End of Master Project at the Western Norway University of Applied Science in Bergen



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icam

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Introduction

Passive houses are buildings where the energy supplied comes only or mainly from renewable energy sources. This type of design is growing rapidly because it makes it possible to limit its environmental impact, to be self-sufficient in energy or to provide energy in places isolated from any electrical network.

Most passive houses in service or under development are houses equipped with solar panels. As solar technologies market and related research are expanding, the Western Norway University of Applied Sciences (HVL University) has invested in a solar laboratory, equipped of a passive house with solar photovoltaic and thermal panels.

During my fifth year at Icam, a general engineering school, I did my final dissertation in the solar laboratory at HVL University. My missions were oriented around the development of the passive house. The purpose of this report is to give an account of what I have achieved during my semester.







Missions

The passive house is the laboratory's showcase. It allows the researcher and the students to work on their studies. Therefore the installation must be adaptable to different situations and has to be understandable by everyone.

The passive house is originally a mobile home that was designed and transformed by different students working under the direction of the HVL University laboratory's researchers.

The system will work with 3 inverters "SMA sunny boy", 1 battery unit and 3 firefighter switches from Santon. 12 crystalline technology and 14 thin flexible technology panels will harvest the solar energy. Each panel is equipped with Tigo Optimisers, which actually are Maximum Power Point trackers (MPP Technology). The system optimization process, by changing the load characteristic, maintains the power transfer at the highest efficiency.

The whole system will be related to a cloud connect controller from the same company; it is a compact, powerful data logger and the communication hub of the Tigo smart platform. It powers the monitoring and safety skills of Tigo smart modules.

To have a general idea of the power production, here is a simple calculation: each crystalline panel is supposed to produce 285W and each thin technology panel can produce about 120W. So, the total energy harvested can be 12*285 + 14*120 = 412 kW in standard test condition.

Solar lab Logo

My first task was to finalize the creation of a logo for the solar laboratory.

The old logo was obsolete : its message as well as its aesthetics were no longer relevant.

The Icam student in the previous semester had come up with an interesting idea that has been conceived from images found on the Internet.

To improve and finalize this logo, I decided to learn how to use "Adobe Illustrator" software, vector graphics software, to come up with a cleaner logo



solconditi
AGRICAMPEGGIO CORTE COMOTTO

After a discussion with my research supervisor, Richard Grant, I created two versions of the logo (see below). The first will be the original version used for presentations and a second version with a thicker font so that the writing can be read if the logo is used smaller (By example a thumbnail).





Then I realised that the name "Solar Lab" is in English language only. The translation in Norwegian is "Sol Lab". I worked on a solution to integrate both languages in the logo without weighting it down. I modified the suffix "ar" in small and different colour letters, to make the name readable in English as well as in Norwegian.





Display Sunny boy

Needs

The solar laboratory is equipped with 3 *Sunny Boys* of the SMA brand. They are inverters which allow the management of the various solar panels of the passive house. Since this house is intended to be the laboratory showcase for the HVL University, it must be able to show the work of the passive house. For this purpose, the laboratory wants to create a dynamic display that can show production data, energy consumption (etc.) in real time.

The goal is also to be able to create a database which references the data of the 3 *Sunny Boys* in a single database and which can be used for the laboratory.

The technical choice

At first, I made the choice to study the use of a Raspberry card for the creation of this dynamic display.

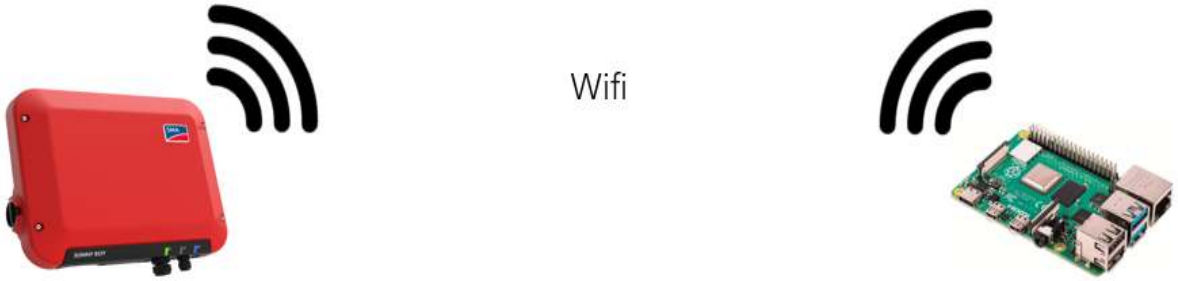
Advantages:

- Easy to find
- Popular programming language
- Powerful
- Great adaptability to different possibilities

I chose not to use an Arduino card, because this card is not powerful enough to make a dynamic display. Then I chose not to use the "Lab view" software suggested by an employee of the solar laboratory, because the programming language is not well enough known by the various students to work on this dynamic display.

Program

The *Sunny Boys* are equipped with a Modbus TCP transfer protocol to communicate data, which takes place via a WLAN connection.



The modbus is processing using a protocol: the *Raspberry pi* card retrieves information from the *Sunny Boys* via the protocol by indicating the information below:

Modbus TCP:

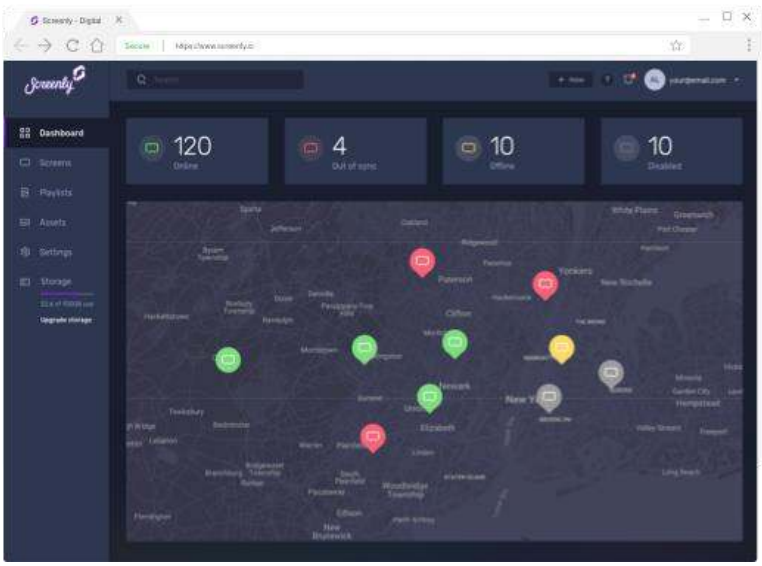
- Device name
- IP address
- Port
- Unit ID
- Serial number
- Register

The registers are preregistered in *the Sunny Boys*. To choose the information you want to retrieve, you must use the Registrer file (extract below)

Inverter.WLim	30231	2	U32	FIX0	RO	40241	WRtg
Inverter.WMax	30233	2	U32	FIX0	RO	-	-
Operation.Evt.EvtNo	30247	2	U32	FIX0	RO	40690 40670 40650 40628 40226	DCEvt DCEvt DCEvt Evt Evt1
Metering.TotWhOut	30513	4	U64	FIX0	RO	40303 40210	ActWh WH

The interface

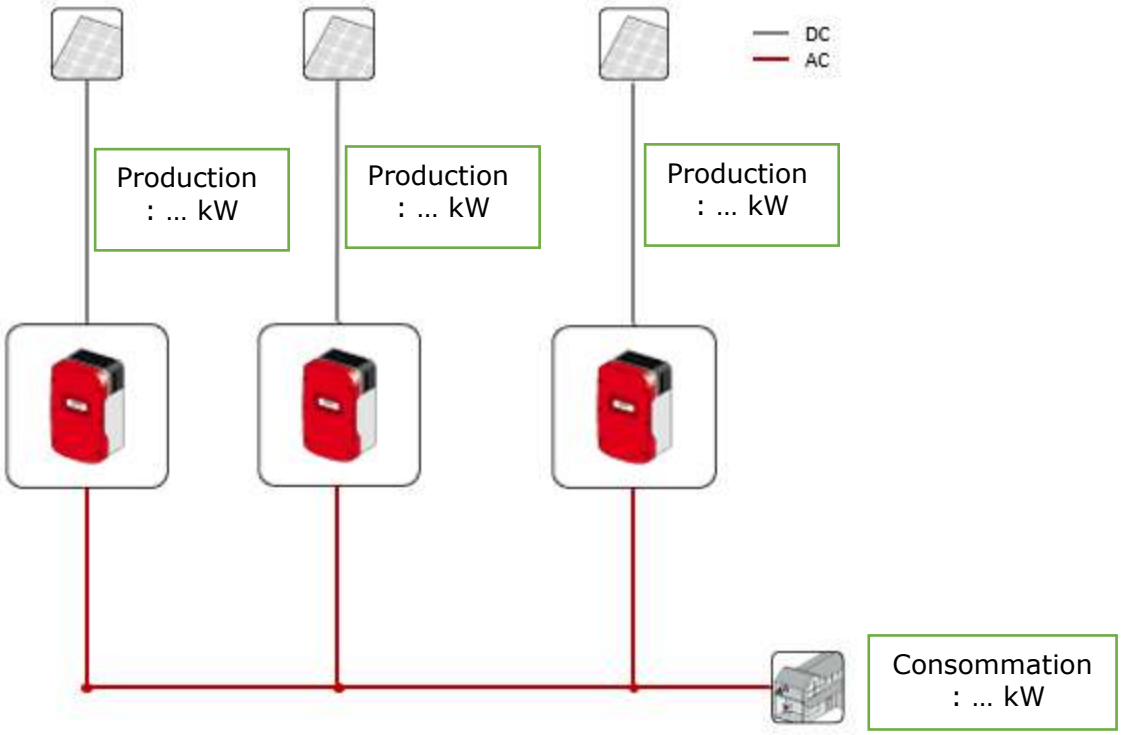
I suggest for the interface to work with applications that help to create a simple and ergonomic dynamic display. The "Screenly" app is a free app that works with Raspberry cards.



First, the dynamic display would display a screen with the following information:

- Daily / weekly energy production (depending on the different types of solar panels)
- Graph showing the evolution of production throughout the day
- Graph showing the evolution of production over the year
- Economic gain made by the resale of surplus energy

Secondly, we can create a display with the diagram of the installation of the house, showing the energy flows.



The Database

The solar lab needs an internal database to study data from their various solar panels. The database must store the data recorded by the 3 *Sunny Boys* in a single database to be able to use the information from the entire installation.

To create the database and store a large amount of data over a long period (several years), you can use applications like *In-fluxDB* or *Grafana*.

Sunny Island

As the passive house is being created, the solar laboratory seeks to improve it and continues research on the use of renewable energy.

One of the university's avenues of research is the development of an internal network in the passive house in which several sources of renewable or so-called green energy are used such as wind turbines, a hydroelectric plant or a hydrogen plant.

The passive house is already equipped with 3 *Sunny Boy* inverters of SMA brand that transform the energy supplied by the various solar panels in the laboratory into energy usable in the house (DC current to AC). To go further, we have carried out research on the possibility to install another equipment of the brand, the *Sunny Island*.

What is it? What is the point?



The *Sunny Island* is an inverter charger from the SMA brand. Its utility is to manage the electrical energy balance in an isolated site network. It is a system for optimizing self-consumption or an emergency power supply system.

The product is suitable for indoor and outdoor use in an area protected from the bad weather. The environmental conditions prescribed for the product must be always observed and the equipment must be used in a stationary system.

Usefulness:

- Receive external AC sources
- Charge the battery from AC source
- Supply the AC loads from the battery
- Create the AC side network

Technical characteristics

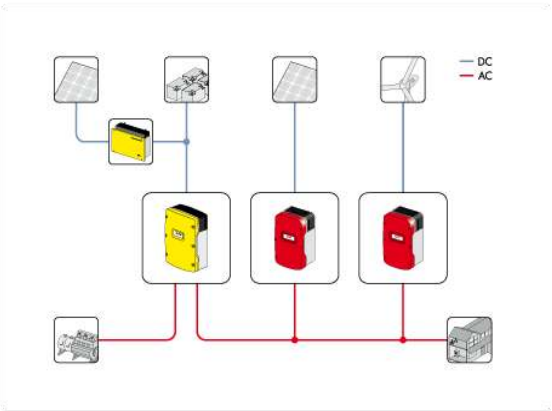
- Extended warranty period: 10 years
- Use of standard Ethernet and WLAN interfaces
- Optimized data logging for maximum transparency, even without permanent online access
- Flexible implementation (professional or private)
    - Isolated network / connection to the national network
    - Possibility of retrofitting and modular expansion for single-phase and three-phase systems from 1 to 30 kilowatts
    - For different batteries
    - Scalable with SMA technologies for systems from 20 to 300 kilowatts

Solar Lab needs

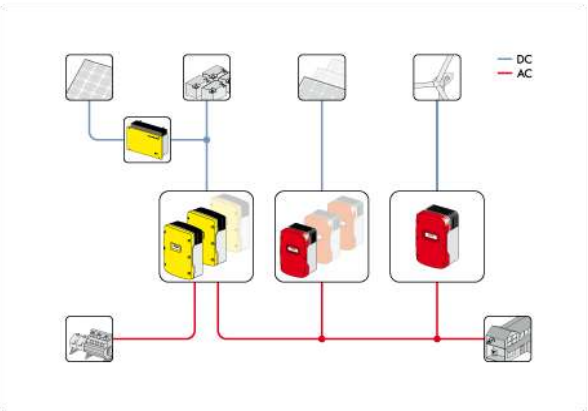
The *Sunny Island* must meet scientific and technical needs.

Scientifically, the solar laboratory wishes to develop by integrating a hydrogen station into its isolated network in order to compensate with green energy the fluctuations in energy production of solar panels due to the presence or absence of sun.

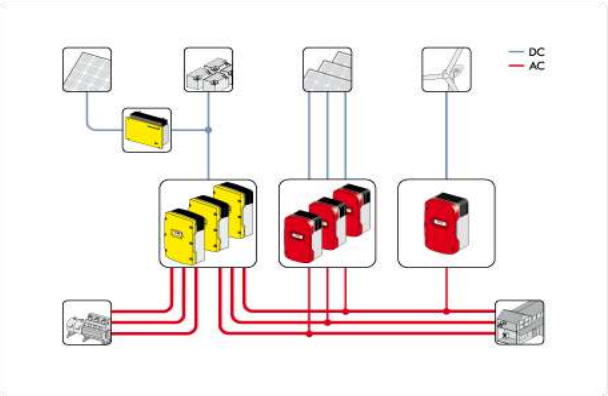
Technically the laboratory is subject to certain constraints due to the installation, but also to Norwegian standards. In particular, the installation must not exceed 3KWatt, because beyond that, the standards would require controls and facilities that the university does not have. For this purpose, we paid attention to the device of the *Sunny Island*.



Single, single-phase
SI 4.4M, SI6.0H and SI 6.0H for systems from 1kW to 8kW.



Singe cluster, single-phase
Up to three SI 6.0H or SI 8.0H inverters can be coupled in parallel in one phase for systems from 3kW to 24kW.



Single cluster, three-phase
Three SI 4.4M, SI 6.0H or SI 8.0H battery inverters can be connected each one to one phase to build a 3-phase system from 5kW to 24kW.

We have therefore chosen to study a single-phase system, which responds to the 3KWatt constraint while allowing the 3 *Sunny Boy*s already present in the passive house to be connected.

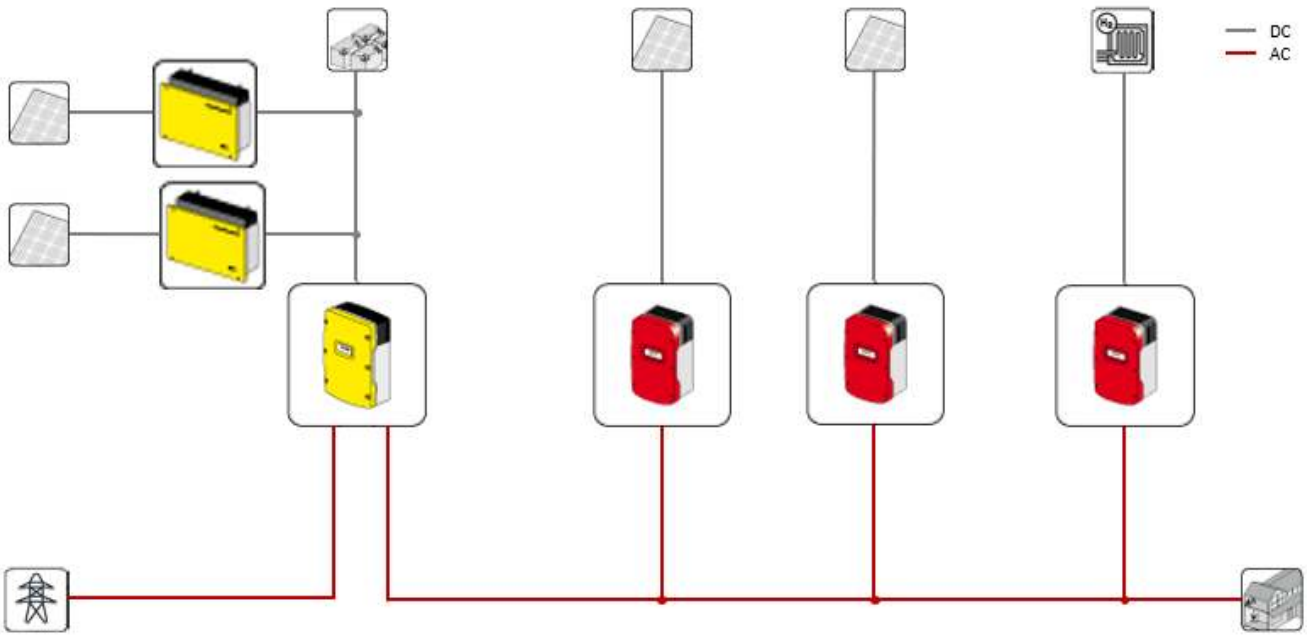
Diagram (laboratory scenario)

On the picture below, there is a diagram of a possible local grid installation within the solar laboratory.

The *Sunny Island* is central in the installation; it manages all the equipment.

The *Sunny Island Charger (40)* is an inverter, which transmits energy to the batteries without going through the Sunny Island to avoid energy losses due to the DC / AC change. The *Sunny Island Charger* has an extended voltage range at the DC input, allowing intelligent system configuration for almost all photovoltaic panels.

The *Sunny Boys (1.5/2.5)* are inverters designed for photovoltaics. They allow management of energy consumption from the installation's solar panels. In this installation, it also makes it possible to transform the DC current which supplies the panels into AC current which can be used by the house.



Equipment operation

The *Sunny Island* can be configured using an application accessible on a smartphone or tablet.

This application makes it possible to monitor the data recorded by the equipment as well as to choose the operating parameters by adapting to the overall installation, to the various equipment and to the energy sources of the local network.

The photo below is an overview of the application.



Then, the *Sunny Islands* could be configured in the app of the equipment to meet the needs of each situation. In fact, the management of the *Sunny Island* is done by programming (which explains the fact that there is not so much cable connection on the equipment).

The first programming that must be done in the configuration of the equipment, it is the battery management. The *Sunny Islands* have safety systems to prevent full battery discharges and optimized charging.

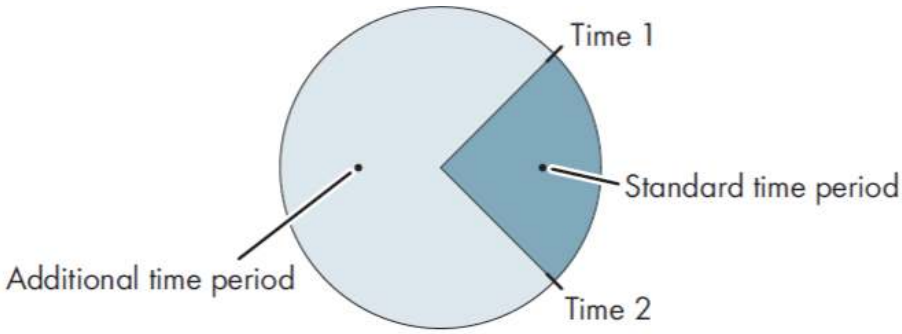
- SMA FLEXIBLE STORAGE

The *SMA Flexible Storage System* is a battery storage system that optimizes self-consumption of PV energy by the following measures:

- Intermediate storage of excess PV energy with the *Sunny Island*
- Visualization of PV system data in *Sunny PortalSYSTEM*

- Setting Time-Dependent Functions

Time-dependent functions, such as time-dependent load shedding, split the day into two time periods. You specify the time periods using two points in time. The standard time period starts with time 1 and ends with time 2. The additional time period starts with time 2 and ends with time 1,



- Setting Time-Controlled Functions

For time-controlled functions, you set the start time, duration and repetition type.

- Configuring the Energy Meter

You can add an energy meter to your PV system or replace an existing energy meter.

- Determining the Battery Capacity

Manufacturers state the battery capacity depending on the discharge time. In the installation assistant and in parameter Rated battery capacity, the battery capacity for a ten-hour electric discharge is always specified.

The following…

The reflexions about the *Sunny Island* are still in the early stages. Before we can start concrete action, there is still some research to be done. Particularly about the hydrogen station and its insertion into an isolated grid managed by a Sunny Island because it is a system that has never been implemented before.

Difficulties

This "Erasmus" semester at the University of Western Norway University of Applied Sciences was special. Indeed, Norway has closed its borders in January due to the COVID19 pandemic, and I had to carry out my entire semester by home office, from France.

This setback proved to be binding. Not being able to go there or discover the team that was working in the solar laboratory hampered my understanding of how the passive house works, and what had to be done in the laboratory. Information was difficult to obtain in order to analyse the needs and carry out my assignments.

In addition, in teleworking, I could not benefit from the local equipment to work concretely on solutions for digital display, which considerably hampered my ability to work.

This semester was rewarding from the standpoint of learning about solar technologies as applied to passive houses, but the lack of direct contact with the lab, with technicians and researchers, and with students at the university prevented me from advancing the passive house project as I had hoped.



Conclusion

In conclusion, this semester at the Solar Laboratory at HVL University was a difficult time. After postponing my departure several times, in the hope of a relaxation of the rules that would allow me to travel to Norway, I had to overcome the disappointment of doing a distance Erasmus. The difficulties in discovering the mission, understanding the issues, and providing significant added value within the laboratory were all the more important.

However, I discovered part of the work environment of a research laboratory and more particularly the field of solar technologies. Not having studied the subject during my training at Icam, my curiosity was aroused, especially since the market for solar technologies is growing rapidly and will probably be more and more present in private homes, as well as in industry, in the coming years.

As the passive house of the University of Bergen is under development, the research for potential to be exploited is still to be developed and could give rise to a lot of interesting Erasmus (provided you can enter Norway!)

