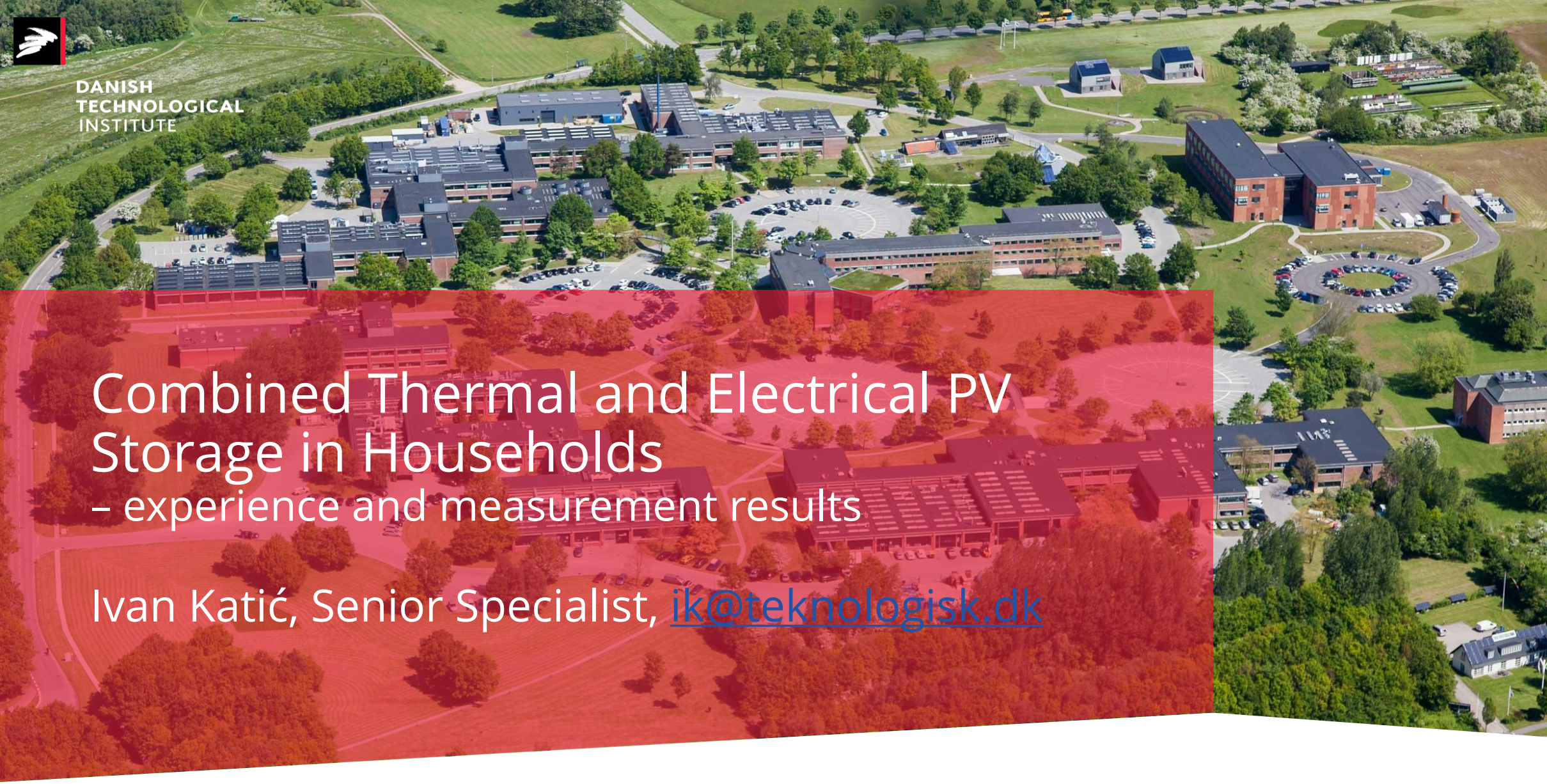

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Combined Thermal and Electrical PV Storage in Households

– experience and measurement results

Ivan Katić, Senior Specialist, ik@teknologisk.dk

Project scope

- Increase self-cuncumption of PV electricity in households
- Evaluate total efficiency of battery energy storage with a new BMS
- Demonstrate cost-effective solutions for thermal storage
- Test a new heat pump controller with smart grid functionality
- Develop a simple tool for system sizing

LiTHIUM BALANCE
BATTERY MANAGEMENT SYSTEMS

NILAN

ELFORSK

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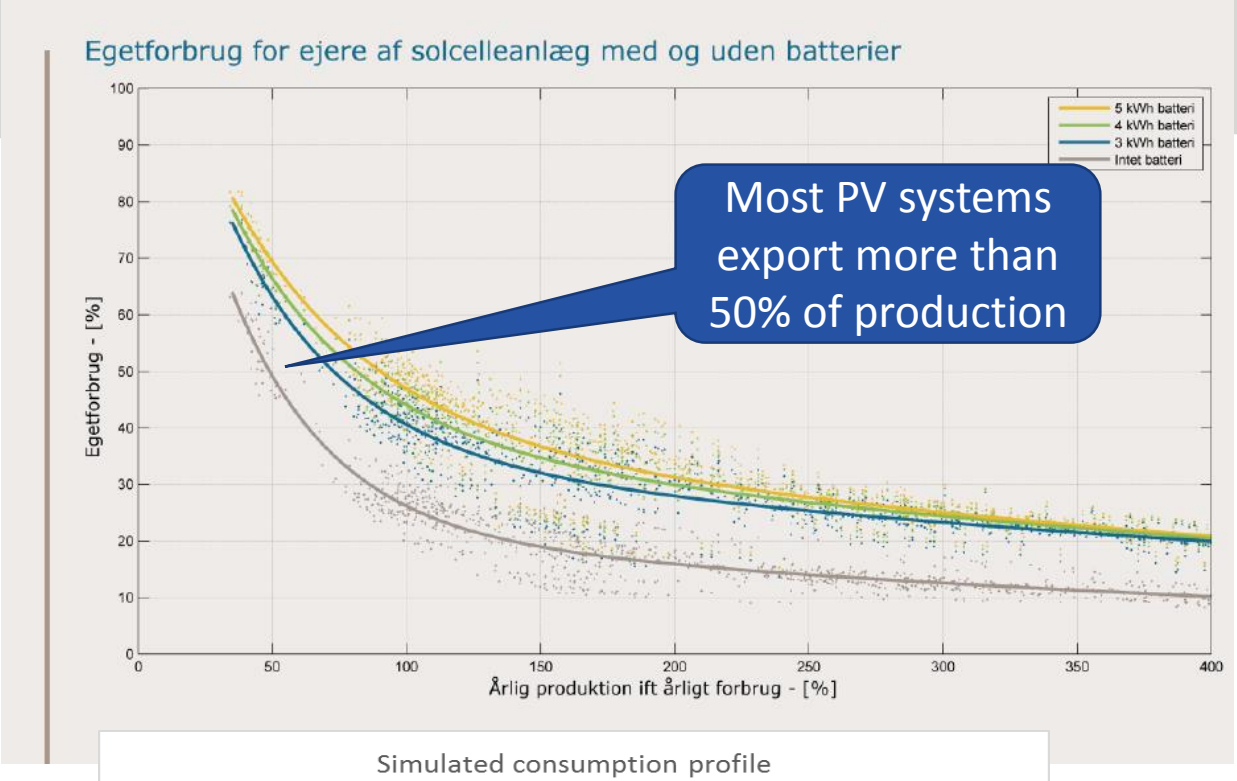
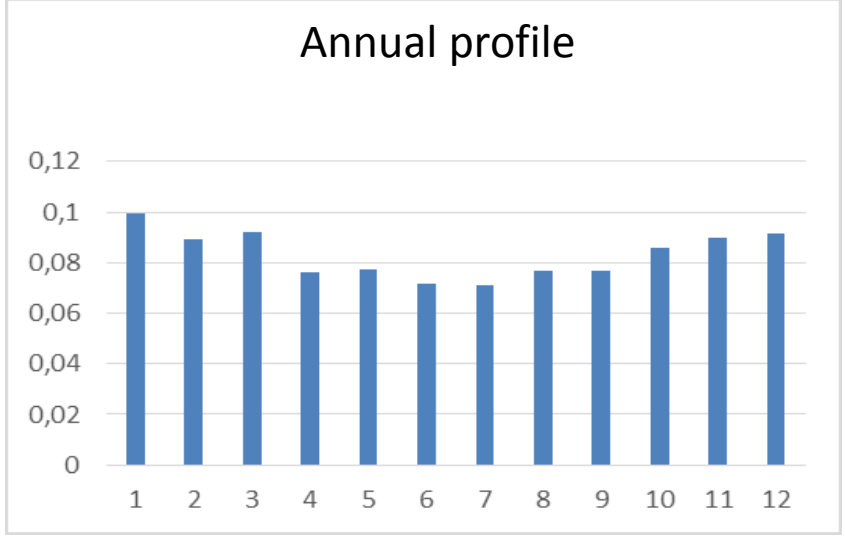
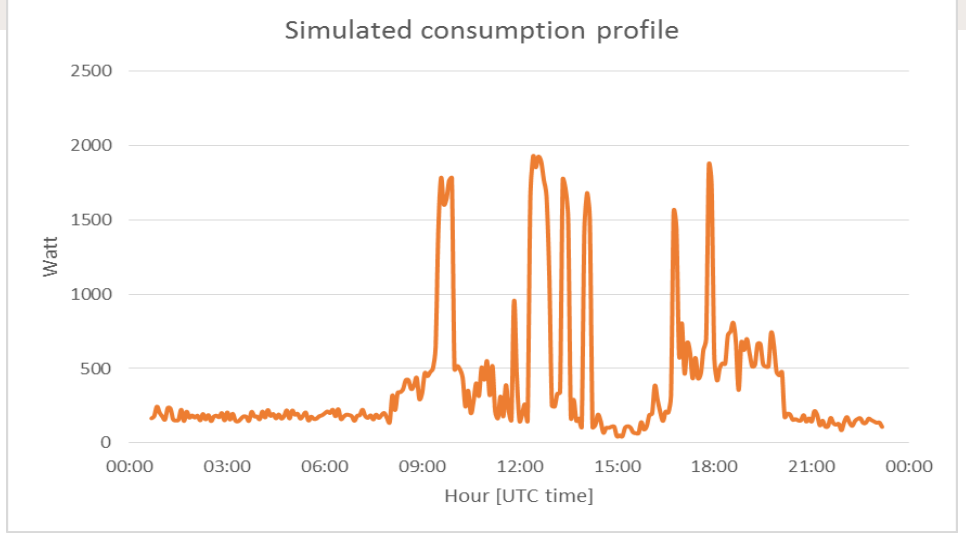
PV owner's pain

- Consumption profiles
  - Seasonal mismatch
  - Daily mismatch







- EnergyFlexHouses
  - NZEB design
  - 500+ data points
  - Side-by side rooms
  - Floor heating
  - Radiator heating

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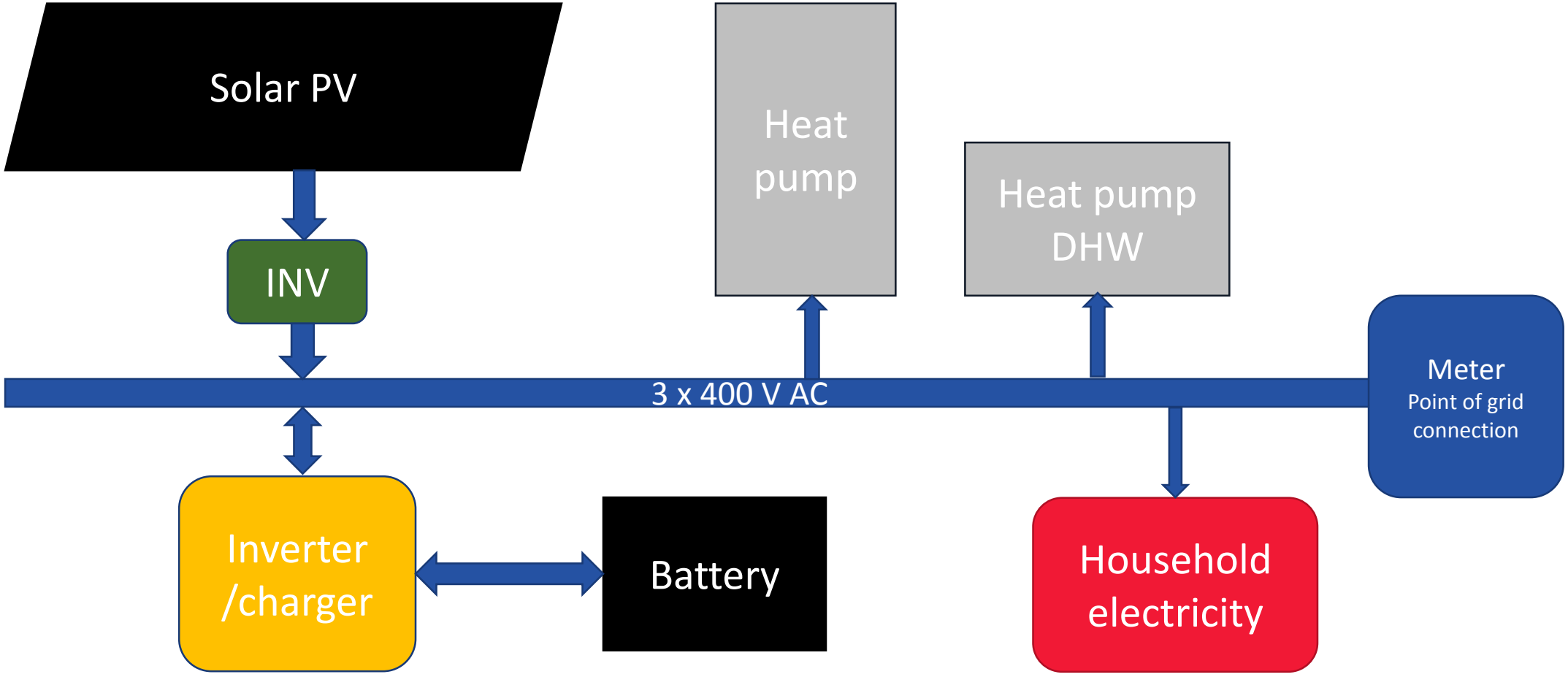
Experimental system configuration



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System components

- 2 x 3.5 kWp PV system
- 4.8 kWh LiFePo battery
- 2.3 kVA battery inverter
- 6 kW(T) heat pump
- 250 l buffertank
- 180 l DHW tank
- Smart electricity meter
- 2 x WiFi sockets

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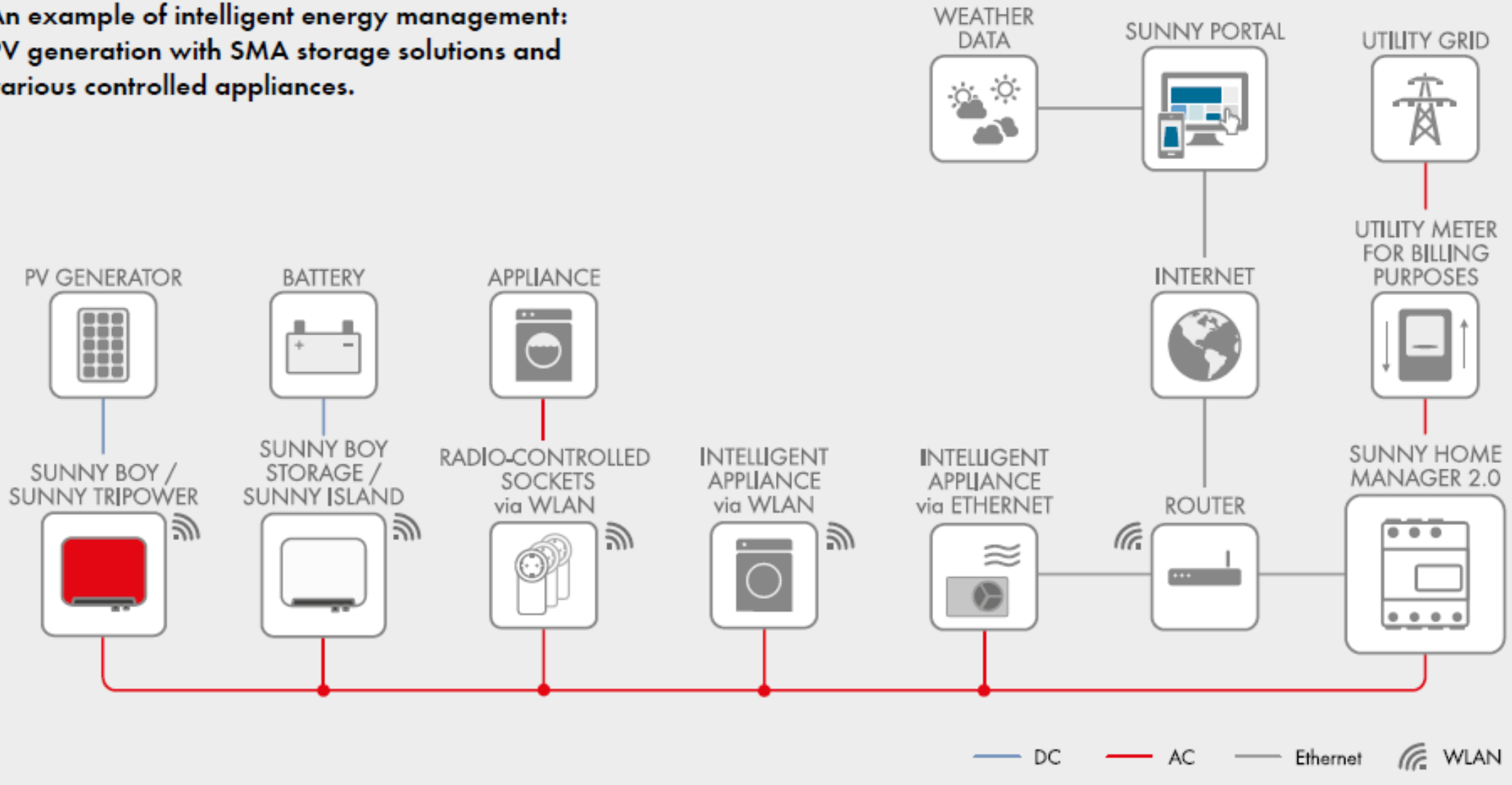
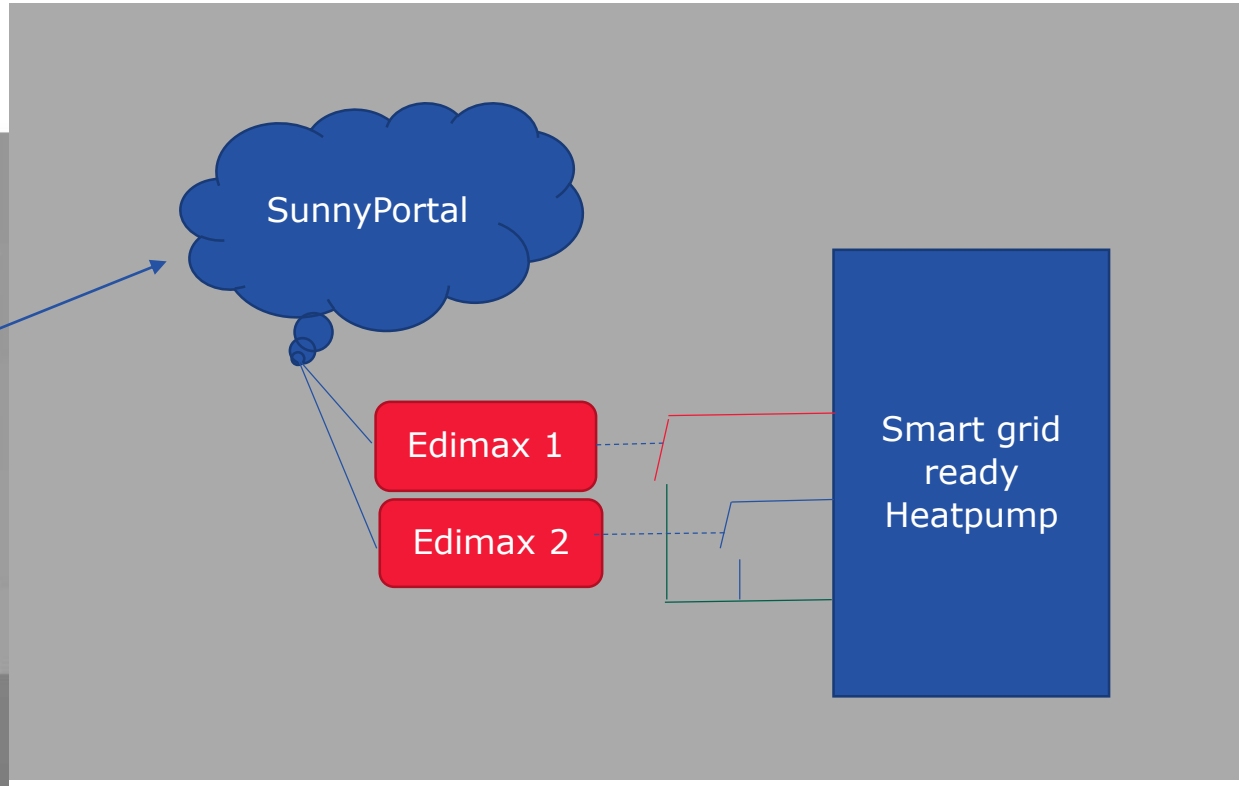
Smart Grid in practice

An example of intelligent energy management: PV generation with SMA storage solutions and various controlled appliances.



- Overall control based on SMA Home Manager 2.0
- Connection to smart grid ready NILAN heatpump
  - 3 modes: Normal, off or high temperature (+10K)



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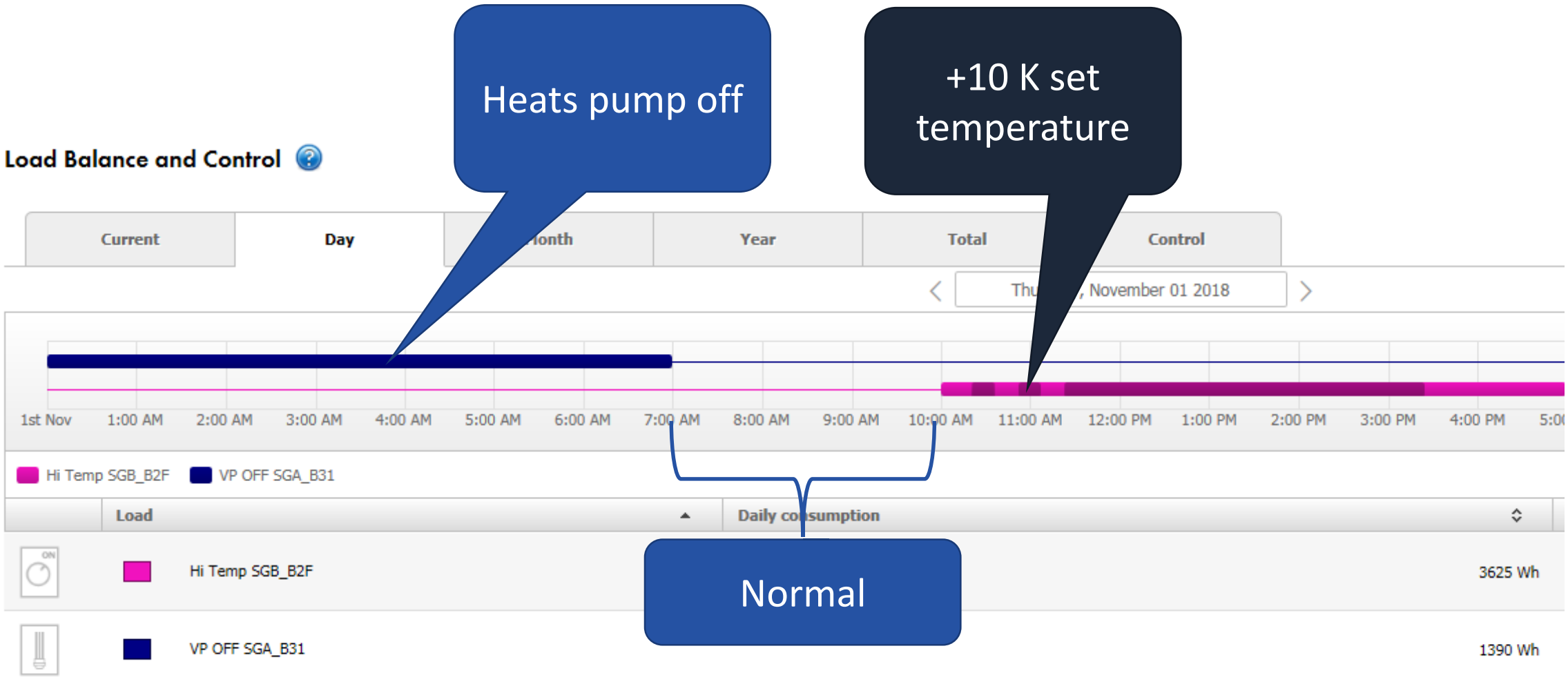
Programming in Sunny Portal



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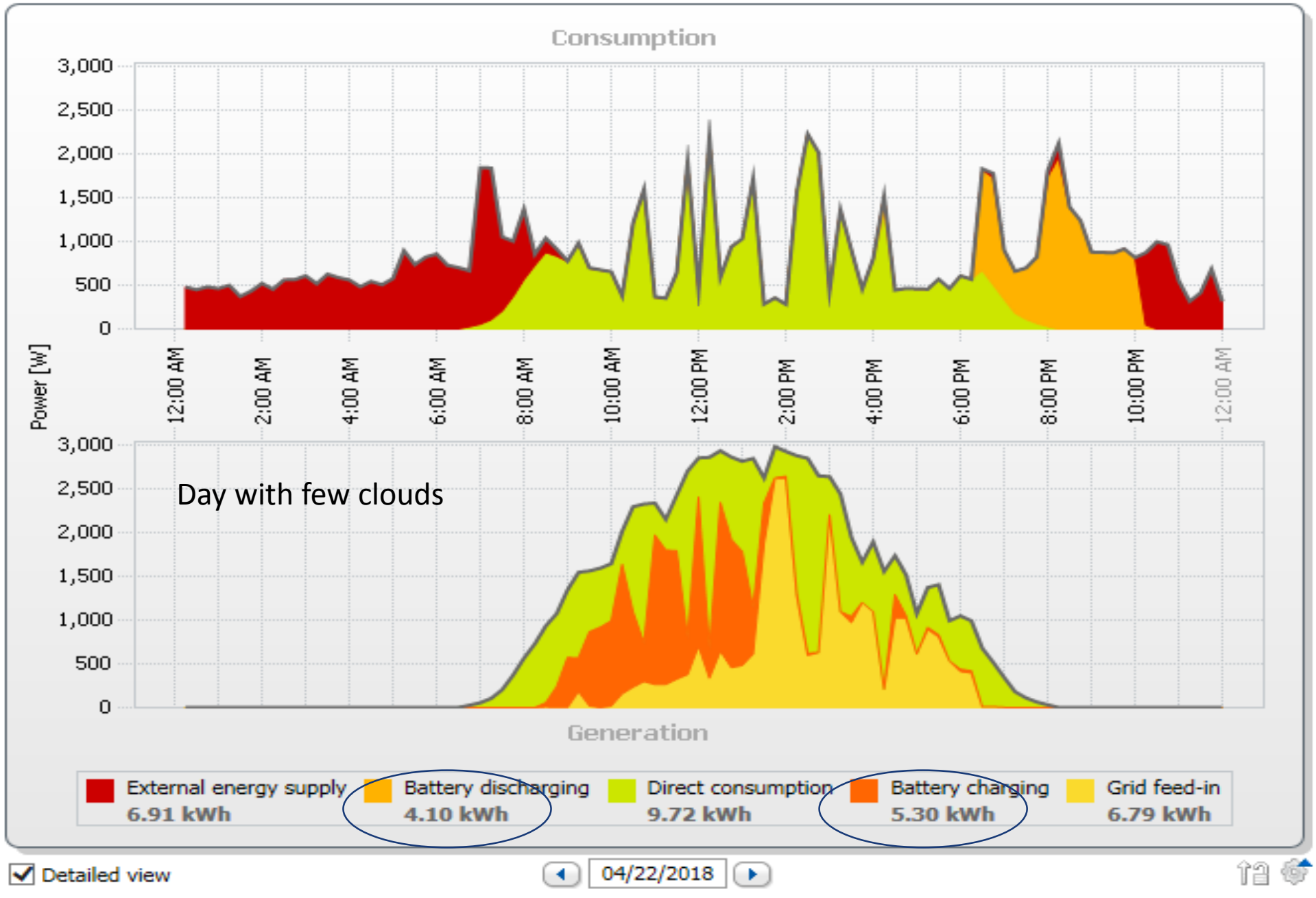

Battery cycling results

- Monthly AC efficiency 66-77%
- Standby losses are significant! It may be better to buy some power insteat of starting up the battery inverter.
- Difficult to determine state of charge when not fully charged. This caused the voltage guard to trip the whole system

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Heat storage solutions in family houses with heatpump

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Theoretical heat storage capacity

- Total water volume = 250 + 180 = 430 liter.
- Q = M*Cp*dT = 430 kg * 4,186 kJ/kgK * 10 K = 18000 kJ =

5,0 kWh thermal (10K)

- Concrete floor mass = 2300 kg/m3 * 0,1m*100m2 = 23000 kg
- Q = M*Cp*dT = 23000 * 2,38 kJ/kgK * 3 K = 164220 kJ =

  45,6 kWh thermal (3K)

- Total equivalent electricity use in a heat pump = 15-20 kWh/cycle

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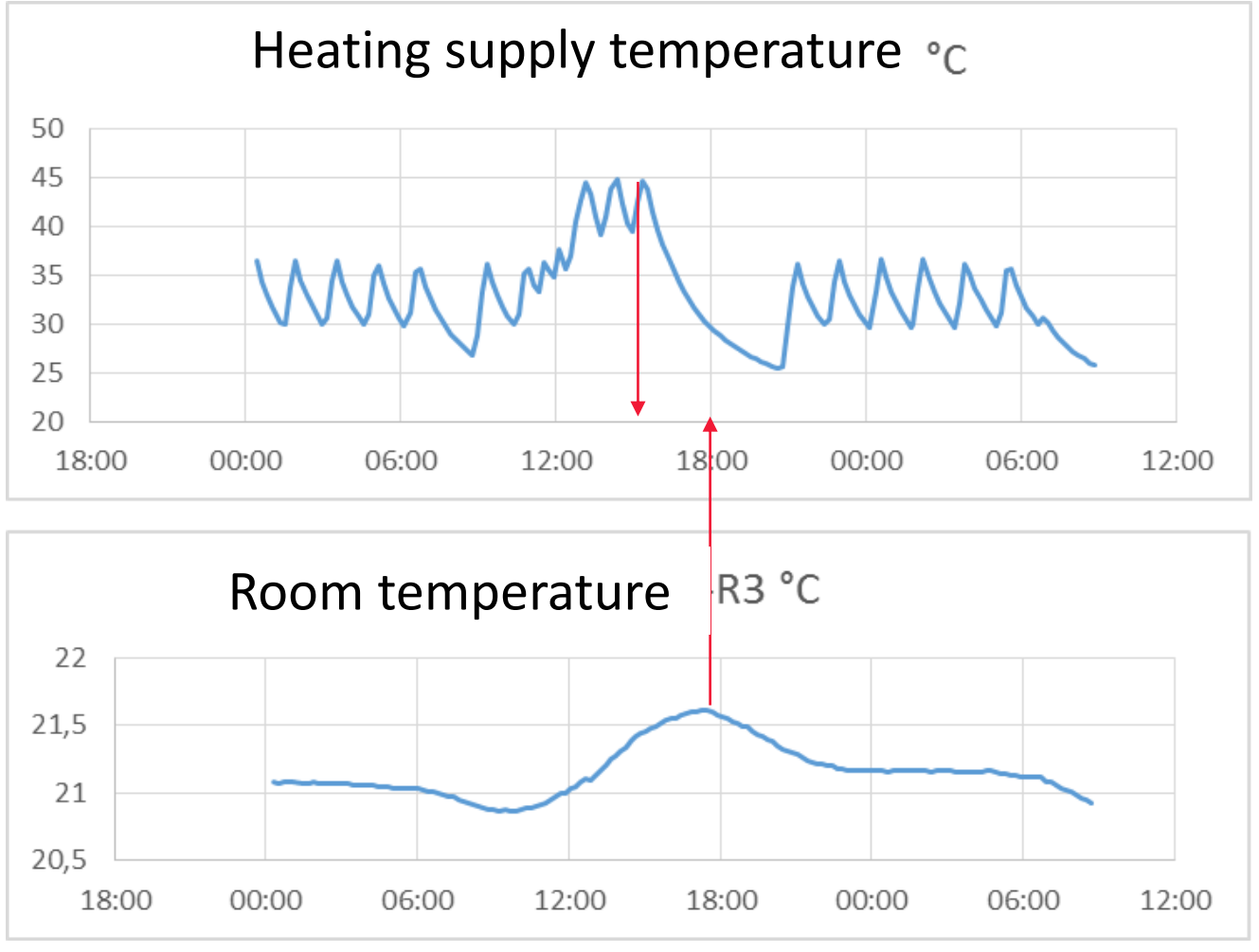
Heat storage in 10 cm thick concrete floor



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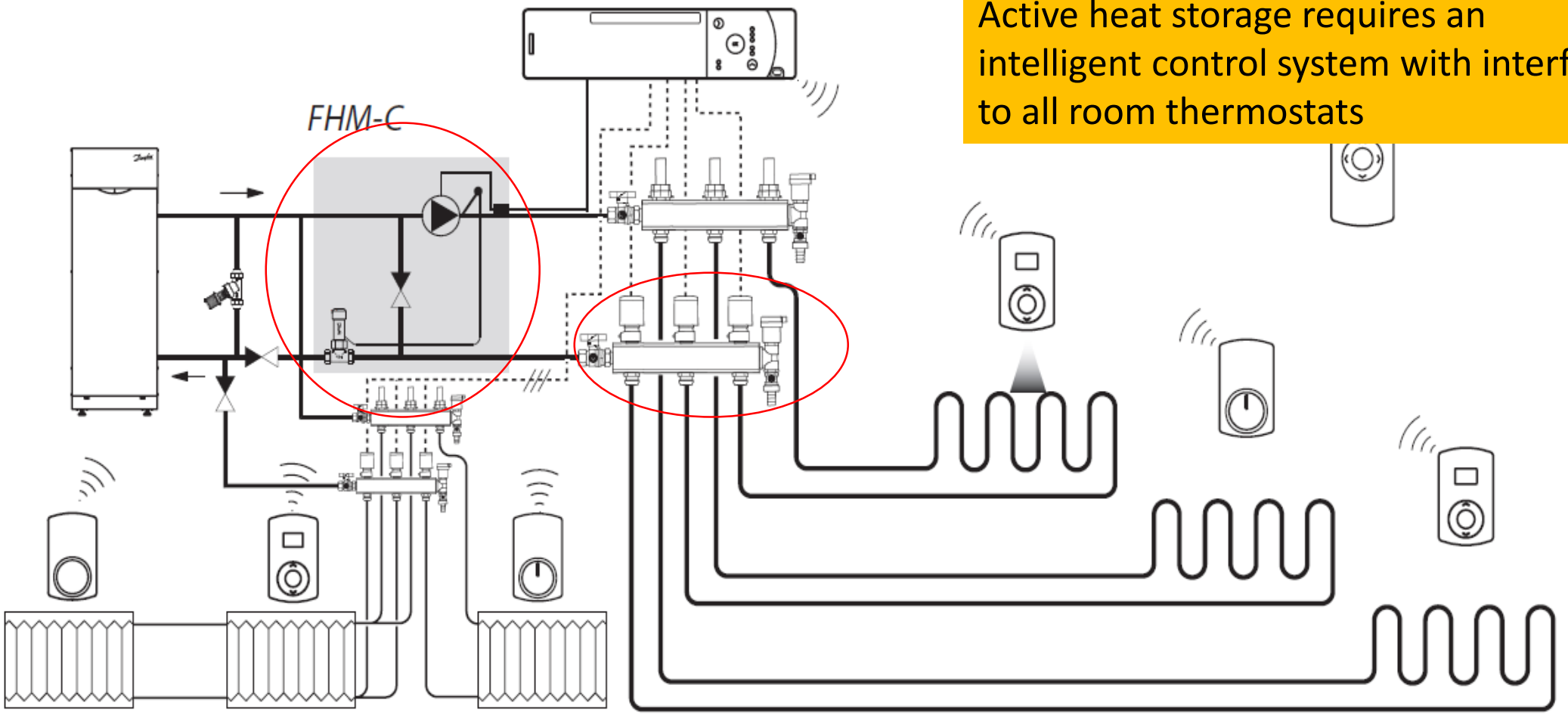
Getting the lowest possible temperature for the heat pump

A generic problem. Bypass circuits should be avoided!



Active heat storage requires an intelligent control system with interface to all room thermostats

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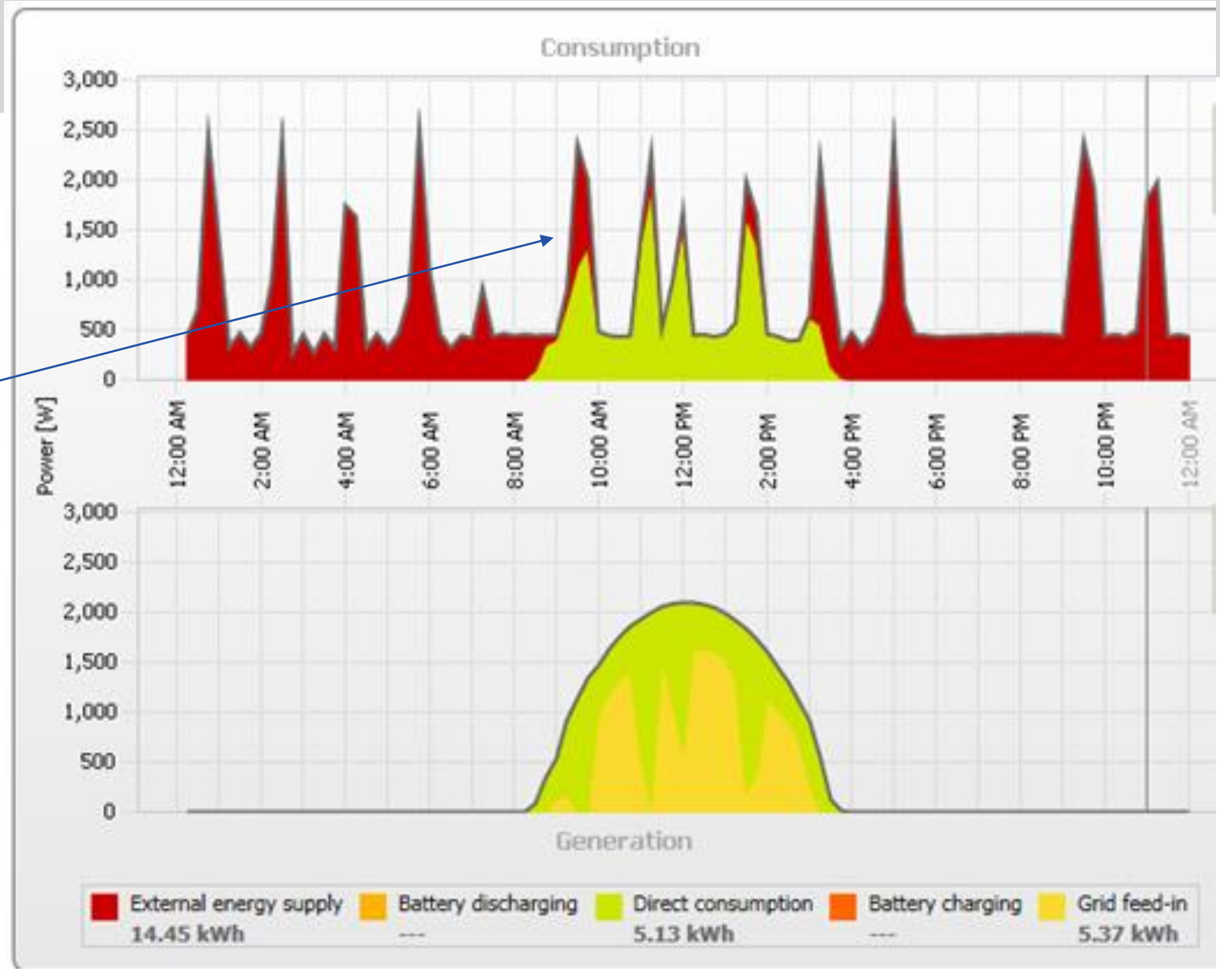
Period with heat storage only

Power modulation of the heatpump could help fill the gaps/cut the peaks



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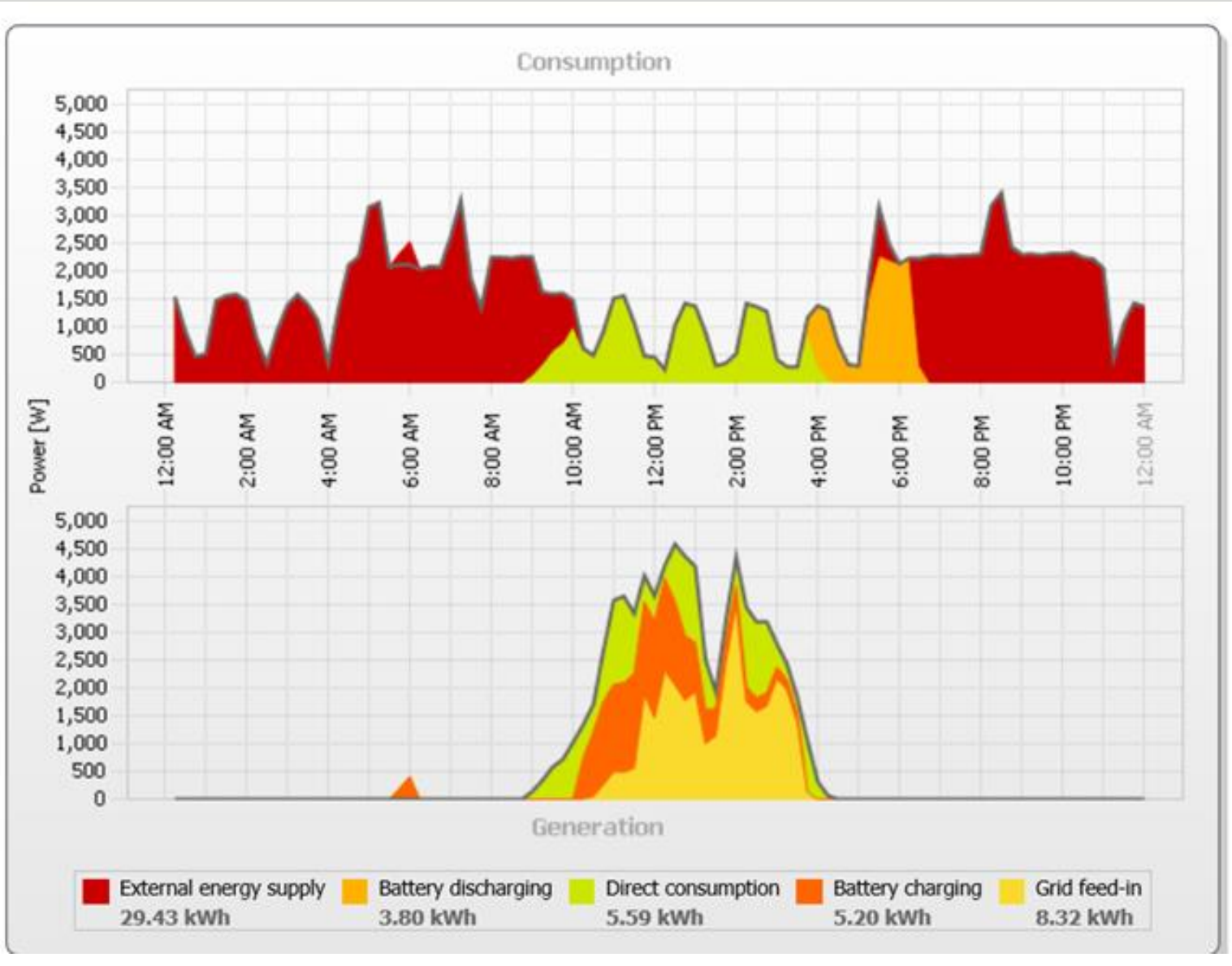
The power was reduced to 60% and the battery connected

Longer runtime and 100% seff consumption in daytime



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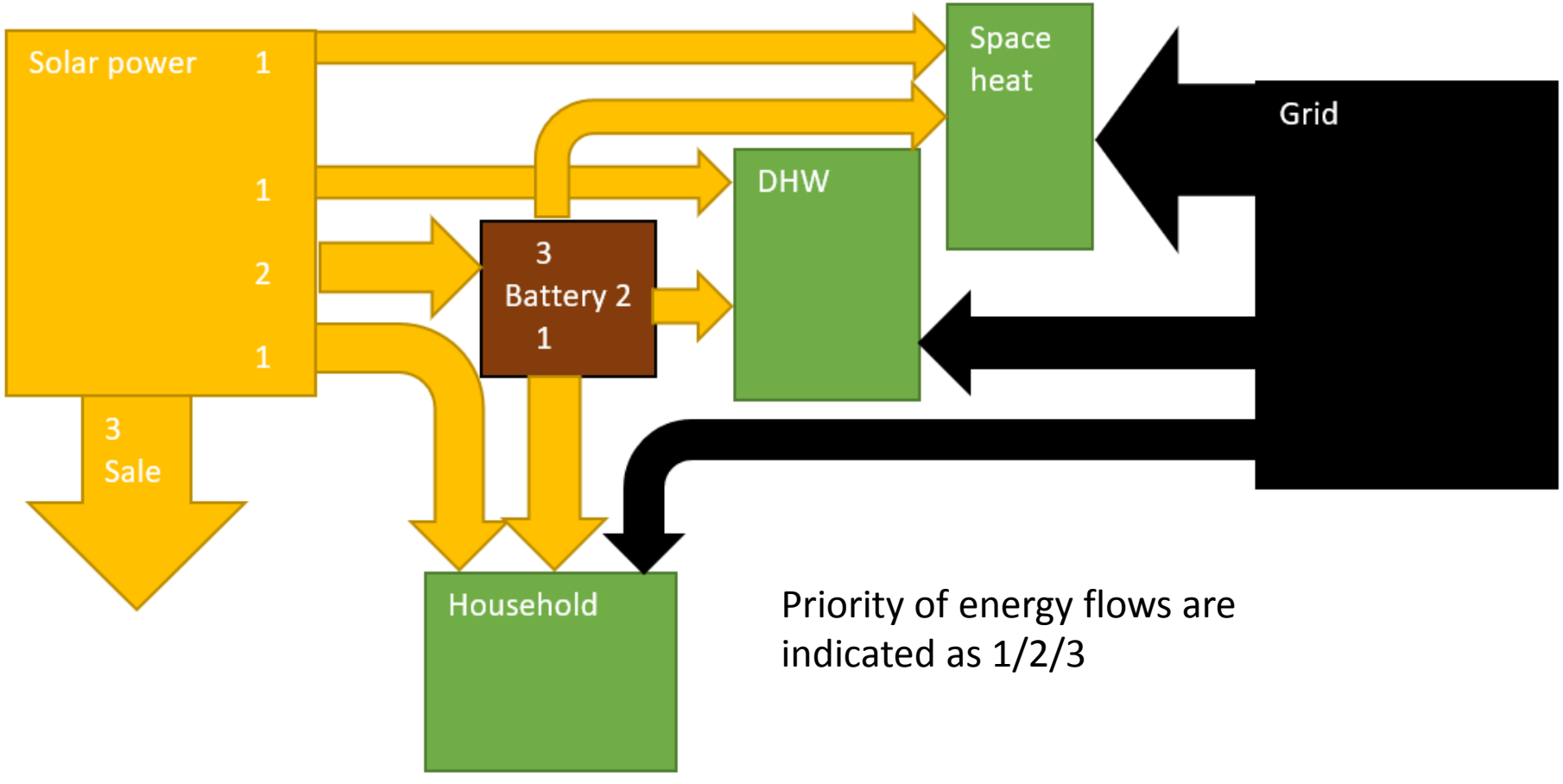
Simulation model



Priority of energy flows are indicated as 1/2/3

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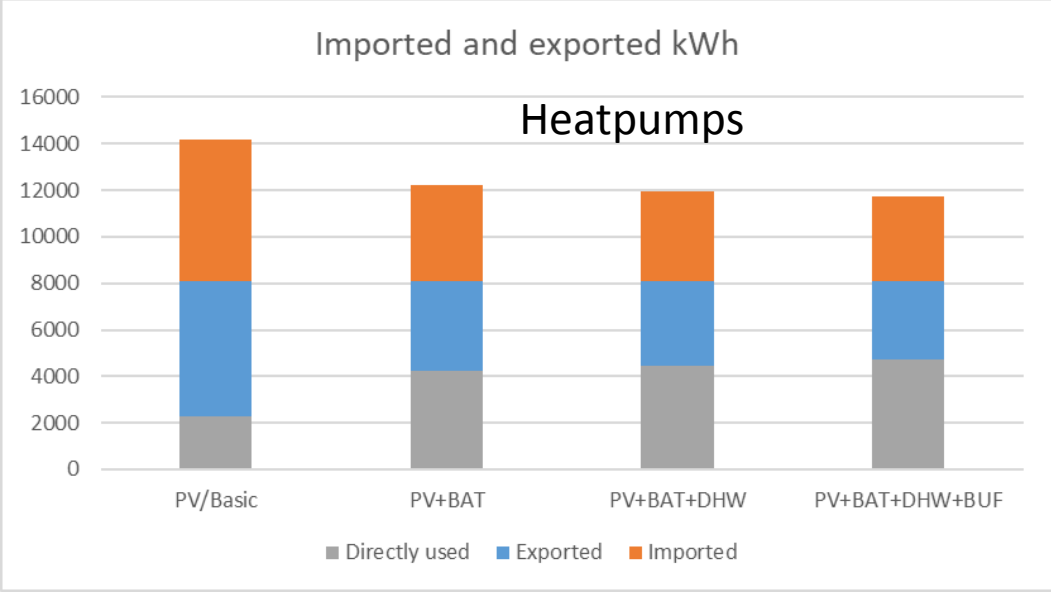
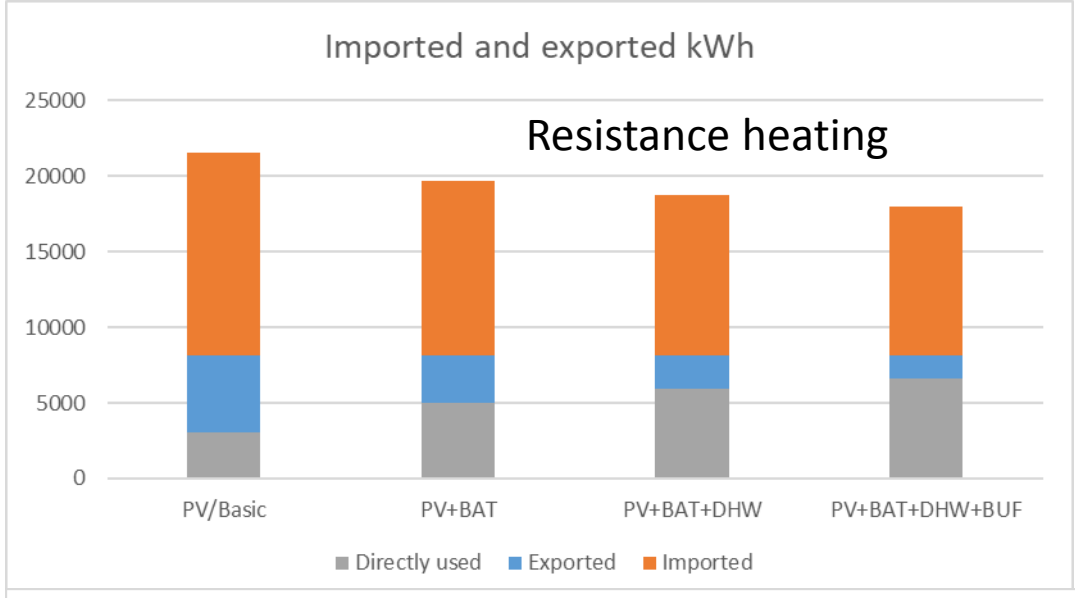
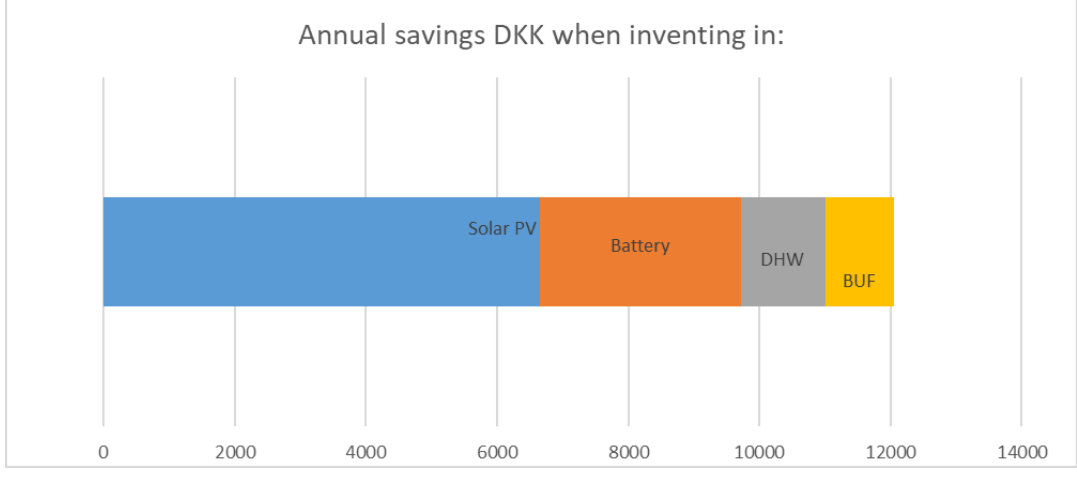
Simulation results





PV system	8	kW
Battery	8	kWh
DHW storage	5	kWh
Buffertank	15	kWh



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What have we learned?

- *Smart Grid Ready* does not mean end of all problems!
- Cloud monitoring and –control requires technical skills and a lot of attention
- Limited options for control of heat pumps as ”dump load” for excess electricity
- Central heating systems are not built for grid flexibility, smarter control systems are required
- The tested system was time consuming to adjust and was sensitive to many small technical problems
- Differentiated tariffs = game changer

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Thank you!

Ivan Katić, Senior specialist, ik@teknologisk.dk