



## **Buildings Interaction with Urban Energy Systems**

### **A Research Agenda**

**Heller, Alfred; Wyckmans, Annemie; Zucker, Gerhard; Petersen, Steffen; Haider, Catrin**

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# Buildings interaction with Urban Energy Systems

## Some glimpse on research

Co-authors:

*Annemie Wyckmans*

*Norwegian University of Science and Technology, Norge*

*Gerhard Zucker*

*Austrian Institute of Technology, Austria*

*Steffen Petersen*

*Aarhus University, Denmark*

*Catrin Haider*

*Austrian Institute of Technology, Austria*

Presenter:

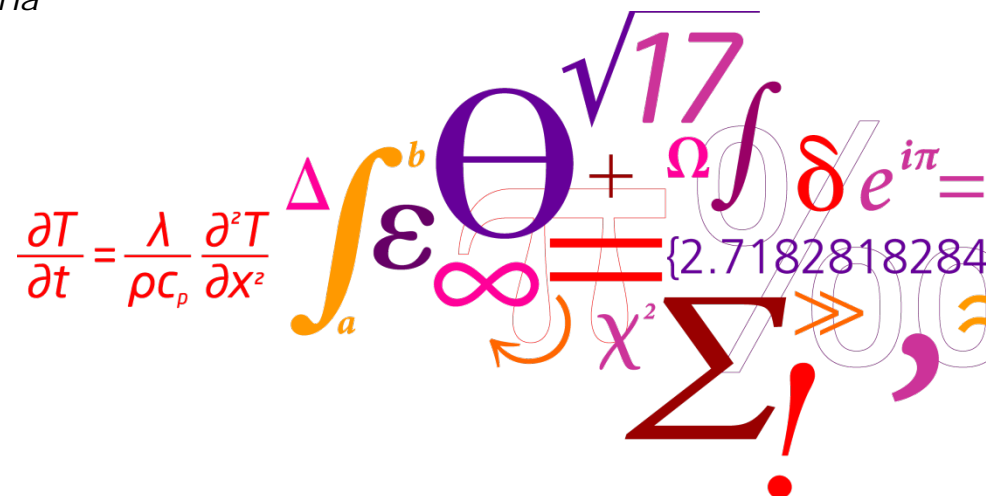
Alfred Heller

Deputy Centre Leader CITIES

Department for Civil Engineering

Technical University of Denmark

[alfh@byg.dtu.dk](mailto:alfh@byg.dtu.dk)



# Drivers

(example Denmark)



## 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.

2020

Half of the traditional consumptions of electricity is covered by wind power

2030

Coal is phased out from Danish power plants  
Oil burners phased out

2035

The electricity and heat supply covered by renewable energy

2050

All energy supply – electricity, heat, industry and transport – is covered by renewable energy

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

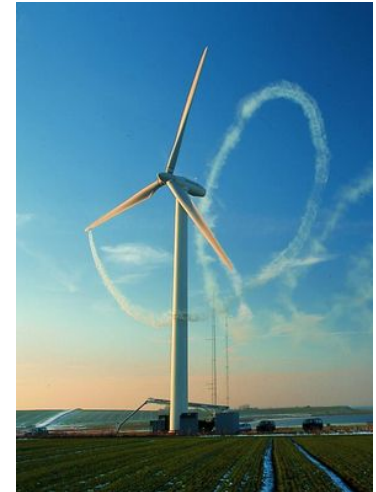
**100% share of RE in the heating sector by 2035**

# Strategy

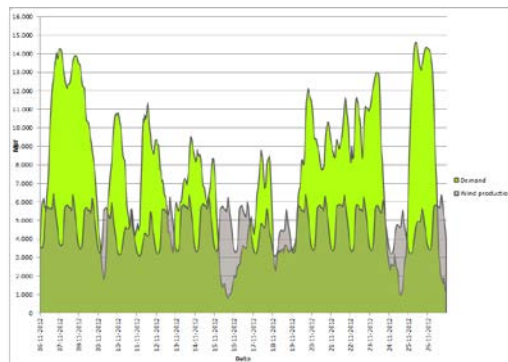


- Energy efficiency and savings

& Renewables



[www.roennebaekskole.skoleintra.dk](http://www.roennebaekskole.skoleintra.dk)

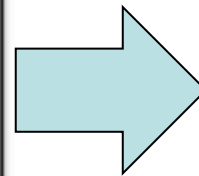
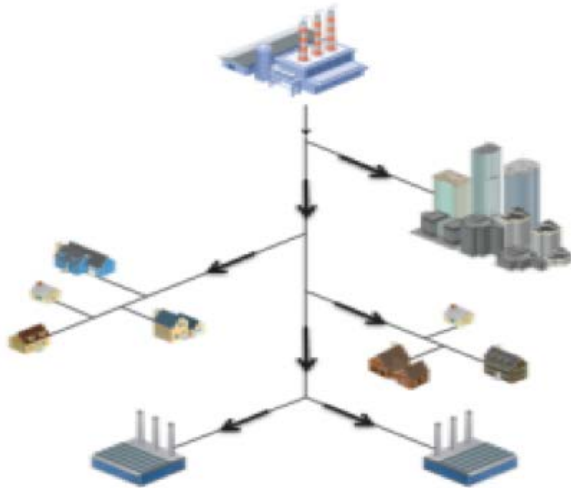


The main challenge

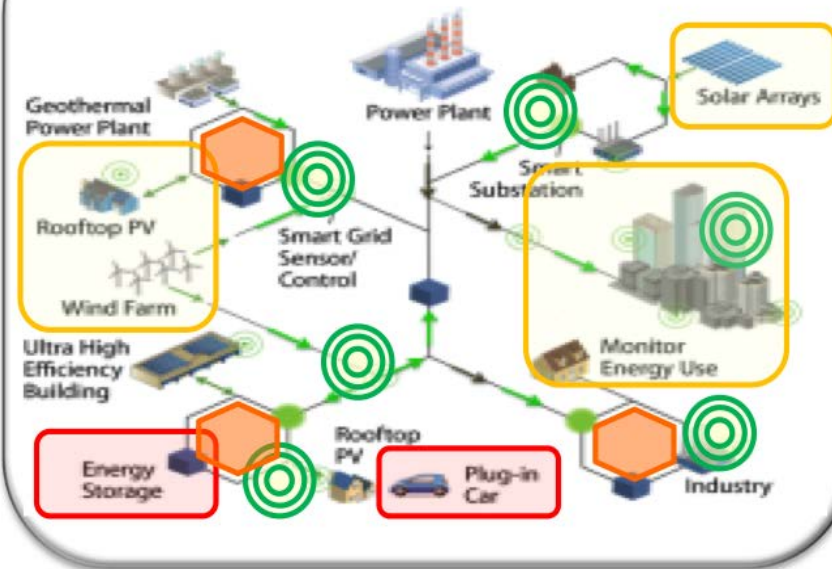
# The Solution and new challenges

## SMART GRID

**Current Energy Systems**



**Future Energy Systems**



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

**Demand for supporting solutions**

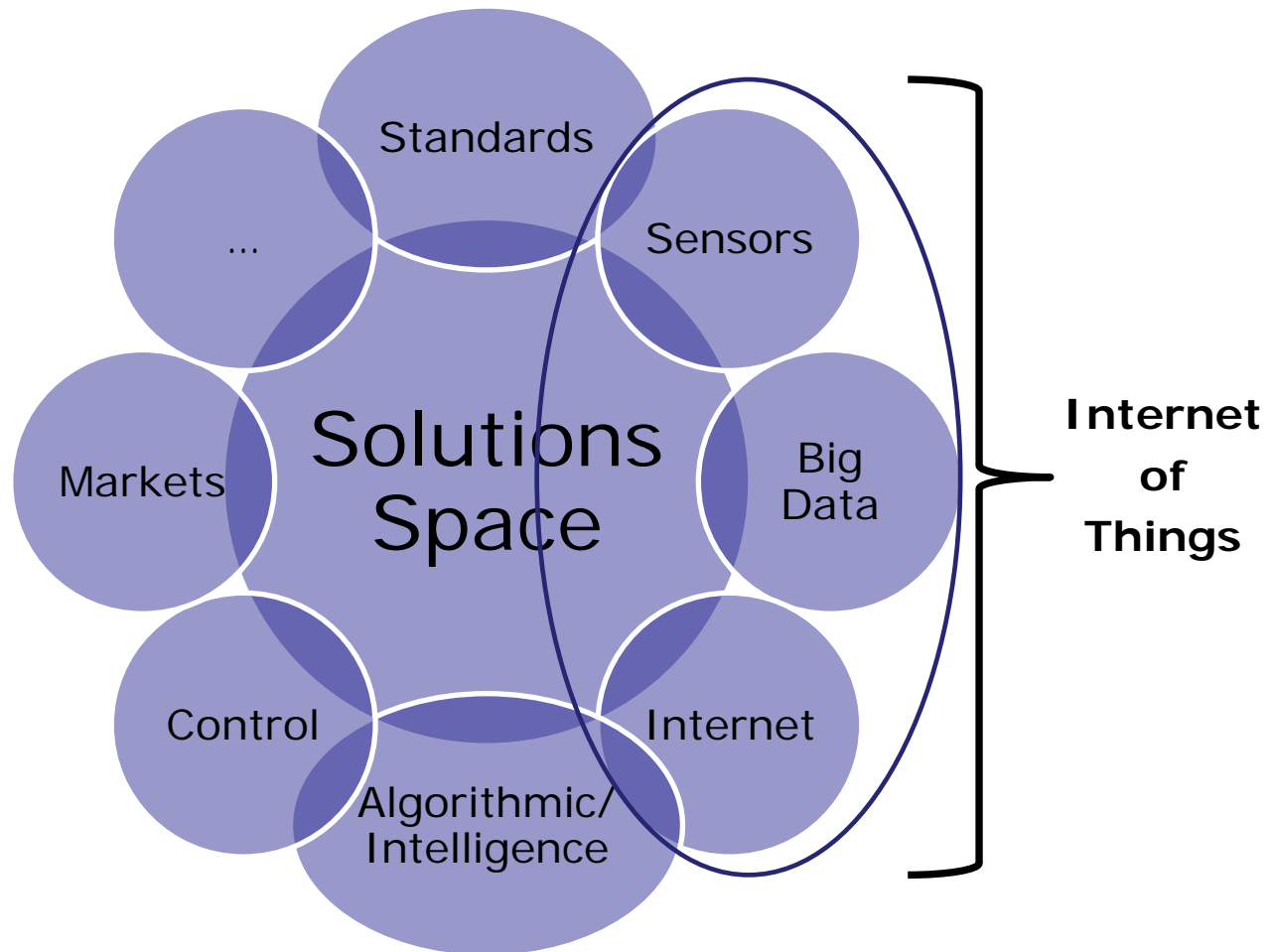
**Examples:**

Electrical cars

Heat Pumps (central – decentral)

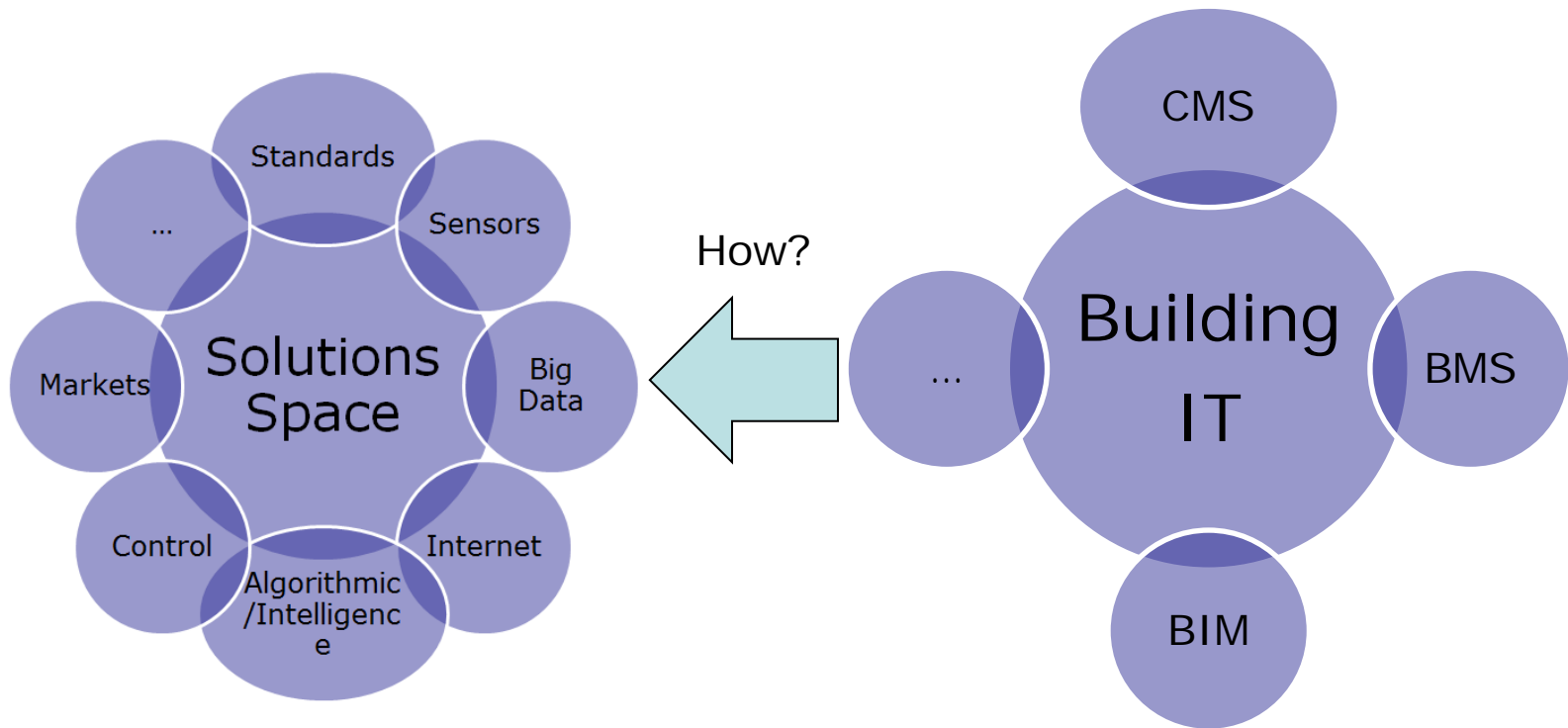
# The (new) opportunities Trends

## Macro Components

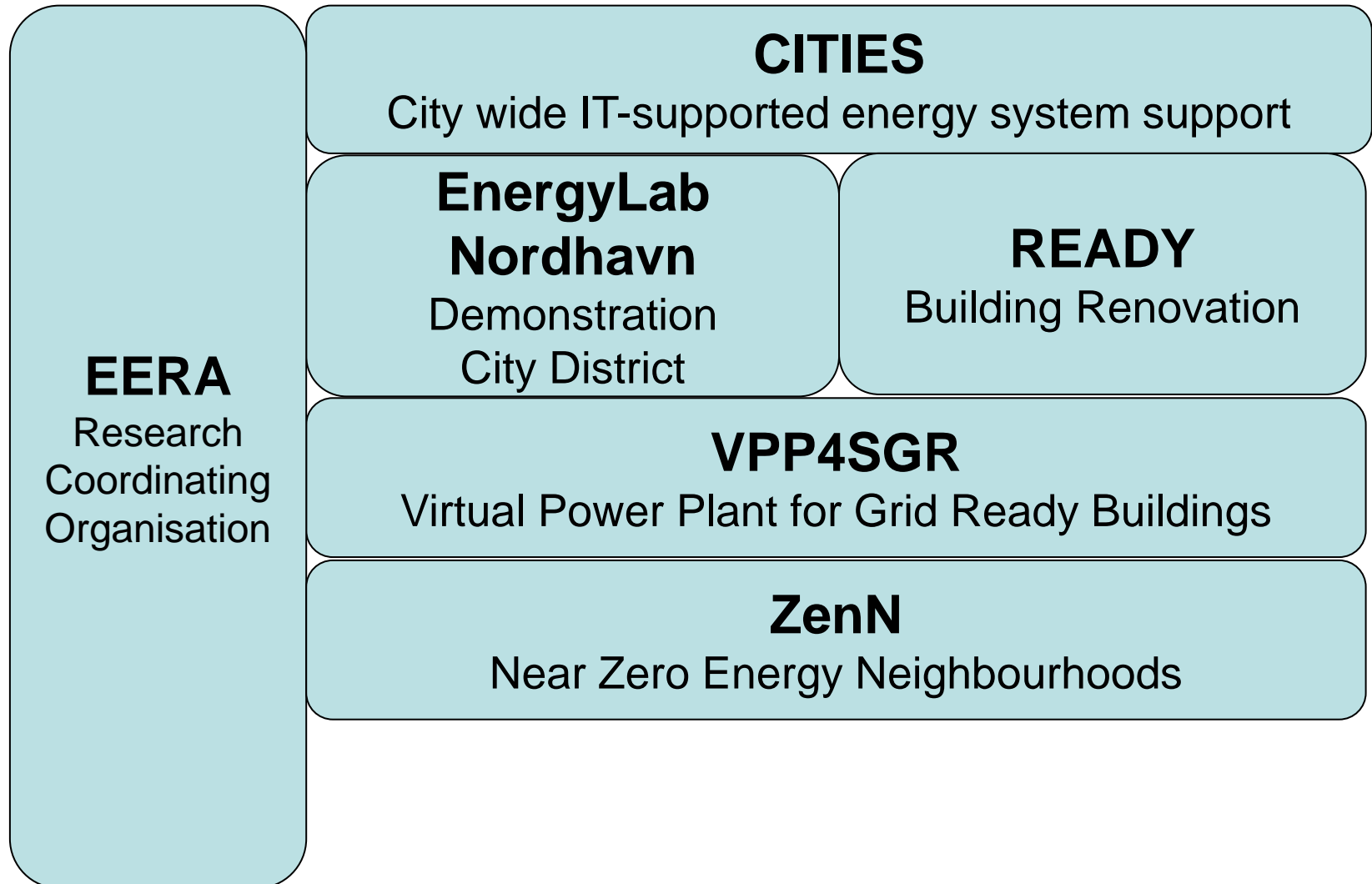


# The opportunity

How will Building-IT interoperate and integrate?



# A Sketch of Research Activities Analysed





# 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.

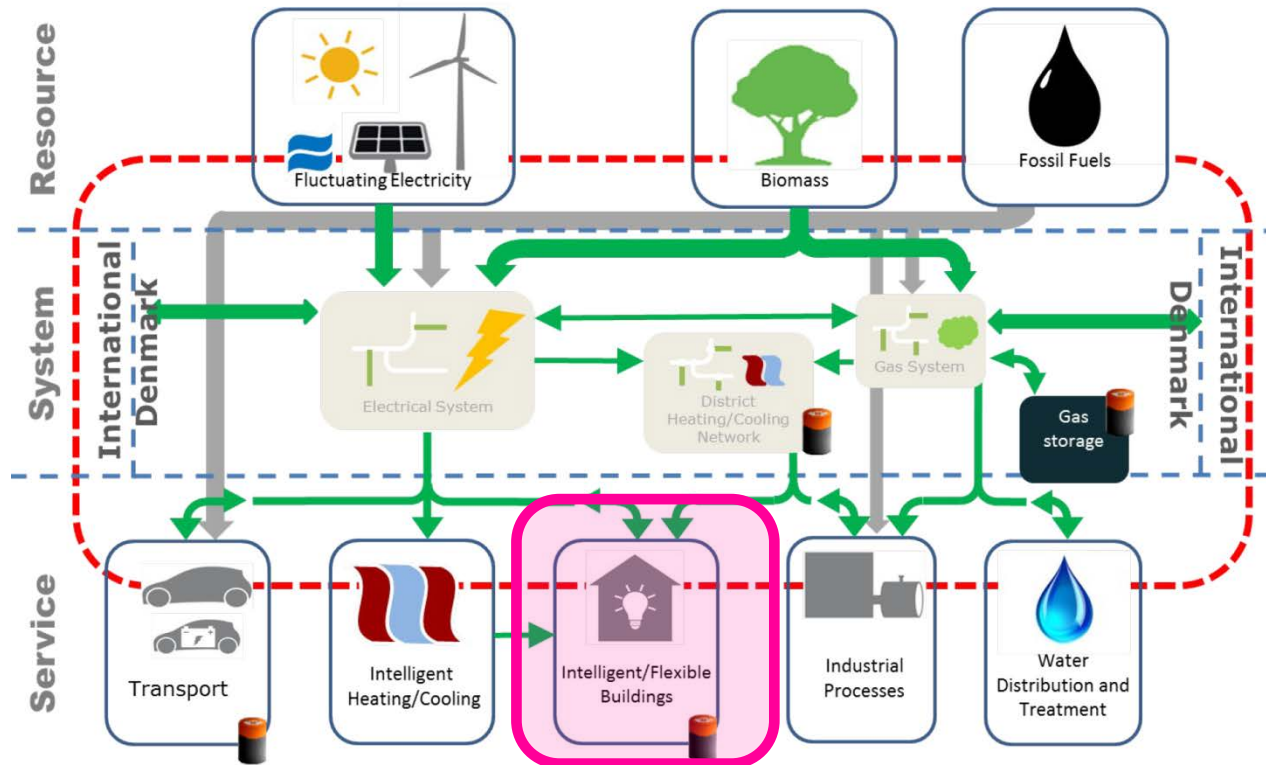
# CITIES (DK)



# CITIES

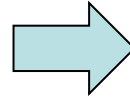
Centre for IT Intelligent Energy Systems

- Holistic Energy System Research





## Copenhagen - Energy Lab Nordhavn The future energy system



Source: <http://www.byoghavn.dk/byudvikling/bydele/nordhavnen/landvindingsprojektet+i+nordhavnen.aspx>

- City District Living Lab
- Monitoring of buildings, energy systems (el, heat, cooling, gas ...)  
    > 100.000 data points
- Experiments
- Living Lab Experiments

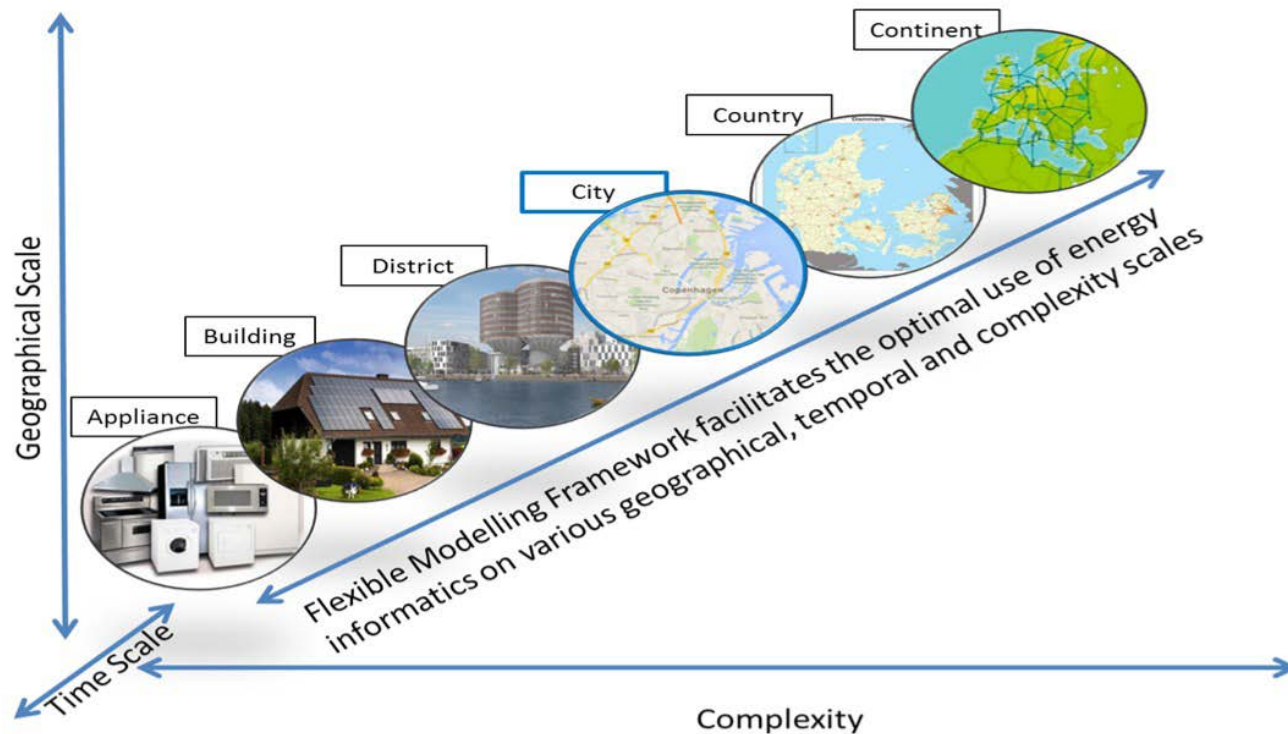
# Grid Ready Buildings in VPP4SGR (DK)

- 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

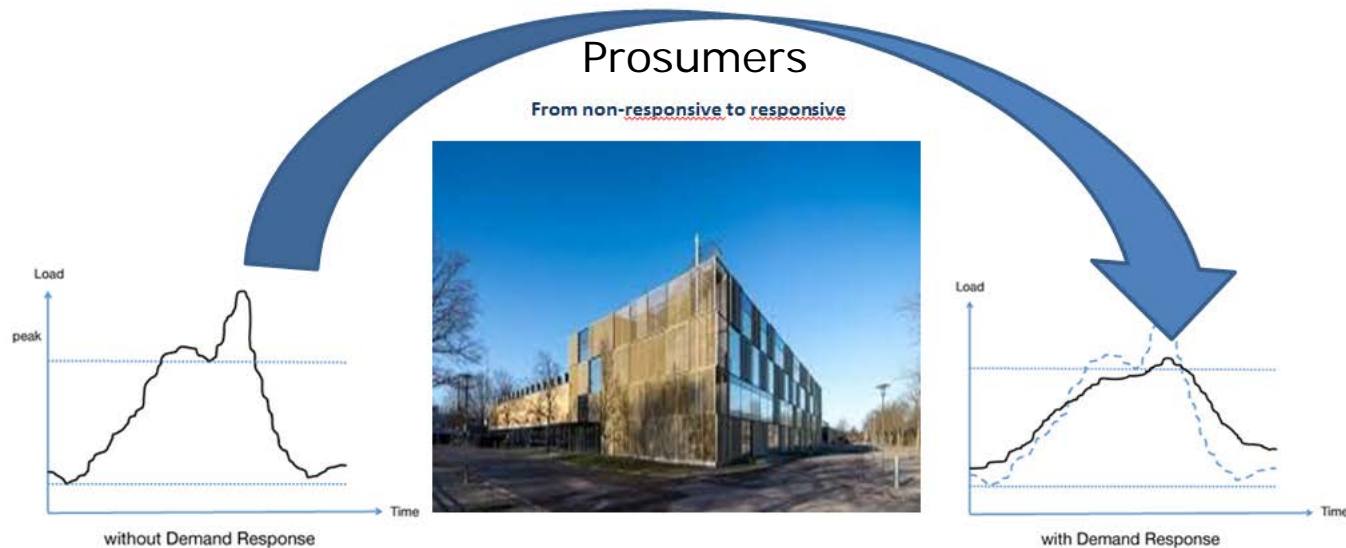
## Flexibility and markets

- 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?

# Conference Topic

## 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

Subject raised this morning

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

**Smart Cities** are  
(often)  
not simple

Claim by Nick Grant

... are they sustainable

... are they robust