ZEBs impact on the energy system

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Karen Byskov Lindberg
PhD Candidate, Dept. of Electric Power Engineering, NTNU
Senior Engineer, The Norwegian Water Resources and Energy Directorate (NVE)
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

Normal building

ZEB

Smart building
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

Energy demand, single family house, Skarpnes (154 m²)

140

Ref: Marit Thyholt, Skanska / ZEB
Zero Energy Building, Zero Emission Building...

Ref.: Igor Sartori, Sintef Byggforsk / ZEB.
The balance concept

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

Reference:
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.*

Electric load profiles towards the grid

- **(1) Generation System**
  - PV, solar collectors, HP, CHP, district heating

- **(2) Demand flexibility**

Ref.: Igor Sartori, Sintef Byggforsk / ZEB.
Demand flexibility

- Heat demand -> flexible
  - Thermal mass
  - Choice of heat distribution system \textit{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)
Regression model of existing buildings

(a start..)

\[ y_{it}^H = \alpha_{i}^H + \beta_{t}^{EMP,H} EMP_i + \beta_{i}^{SQM,H} SQM_i + \beta_{i}^{AGE,H} AGE_i + \gamma_{t}^{CR,T,H} D_{t}^{CR,T} + \sum_{g \in G} \beta_{g} D_{g,i} + \sum_{s \in S} \beta_{s}^{T} T_{s,t} D_{s,t} + \sum_{s \in S} \beta_{s}^{2} T_{s,t}^2 D_{s,t} \]

\[ + \sum_{s \in S} \beta_{s}^{TMA} TMA_{s,t} D_{s,t} + \sum_{s \in S} \beta_{s}^{W} W_{s,t} D_{s,t} + \sum_{s \in S} \beta_{s}^{WMA} WMA_{s,t} D_{s,t} + \sum_{m \in M} \beta_{m}^{SH} SH_{s,t} D_{m,t} + \sum_{m \in M} \beta_{m}^{MSH} MSH_{s,t} D_{m,t} \]

\[ + \sum_{p \in \mathcal{P} \text{ wh}=1} \sum_{t \text{ wh}=1}^{24} \beta_{p,wh,t}^{WD} D_{p,wh,t}^{WD} + \sum_{s \in S \text{ wh}=1} \sum_{t \text{ wh}=1}^{24} \beta_{s,wh,t}^{WE} D_{s,wh,t}^{WE} + \sum_{d \text{ wh}=1}^{6} \beta_{d} D_{d,t} + \sum_{m \text{ wh}=1}^{11} \beta_{m} D_{m,t} + \varepsilon_{it}^H \]

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

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 and presence 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
Thank you for your attention

kli@nve.no