Market Dialogue on Greening Humanitarian Responses Through Enhanced Solar Energy Harvesting

Tuesday, 13 Dec 2022
10:00 - 11:15 CET

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European Union Humanitarian Aid

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Agenda

	Speakers
Project presentation from IOM	Alberto Ibanez IOM
Input on research collaboration	Prof. Salvador Segui Chilet Polytechnique University of Valencia
Q&A	All

Presenter

Alberto Llario, IOM UN Migration

Alberto is a WASH and Energy Manager with the International Organization for Migration. He has over 15 years of experience in the relief sector in various country, regional and global positions with Action Against Hunger, OXFAM, UNHCR and IOM in Europe, West and East Africa and South East Asia. During the last 5 years he has been coordinating the implementation of the Global Solar & Water Initiative to support the introduction and scaling up of solar energy-based solutions across relief organizations all around the world.

Maximizing Solar Energy Harvesting

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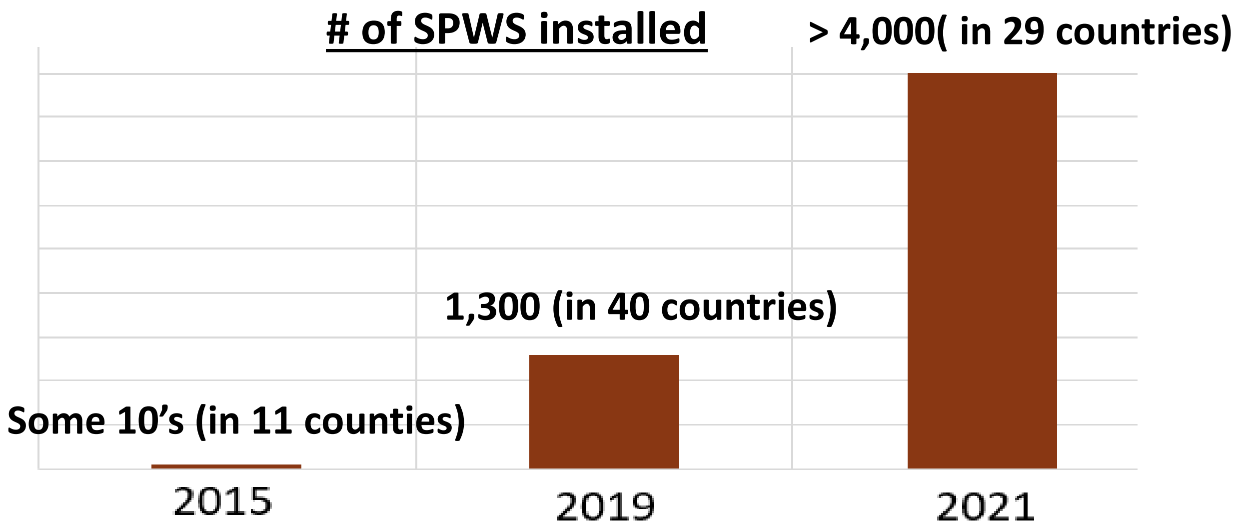
Humanitarian Aid and Civil Protection

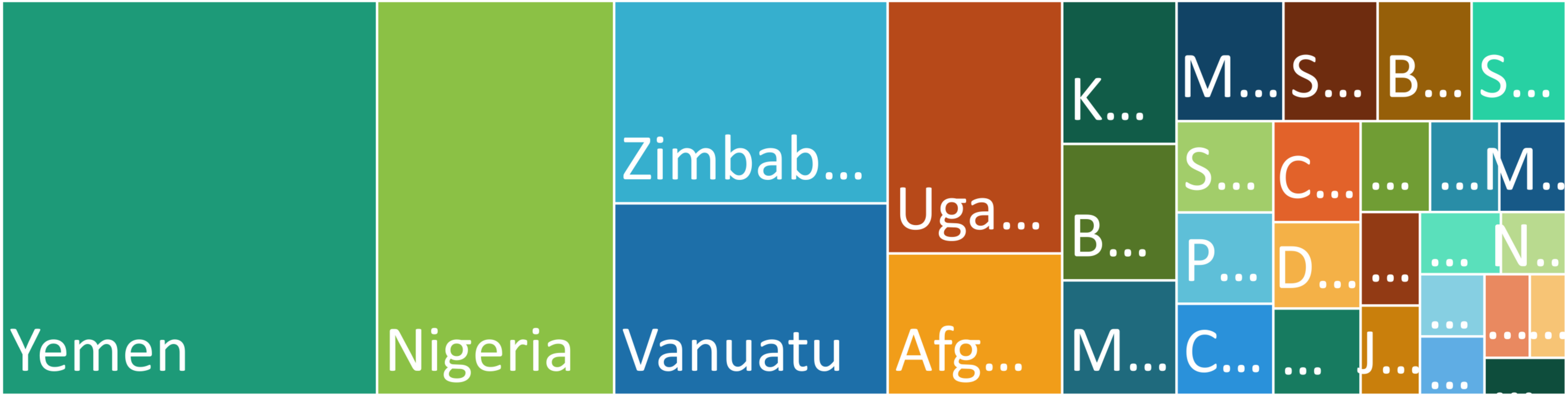
Global Solar & Water Initiative 2016-2021

Replacing the use of diesel generators by solar panels at scale in humanitarian contexts.

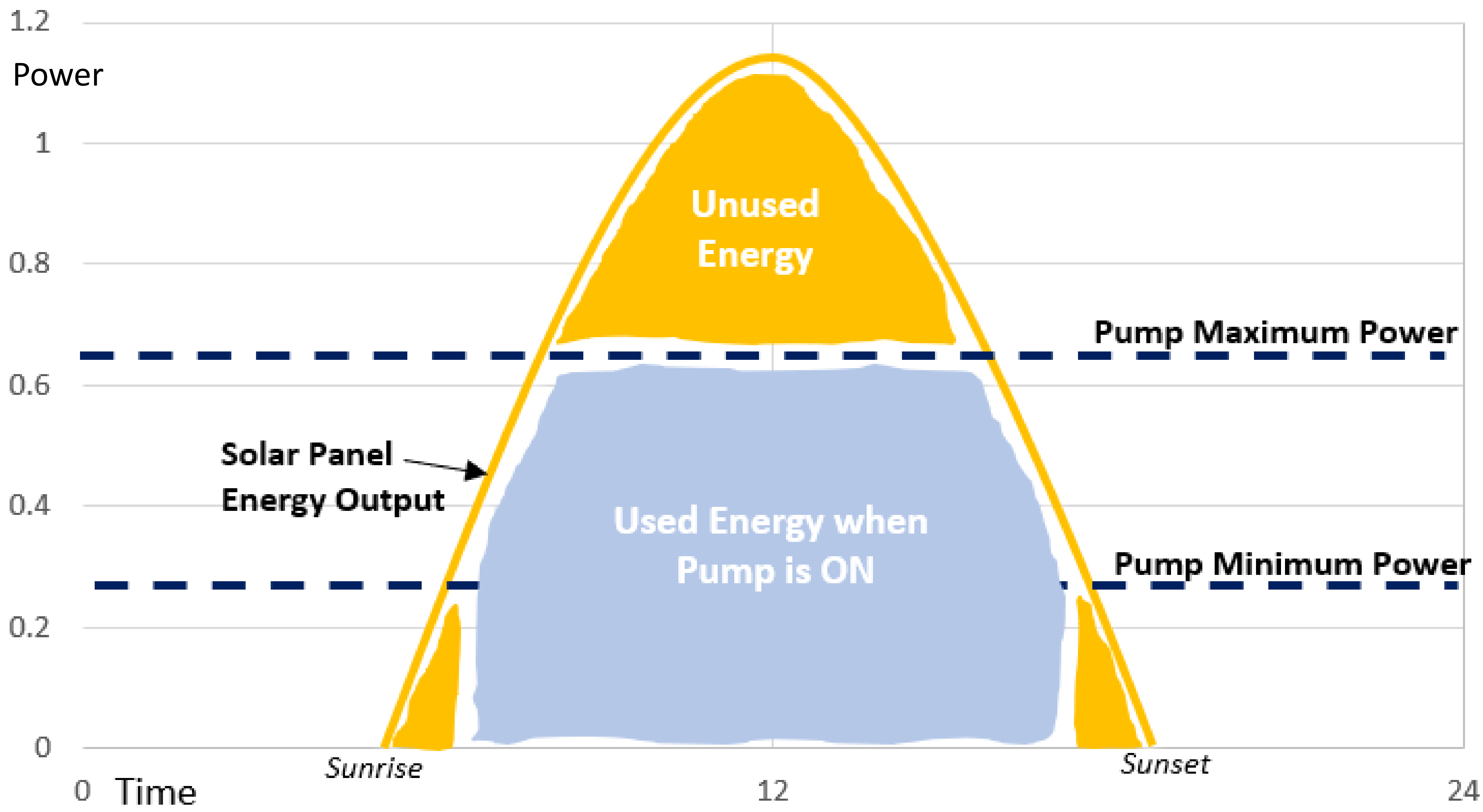
- ✓ +1,000 WASH officers trained from 226 Organizations in 37 Countries.
- ✓ +500 Technical Consultations from 109 Organizations in 71 Countries.
- ✓ 21 Country visits with 98 sites assessed.
- ✓ Market and economic analysis in 10 countries
- ✓ +120,000 pages visited per year at dedicated webpage
- ✓ Knowledge material, tools, articles and book published.

Mapping: Solar Powered Water Schemes installed.

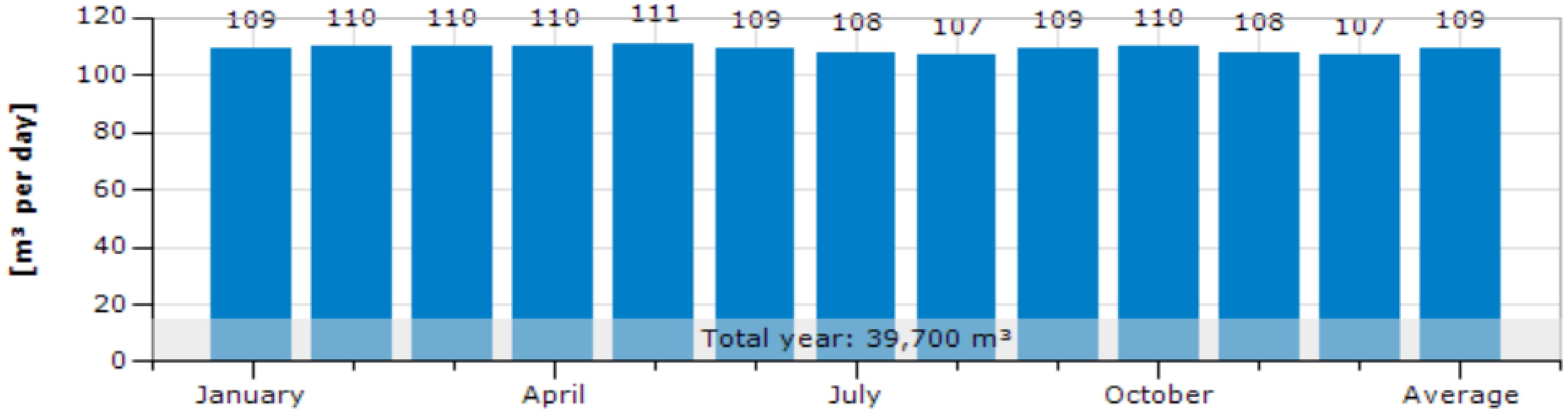


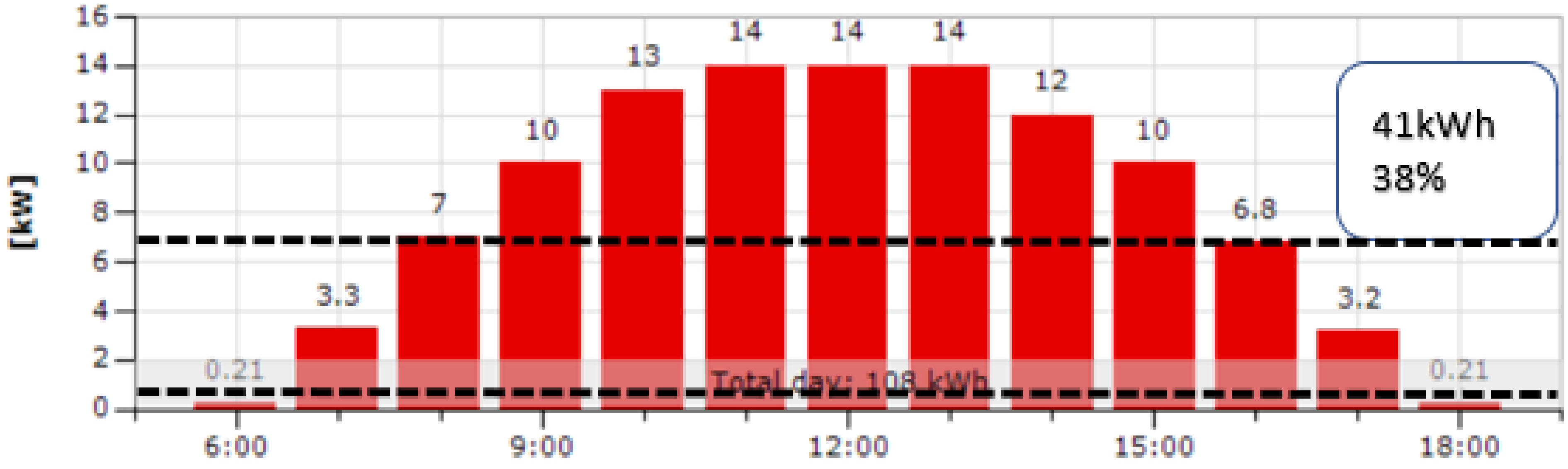


Solar Pumping Scheme : Energy Provided vs Demand



Ethiopian Somali Region – single use Solar Powered Water Scheme





Surplus Energy & Possible Applications

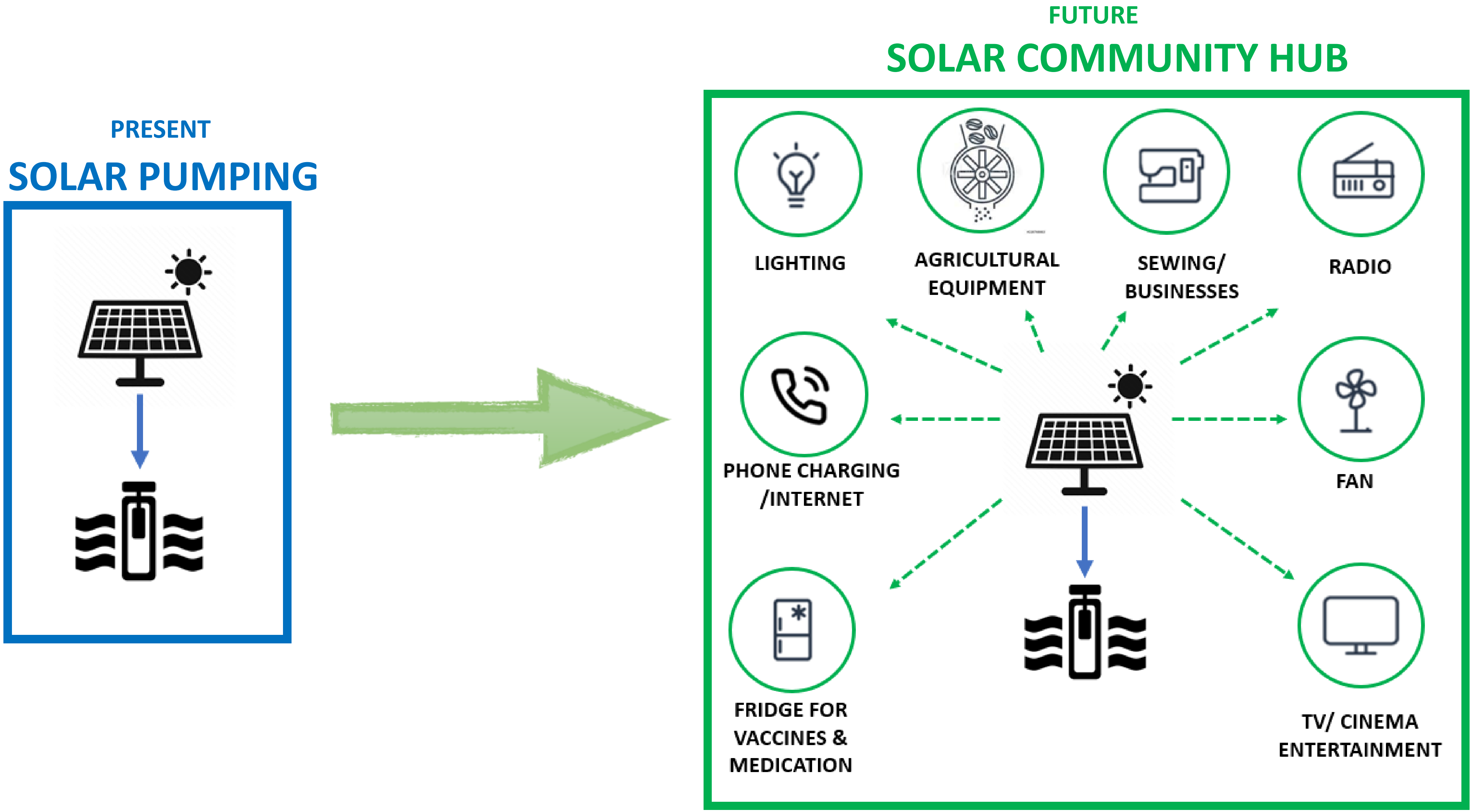
Location	Pump power/ TDH	Remarks	Population served (20lpd)	Solar Panels Ouput (Wh/ day)	Surplus Unused Energy		POWERED EQUIPMENT FOR AVERAGE SOLAR DAY WITH UNUSED ENERGY											Possible Applications	Additional Idle Energy - 1h of pump stoppage
					(Wh/ day)	% of total	Phone	Lights	TV/ DVD	Ceiling Fan	Public Lighting	Desktop / Laptop	Fridge (150L)	Printer	Portable X-Ray	Sterilisation Equipment (20L)	Vaccine Fridge (75L)		
Ethiopia-Jijiga	4 kW/ 50m	Solar handpump	600	9,800	6,063	62%	300 phones	10 x 8 hours	1 x 4 hours	8 x 8 hours								Phones, Community center	15%
Yemen-Saana	5.5 kW/ 100m	Limiting yield	4,000	108,000	69,195	64%	800 phones	800 x 4 hours		8 x 10 hours		5 x 8 hours	2 x 24 hours	1 x 2 hours	1 x 1 hour	1 x 3 hours	1 x 24 hours	Phones, 1 light per HH, Health Center	14%
Nigeria-Mauduguri	7.5 kW/ 80m	No limiting yield	7,500	90,000	9,040	10%	700 phones			2 x 8 hours		3 x 8 hours	1 x 8 hours	1 x 3 hours				Phones, Internet café	91%
Nigeria-Mauduguri	15 kW/ 200m	No limiting yield	7,000	189,000	42,950	23%	3,500 phones				25 x 8 hours							Phones, Public Lighting	40%
Yemen-Saana	30kW/ 200m	Limiting yield	15,000	438,000	108,940	25%	7,500 phones	10 x 8 hours	1 x 4 hours	10 x 8 hours	50 x 8 hours	10 x 8 hours	3 x 8 hours	1 x 3 hours	1 x 1 hour	1 x 3 hours	3 x 24 hours	Phones, Community Center, Public Lighting, Internet Café, Health Center	37%

*Phone 5W (Nokia 3320) , Lights 10W, TV/DVD 75W, Desktop 45W, Ceiling Fan 30W, Fridge (150L) 42W, Printer 10W, Portable X-Ray 150W, Sterilization equipment 2000W, Vaccine Fridge 30W

**Energy losses at charge&transmission estimated at +40%

Source: https://poweringhealth.homerenergy.com/

From Solar Pumping Schemes to Sector Integrated Solar Approach



Integrated vs Separated Water and Energy Approach

ENGINEERING CAPACITY

Thousands of water engineers already deployed at field locations

ALLOCATED BUDGETS

Multi-billion budgets allocated for water porjects every year

MANAGMENT MODELS

Existing established management models and fee collection systems

BETTER ASSET/ RESOURCE USE

More efficient use of equipment and water resource. More options for better social engineering

3-year Road Map…

Maintain

Support for uptake & quality implementation

Dialogue

Establish Market dialogues with manufacturers/ developers

Test

Design and test concept for different applications

Install

New schemes in selected humanitarin settings, M&E

Transfer

Knowledge sharing with WASH actors

Visit TheSolarHub www.thesolarhub.org – Contact: Alberto Ibáñez Llario at allario@iom.int

Presenter

Salvador, Segui Chilet, Polytechnique University of Valencia

Professor at the Polytechnic University of Valencia since 1991 in the Electronic Engineering department. Since 1999 he has given face-to-face training courses in the area of photovoltaic installations, starting in 2010 with the on-line tuition in PV systems. Currently is the director of several courses in PV systems, in Spanish and English (https://www.cursofotovoltaica.com/). He has more than 23 publications in indexed journals, numerous publications in conferences and participates in R&D projects in the field of energy.

Greening humanitarian responses through enhanced Solar Energy harvesting (EnSWPS+LIB22)

EnSWPS+LIB22: project status and goals

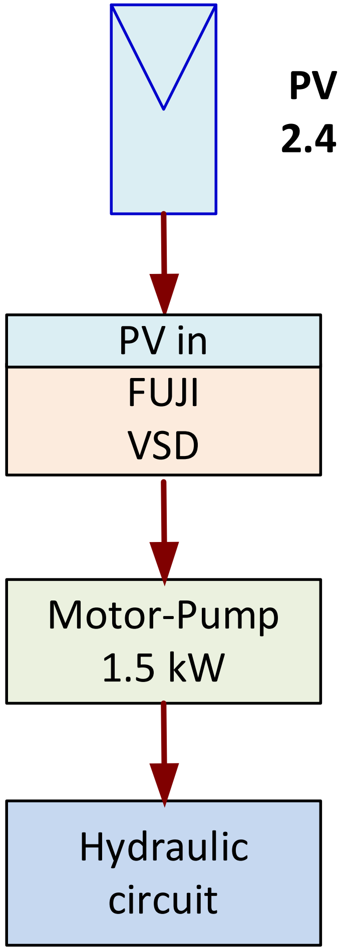
Presenter: Salvador Seguí

PI (principal investigator): Salvador Orts fotovoltaica@upv.es

Presentation of the R&D team

- Six professors from the Polytechnic University of Valencia working in Electronic Engineering and in Agronomic and Environmental Engineering (short biography available at https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9775673).
- Next incorporation of a support researcher to the project with the aim of developing a doctoral thesis within the framework of this project.
- Previous experience in R&D contracts with companies in the areas of renewable energy monitoring, electronic converters, pumping systems, photovoltaic pumping, irrigation and hydraulic systems, etc.
- Extensive experience in courses on PV systems and PV water pumping systems (https://www.cursofotovoltaica.com/en/solar-powered-water-systems/).

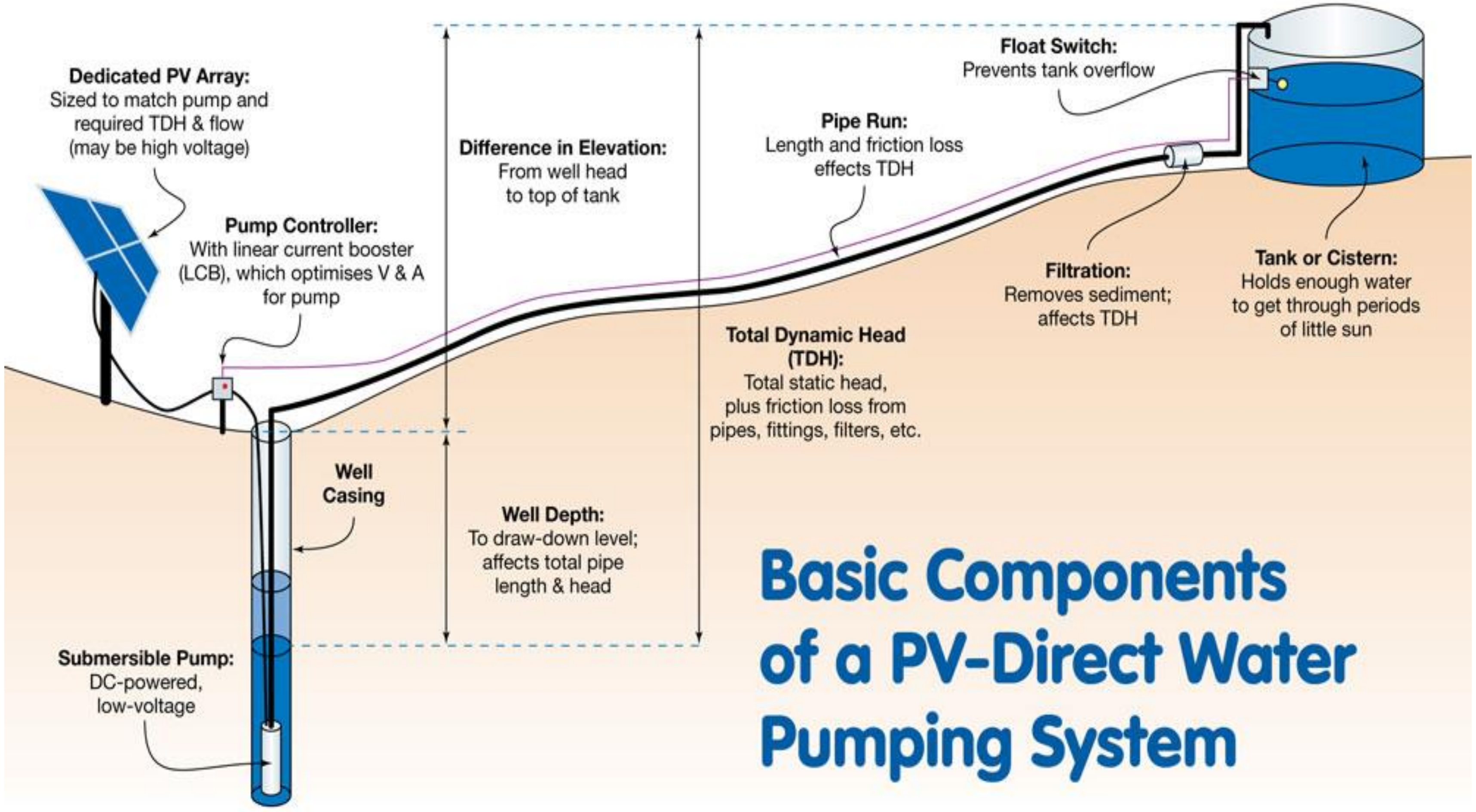
Direct photovoltaic water pumping system components (DPVWPS)



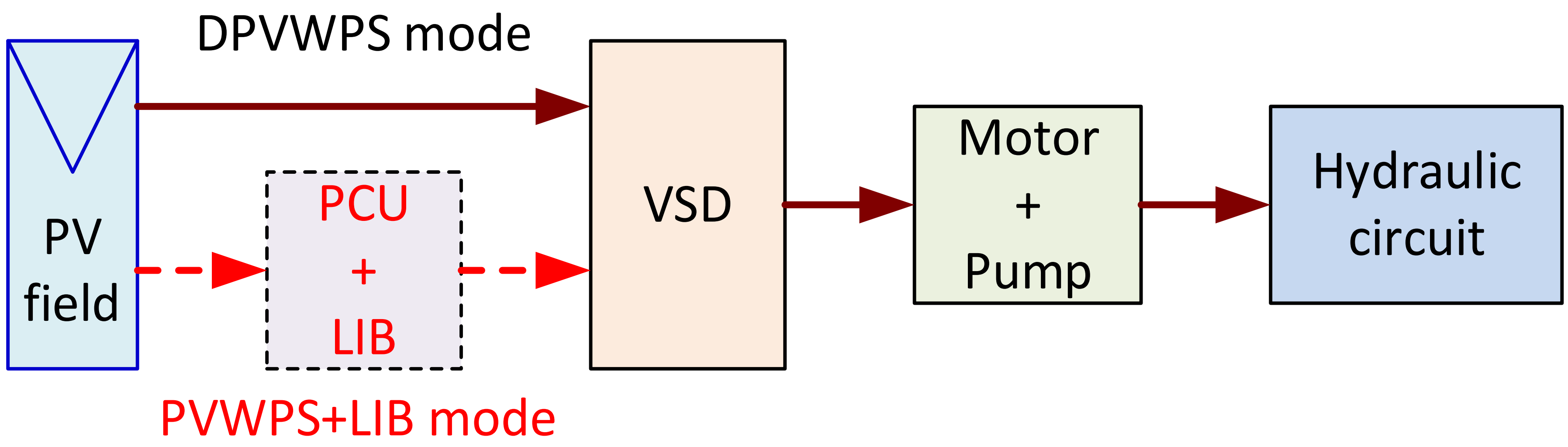
PV field
2.4 kW$_{pk}$

Atersa - EASY SUN PUMP
ESP-2,2/230-IP20-F200
Variable Speed Drive
(DC/AC converter)

Submersible pump
Three-phase motor



Battery-based PVWPS vs Direct PVWPS



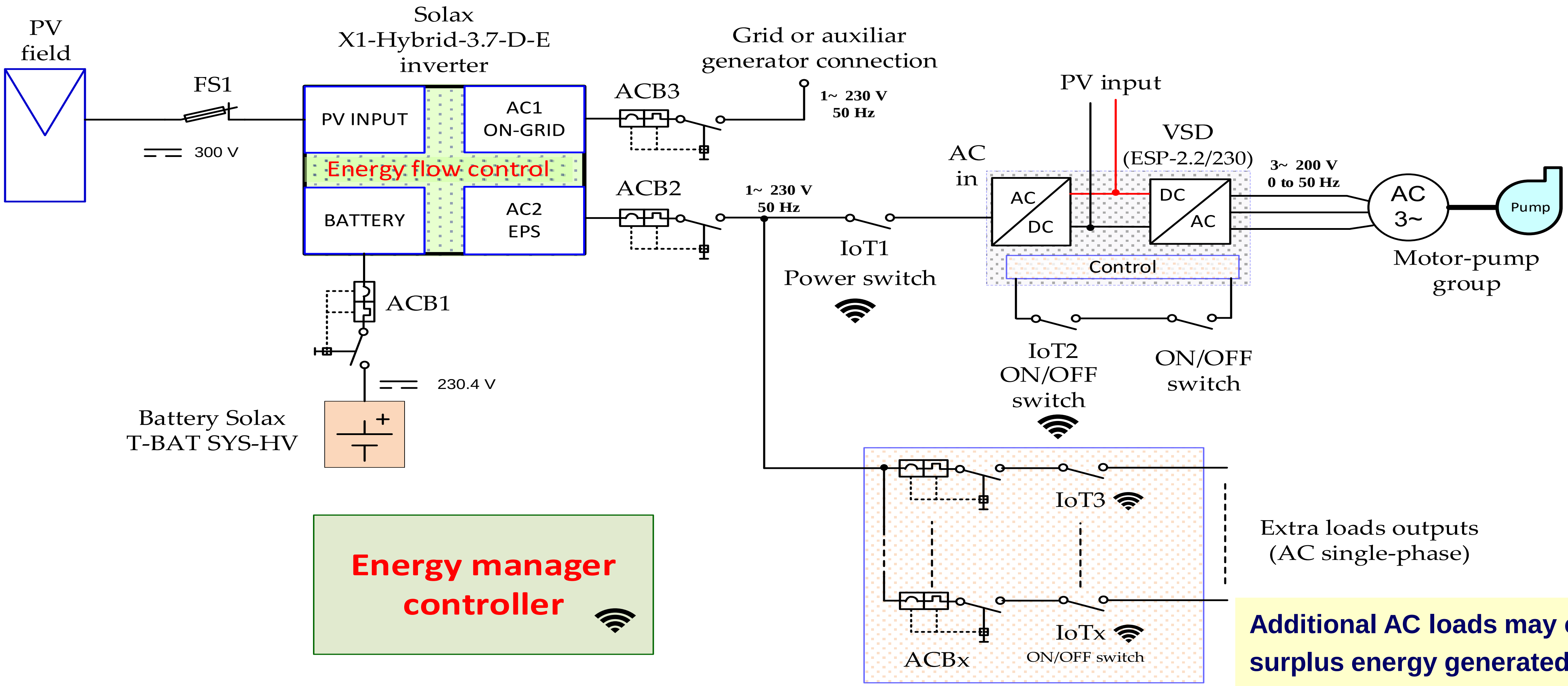
The main disadvantages of PVWPS with batteries are:

- **Reduction in the efficiency of the overall system.**
- **Capital costs higher than equivalent DPVWPS'.**

The main advantages of PVWPS with batteries are:

- **Improved coupling between the PV generator and the motor-pump group, with a PV generator operating in the MPP for a wide range of irradiance levels.**
- **The current required for start-up and normal operation of the motor can be supplied continuously.**
- **The pump will operate longer, and so a higher volume of water could be provided if needed.**
- **The system prevents pump stop/start cycles caused by the passage of clouds.**
- **Energy not used for pumping can be used for other purposes: lighting, battery-banks recharge, etc.**

Layout of the R&D facility



Additional AC loads may consume the surplus energy generated that is not immediately needed for pumping water.

Why is the battery needed in the hybrid solution?

- While in the direct PVWPS the PV power is balanced by the power delivered to the motor (where the voltage, current and operating frequency of the motor are controlled by the variable speed drive).
- With the hybrid inverter working in off-grid mode (and without battery), the connection of additional AC loads (where we cannot control the power demand and can only control if they are connected or not) would cause unbalances in the energy flow between PV field and loads.
- The battery manages these power unbalances by charging with surplus energy and discharging when there is an energy deficit in the system (energy buffer), thus ensuring that the PV field can always be on the MPPT and that the back-up AC output has all the power required by the consumptions (pumping and additional loads).

EnSWPS+LIB22: project-related facilities

Parts of the facility

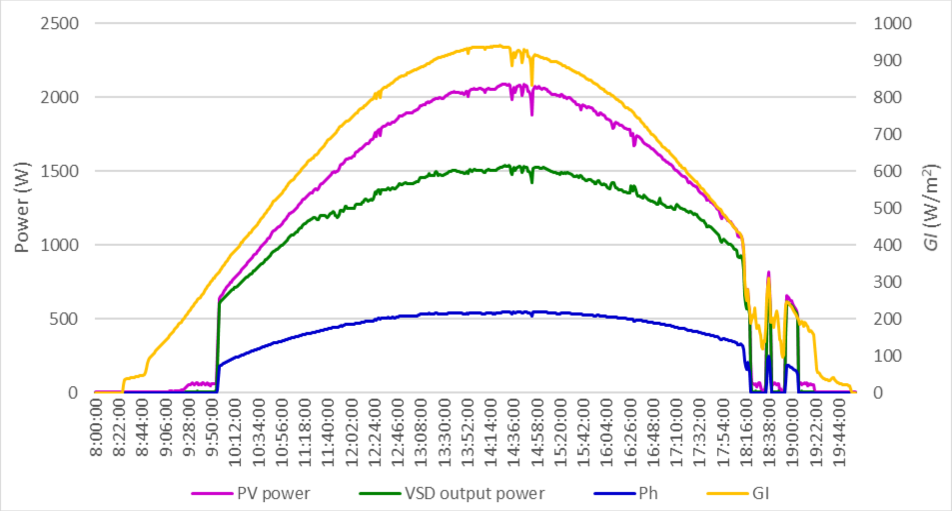


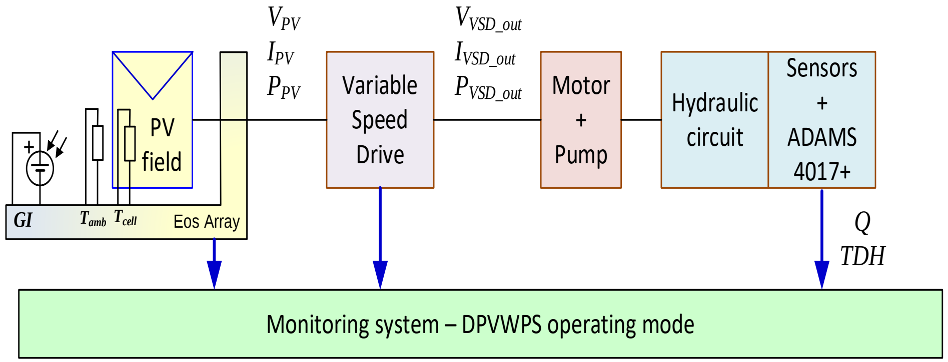

- **PV field with 2.4 kW_{pk} (up to 3 kW_{pk} for PVWPS+LIB)**
- **Hybrid inverter with off-grid operation (GW3648D-ES from GoodWe and X1-Hybrid-3.7-D-E from Solax).**
- **Lithium-ion batteries: LG RESU3.3 (3 kW@3.3 kWh@48 V) and SOLAX T-BAT SYS-HV (3,5kW @ 11,5kWh @ 230 V) .**
- **Direct PVWPS: Atersa ESP-2,2/230-IP20-F200 (2,2 kW)**
- **Monitoring system based on Eos Array and UWP3.0 from Carlo Gavazzi and open-access SW.**

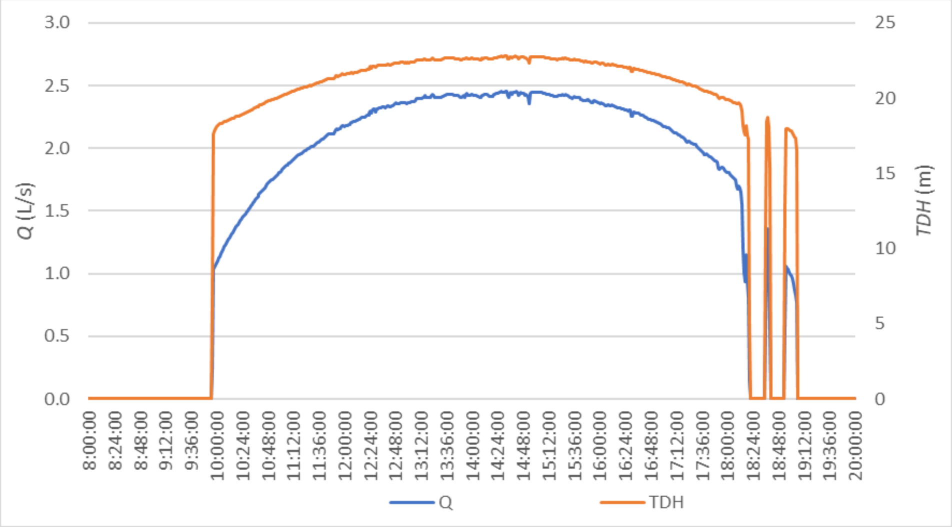
More information and results in open-access articles

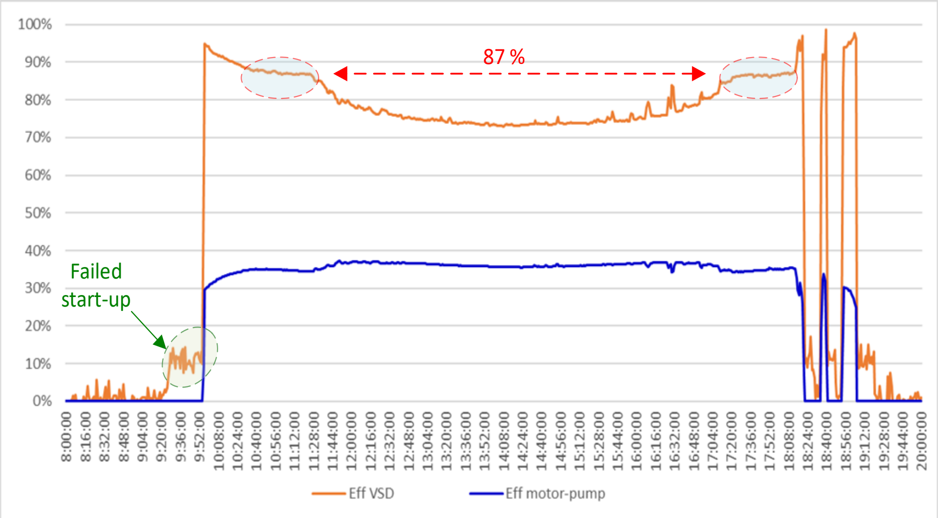
- Energy Efficiency Optimization in Battery-Based Photovoltaic Pumping Schemes (2022 - IEEE Access - https://ieeexplore.ieee.org/document/9775673).
- Photovoltaic water pumping: comparison between direct and lithium battery solutions (2021 - IEEE Access - https://ieeexplore.ieee.org/document/9483902)
- PV monitoring system for a water pumping scheme with lithium-ion battery using free open-source software and IoT technologies (2020 - Sustainability - https://www.mdpi.com/2071-1050/12/24/10651/htm)

Direct PVWPS: first results (article in Sustainability journal)

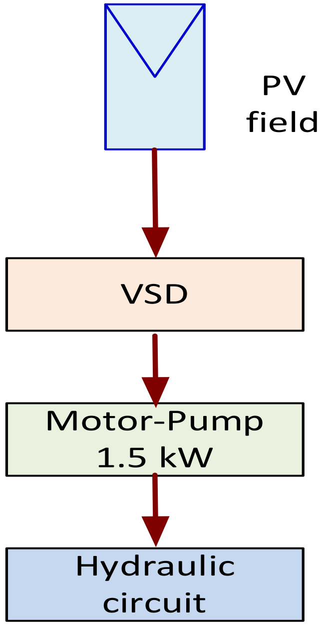


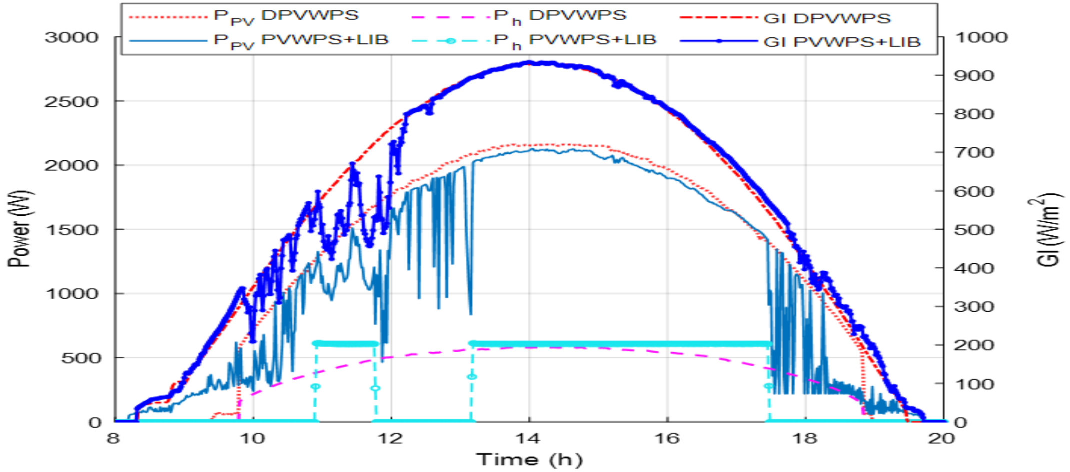


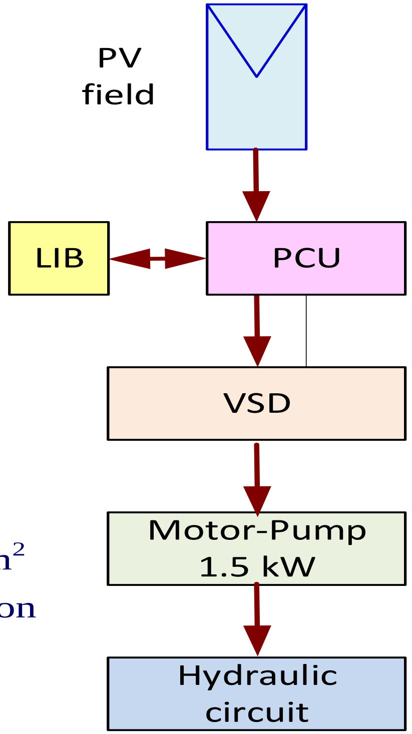




PVWPS: comparison between direct and battery-based solutions (IEEE Access)







Q is variable with *GI*
Pumping if $GI>GI_{threshold}$
Cloudy days→ start/stop cycles
Average PR: 27.9 %
Average efficiency: 27.8 %

Q is constant
Pumping if $GI>GI_{min}\approx 10$ W/m^2
Cloudy days→ normal operation
Average PR: 21.7 %
Average efficiency: 24.8 %

DPVWPS ⟷ PVWPS+LIB

Q_{min} =1 L/s at 30 Hz ($GI_{threshold}$)
Q_{max} =2.59 L/s at 50 Hz (rated conditions)

Q = 2.59 L/s at 50 Hz
(constantly at rated conditions)

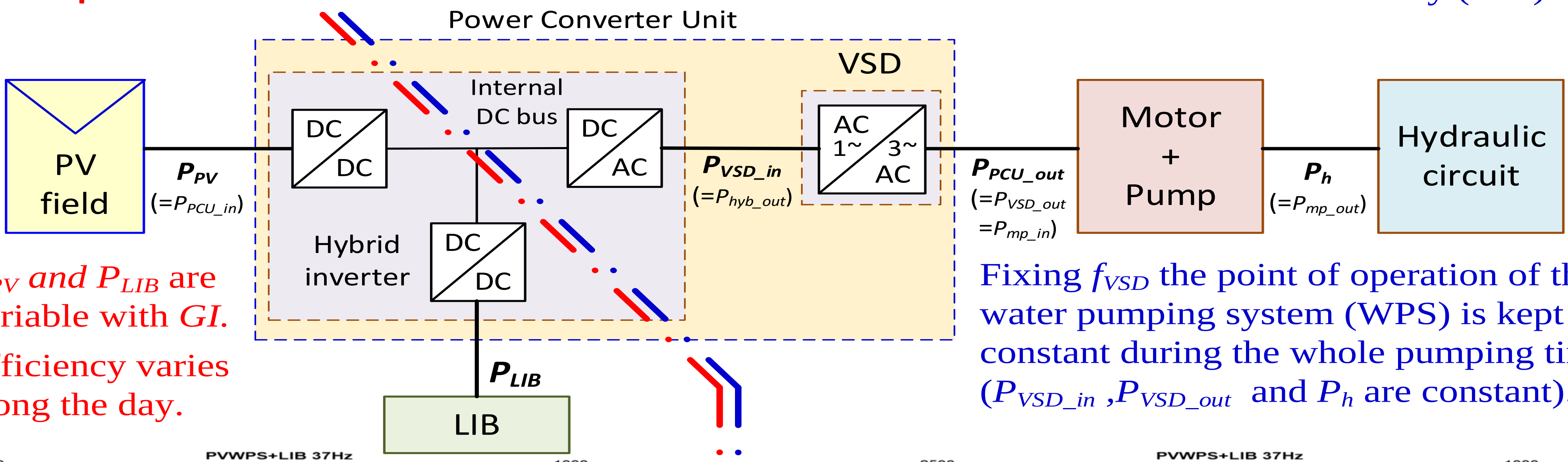
Problems in the MPPT decrease average PR of the battery-based solution

Energy efficiency optimization in battery-based PVWPS (IEEE Access)

PV source and storage: variable power

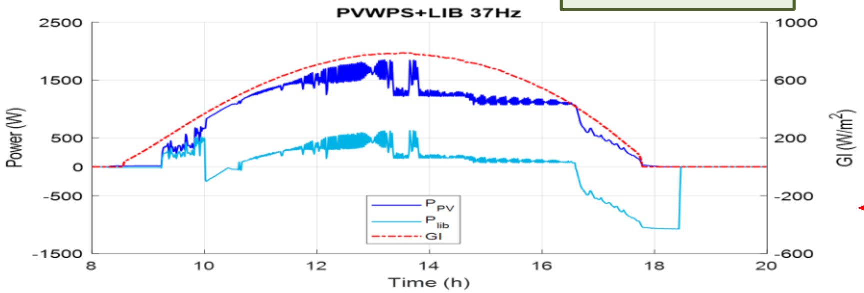
WPS section: constant power

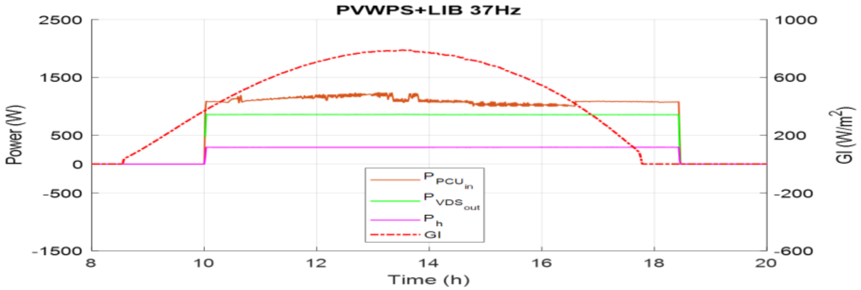
- The WPS best efficiency point can be set by means of f_{VSD}.
- The WPS best efficiency point ensures a better use of the lithium-ion battery (LIB).



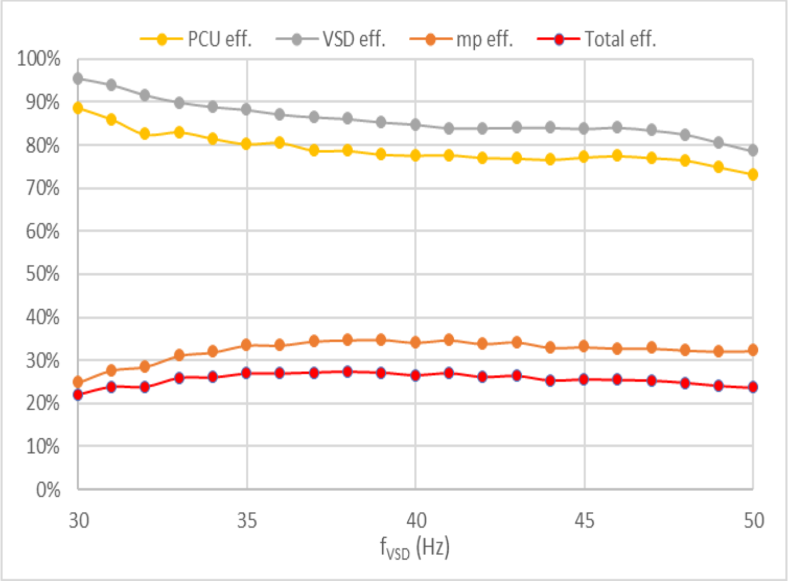
- P_{PV} and P_{LIB} are variable with *GI*.
- Efficiency varies along the day.

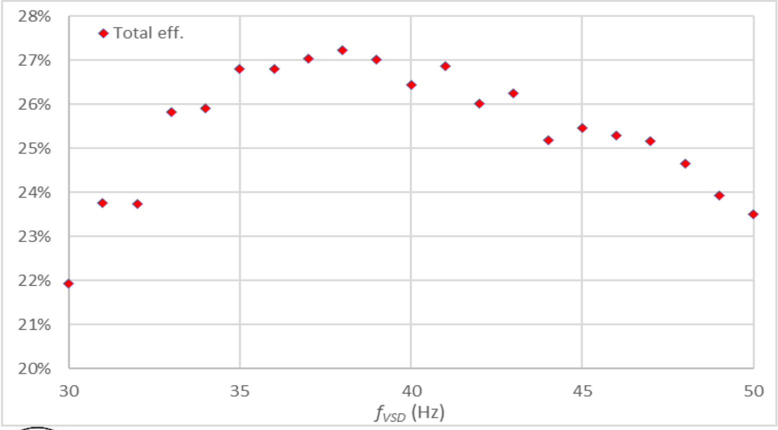
Fixing f_{VSD} the point of operation of the water pumping system (WPS) is kept constant during the whole pumping time (P_{VSD_in} ,P_{VSD_out} and P_h are constant).

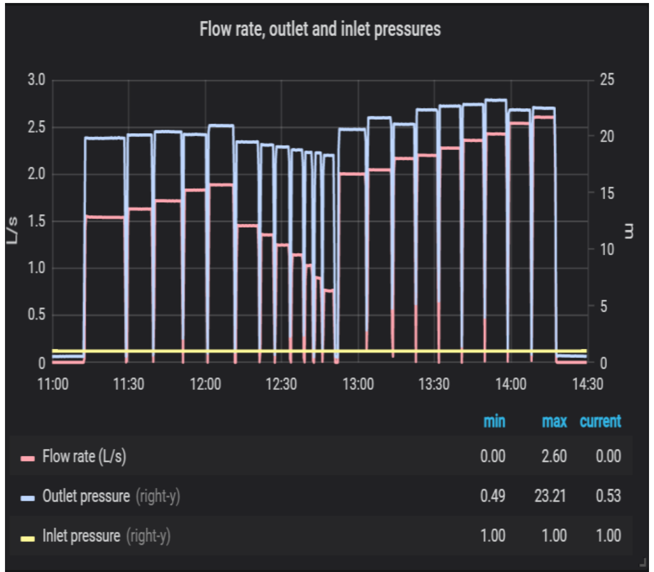


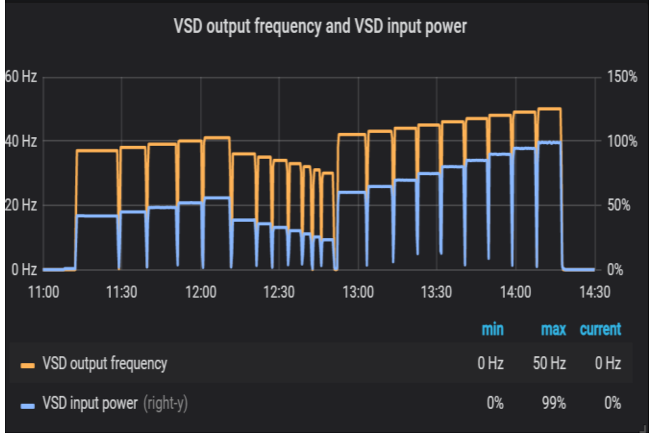


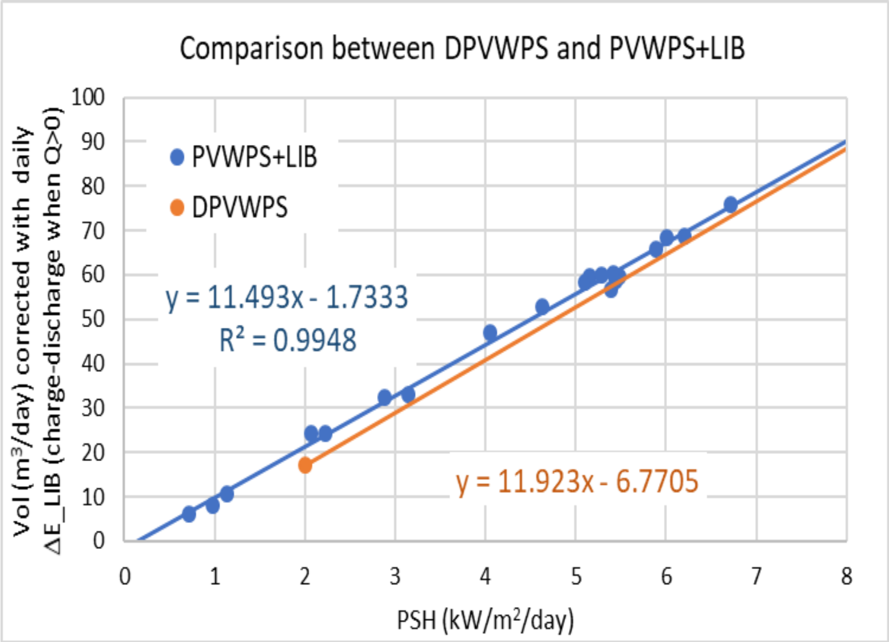
Energy efficiency analysis in battery-based PVWPS with Solax hybrid inverter





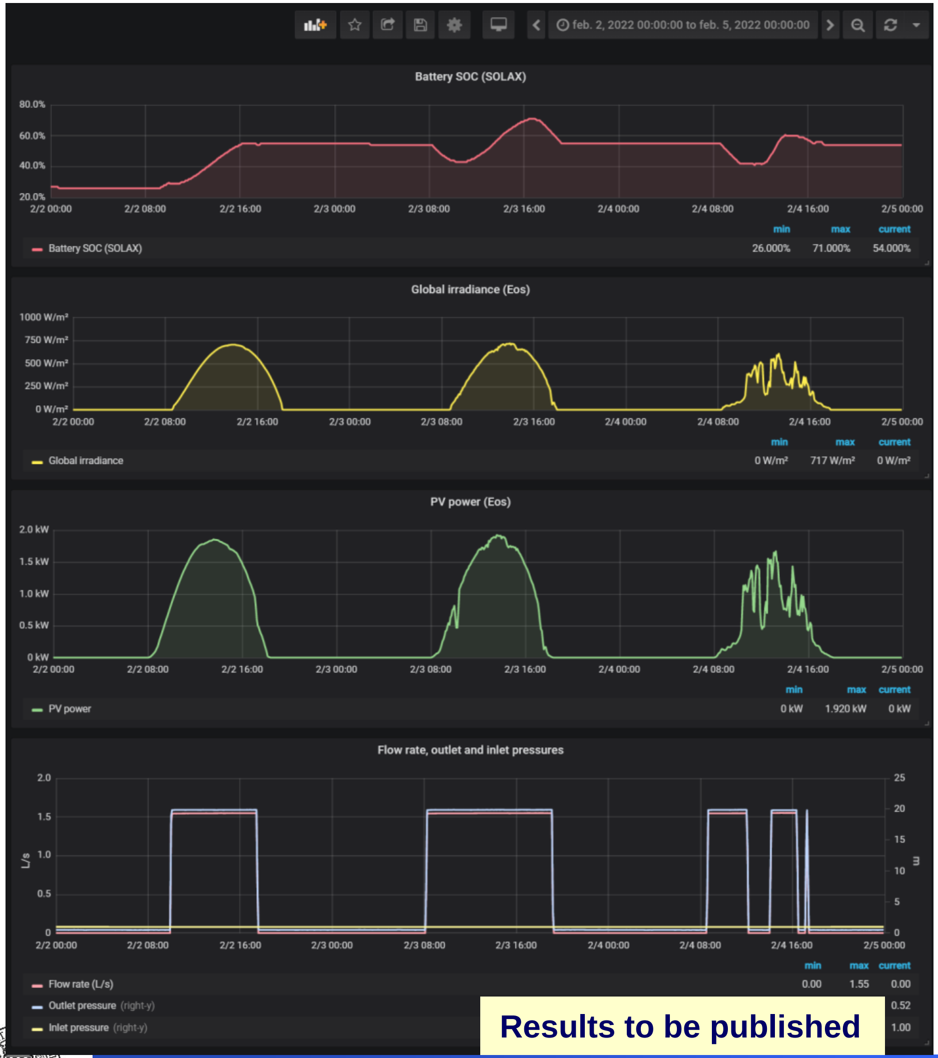






Results to be published

First results of the battery-based PVWPS with f_{VSD}=37 Hz



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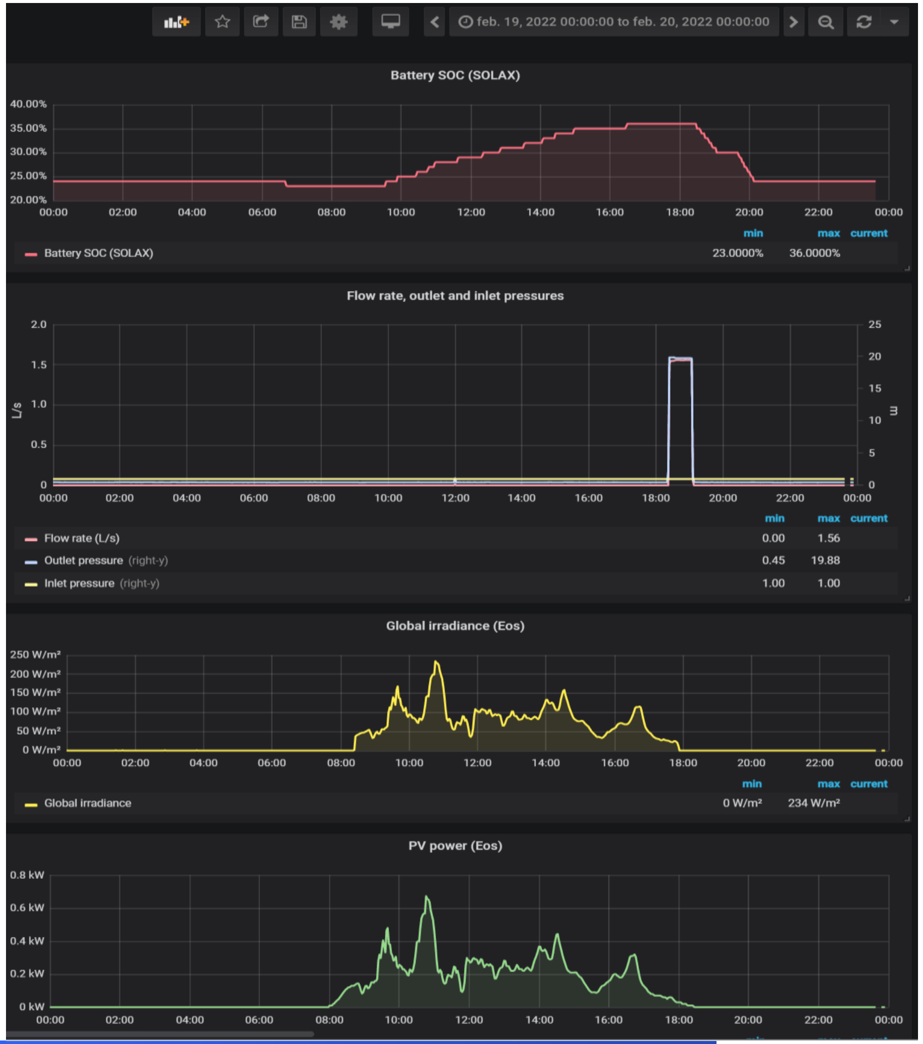
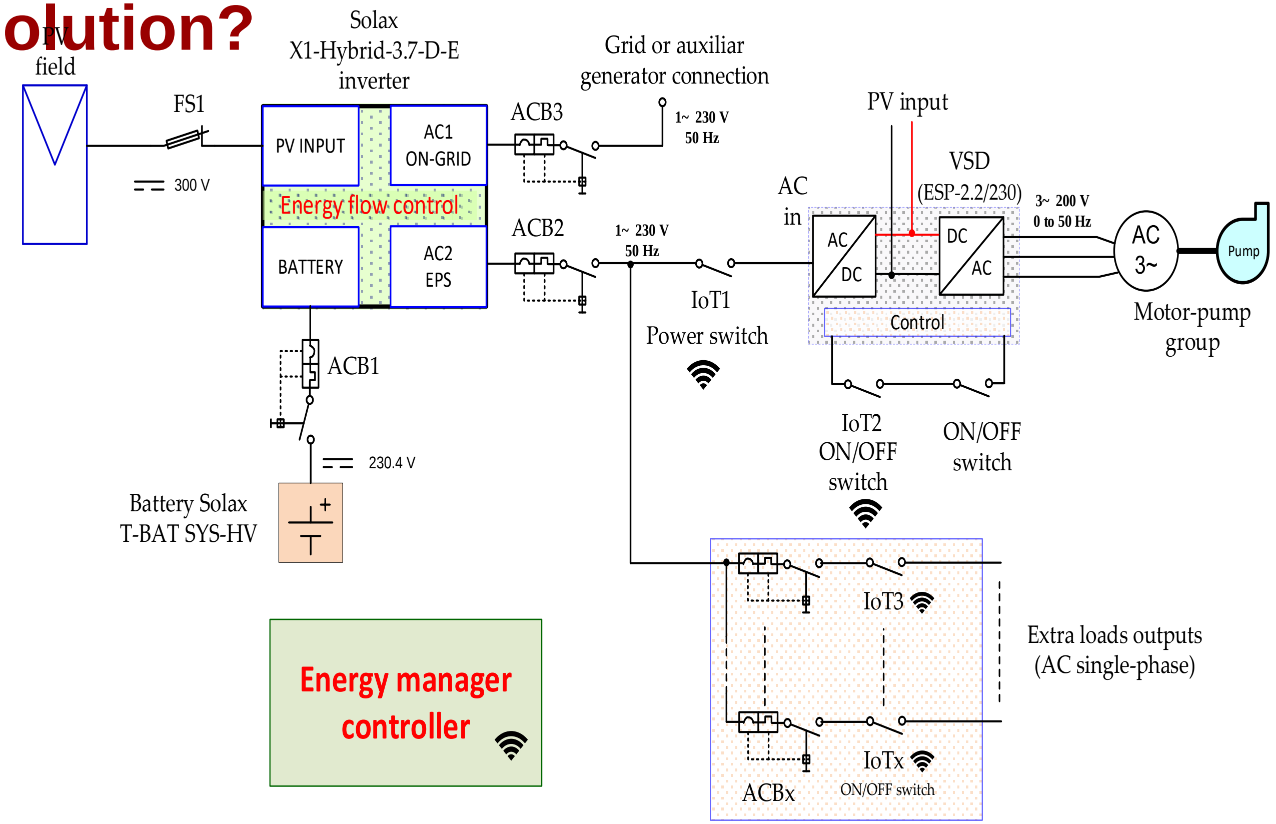


Where are we focusing our research at the moment?

- **Which types of existing DPVWPS could be transformed to a battery-based solution?**
- **How much energy is not used by the pump during the year (and can be used by other loads)?**
- **How can we improve the overall efficiency of the system to make more surplus energy available?**
- **How can we use this energy for other purposes?**

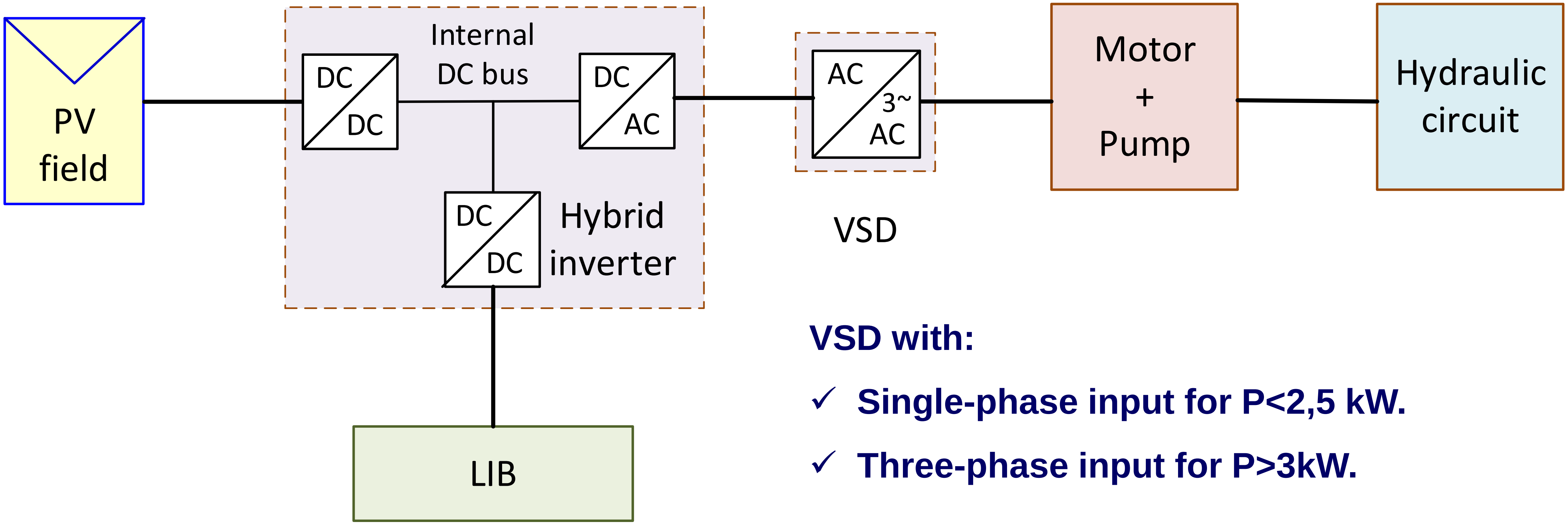
Open to establishing new win-win partnerships related to the implementation of the project: funding, pilot testing of the system in the field, testing of new converters with higher power, etc.

How are we planning the PVWPS+LIB solution?



- **Use of existing commercial solutions for easy implementation in the field conditions.**
- **Compatibility of PV field for the two solutions (direct and battery-based PVWPS).**
- **Simple assembly that can be retrofitted to existing systems.**
- **Inclusion of an energy manager to establish surplus energy and manage its use.**
- **Take advantage of the characteristics of hybrid inverters to expand the PV field and increase the available surplus energy.**

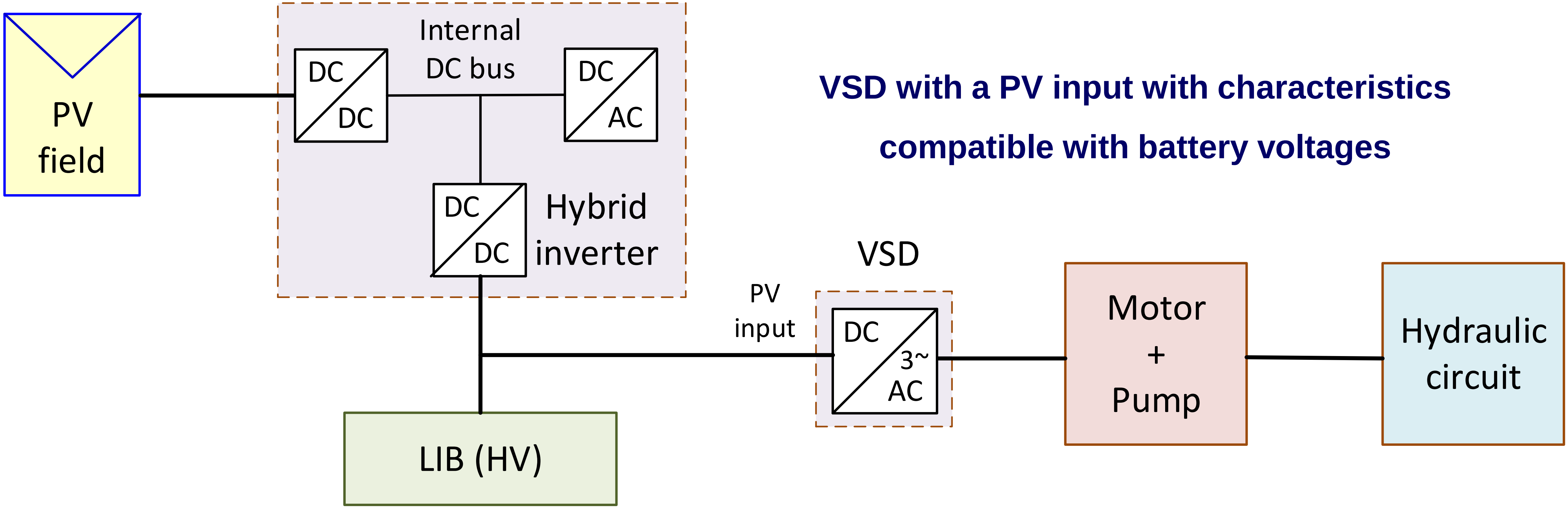
Approach 1: AC bus solution for WPS facilities



VSD with:

- ✓ **Single-phase input for P<2,5 kW.**
- ✓ **Three-phase input for P>3kW.**

Approach 2: DC bus solution for WPS facilities



VSD with a PV input with characteristics compatible with battery voltages

Greening humanitarian responses through enhanced Solar Energy harvesting (EnSWPS+LIB22)

The end
EnSWPS+LIB22: project status and goals

Presenter: Salvador Seguí

PI (principal investigator): Salvador Orts fotovoltaica@upv.es

Q&A

Thank you

- **Feedback: info@energypedia.info**
- **Survey link: https://forms.gle/aFfCnxPtAASJspnTA**