ZEB
The Research Centre on Zero Emission Buildings

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ZEBs impact on the energy system

CenSES Årskonferanse
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Zero Emmission Buildings' impact on the energy system

through *smartgrid* and *demand side management*

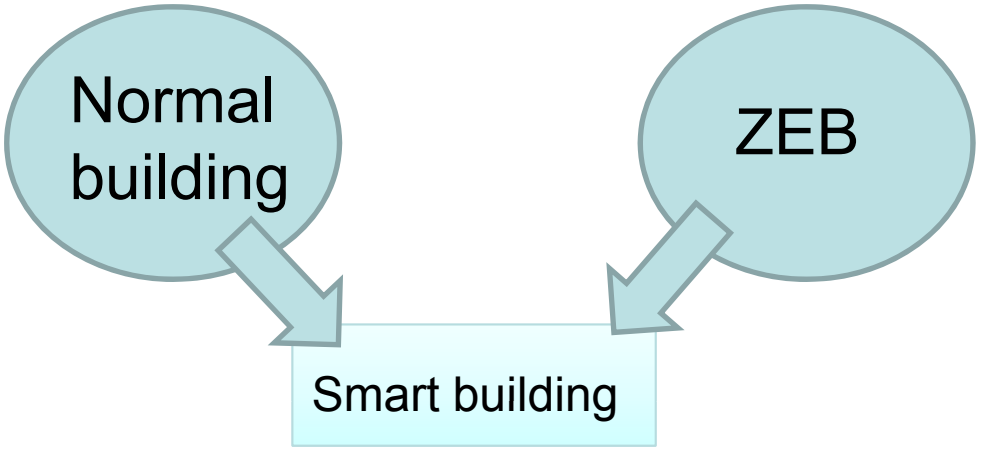
Outline

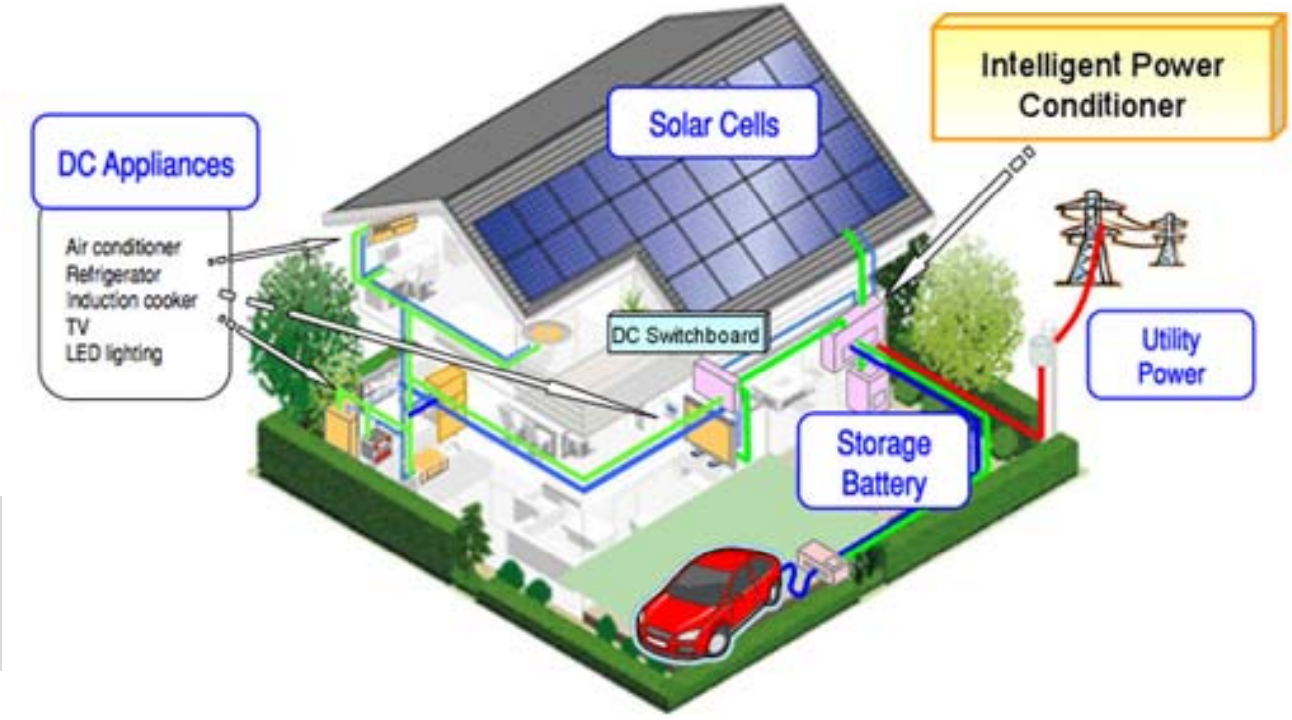
- ZEB – zero energy buildings, zero emission buildings
  - What is it?

- Impact on the energy system
  - … of altered load towards the grid?

Smart house

- Type of building not specified
- Arbitrary building with smart appliances integrated





Zero Energy Building

- Passive house
  - Extremely low energy demand
  - Adapted architecture
  - Utilisation of daylight, thermal mass, passive heating and cooling, natural ventilation

- Local energy production
  - PV, solar thermal, heat pump, combined heat and power (CHP), wind

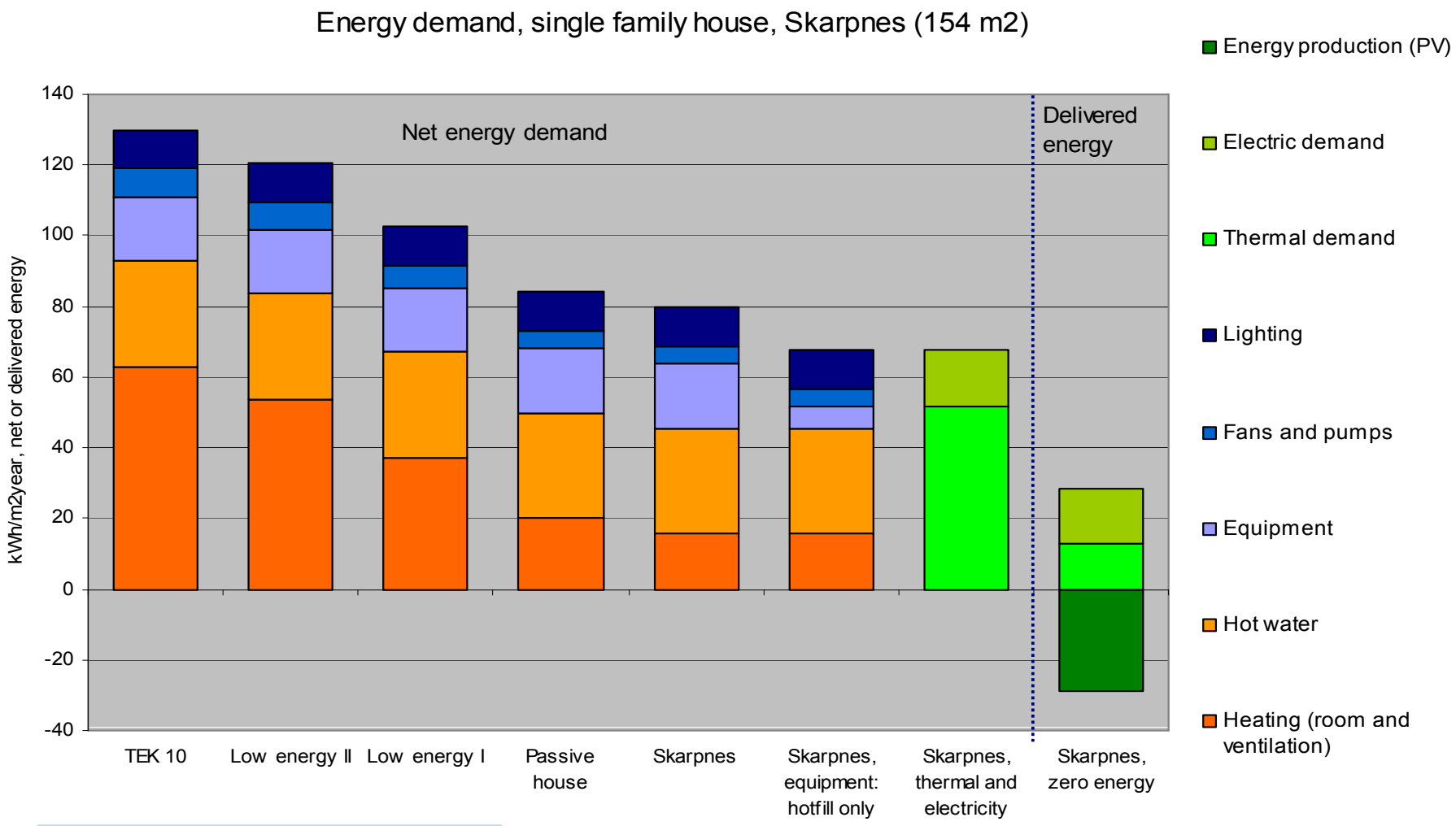
- Zero yearly energy demand

Example: Skarpnes project

- Heat production
  - Solar collectors
  - Heat pump + energy wells
- Electricity production
  - PV
- Low demand
  - Heat recovery ventilation: 90%
  - Water based heating + radiator
  - Hot-fill machines

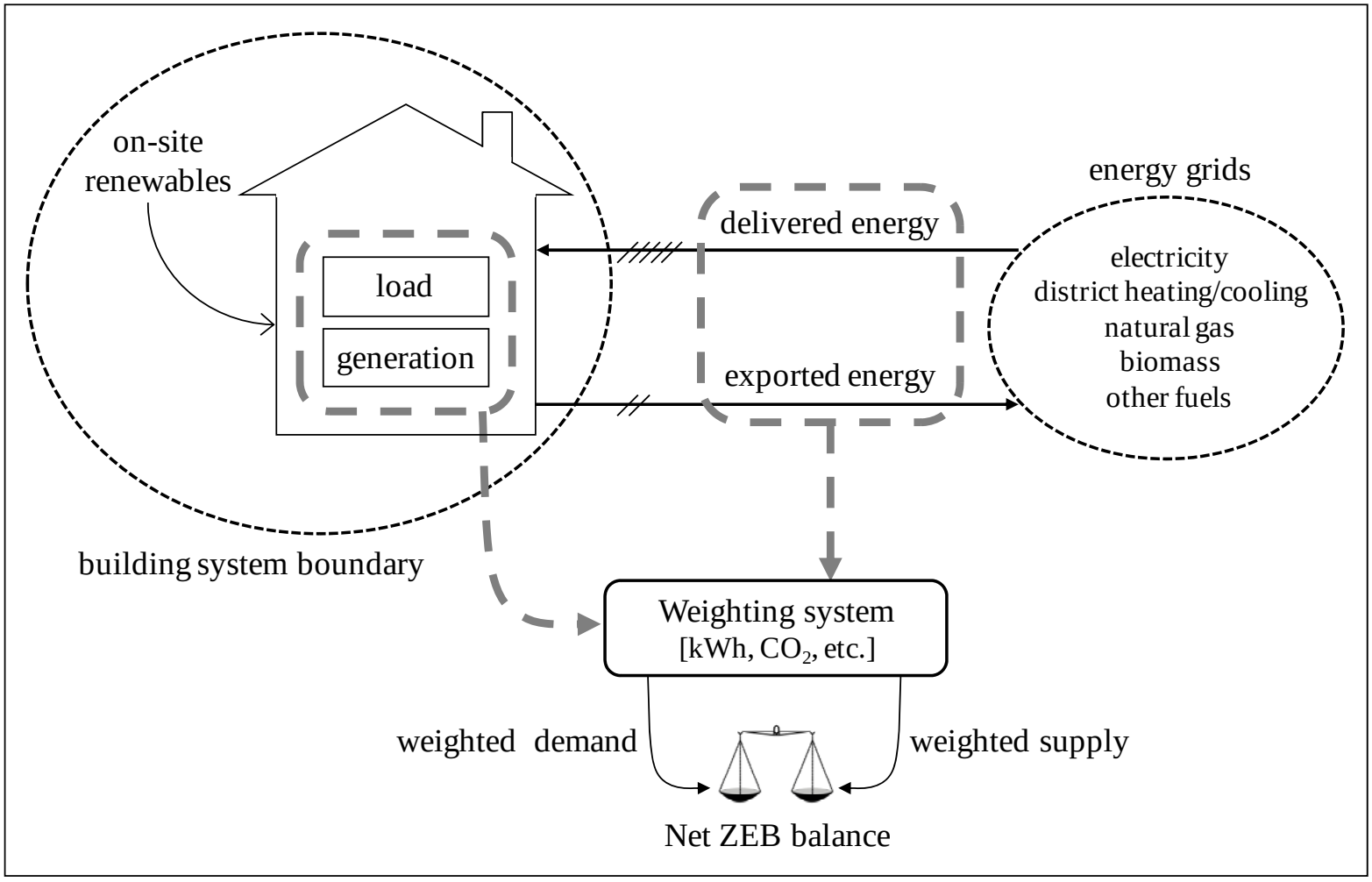
Ref: Marit Thyholt, Skanska / ZEB

Energy budget and balance



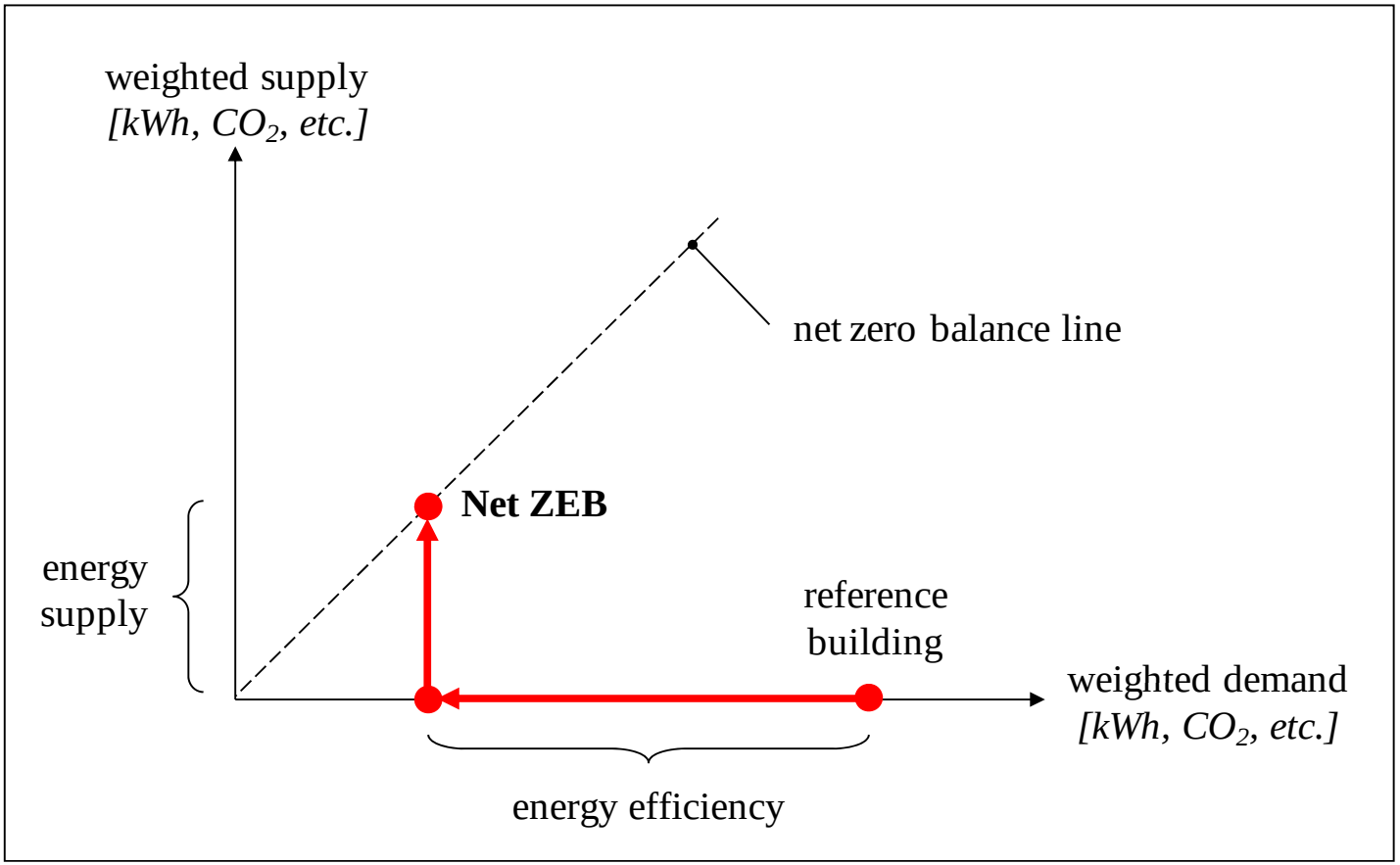
Ref: Marit Thyholt, Skanska / ZEB

Zero Energy Building, Zero Emission Building...



Ref.: Igor Sartori, Sintef Byggforsk / ZEB.

The balance concept



Reference: Sartori, Dokka and Andersen, 2011. "Proposal of a Norwegian ZEB definition: Assessing the Implications for Design." Journal of Green Building, Vol.6, No.3, pp.133-150, Summer 2011

Net ZEB balance: | weighted supply | – | weighted demand | ≥ 0

Hourly balance….

- ZEB definition is on a yearly scale
- Impact on the grid demands investigation on hourly basis

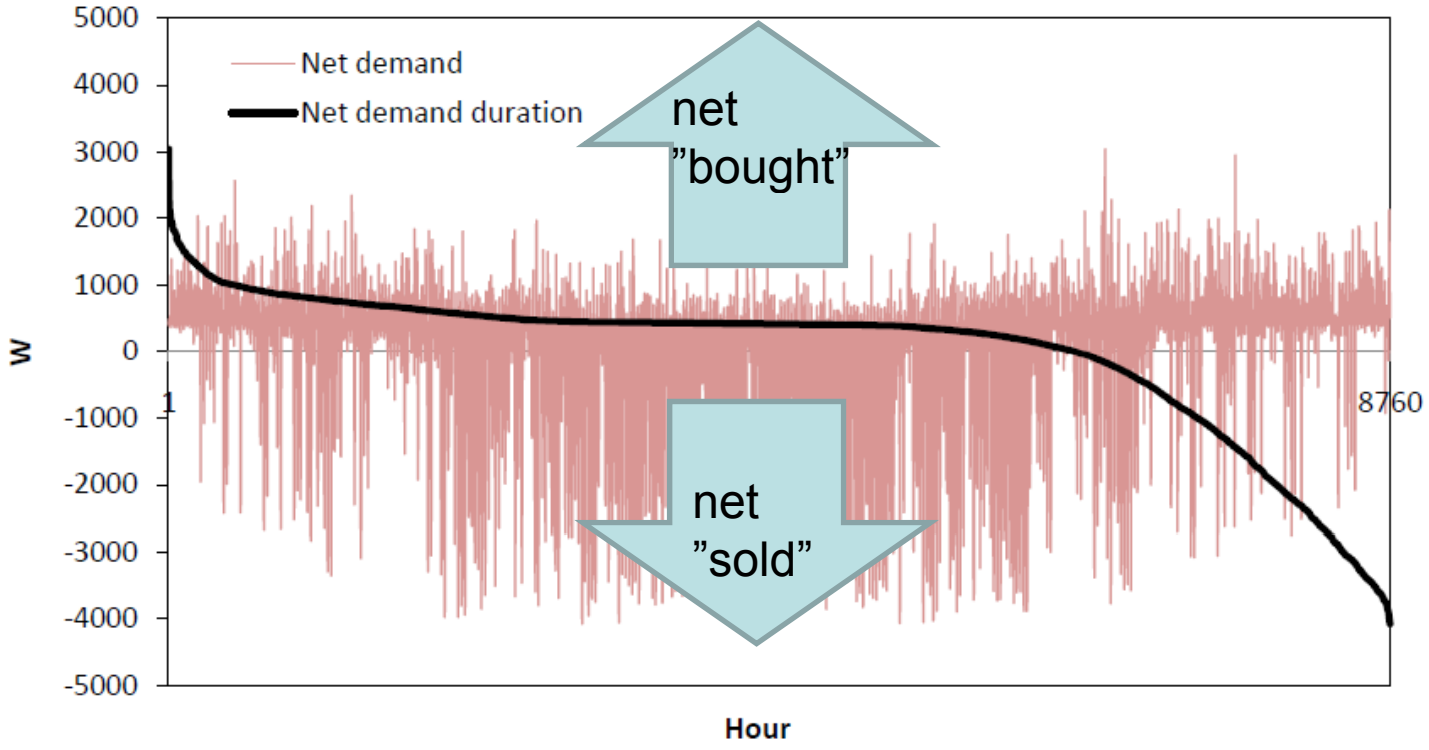


Figure 3. Hourly net demand over the studied year together with the same data sorted in a duration graph. Net generation is represented as negative demand.

Reference:
Widén and Wäckelgård, 2010. EASST Conference, 2010, Italy

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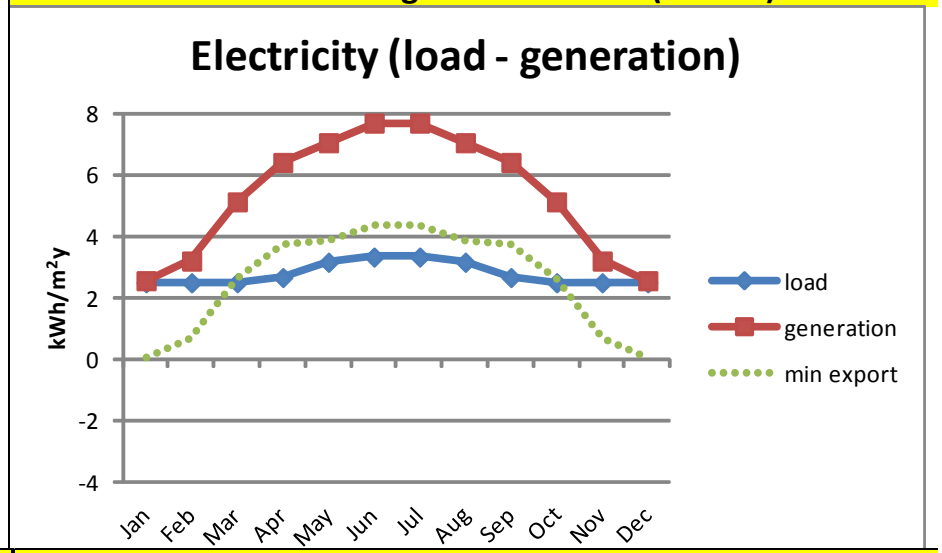
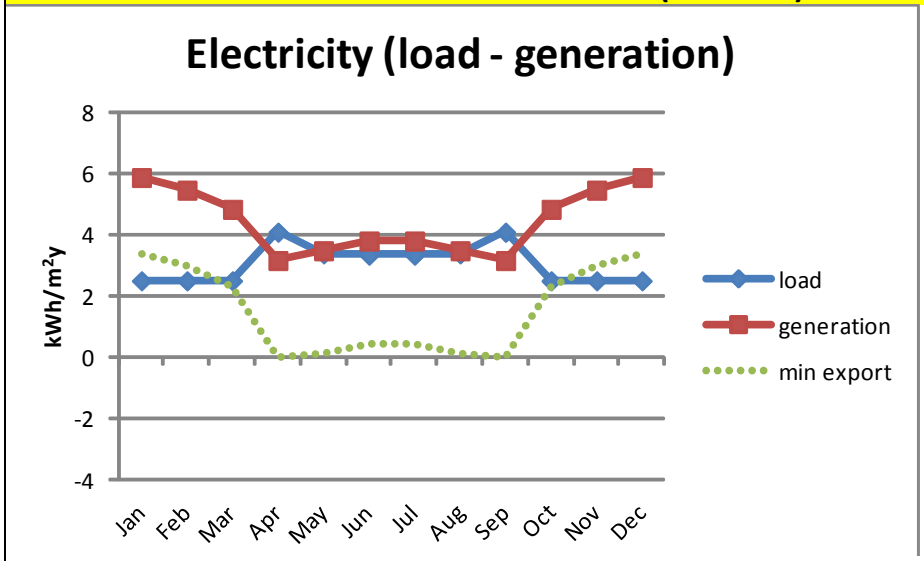
Electric load profiles towards the grid

- (1) Generation System
  - PV, solar collectors, HP, CHP, district heating
- (2) Demand flexibility

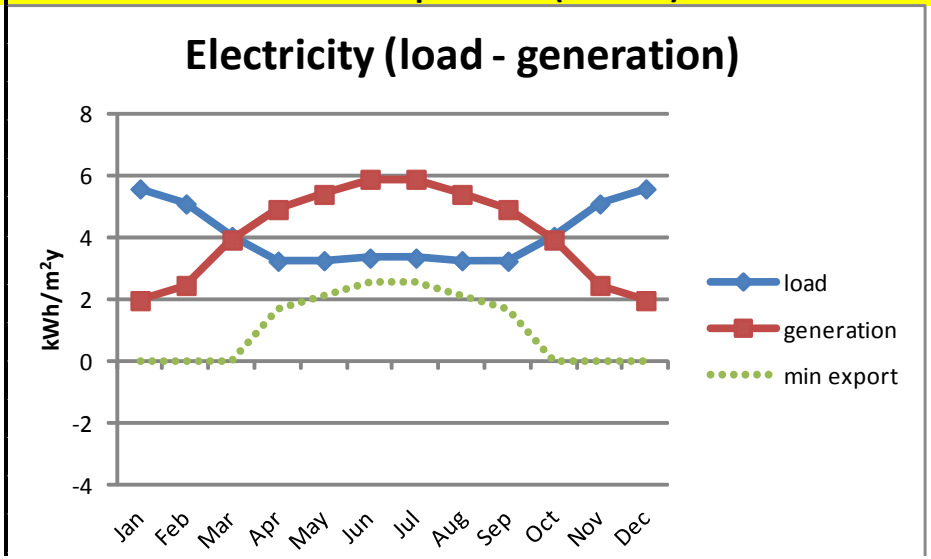
District Heating + Photovoltaic (DH+PV)



Combined Heat and Power + Solar (CHP+Sol)



Heat Pump + Solar (HP+Sol)



Ref.: Igor Sartori, Sintef Byggforsk / ZEB.

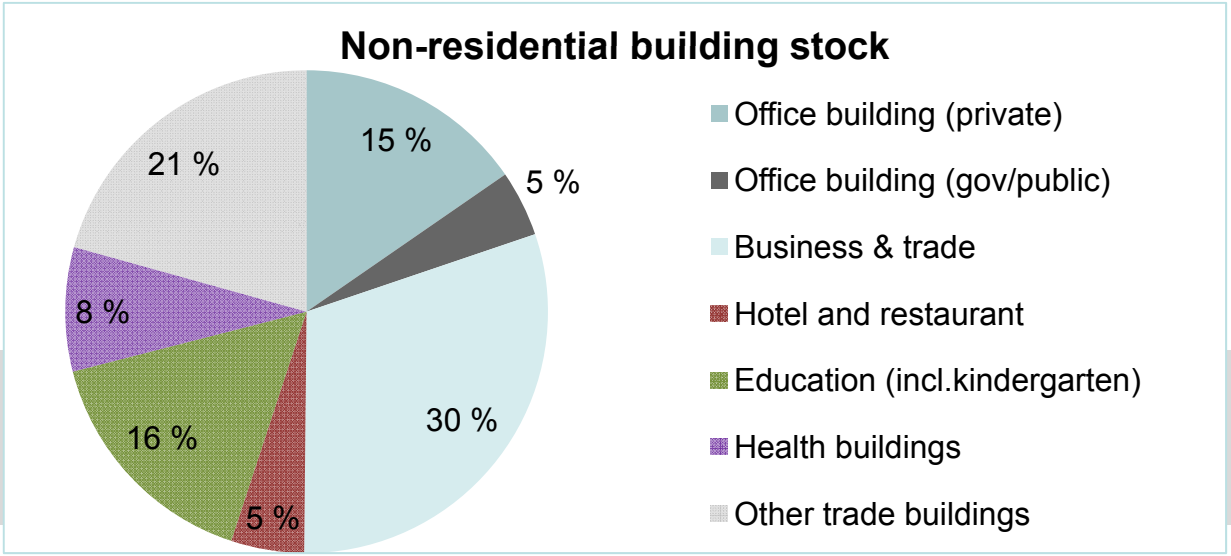
Demand flexibility

- Heat demand -> flexible
  - Thermal mass
  - Choice of heat distribution system within the building
  - Storage (?)
- Electric appliances -> less flexible
  - Battery (?)
- Load shifting and shaving
  - What, how much and how long?

PhD work (1/3)

- Predicting load profiles for existing buildings in Norway
  - Focus on non-residential buildings. (Households from El-dek)
  - Regression of 200 existing buildings (and passive buildings)
  - Identifying demand of:
    - lighting&electric equipment, hot tap water and cooling demand.

- Office (50), schools (40), kindergarten (40), nursery homes (30)



Ref.: Enovas Byggstatistikk 2010 (Enova Report 2011:8)

Regression model of existing buildings

- (a start..)

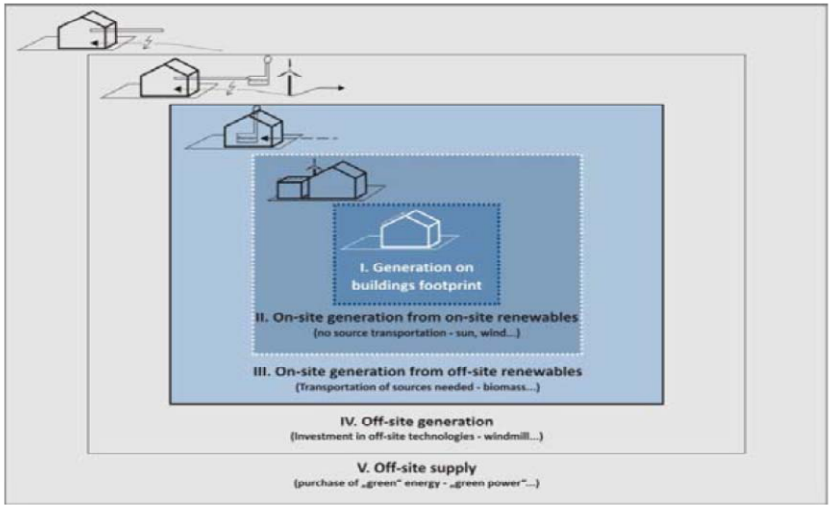
$$y_{it}^{H} = \alpha_i^H + \beta_i^{EMP,H} EMP_i + \beta_i^{SQM,H} SQM_i + \beta_i^{AGE,H} AGE_i + \gamma_i^{CRT,H} D_i^{CRT} + \sum_{g \in G} \beta_g D_{g,i} + \sum_{s \in S} \beta_s^T T_t D_{s,t} + \sum_{s \in S} \beta_s^{T^2} T_t^2 D_{s,t}$$
$$+ \sum_{s \in S} \beta_s^{TMA} TMA_t D_{s,t} + \sum_{s \in S} \beta_s^W W_t D_{s,t} + \sum_{s \in S} \beta_s^{WMA} WMA_t D_{s,t} + \sum_{m \in M} \beta_m^{SH} SH_t D_{m,t} + \sum_{m \in M} \beta_m^{MSH} MSH_t D_{m,t}$$
$$+ \sum_{p \in P} \sum_{wdh=1}^{24} \beta_{p,wdh}^{WD} D_{p,wdh,t}^{WD} + \sum_{s \in S} \sum_{weh=1}^{24} \beta_{s,weh}^{WE} D_{s,weh,t}^{WE} + \sum_{d=1}^{6} \beta_d D_{d,t} + \sum_{m=1}^{11} \beta_m D_{m,t} + \varepsilon_{it}^H$$

  - Office (50), schools (40), kindergarten (40), nursery homes (30)
  - Hourly measurements 1.1.2009 – 31.12.2011, separated on heat and electricity
  - Explanatory variables:
    - temperature, wind, solar irradiation, building size, age, no of employees.

PhD work (2/3)

- Predicting net load profiles for ZEB buildings in Norway
  - Load profiles of passive buildings
  - Production profiles for 4-5 different generation systems
  - System boundaries
    - Representative ”ZEB-building” or ”ZEB-area”?
  - Assessing flexibility
    - Load shifting and shaving
    - Storage
    - Heat demand

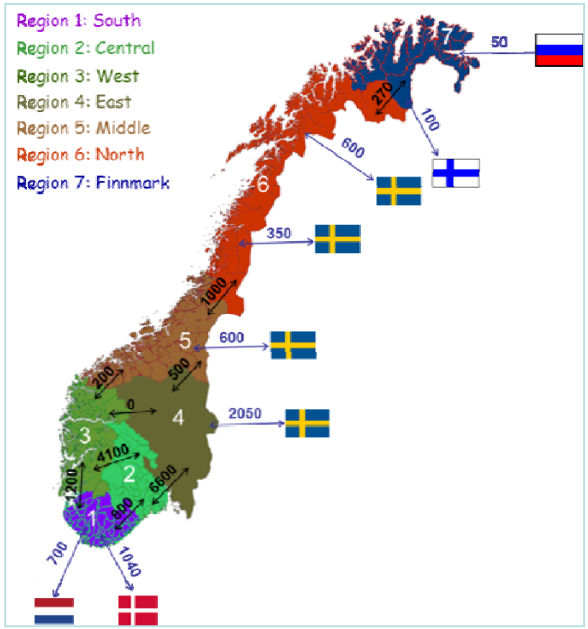
Shiftable & storageable -> but large enough?



Ref.: Marszal, Bourrelle, et.al, 2011.
Based on the work of IEA SHC Task 40.

PhD work (3/3)

- Investigating impact on the energy system
  - TIMES model
    - Technical Economic bottom-up model
    - Investments and operational costs
    - Entire energy system
    - Optimising by least cost principle. Demand driven.
  - EMPS model
    - Power market model
    - Operation of the market

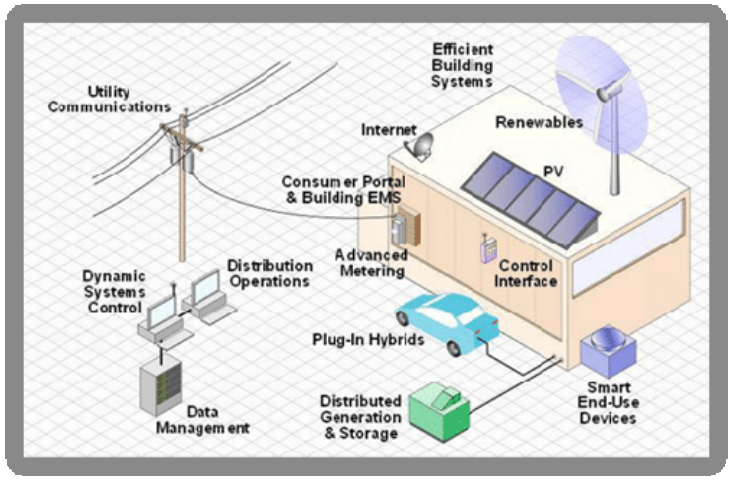


  - Impact on operation and investments in the energy system?
  - Impact on price formation and import/export in the power market?
  - Impact on Norway's ability to export capacity?

Summary

- The building's net demand will alter as they act as **prosumers** – both consuming and producing energy

- ZEBs
  - … have low flexible electricity demand
  - … may have flexible heat demand
  - … interaction with the grid is dependent on choice of energy production system amd presens of storage



- Investigating:
  - Impact on operation and investments in the energy system
  - Impact on price formation and import/export in the power market
  - Impact on Norway's ability to export capacity

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Thank you for your attention

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