Buildings Interaction with Urban Energy Systems
A Research Agenda

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Published in:
Proceedings of 7PHN Sustainable Cities and Buildings

Publication date:
2015

Citation (APA):
Buildings interaction with Urban Energy Systems

Some glimpse on research

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**Drivers**
(example Danmark)

## ENERGY POLICIES – THE SOCIETAL MOTIVATION

The government’s energy policy milestones up to 2050

In order to secure 100 pct. renewable energy in 2050 the government has several energy policy milestones in the years 2020, 2030 and 2035. These milestones are each a step in the right direction, securing progress towards 2050.

<table>
<thead>
<tr>
<th>2020</th>
<th>2030</th>
<th>2035</th>
<th>2050</th>
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<tbody>
<tr>
<td>Half of the traditional consumptions of electricity is covered by wind power</td>
<td>Coal is phased out from Danish power plants</td>
<td>The electricity and heat supply covered by renewable energy</td>
<td>All energy supply – electricity, heat, industry and transport – is covered by renewable energy</td>
</tr>
<tr>
<td>Oil burners phased out</td>
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The initiatives up to 2020 will result in a greenhouse gas reduction by 35 pct. in relation to 1990.

Source: "Our Future Energy", the Danish Parliament, Nov. 2011

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100% share of RE in the heating sector by 2035
Strategy

- Energy efficiency and savings
- & Renewables

The main challenge
The smart grid cannot solve the challenge of fluctuating energy production and demand by itself.

**Current Energy Systems**

**Future Energy Systems**

**Demand for supporting solutions**

**Examples:**
- Electrical cars
- Heat Pumps (central – decentral)
The (new) opportunities

Trends

Macro Components

Solutions Space

- Standards
- Sensors
- Big Data
- Internet
- Algorithmic/Intelligence
- Control
- Markets
- ...
The opportunity

How will Building-IT interoperate and integrate?
A Sketch of Research Activities Analysed

CITIES
City wide IT-supported energy system support

EnergyLab
Nordhavn
Demonstration
City District

READY
Building Renovation

VPP4SGR
Virtual Power Plant for Grid Ready Buildings

ZenN
Near Zero Energy Neighbourhoods
EERA – European Energy Research Alliance

• EU wide research cooperation

• Joint Programme
  – Energy in Cities
  – Urban Energy Networks
  – Energy-efficient Interactive Buildings
Ready (EU project)

- Resource Efficient cities implementing Advanced smart citY solutions

- Energy retrofitting in buildings in DK and S (multi and single fam. housings)

- Additional READY.dk (multi-family houses retrofitting – measure renovation and flexibility potentials and demonstrate by implementation)
- Potentials retrofit-level vs. investments vs. system investments

- READY (BONUS) – University invested a PhD extra on single family houses

- Finding the new balance of energy savings – local RES – system optimization
ZenN Near Zero Energy Neighbourhoods

- **Technical challenges** Providing cost effective technical solutions that substantially improve building energy performance while allowing for reasonable return of investment periods and are accepted by users.

- **Financial challenges** Providing an adequate financial scheme to facilitate involvement from population sectors with limited resources.

- **Property Structure** challenges Complex property structures at the neighborhood scale often lead to actions that require broad and complex agreements.

- **Social Challenges** Challenges related to the conservation of architectural qualities of buildings, user acceptance issues, etc.
CITIES (DK)

- Holistic Energy System Research
Copenhagen - Energy Lab Nordhavn
The future energy system

- City District Living Lab

- Monitoring of buildings, energy systems (el, heat, cooling, gas ...)
  - > 100,000 data points

- Experiments

- Living Lab Experiments

Source: http://www.byoghavn.dk/byudvikling/bydele/nordhavnen/landvindingsprojektet+i+nordhavnen.aspx
Grid Ready Buildings in VPP4SGR (DK)

- Virtual Power Plant for Grid Ready Building
- Single Building Living Lab
- Dormitory with very heavily equipped unit level, high frequency logging (5 sec, 5 min, hourly) – Not smart grid ready
- Virtual building models for forecasting and control (heating and ventilation) MPC test case
Research Topics (examples to show the wide space)
Cross domain solutions

- Domains: Energy Carriers: Electricity, District Heating etc.
- Sectors: Water, Transport, Energy etc.
- Scale: Component ... Cities ... Energy Systems and Continents
- Time scale: mili-sec ... hours ... days ... years ... long term planning
Research Topics
IT, control, automation

- Cross tech solutions
  - District optimisation algorithms and services across the energy carriers
  - Water for energy storage
  - Transport for flexibility

- IT-intelligence into the energy system
  - Prediction and forecasting
  - Model Predictive Control
  - Big Data Services (data collection, mining, algorithmics, services etc.)
Research Questions in Smart Cities and Buildings Research

- Single building **models** that represents the "flexibility" realistically

- Finding methods for **aggregating** to energy demands for **clusters of buildings** and their impact on the city energy system
  - Archetype and aggregation modelling
  - **City modelling** – Cross technology modelling
    - Consequence: How to integrate different types of models into one simulation framework?

- Validating on large scale by utilizing "big data" (user demand data)
- Privacy Issue to be considered
- And may more

- **THANK YOU FOR LISTENING**

- **QUESTIONS?**
Research Topics
Flexibility and markets

• Flexibility
  – Goal: Demand Side Management – Energy Load Control
  – Ways:
    • Heat Pumps decentralized and centralized – remotely controlled
    • Electrical Car Energy Management
    • Issue of the Day: Building Energy Management
  – Methods:
    • Direct, controlled remotely by the energy provider/accumulator
    • Indirect, through legal contracts

• What role do buildings play?
Can Passive Houses be part of the development?

- Inspiration for Building Research

Research question:
Can a more proactive building energy management help stabilize the overall energy system?

Can we shift demand within buildings?
Can we offer “flexibility”?  
How?
Some answers from the before presentations

Autonomous houses have
No flexibility

Smart Cities are
(often)
not simple

Local RES do (mostly) not support the surrounding Grid(s)

Energy System

... are they sustainable

... are they robust

Claim by Nick Grant

Subject raised this morning