



Buildings Interaction with Urban Energy Systems

A Research Agenda

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Buildings interaction with Urban Energy Systems

Some glimpse on research

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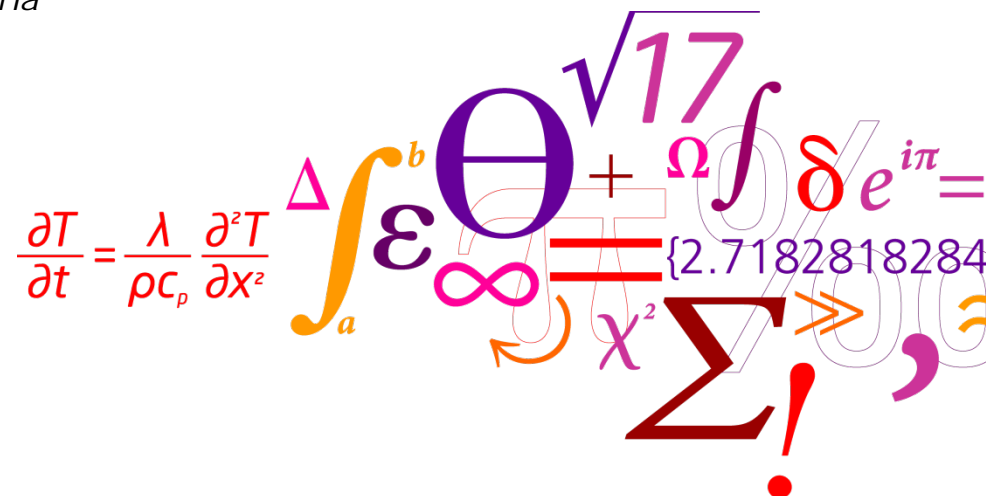
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A collage of mathematical symbols including integrals, derivatives, and constants. The symbols are rendered in various colors and sizes, creating a complex and abstract visual representation of mathematics. The symbols include $\frac{\partial T}{\partial t} = \frac{\lambda}{\rho c_p} \frac{\partial^2 T}{\partial x^2}$, $\int_a^b \epsilon \Theta$, $\sqrt{17}$, $\Omega \int \delta e^{i\pi} =$, ∞ , χ^2 , Σ , and $\{2.7182818284\}$.

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

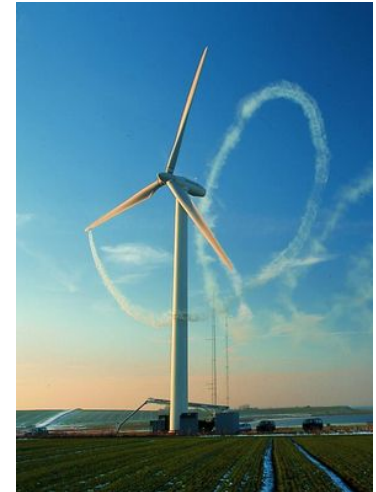
100% share of RE in the heating sector by 2035

Strategy

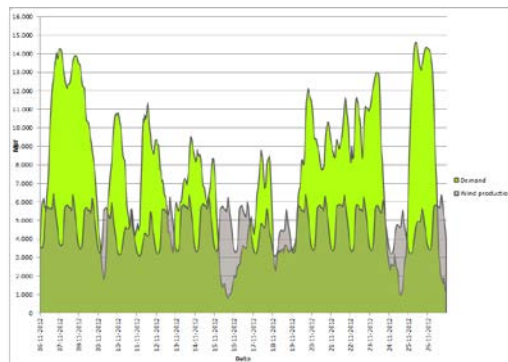


- Energy efficiency and savings

& Renewables



www.roennebaekskole.skoleintra.dk

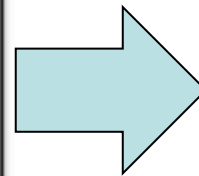
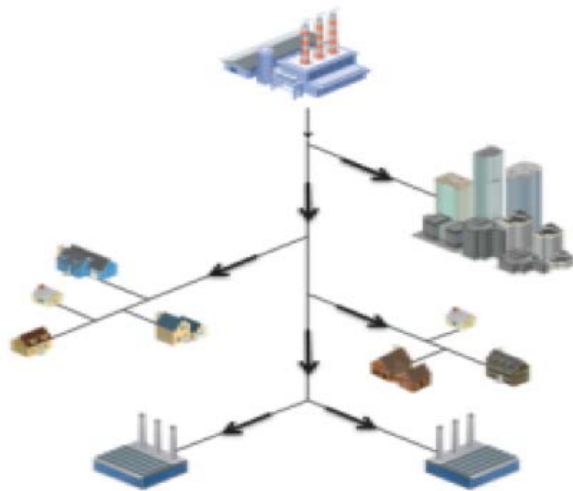


The main challenge

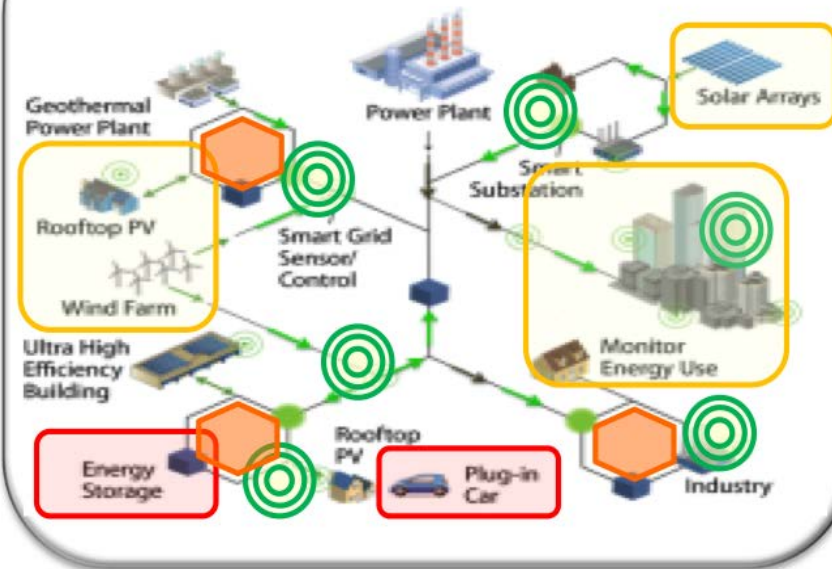
The Solution and new challenges

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

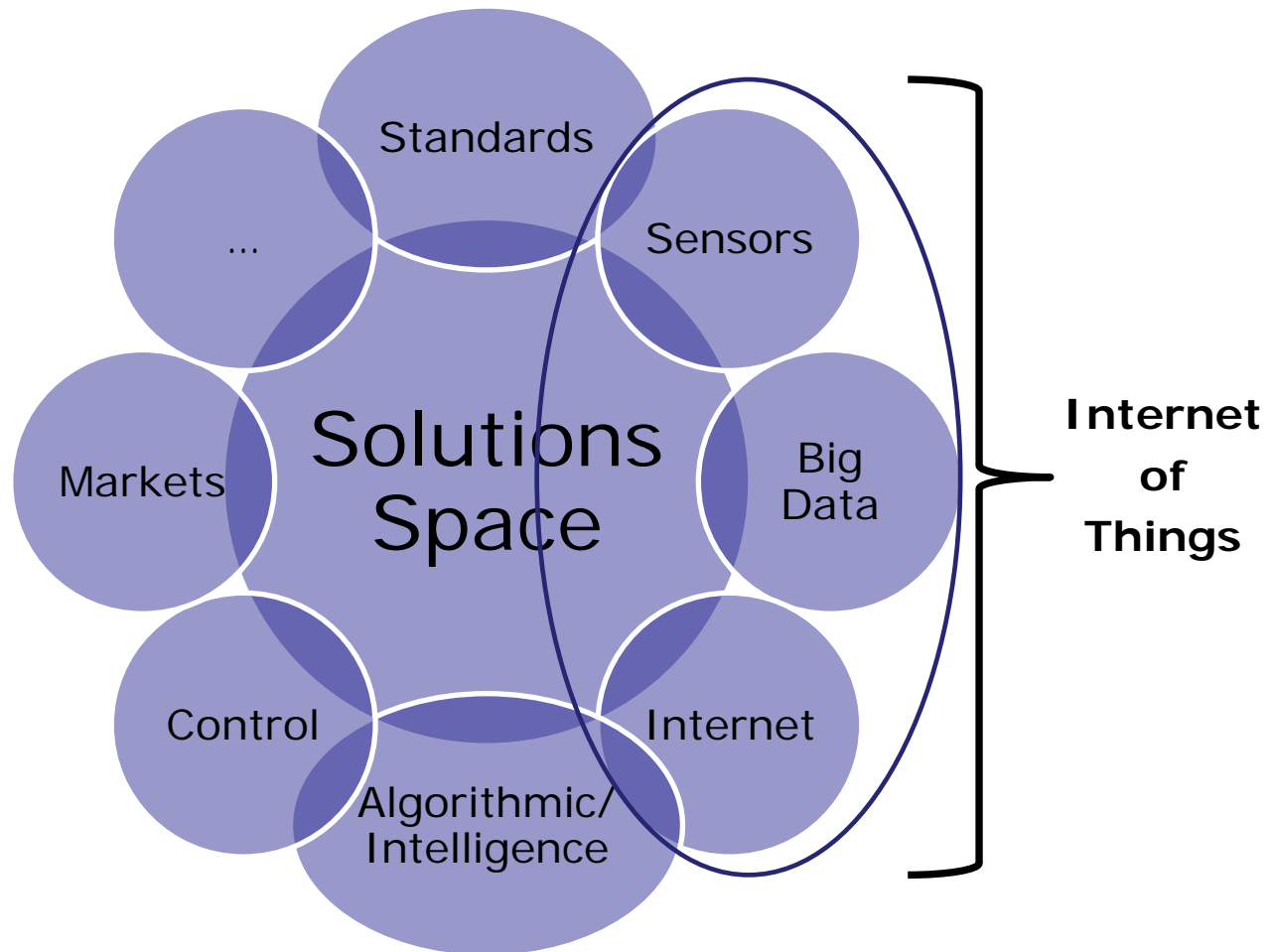
Examples:

Electrical cars

Heat Pumps (central – decentral)

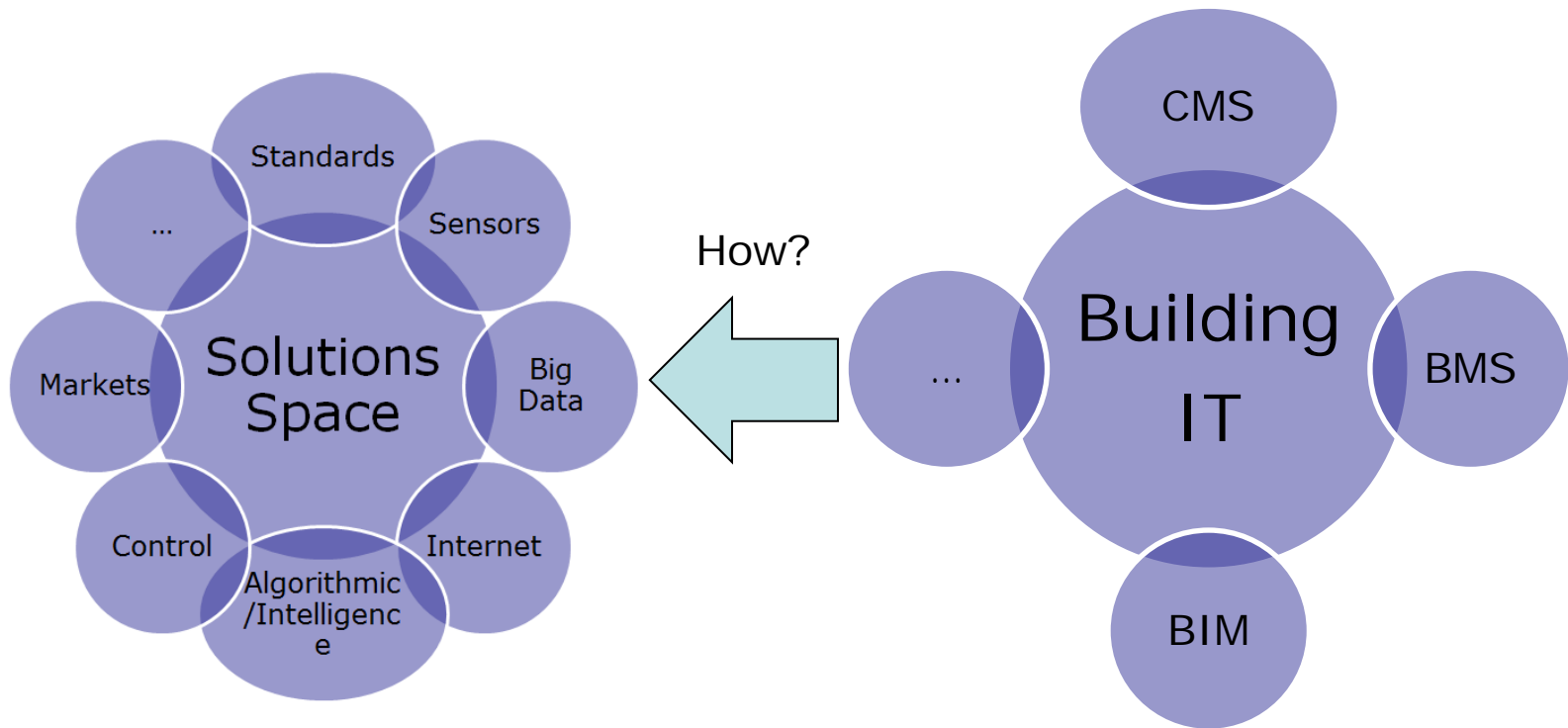
The (new) opportunities Trends

Macro Components

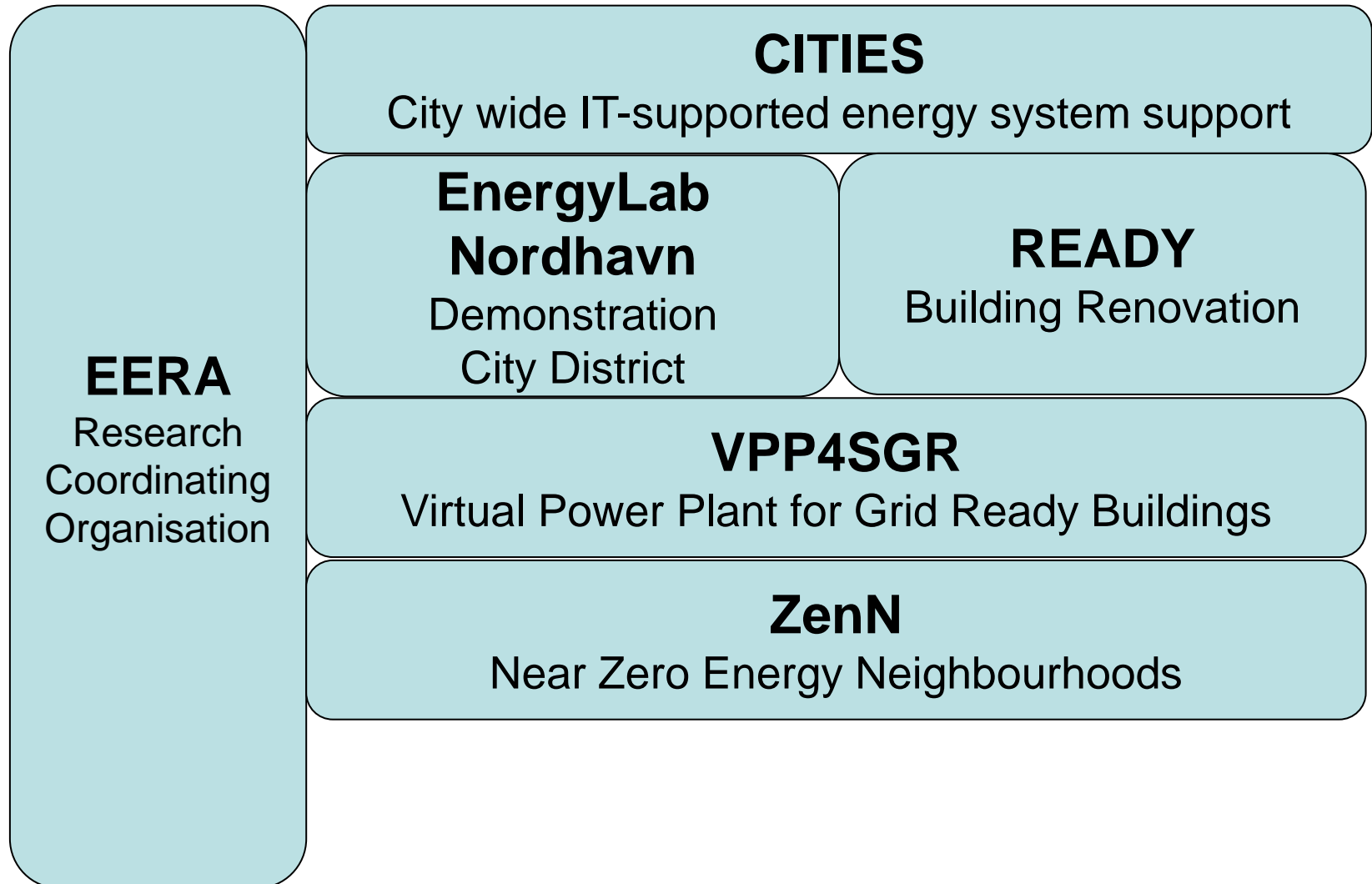


The opportunity

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.

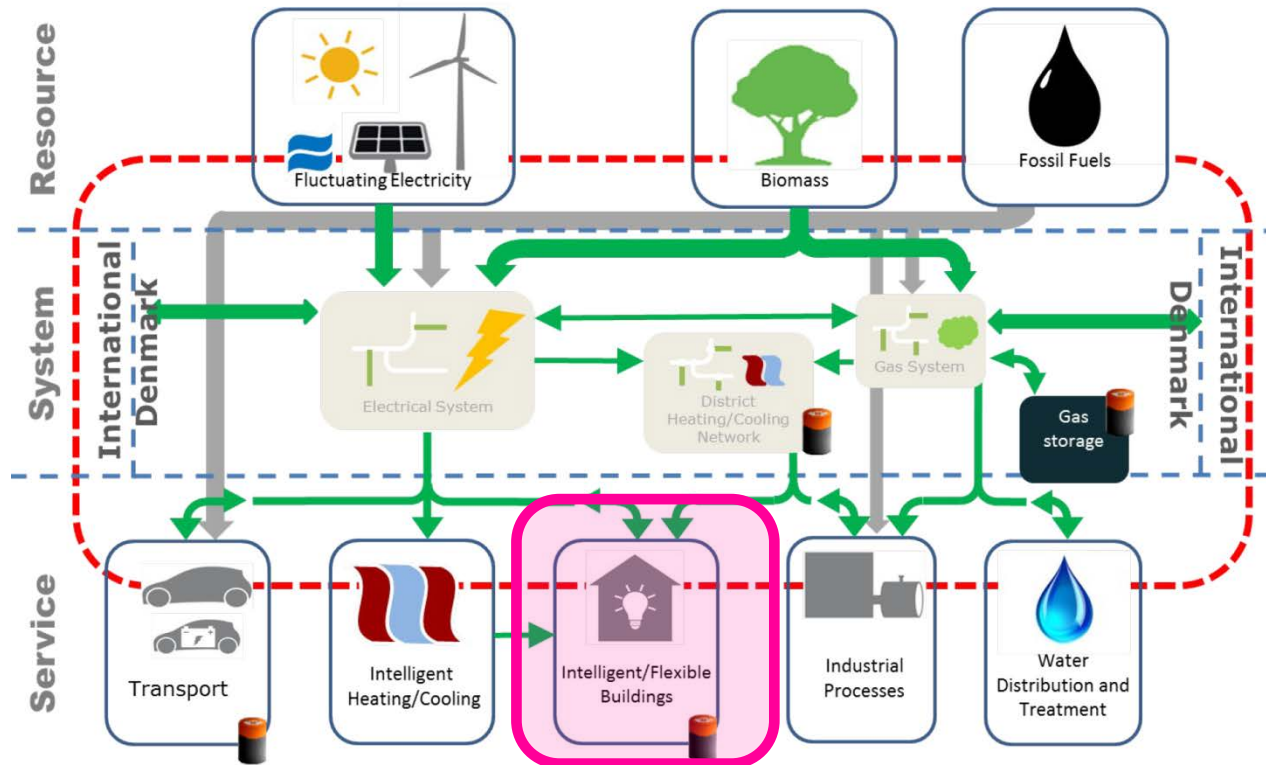
CITIES (DK)



CITIES

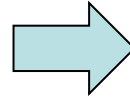
Centre for IT Intelligent Energy Systems

- 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

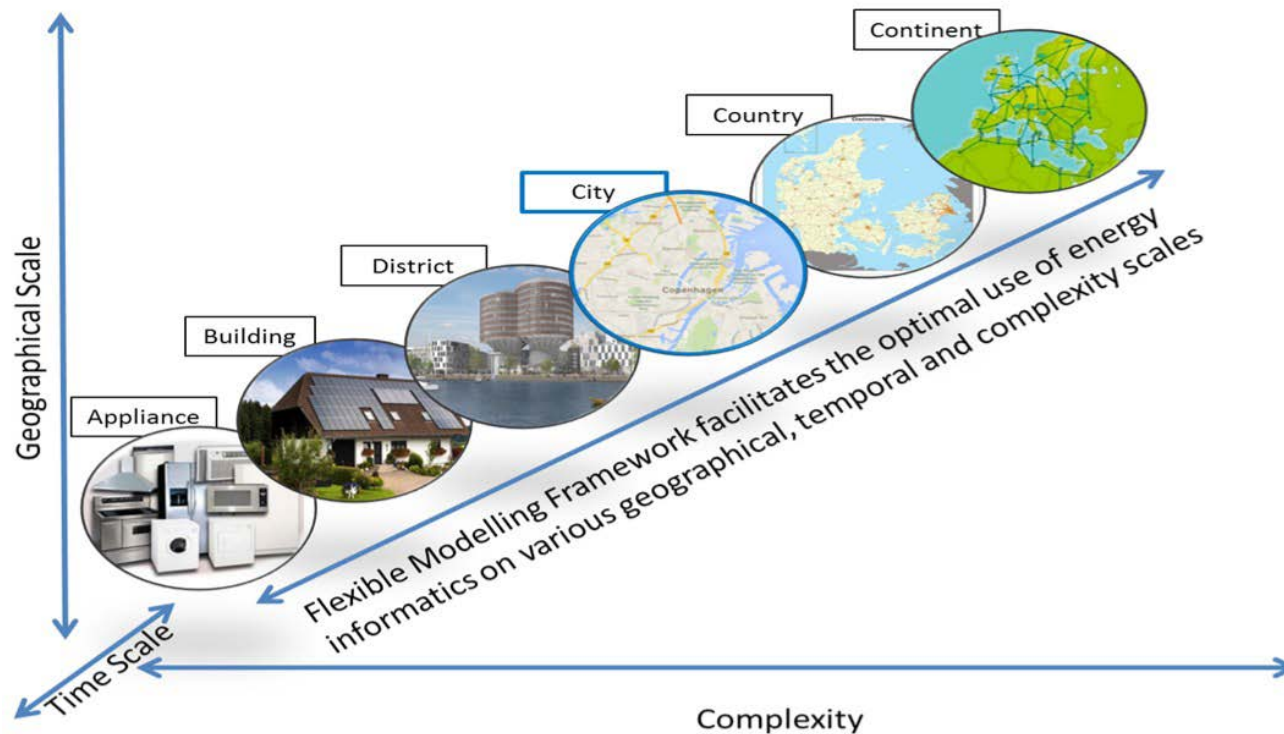
Grid Ready Buildings in VPP4SGR (DK)

- 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

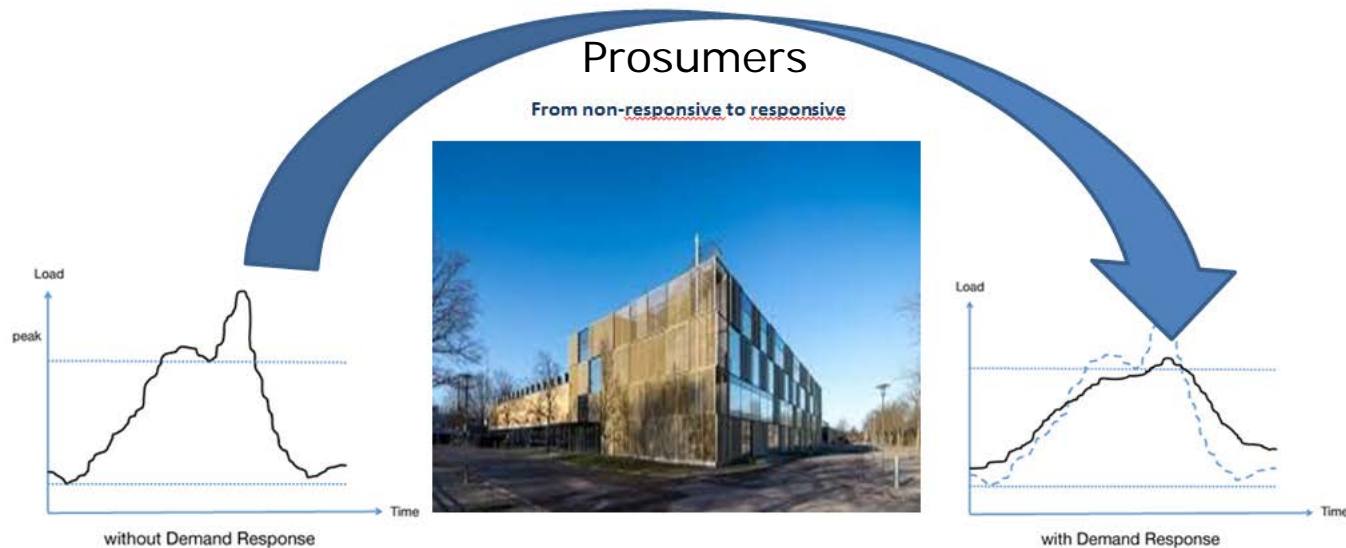
Flexibility and markets

- 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 robust

... are they sustainable