REACT
Renewable Energy for Self-Sustainable Island Communities

MPC for a single-family house with a heat pump and PV installation

Laura Zabala Urrutia (Tekniker)
laura.zabala@tekniker.es

Tekniker
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

30/09/21

SUSTAINABLE PLACES 2021
Sep. 28 - Oct. 1, 2021 | Rome, Italy

This project has received funding from the H2020 programme under Grant Agreement No. 824395

REACT

Renewable Energy for Self-Sustainable Island Communities

REACT is a 4-year research project funded by the EU's **Horizon 2020** programme.

Its objective is to **achieve island energy independency** through maximal **exploitation of renewable energy** sources, its optimal utilization by managing the energy consumption and available storage assets via **demand response platforms**, and **engaging end-users** as key players in a local **energy community**.

CONSORTIUM PARTNERS

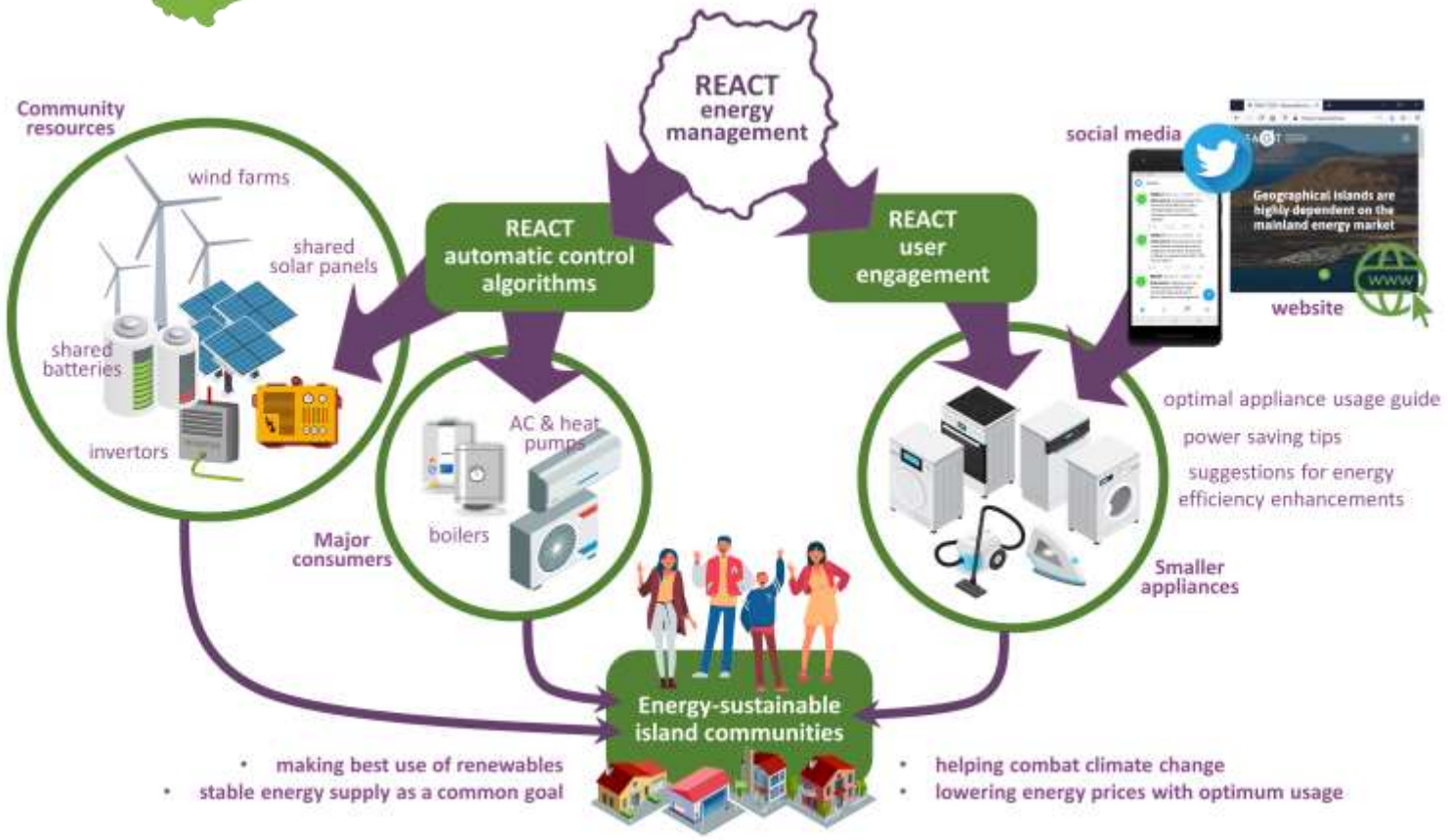
Coordinator: **VEOLIA**

R2M SOLUTION · UNIVERSITÉ DE LA RÉUNION · seai · Teesside University · Tekniker · Udaremi Gaitzaketa · UPPSALA UNIVERSITET · VEOLIA · ORDUÑA · NUI Galway OÉ Gaillimh · MITSUBISHI ELECTRIC · MP Institut Mihajlo Pupin · MIDAC · Fraunhofer ISE · fenie energia · UNIVERSITY OF THE AEGEAN · cielpa · AIT Austrian Institute of Technology · albufera · COMUNE DI CARLOFORTE · comet · Electrochaea · ESB NETWORKS

https://react2020.eu/

REACT

Renewable Energy
for Self-Sustainable
Island Communities



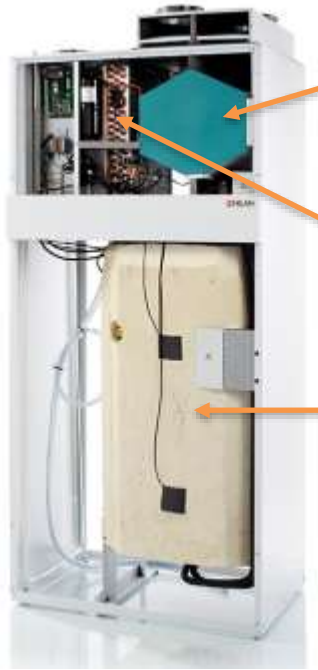
MPC development for the energy management of a single-family house with a heat pump and PV installation.

Single family house case study

Twin installation to one in La Graciosa island.
Single family house certified with the *Passivhaus* standard (*Enerphit*).

Nilan Compact P single HVAC equipment

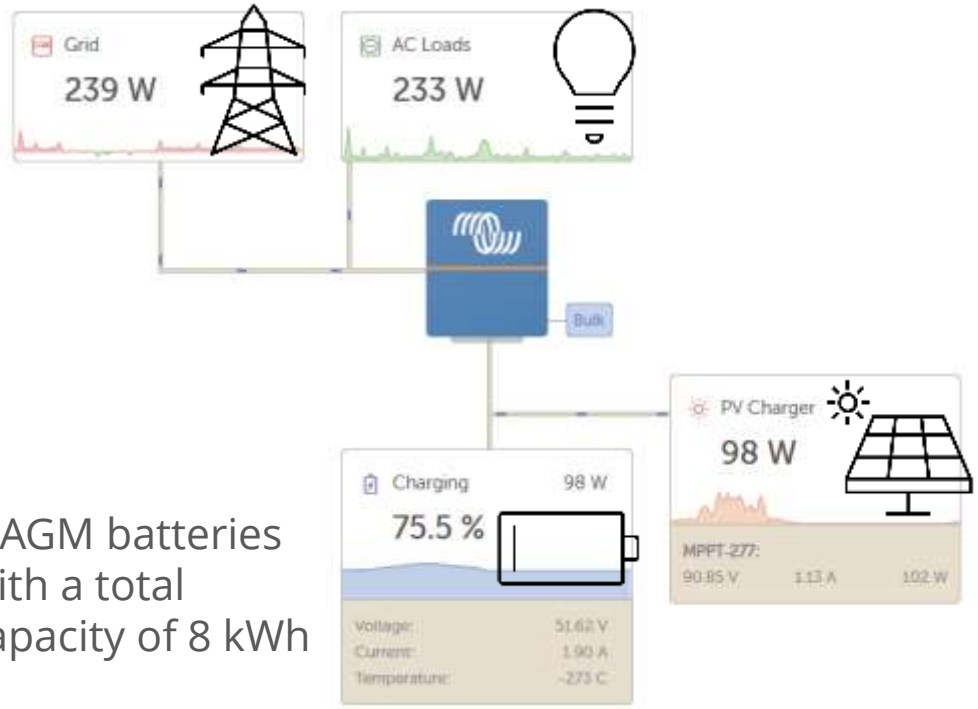
- Ventilation
- Heating + Cooling (ventilation)
- Hot water



https://en.nilan.dk/en-gb/frontpage/solutions/domestic-solutions/compact-solutions/compact-p

Single family house

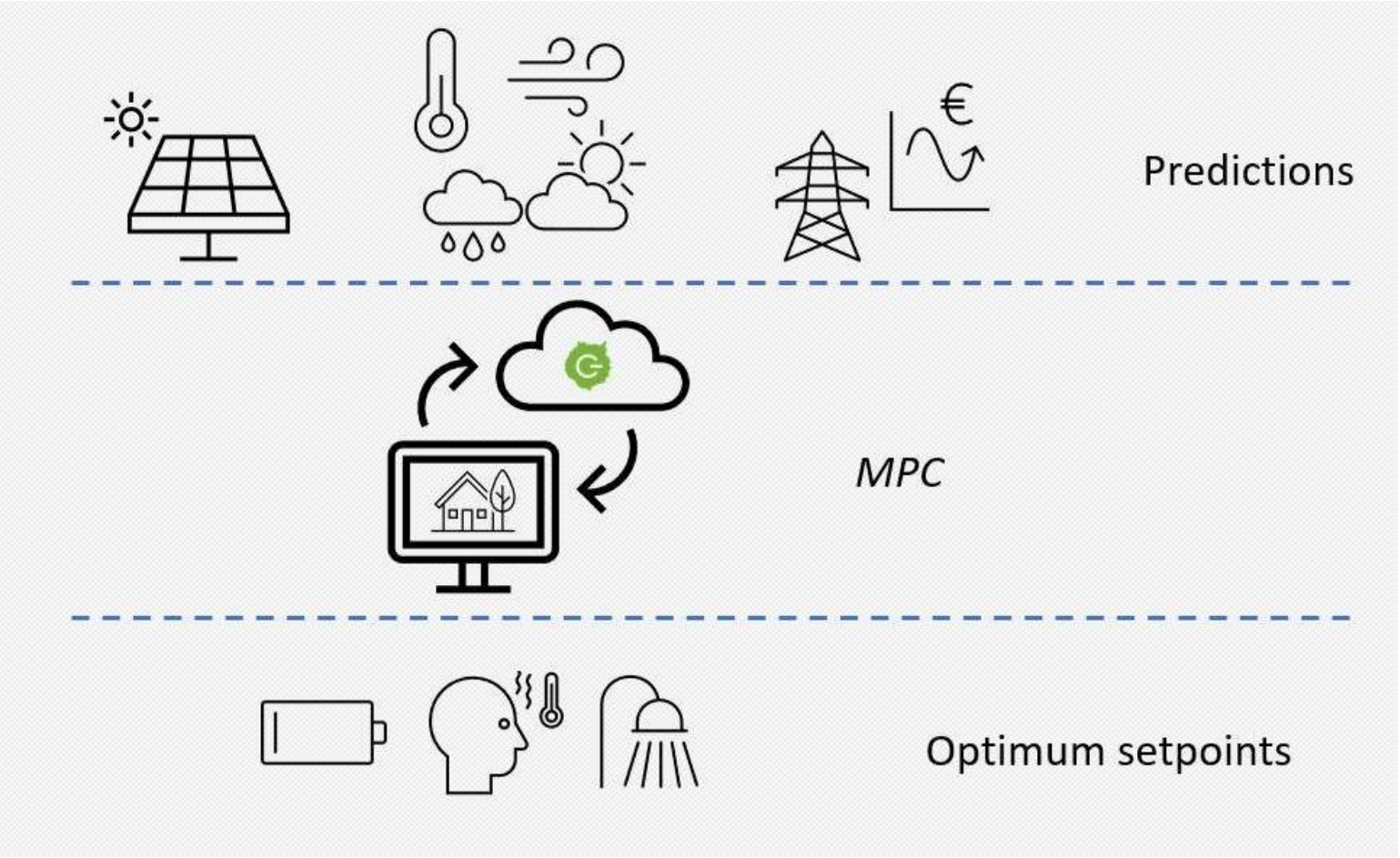
PV installation



4 AGM batteries with a total capacity of 8 kWh

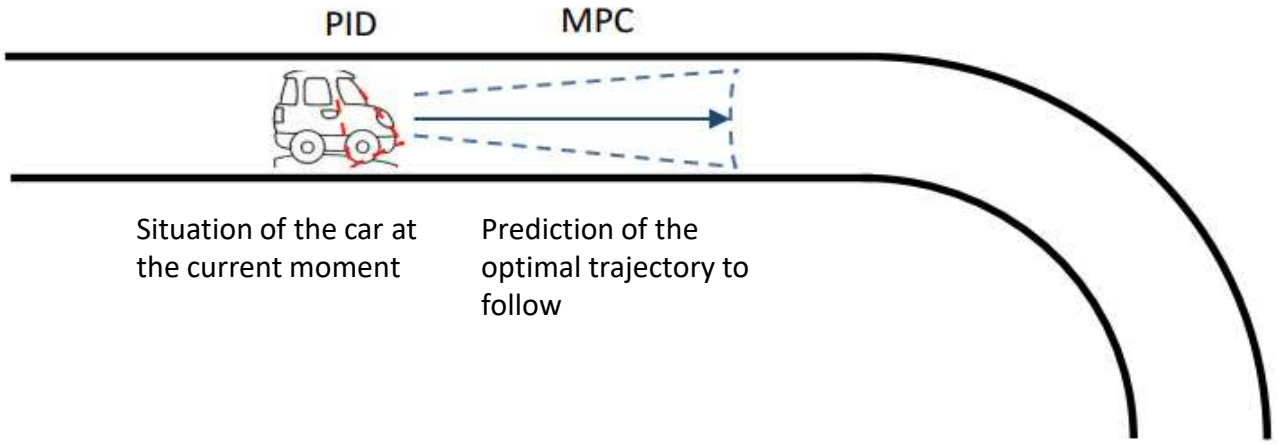
6 PV p-Si panels with 2010 Wp

MPC for a single family house



MPC concept

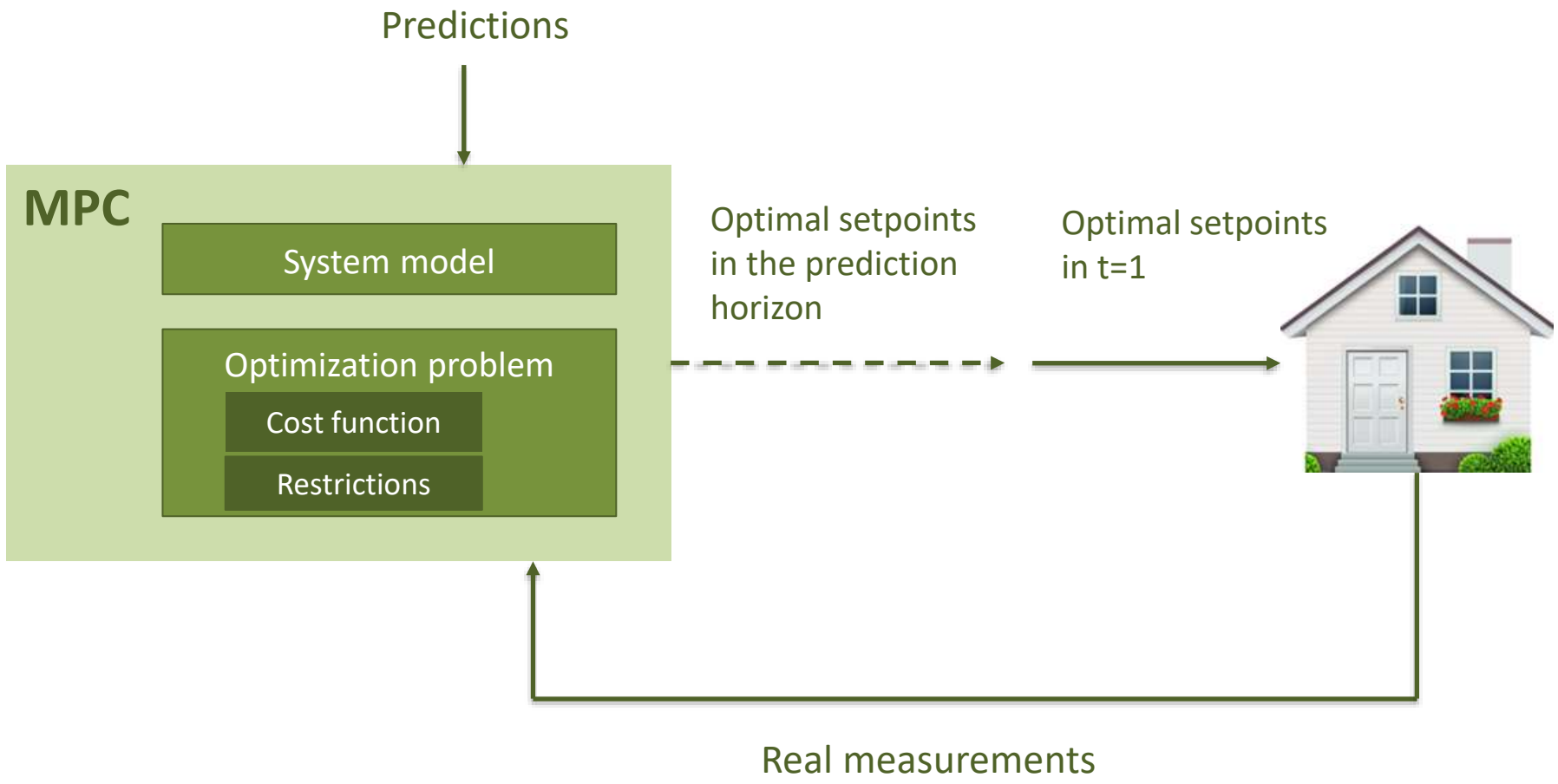
- What is an ***Model Predictive Control*** (MPC)?



- Conventional controllers (PID) → correct the **current error**
- MPC → minimizes the **future error**

Very powerful for Buildings control

MPC concept


Predictions
MPC
System model
Optimization problem
Cost function
Restrictions
Optimal setpoints in the prediction horizon
Optimal setpoints in t=1
Real measurements

MPC objectives

The main targets of the MPC are:

Assure **thermal comfort** inside the house

- **ISO 7730** standards
- Indoor **temperature** and **relative humidity**

Minimize the **electric consumption cost**

- **Variable energy tariffs** considered
- Self-consumption of **PV production** boosted

MPC predictions

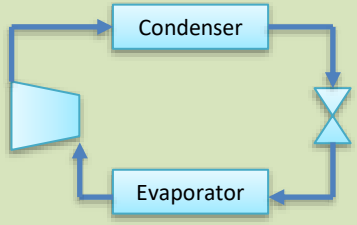
MPC input predictions

Weather predictions	Energy tariff	PV production	Electric demand	DHW demand
				
External weather predictions service	External service	Machine learning models based on weather predictions and historic production data	Machine Learning models based on historic consumption data	Machine Learning models based on DHW consumption data

MPC's system model

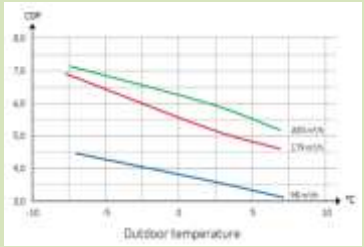
COMPACT P equipment

Physical model



+

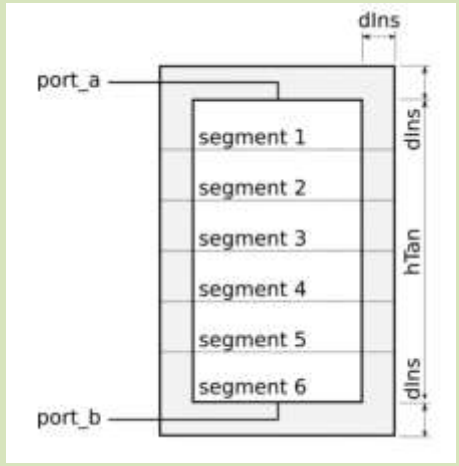
Performance curves (manufacturer)



DHW tank

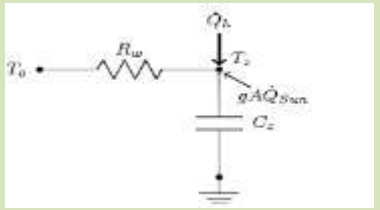
Modelica Buildings Library

Stratified tank model



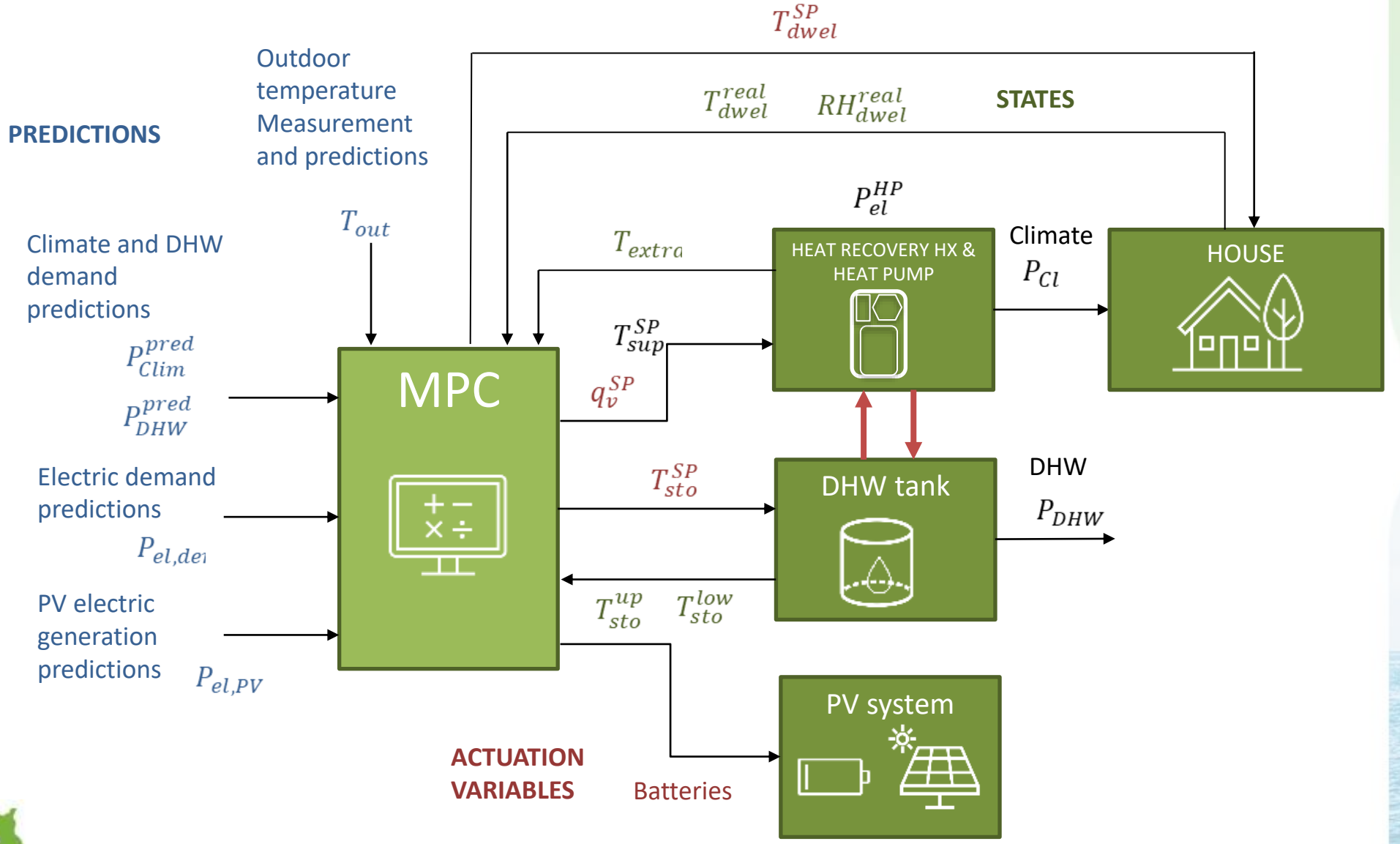
House

R-C simplied models



Calibration with information from the BIM

MPC scheme


T^{SP}_{dwel}
Outdoor temperature Measurement and predictions
T^{real}_{dwel}
RH^{real}_{dwel}
STATES
PREDICTIONS
P^{HP}_{el}
T_{out}
Climate and DHW demand predictions
T_{extra}
HEAT RECOVERY HX & HEAT PUMP
Climate
P_{Cl}
HOUSE
T^{SP}_{sup}
P^{pred}_{Clim}
MPC
q^{SP}_{v}
P^{pred}_{DHW}
T^{SP}_{sto}
DHW tank
DHW
P_{DHW}
Electric demand predictions
$P_{el,dei}$
T^{up}_{sto}
T^{low}_{sto}
PV electric generation predictions
$P_{el,PV}$
PV system
ACTUATION VARIABLES
Batteries

MPC INTEGRATION

The MPC runs on the REACT platform, through which all communications are also carried out.

INPUTS

Influxdb
Real-time measurements of HP, dwelling…

MySQL
Predictions for the next 24h
- Weather
- PV production
- Electric demand

OUTPUTS

mqtt
- Ventilation mode
- Dwelling inside temperature SP
- Storage tank temperature SP

Undergoing work

Collecting data from the installation in the study case house

Baseline scenario definition: to estimate the savings

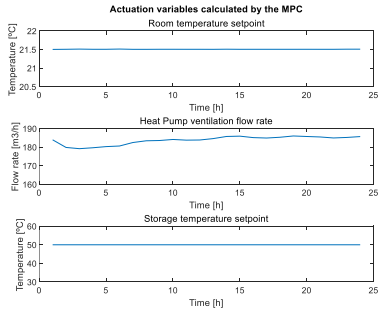
Train the **Machine Learning models** (PV production, electric consumption, correct performance curves)

Data from the Nilan equipment and the indoor conditions of the house

Undergoing work

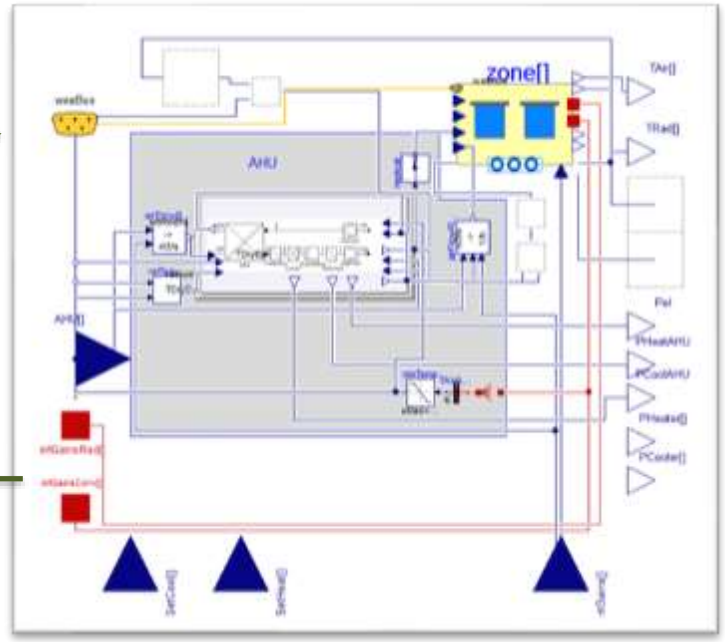
- MPC working at virtual level
- Improvement of the R-C equivalent model for the house is being investigated
- Virtual verifications towards a more detailed model

Actuation variables from the MPC

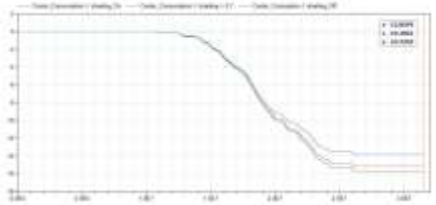


Predictions

MPC



State measurements



Future steps

Testing phase of the MPC

- Experimental validation of the controlled operation in the real installation
- Estimation of the energy & cost savings compared to baseline operation

THANK YOU FOR YOUR ATTENTION

REACT

Renewable Energy for
Self-Sustainable Island Communities

This project has received funding from the H2020 programme under Grant Agreement No. 824395