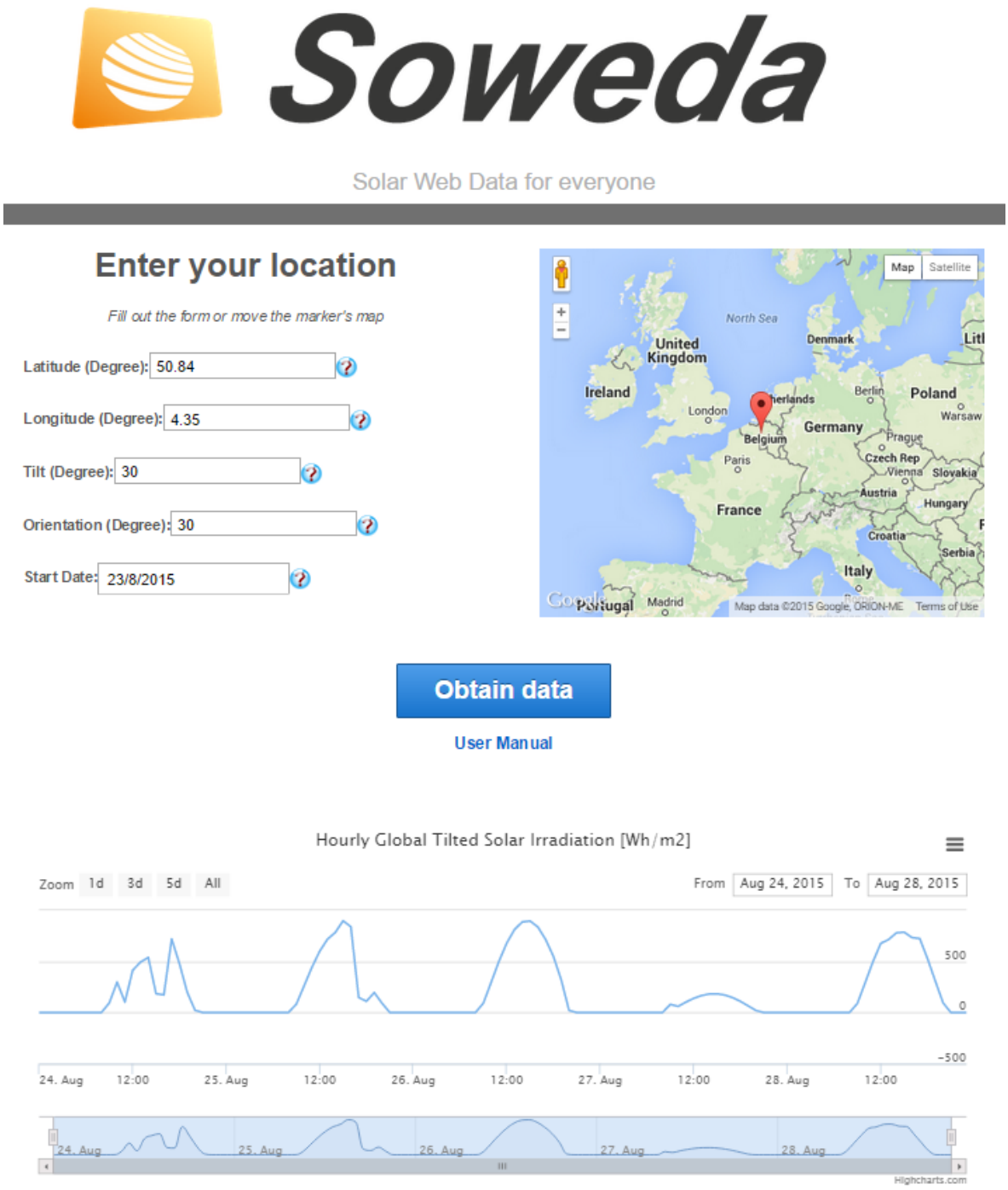


Figure 16. SOWEDA tool and its web interface to retrieve the solar irradiation in Brussels from the 24th to the 28th of August 2015 (www.soweda.net).

(a) (b)

Figure 17. Testing kits: (a) Single reference module that has been modified to measure simultaneously boh G_{ef} and T_C. (b) Connection box added to the module with the shunt resistor and the wiring to get both signals simultaneously (in the module's junction box can be noticed the internal modification).

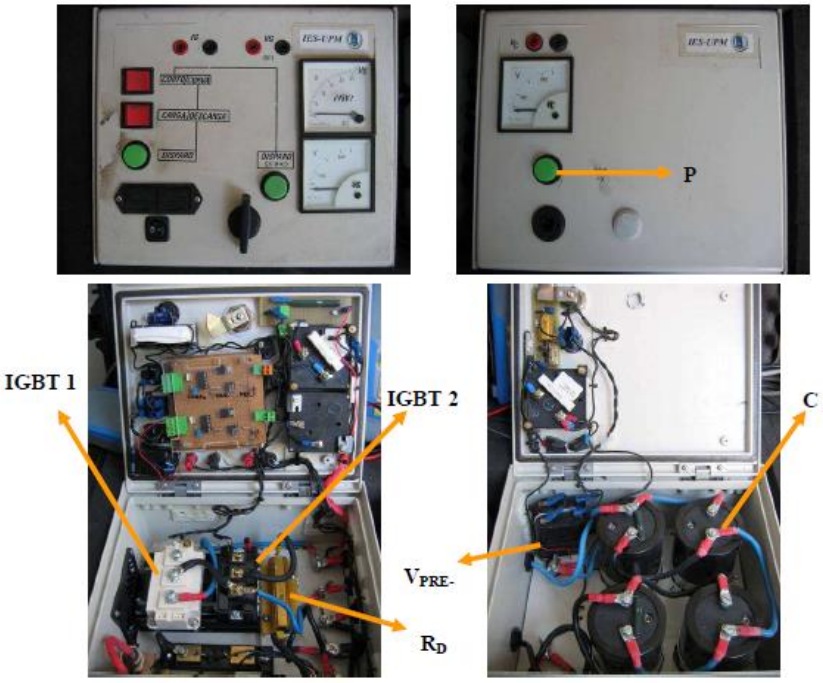
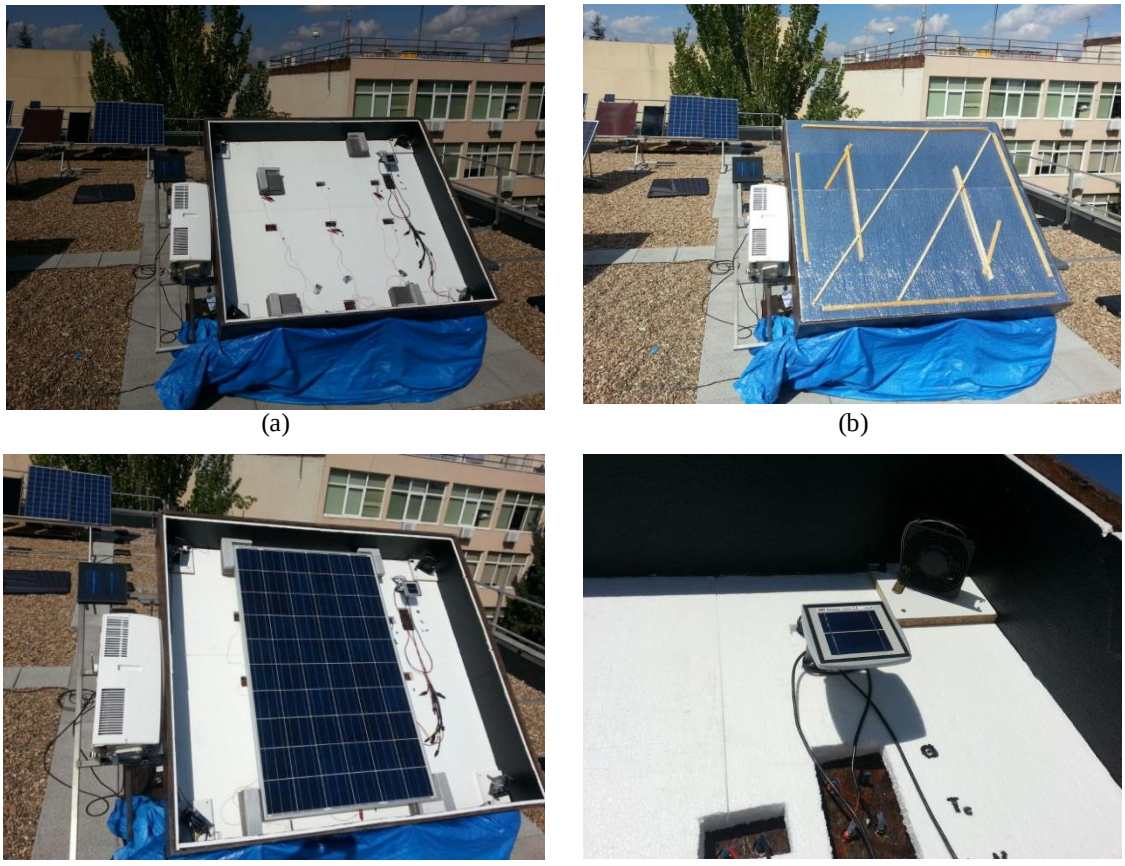


Figure 18. Testing kits: External and internal views of the first capacitive *I-V* curve tracer implemented by the IES-UPM. Left box contains the IGBTs and the driver and supply circuits. Right box contains the capacitors and the negative pre-charging circuit.

(a) (b) (c)

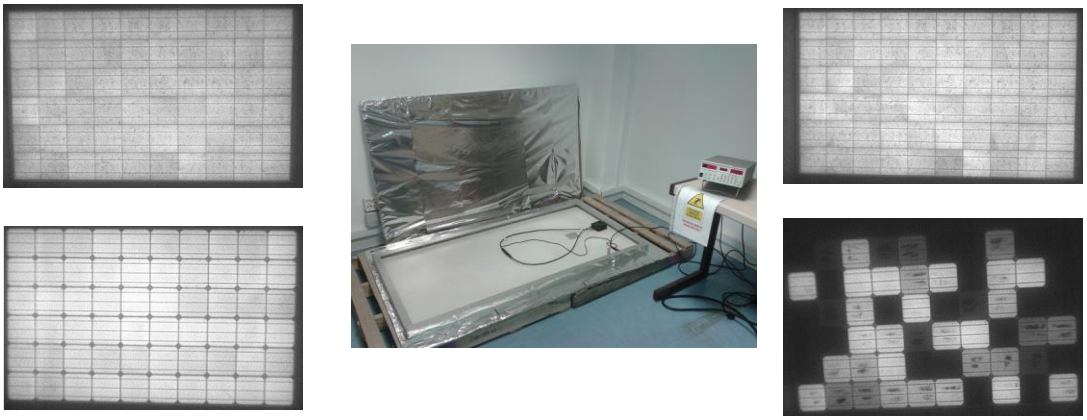
Figure 19. Testing kits: (a). View of the *I-V* curve capacitive tracer implemented by the IES-UPM specifically designed to measure individual PV modules. It includes all the required devices and circuits in a single box. (b). View of the *I-V* curve capacitive tracer implemented by the IES-UPM specifically designed to measure large PV arrays up to 2 MW. This box includes the IGBTs, the driver circuit, the supply circuit and the negative pre-charging circuit. (c) View of the one of the boxes with the capacitors for the *I-V* curve tracer of picture b.



(a) (b)

(c) (d)

Figure 20. Testing kits: Climatic box used for testing PV modules outdoors. This second version is made of wood and it is filled with white polystyrene to decrease the heating of the whole box once the cover is removed (a) Climatic box opened, with the PT1000 sensors, the fans and the internal reference solar cell inside. (b) Before the test, the PV module is placed inside the thermally insulated box, the inside temperature is forced to 25ºC by means of an air conditioner and the box is manually positioned to reach incident irradiance close to 1000 W/m^2 thanks to the external reference solar cell (c) The cover is removed and *I-V* curves are recorded at 25ºC and also along the natural heating process. (d) Detail of the fans and the internal reference solar cell.



BEFORE **7 DAYS AT ±1000 V** **AFTER**

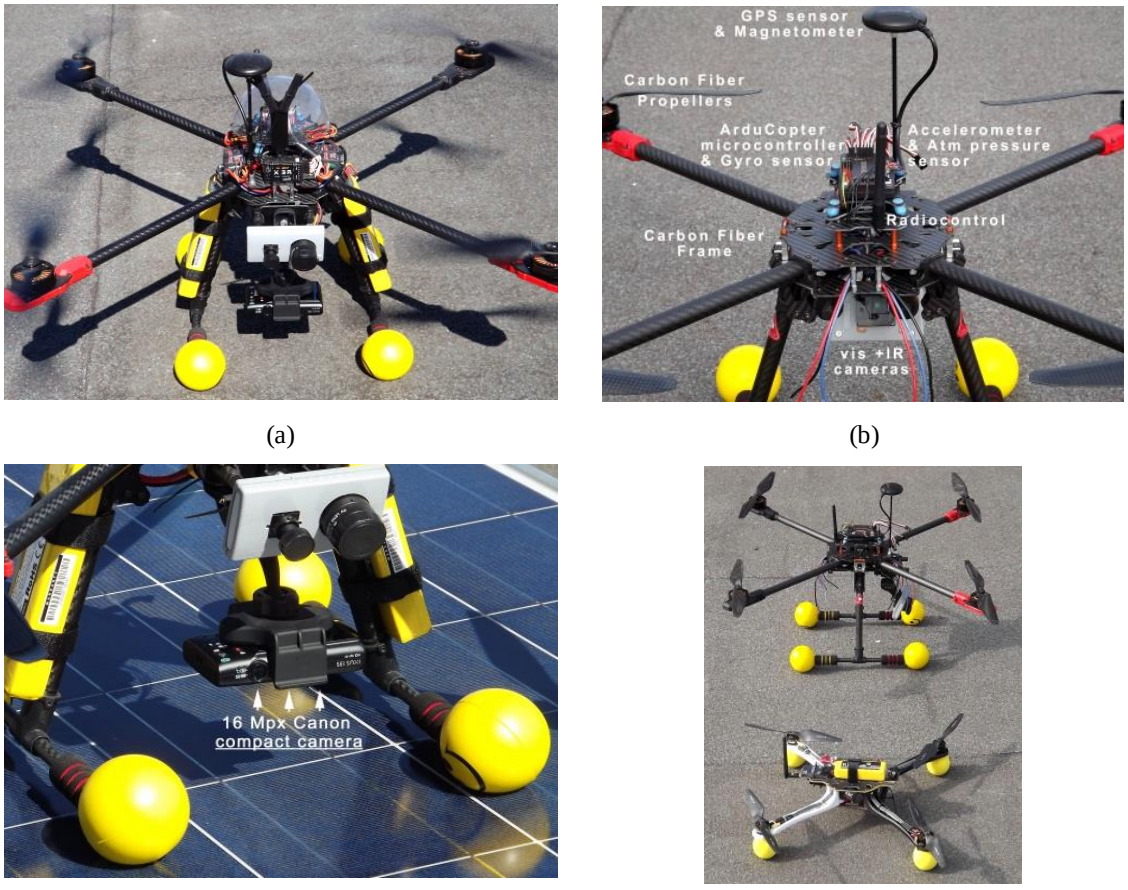
(a) (b) (c)

Figure 21. Testing kits: Accelerated test to degrade modules in the laboratory. (a) First, the EL image of the module is taken. (b) Then, a voltage of ± 1000V is applied between the short-circuited active poles and the frame of the module, once its front surface has been covered with an aluminium foil. (c) Finally, after a period of 7 days the EL image of the module is taken again. If the module is prone to PID phenomenon some of their cells become inactive (dark ones, down module).

Figure 22. Testing kits: First version of the developed quadcopter (PV drone). It has an IR camera and a visible camera for monitoring a PV installation.

(a) (b)

Figure 23. (a) Quadcopter flying mission planned for a 150 kW PV plant. (b) Quadcopter during the inspection flying mission above the array PV modules.



(a) (b)

(c) (d)

Figure 24 Testing kits: (a) and (b) PV drone configuration enabling 3-D mapping missions. (c) IR camera and visible camera for monitoring a PV installation and compact digital camera for photogrammetry analysis. (d) UAVs developed by PVCROPS team (CLSENES)

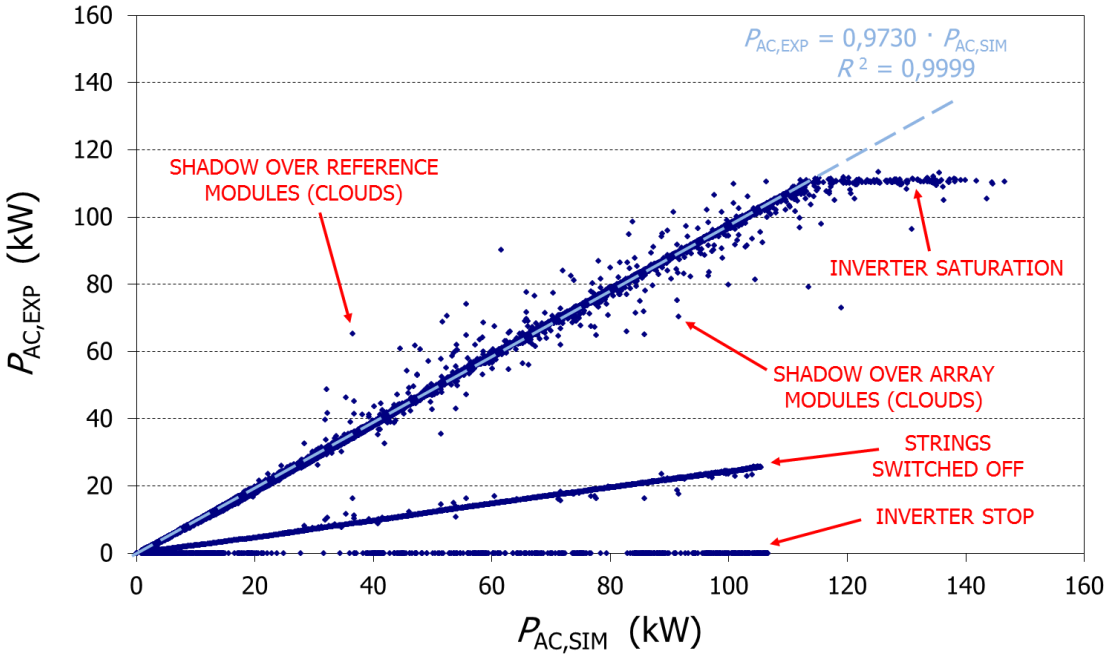


Figure 25. Testing kits: AC power response of a 110 kW nominal power PV array measured on-site with a watt-meter. The normal operation is represented by the linear dotted behaviour. The other anomalous situations can be noticed in the graph: shadow over sensors or over PV array modules due to clouds, strings switched off, inverter saturation and inverter stop.

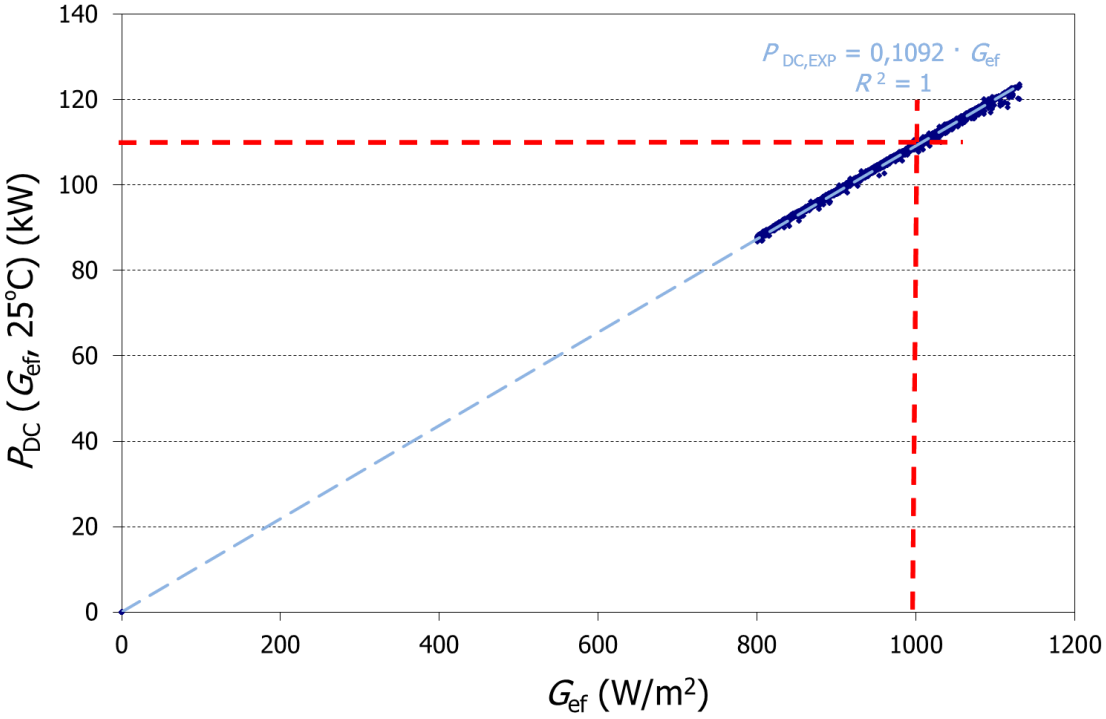


Figure 26. Testing kits: DC power corrected at 25ºC of a 110 kW nominal power PV array measured on-site with a watt-meter. The DC power records related to anomalous situations and to low irradiances have been previously removed to obtain the DC peak power value at STC.

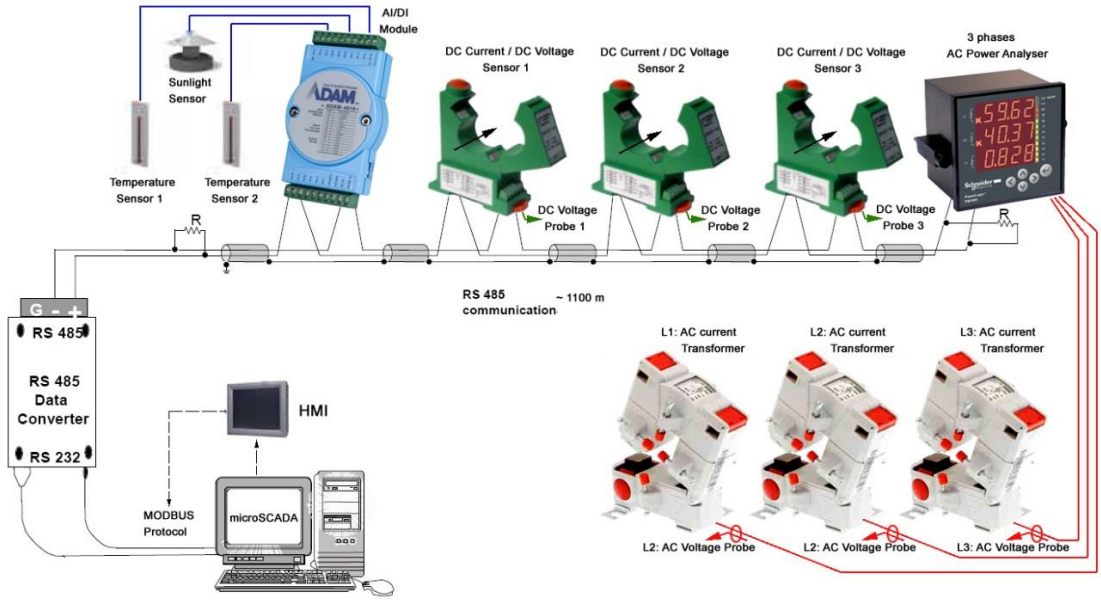


Figure 27. Testing kits: Low cost portable SCADA scheme for DC and AC measurements, as well as operating conditions measurements.

Figure 28. Presentation of during the PVCROPS dissemination Event at EU PV SEC - Amsterdam 2014

Figure 28. L. Fialho and T. Fartaria (UEVORA) describing the management of the REDOX Vanadium battery (from REDT) during the first demonstrator event (EVORA 2014).

Figure 29. Morning panel during the last workshop event (Common final project event managed in cooperation with Performance Plus project) October 2015.

Figure 30. Tom Flanagan (DIT) presents to Irish renewable energy companies at a PVCROPS breakfast meeting in Dublin Institute of Technology in April 2013.

Figure 31. Luis Narvarte discusses the PVCROPS project at the InterSolar Exploitation side Event in June 2014.

Figure 32. Stephen Wright attending the PVCROPS Exhibition Stand at the solar Energy UK Exhibition, October 2015.