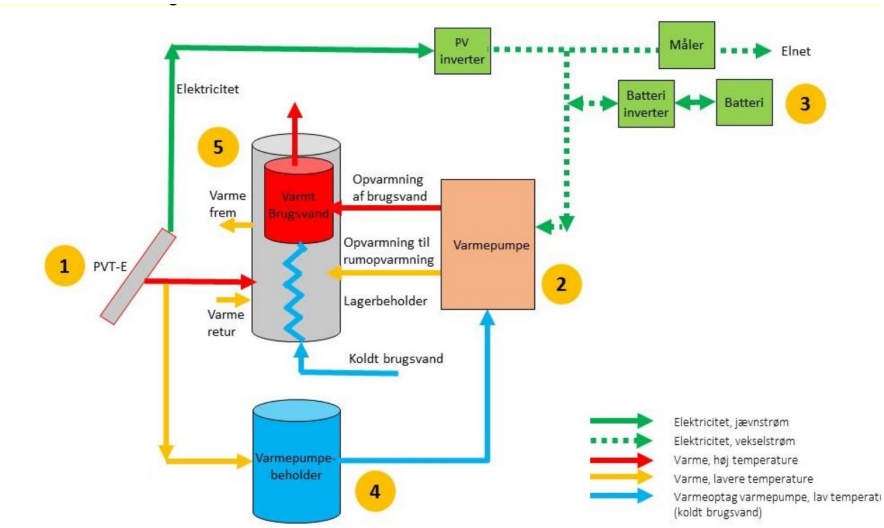
CITIES
Centre for IT Intelligent Energy Systems

Optimal control of BIPVT-E systems

Objective

The objective of this demo project is to develop methods for optimal control of heating systems with Building Integrated PhotoVoltaic-Thermal Energy absorbers (BIPVT-E). The BIPVT is a combined solar electric and -thermal module, which is installed directly into the facade or roof surface of the building. The “-E” is short for energy absorber, which refers to the module being used as the heat exchange surface for the cold side of a heat pump delivering heat to the building. A battery is included for storing energy and enabling the system to provide flexibility to the grid. A simplified diagram of the system:



Thus the system generates both electricity and heat, and has both electricity and heat storage. The methods and models developed in this demo project are used for predictive control, and more specifically for:

- Optimal charging of the battery given a varying price signal
- Optimal operation of the heat pump

Hence optimize the cost of operation of the system, which given that the price of electricity reflects the needs of the surrounding energy system, leads to providing services to the grid by using power when needed (e.g. in periods with high wind power generation the price is low).

This involves the use of weather forecasts as inputs to statistical forecast models and MPC as governing optimization principle. The following is needed for both control setups:

- Solar PV electricity generation forecast
- Electrical consumption forecast
- Price (or other penalty signal) forecast
- State-space models for the energy storage components (battery and tanks)

Further, for the battery charge optimization a forecast model of the electricity consumption of the heat pump is needed, and finally, for control of the heat pump operation a forecast of the indoor temperature of the building is needed, since it must be kept in a comfort band.

The data for the modelling applications is collected at two test sites, see below for more details. The controllers and the grey-box models are developed primarily within the CITIES project, whereas both systems are being built and monitored in other projects (EUDP, Elforsk and Landsbyggefonden funded), thus the modelling work is carried out in collaboration with these projects led by Racell and COWI. For the demo case on Bornholm also Bornholms Energi is participating.

Test site 1

Test site 1 is a terraced single-floor house with floor area around 80 m², where the roof has been replaced entirely with the BIPVT-E modules. The south facing roof have both thermal and PV, the north facing has only PV.

Test site 2

Test site 2 is a pilot system, which will be installed to supply partly the heat to the terminal at the airport of Bornholm. The system is still under construction, images will be added later.

Main partners

- DTU Compute
- DTU Byg
- Racell
- COWI
- KAB and Stenløse-Ølstykke boligforening
- Bornholms Energi

Deliverables

- Models for forecasts
- Controllers for the battery charging
- Controllers for heat pump operation
- Report describing the results

Time schedule

April 2018 to September 2019.