Retrofitting Buildings for Energy Flexibility

CITIES WP3 WORKSHOP

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  - **Experiments with time constants and control strategies**
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Buildings are already flexible or are they?

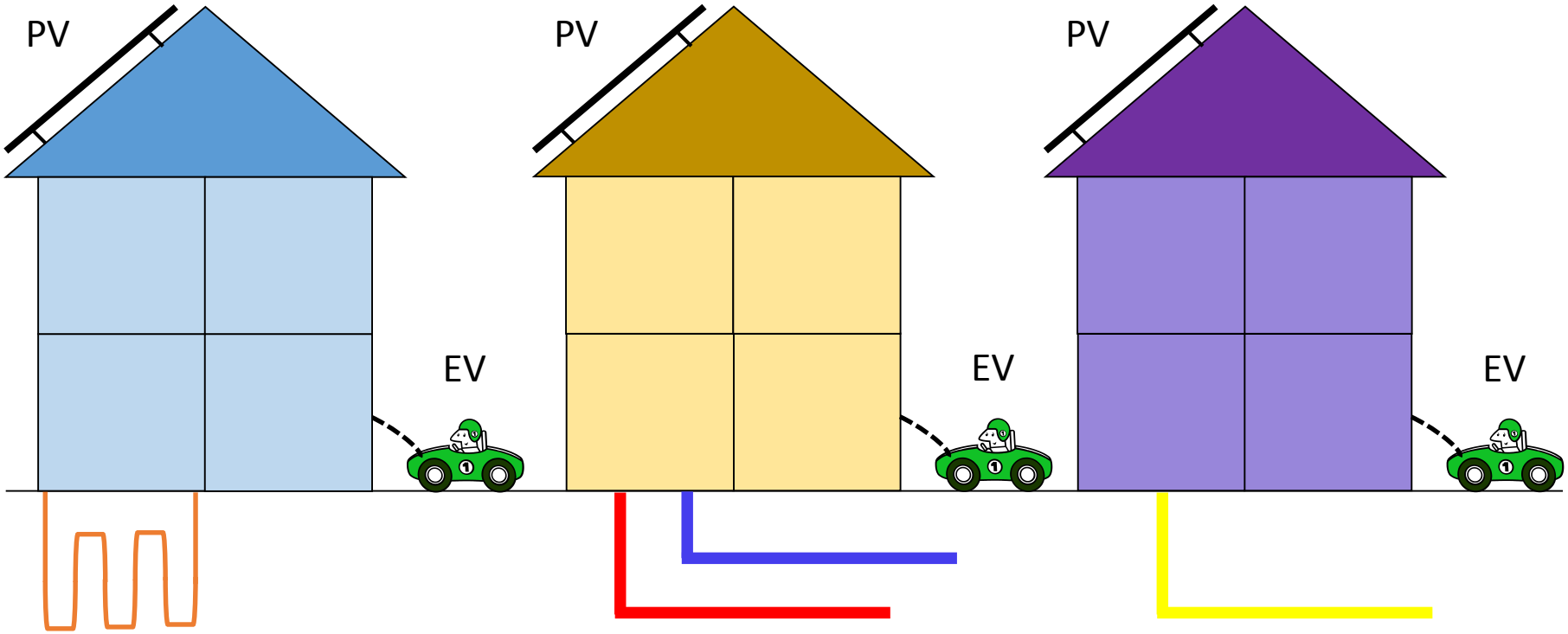
DS 469:2013 Danish Standard for heating and cooling systems in buildings

- (8.1) Room temperature control in each room
- (8.2) Flow temperature control
- (8.3) Time control shall be installed in buildings with well defined opening hours/usage time (e.g. offices, stores, schools). In the design shall be taking into consideration:
  - **Heat capacity and usage of the building**
  - **Characteristics of supply and heating system** (special requirements for heat pumps and district heating)
- (6.6.1) Heat-up capacity of heat emitters
  - Normal design capacity typically sufficient most of the year
  - **Discontinuos operation of district heating and heat pumps may not be feasible (under current conditions ☺)**

Experience: Little savings by time control in residential buildings

Residential buildings and heat supply in DK

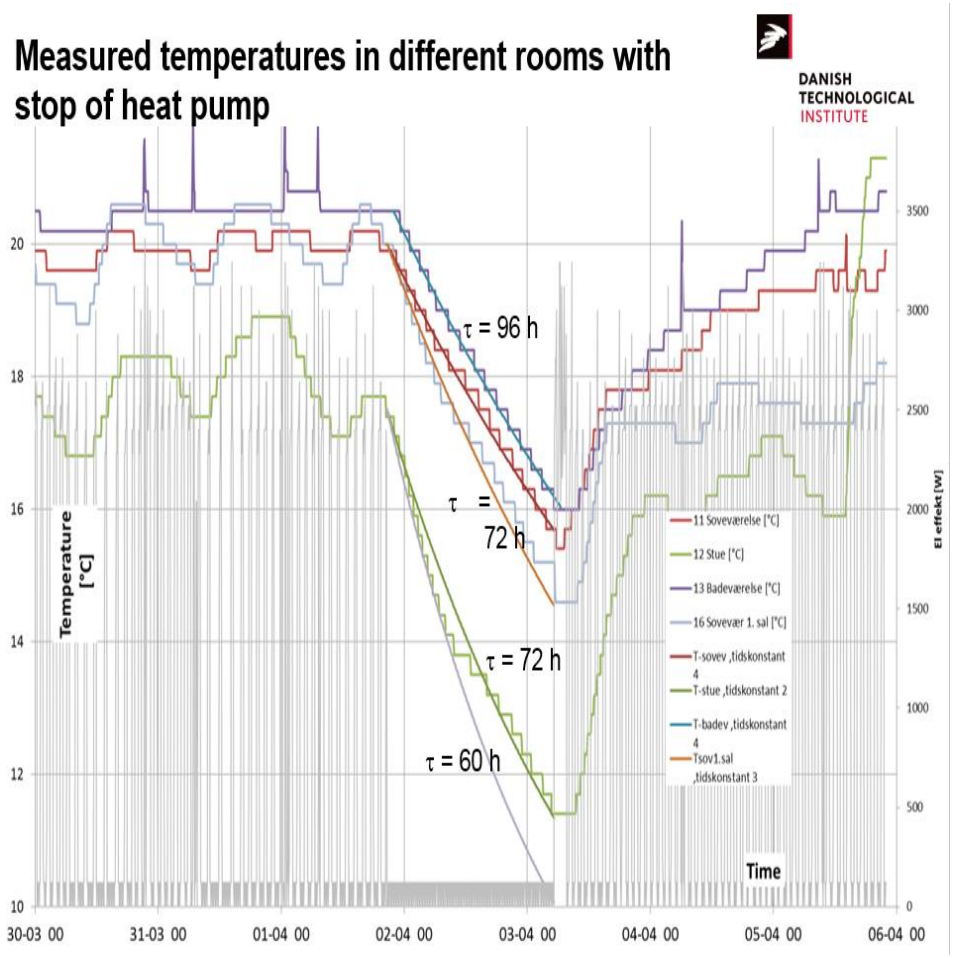
Heat pumps **District heating** **Gas**



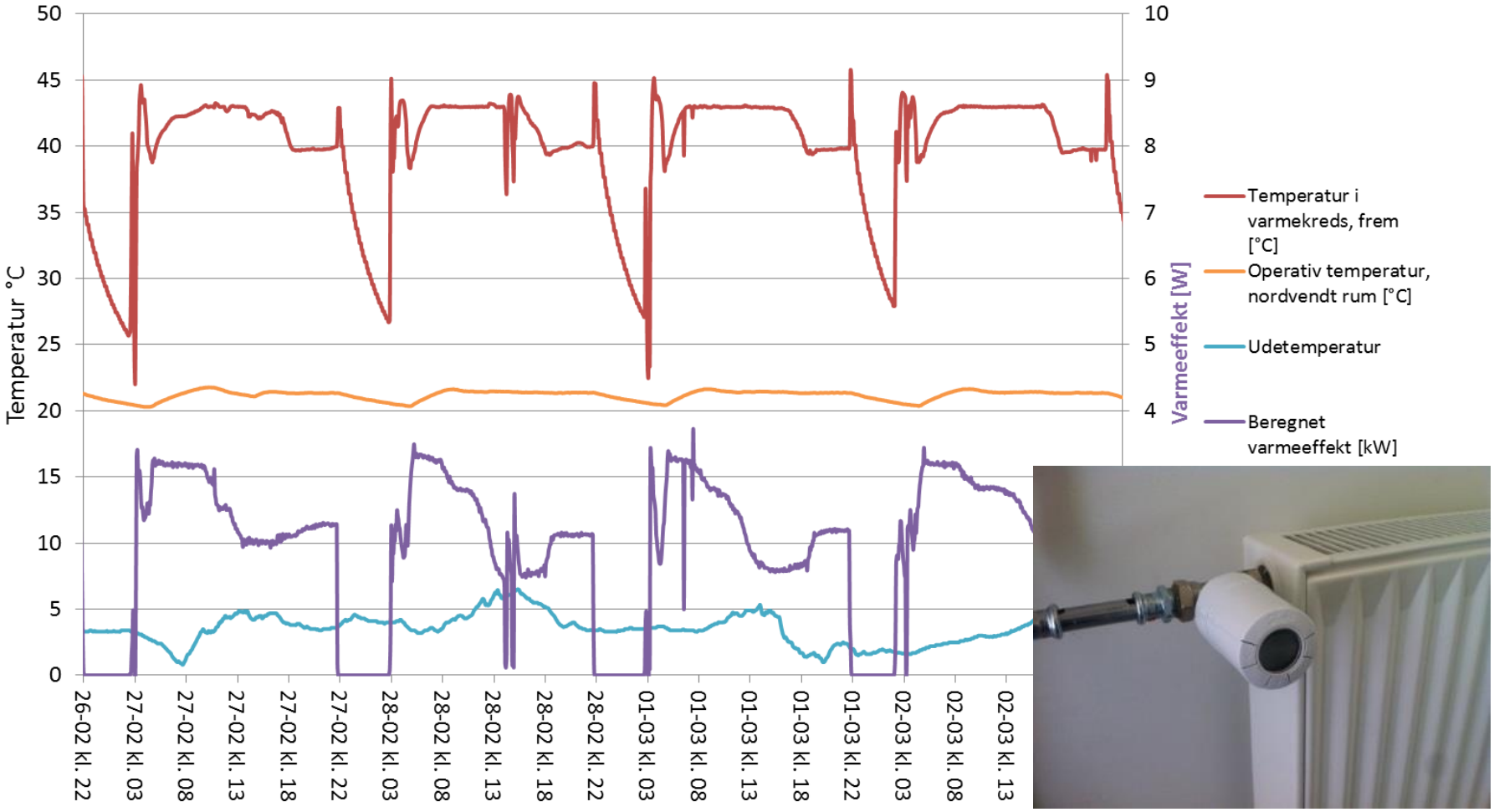
Households: approx. 30,000 approx. 1.6 millioner approx. 390,000 (2012)

Control by heat pump, stop/start (setback >24 h) – time constants

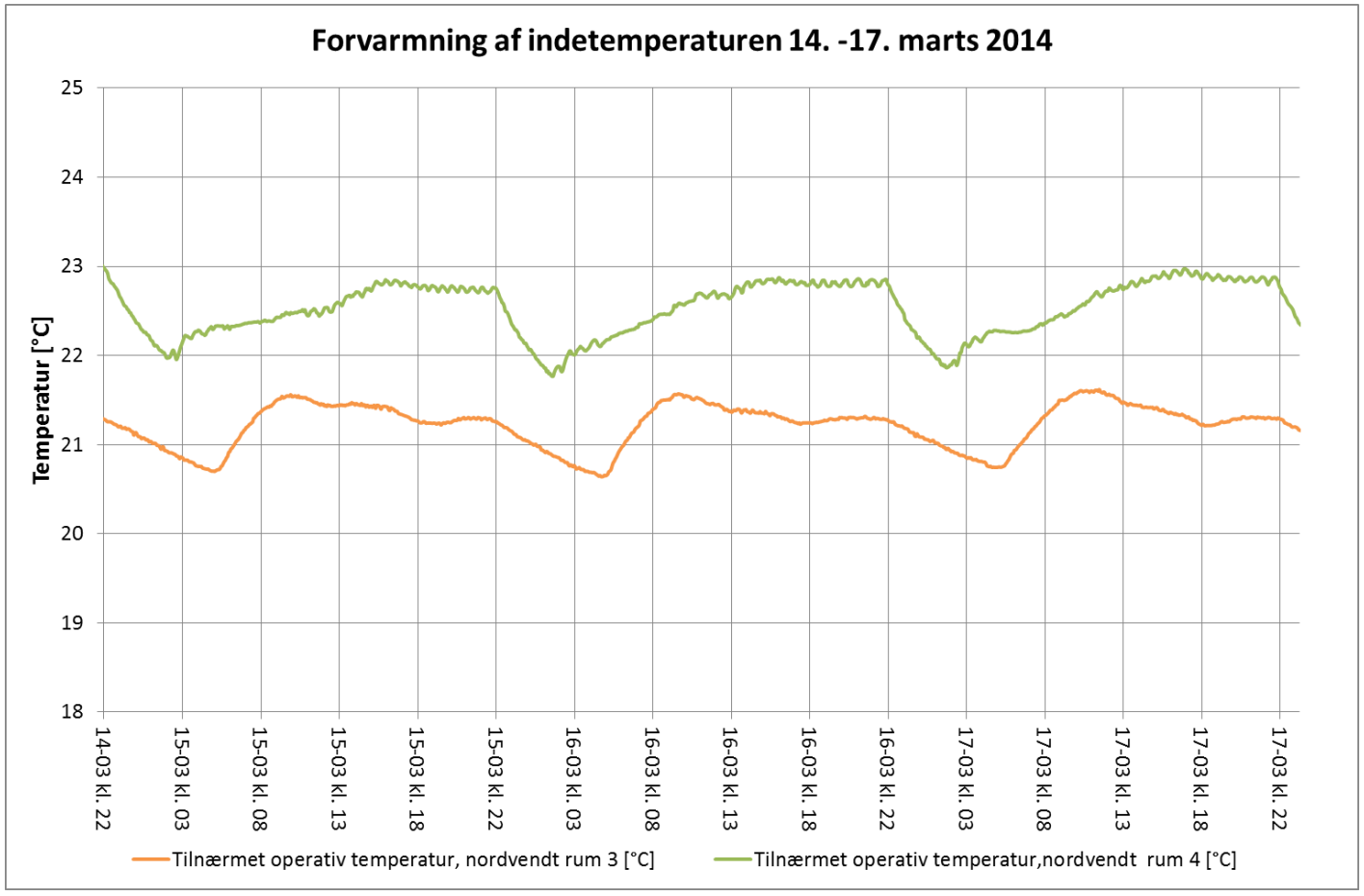
- Monitoring in 12 houses with stop of heat pumps in 4 to 36 hours to test variation of room temperatures
- 8 houses with monitoring in one room
- 4 houses with detailed monitoring in more rooms
- Estimation of time constants from measurement
- Comparison with estimated time constants



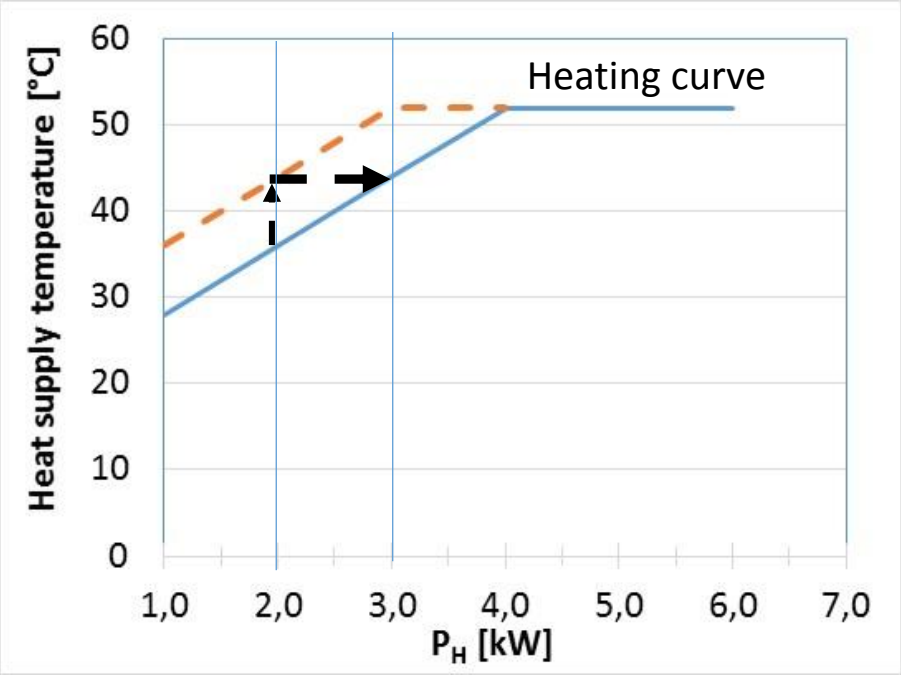
Control by programmable radiator thermostats in each room (setback 22:00 to 8:00)

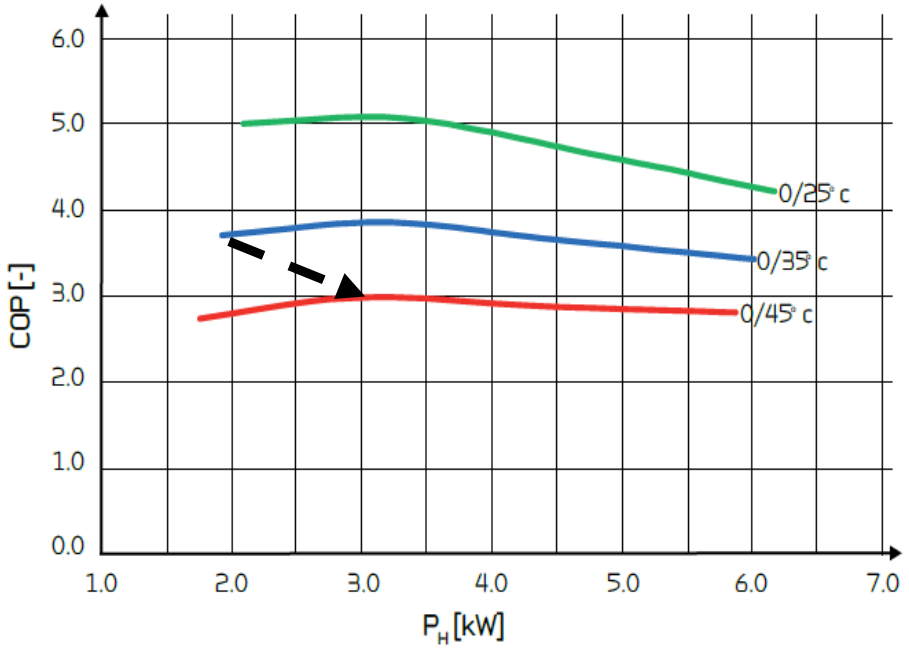


Control by programmable radiator thermostats in each room (setback 22:00 to 8:00 + 21/23°C)



Temperature boost to reduce heat-up-time (temperature off-set e.g. 10 °C). Drawback: reduces COP as well





Retrofitting residential buildings

Control by central heating unit only (heat pump, DH substation etc.)

- By external signal:
  - On/off operation
  - Increase flow temperature
- Comfort control typically based on one temperature sensor (more may be needed – Two zone approach)
- Not possible to pre-heat due to thermostats (typical mechanic)

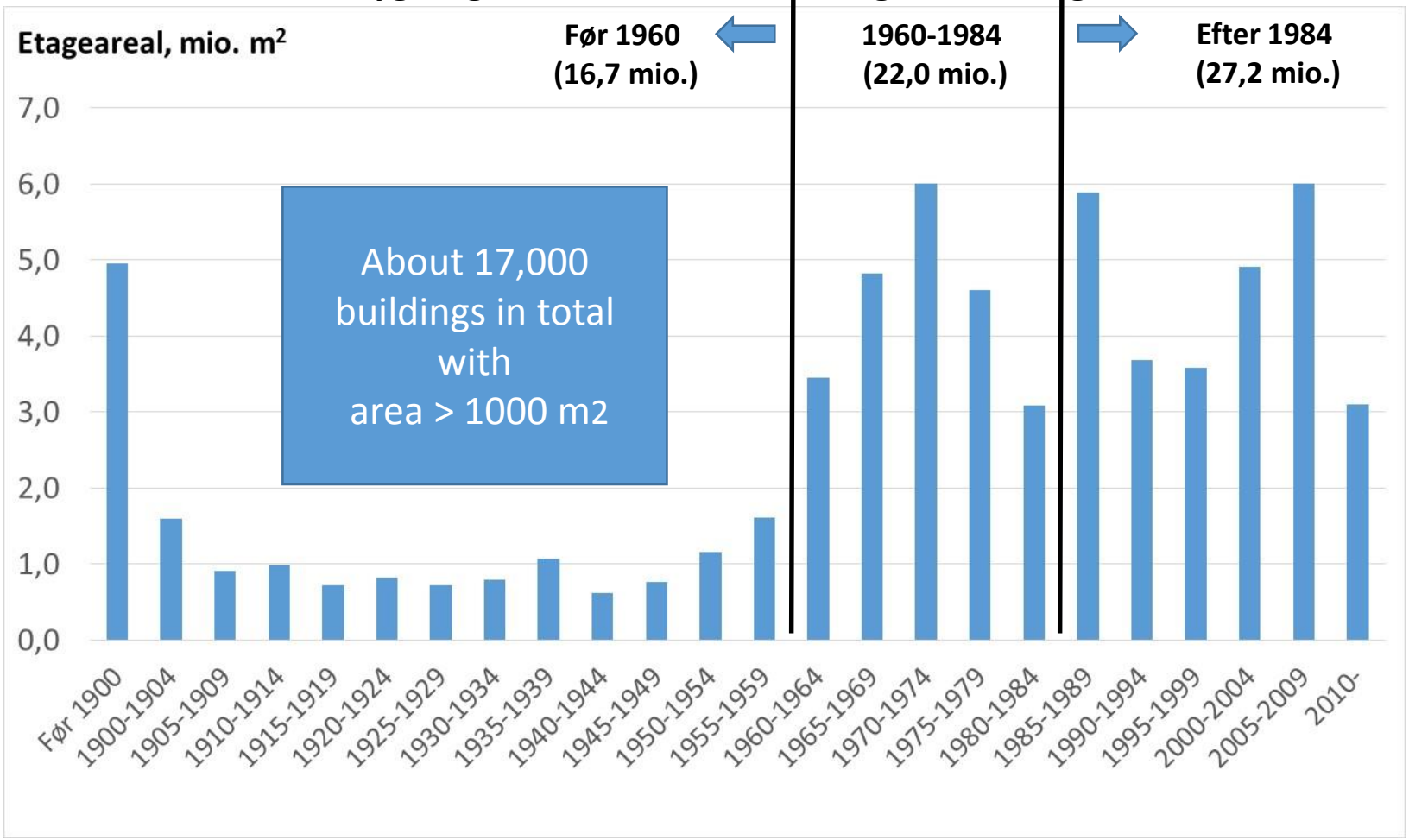
Control by electronic (programable) radiator thermostats only

- By external signal:
  - Increase/decrease temperature setting on each thermostat individually to reduce load, pre-heat and store energy for later use (in building structure)
- Not possible to Increase flow temperature

Control by both central heating unit and thermostats

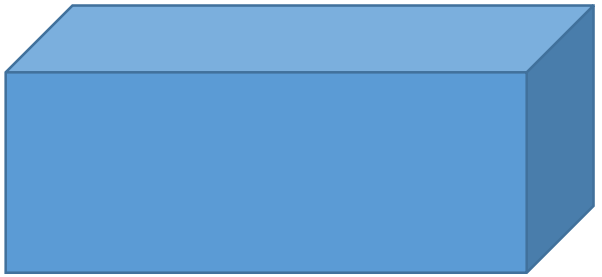
Offices buildings (and supermarkets, malls, warehouses etc.) in DK

Danmarks statistik: Bygninger til kontor, handel, lager, offentlig administration mv.



Office buildings in DK

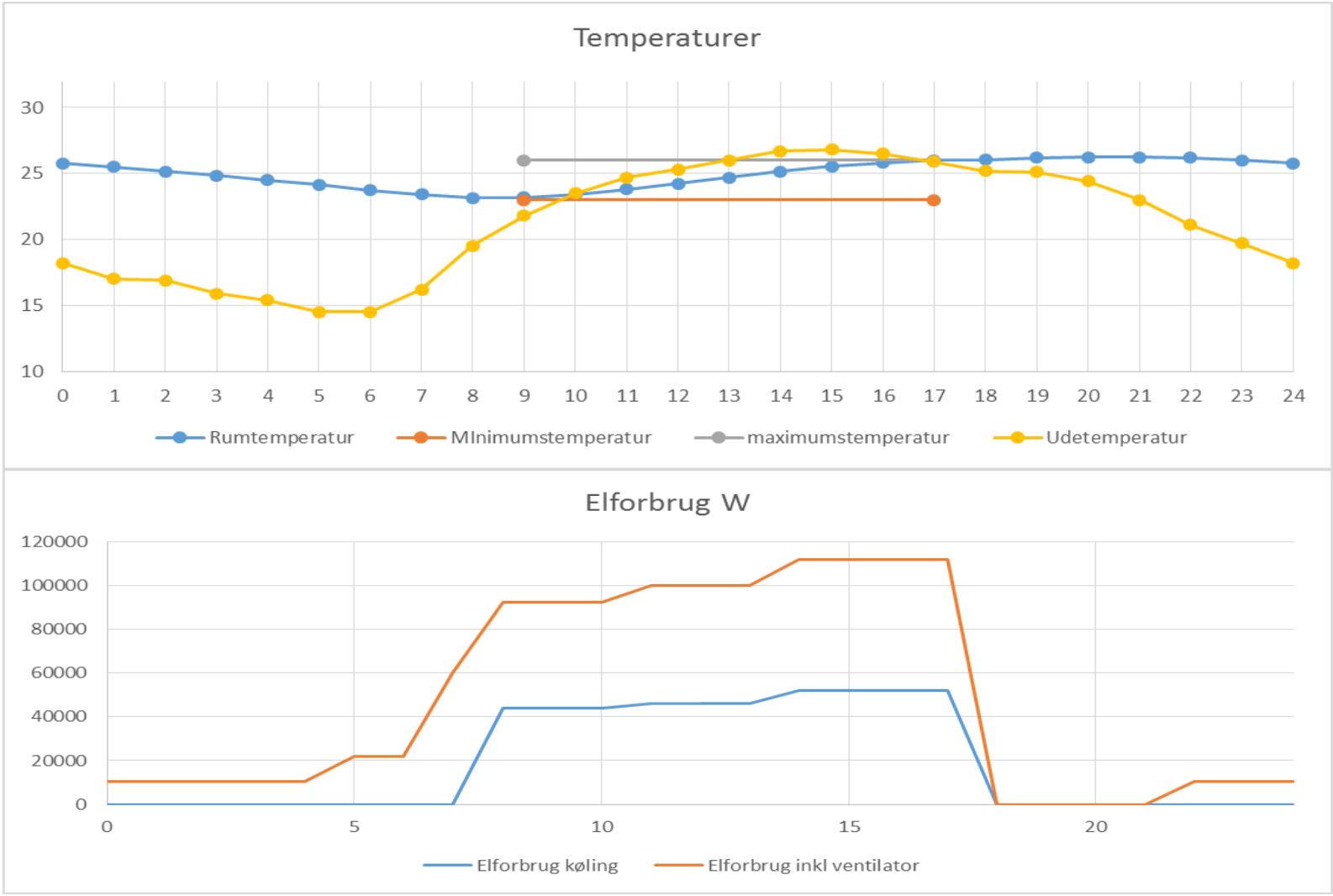
Simple simulation of flexibility
Getting an idea about the potential?



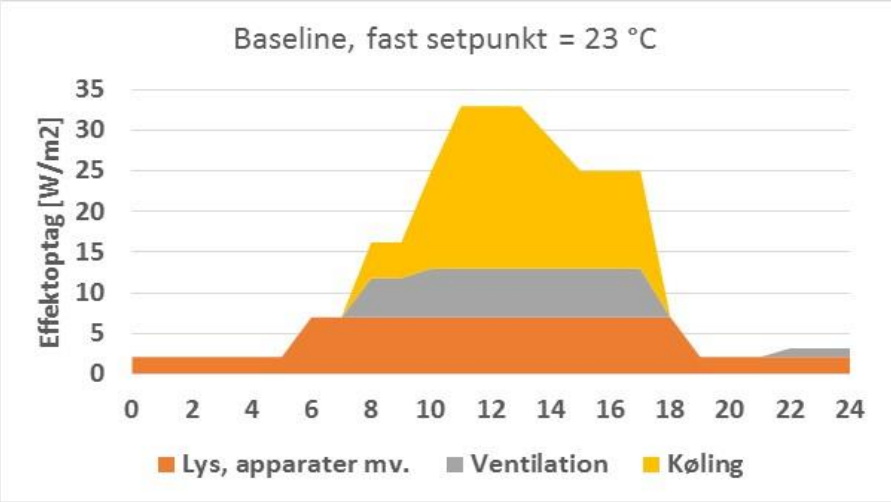
Building model:	1. order	
Area:	10.000 m^2	
Volume:	30.000 m^2	
Transmissions loss:	1,25 W/Km^2	
Heat capacity:	75 Wh/Km^2	
Maksimum flow, ventilation:	30 m^3/s (air change rate: 3,6 h^{-1}, SEL = 2000)	
Usage time:	kl. 9-17	
Max. solar contribution:	Summer: 30 W/m^2,	Winter: 9 W/m^2
Required indoor temp.:	Summer: 23-26 °C,	Winter: 21-24 °C
Max. CO_2 concentration:	800 (1000) ppm	
Control strategy:	Summer: Temperature,	Winter: CO_2 concentration

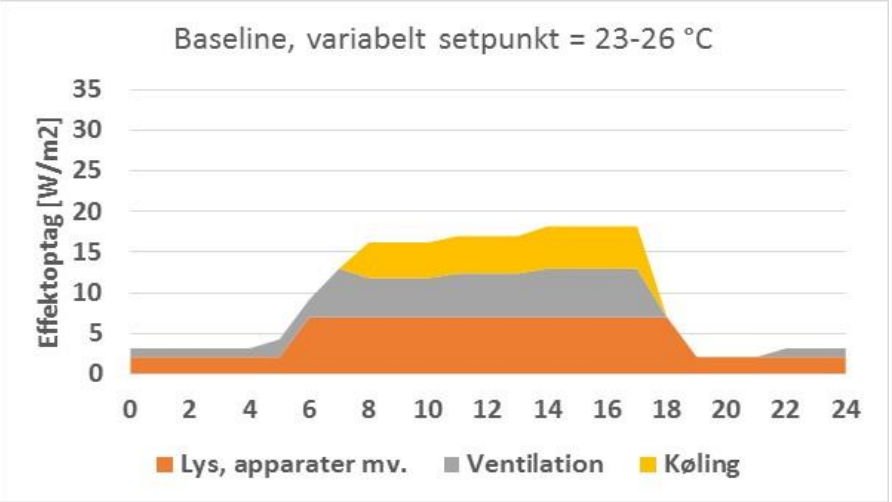
Weather/load forecast required day ahead in order to plan flexibility/moving energy

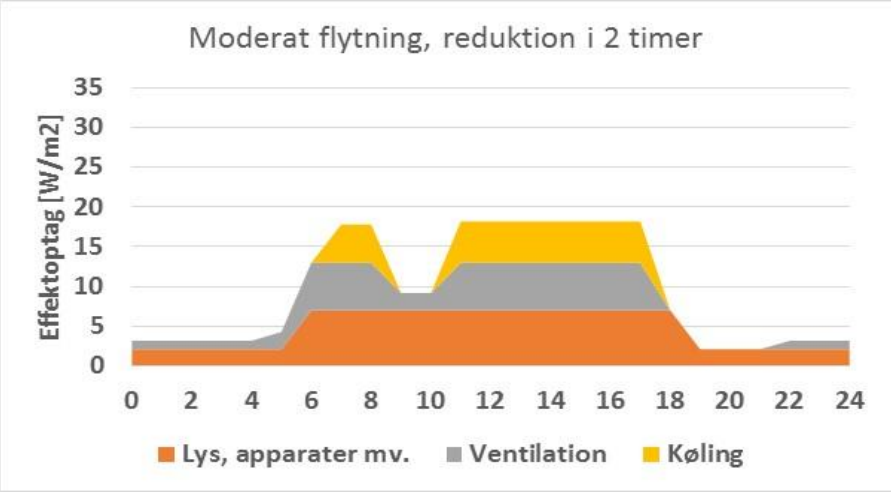
Simple simulation of flexibility – summer day

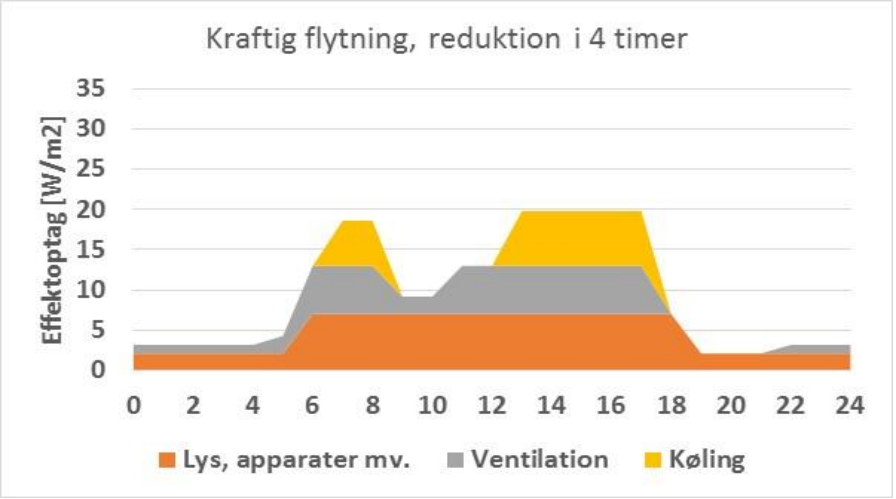


Simple simulations of flexibility – summer day



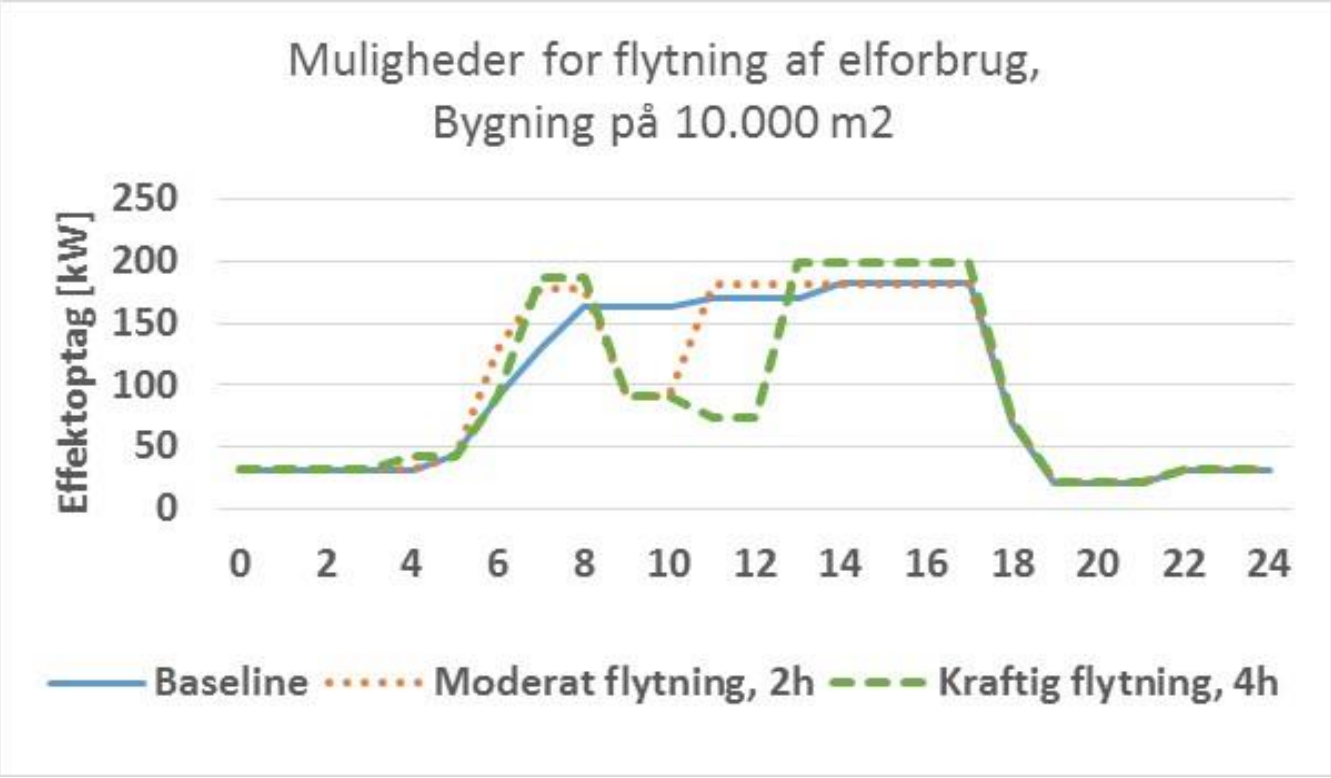






Simple simulations of flexibility

Three examples of electric power curves fullfilling the comfort criteria for an office building. So multiple ways to support system operators with in a single day.



Retrofitting office buildings

Ventilation and cooling

- Short term interruptions of ventilation and cooling systems are possible with simple technical solutions
- Exploiting energy flexibility fully requires the systems can be controlled by variable (dynamic) set point. Possibly, it is necessary to invest in more room temperature sensors than those available in the building today.
- Coordinated management, so systems are not opposing the attempts to reduce or increase electricity or heat power
- Cost to reprogram the BMS, so it can use variable set points and communicate with buyers of flexibility services or providers of weather forecasts.

Heating

- Mechanical radiator valves will restrict the room temperature can be increased to more than their fixed set point.
- Lack of heating capacity can reduce flexibility. In such a situation, it is also possible to add extra heating capacity in the form of, for example, electric heating panels in the rooms or electric heating coil in ventilation units

Retrofitting office buildings

Bi-meters

- It may in practice be difficult to separate the flexible and inflexible energy consumption in office buildings. Bi-meters (secondary) are a tool to identify and document the flexible consumption - also to the customer for the flexible services.

Energy savings (pay themselves)

- In general, many of the above measures also have a significant energy saving effect, for example, the strategy of the varying set point (23-26 ° C). The energy-saving measures will most often have a short payback time and can drive update of the installations, so that they can actively participate in the smart-grid. Alone because of the energy savings, it will often make sense to upgrade or update the BMS in an office building.

Knowledge building

- Generally, there is a great need for knowledge building around office buildings and their energy flexibility in practice. There is a large task in getting collected systematic data and experience for office buildings, electricity and heating consumption, indoor climate and dynamics in order to develop solutions for the realization of the technical potential for energy flexibility.

Thank you

Related projects to adress some of the issues of energy flexibility and buildings

COORDICY: ICT-driven Coordination for Reaching 2020 Energy Efficiency Goals in Public and Commercial Buildings (Project management: Syddansk Universitet)

IEA EBC Annex 67 Energy Flexible Buildings (Project management: Teknologisk Institut/Aalborg Universitet

iBygning – Intelligente bygninger til et intelligent energisystem (Resultatkontraktforslag: Teknologisk Institut)