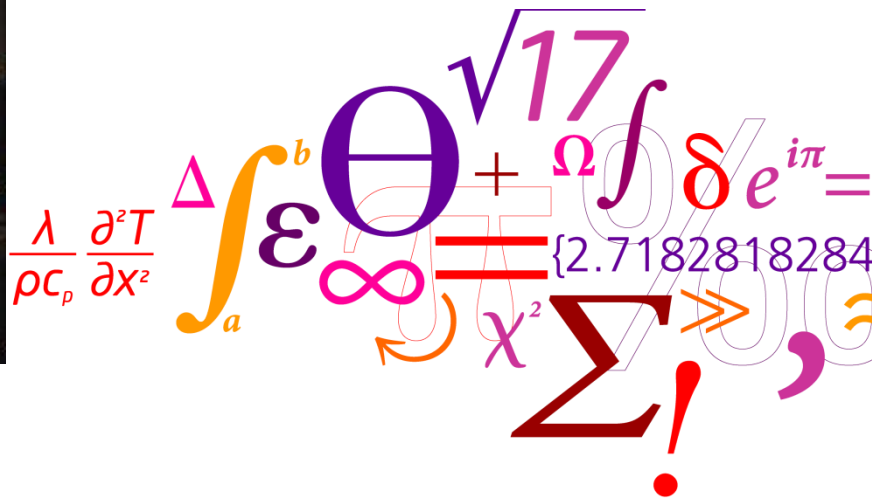
SMART CITIES NEED SMART ENERGY

Centre for IT-Intelligent Energy Systems in Cities (CITIES)

Prof. Carsten RODE

Technical University of Denmark



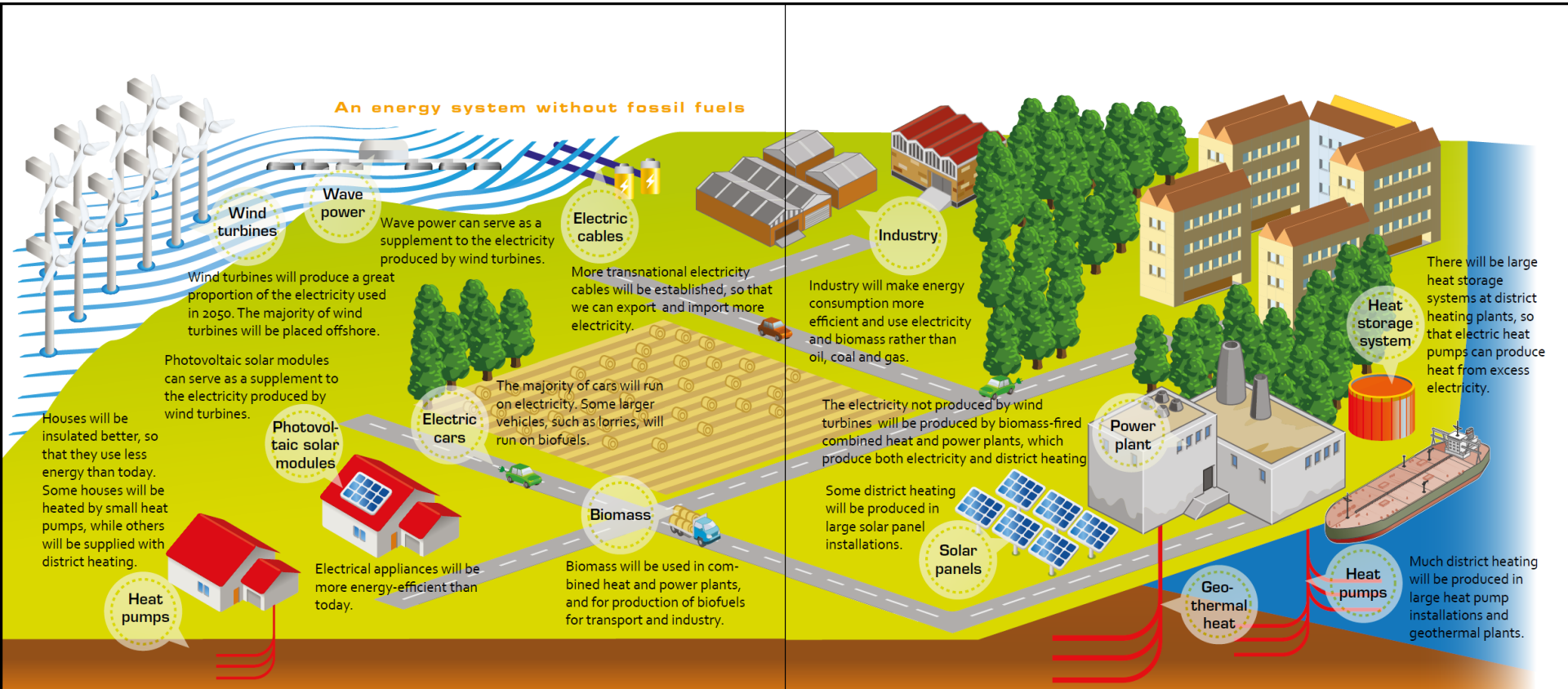
DTU Civil Engineering

Department of Civil Engineering

CITIES - A STRATEGIC RESEARCH CENTRE

CITIES was launched Jan. 2014 as a 6 year research centre which has been financially supported in excess of € 10 million from a range of industrial and academic partners, and the Danish Council for Strategic Research.

Homepage: www.smart-cities-centre.org



ENERGY POLICIES

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

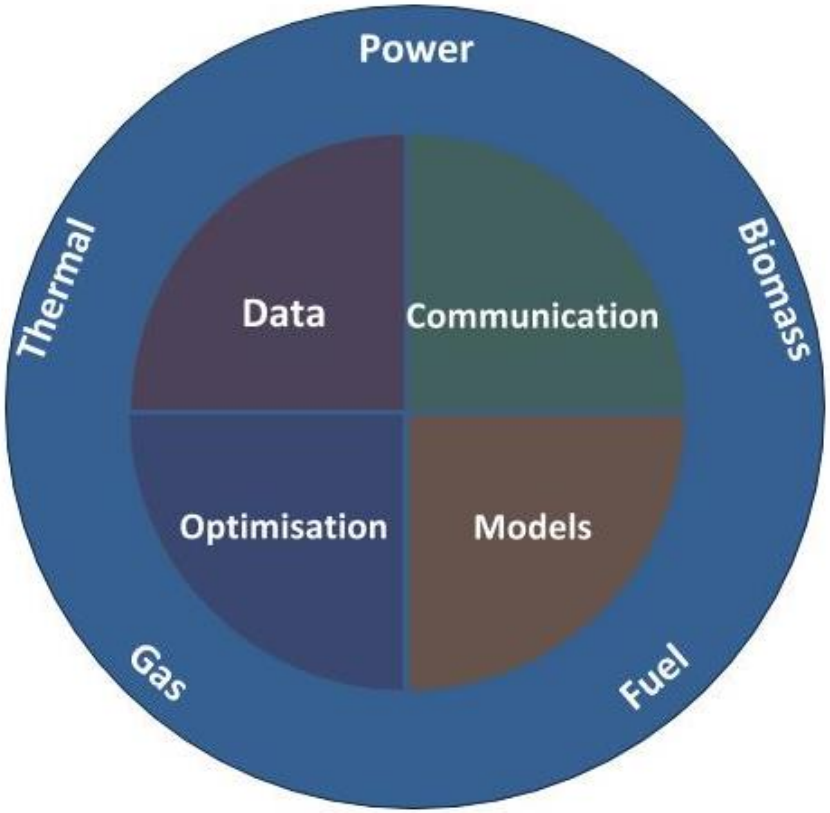
100% share of RE in the heating sector by 2035

THE CENTRAL HYPOTHESIS OF *CITIES*

By intelligently integrating currently distinct energy flows
- Heat
- Power
- Gas
- Biomass

in urban environments we can enable very large shares of renewables, and consequently obtain substantial reductions in CO_2 emissions.

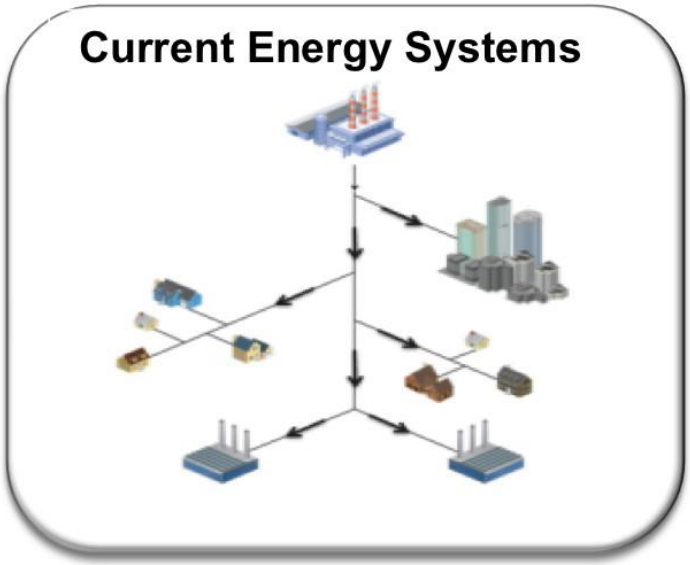
Intelligent integration will enable lossless 'virtual' storage on a number of different timescales.

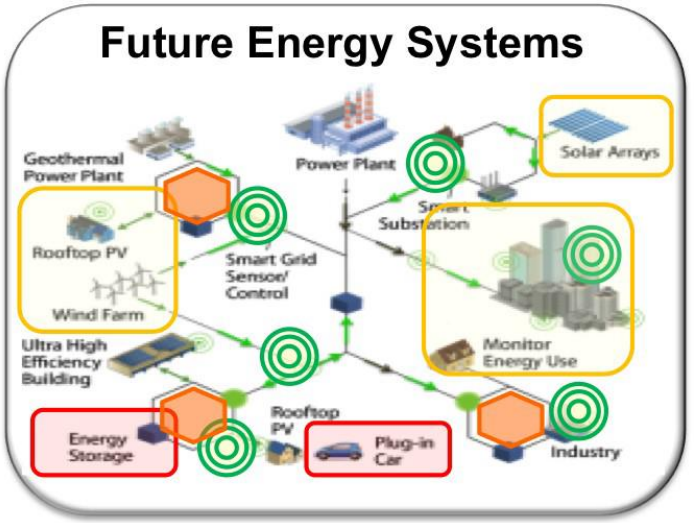


TRANSITION IN THE ENERGY WORLD

Due to the rapidly changing energy world we observe a need for the next generation of tools for simulation, planning, optimization, decision support, control and operation. These tools call for research focusing on:

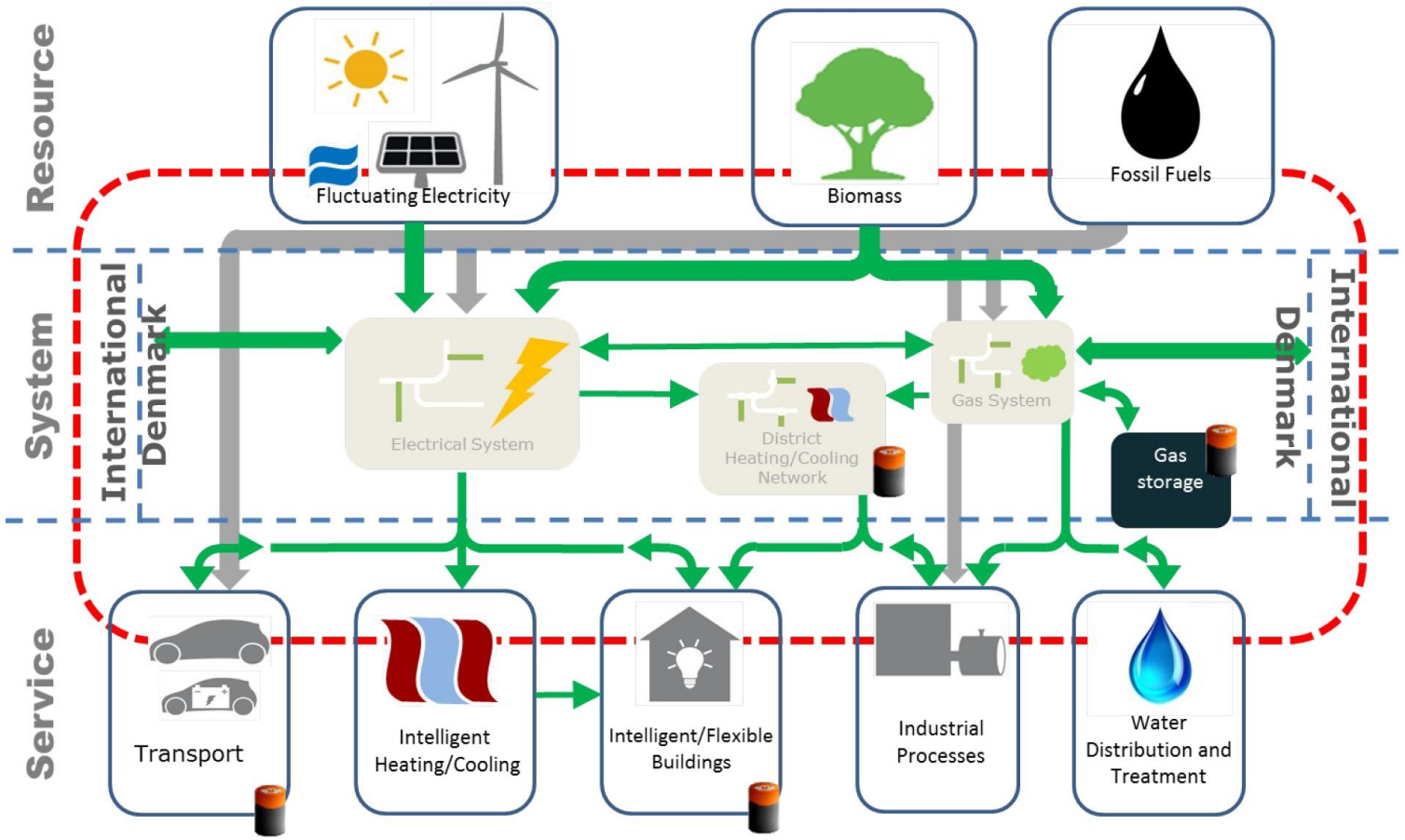
- Increasing penetration of variable RE in grid
- Increasing ultra high energy efficiency buildings and controllable loads
- New data, information, communications and controls
- Electrification of transportation and alternative fuels
- Enable (virtual) energy storage by energy systems integration
- Interactions between flows of electricity / heat / fuels / data
- Increasing system flexibility and intelligence





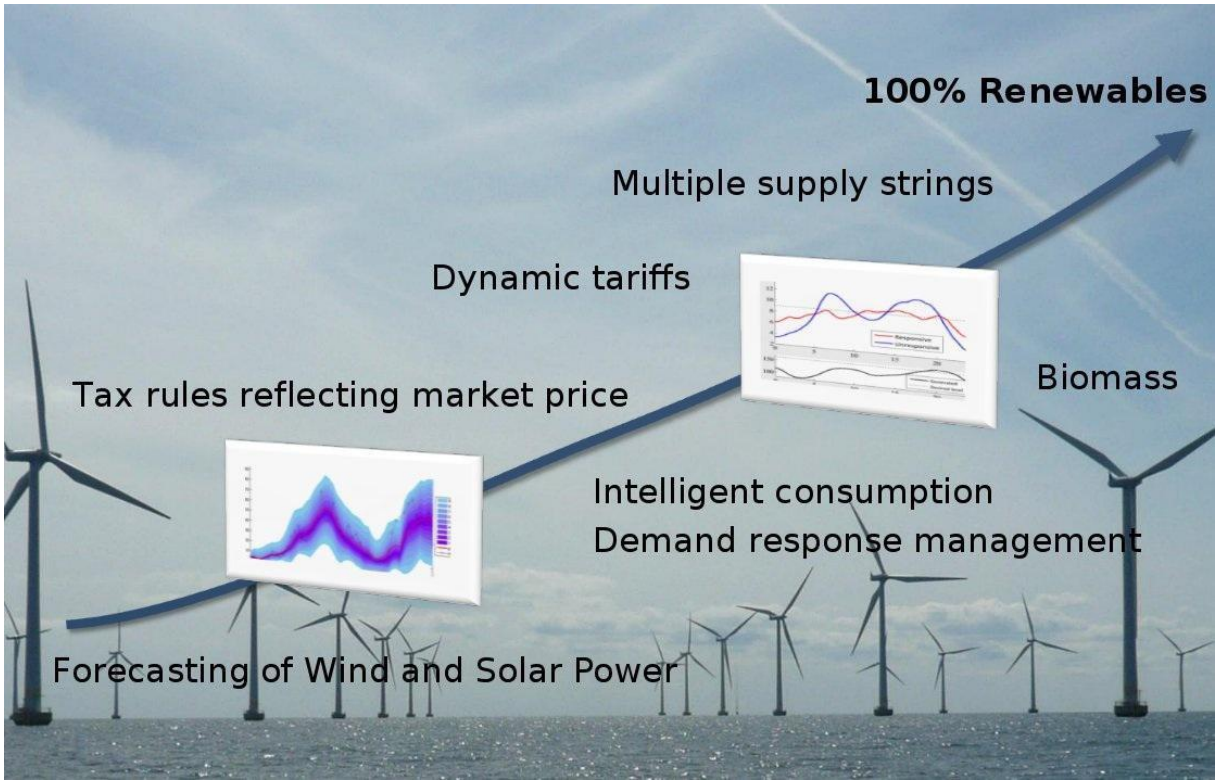
CONCEPT

Integration based on *ICT solutions* leading to methods for *operation* and *planning* for future energy systems



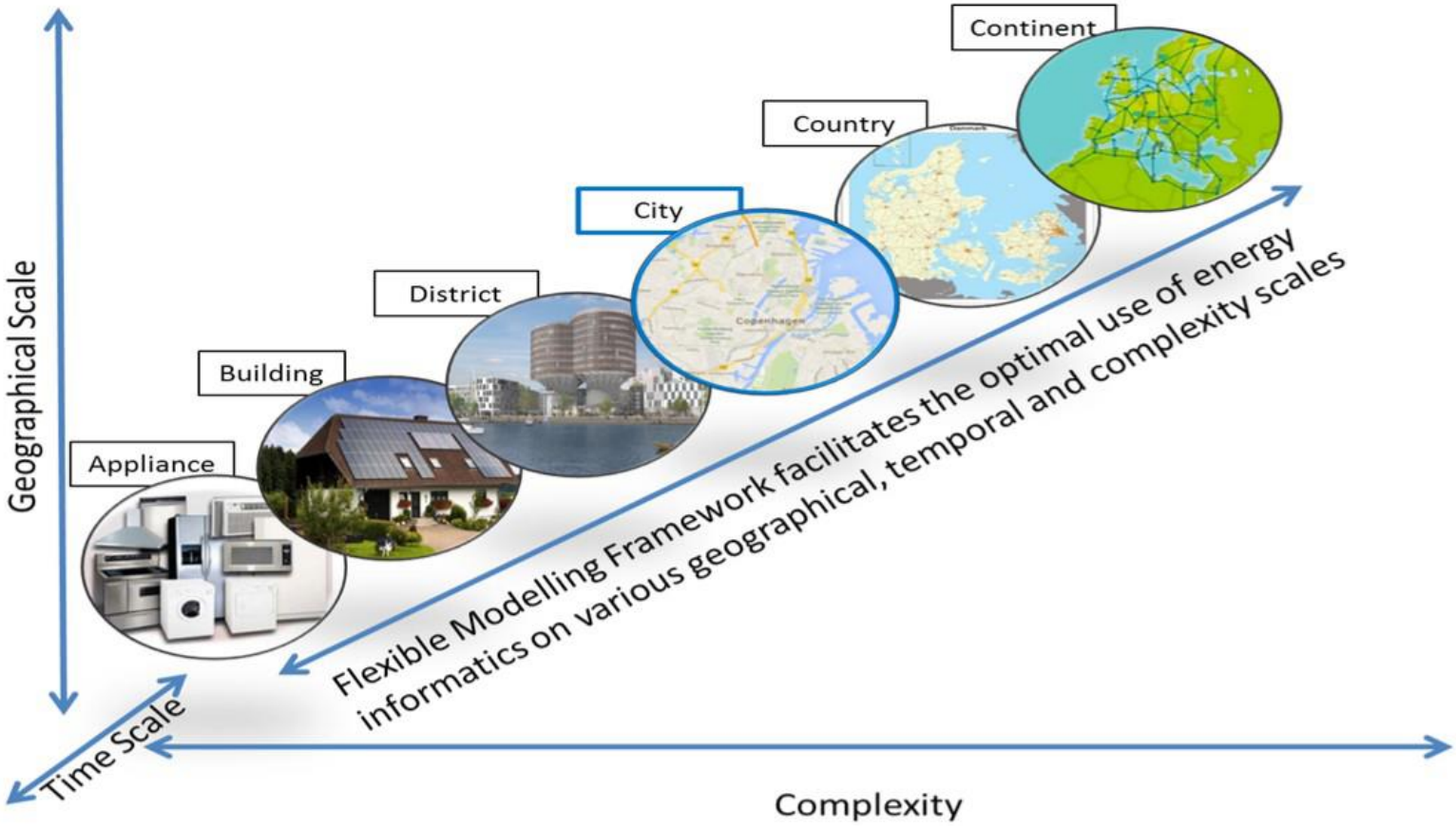
SOCIETAL OBJECTIVES

To establish methods and realistic scenarios for ultimately achieving independency from fossil fuels by harnessing the latent flexibility of energy systems in cities through *intelligence, integration*, and *planning*.



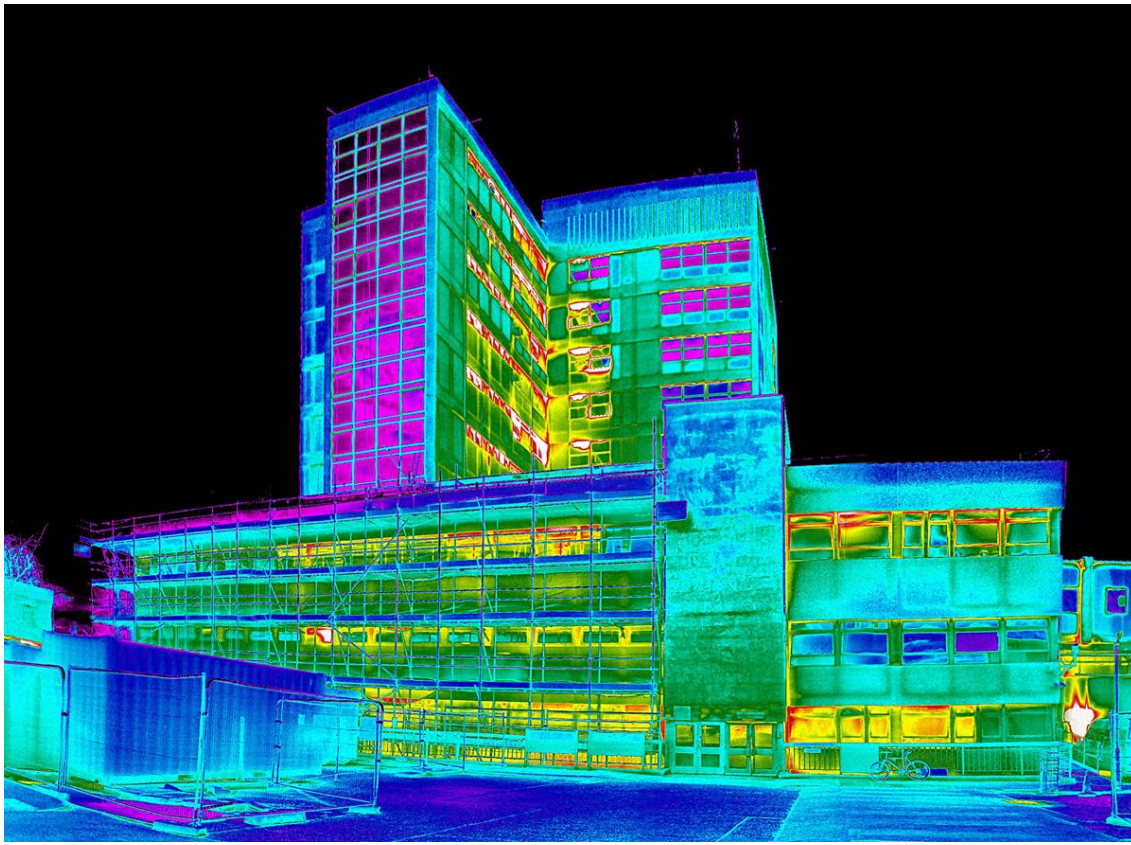
SCIENTIFIC OBJECTIVES

To establish methodologies and ICT solutions for design and operation of integrated electrical, thermal, fuel pathways at all scales

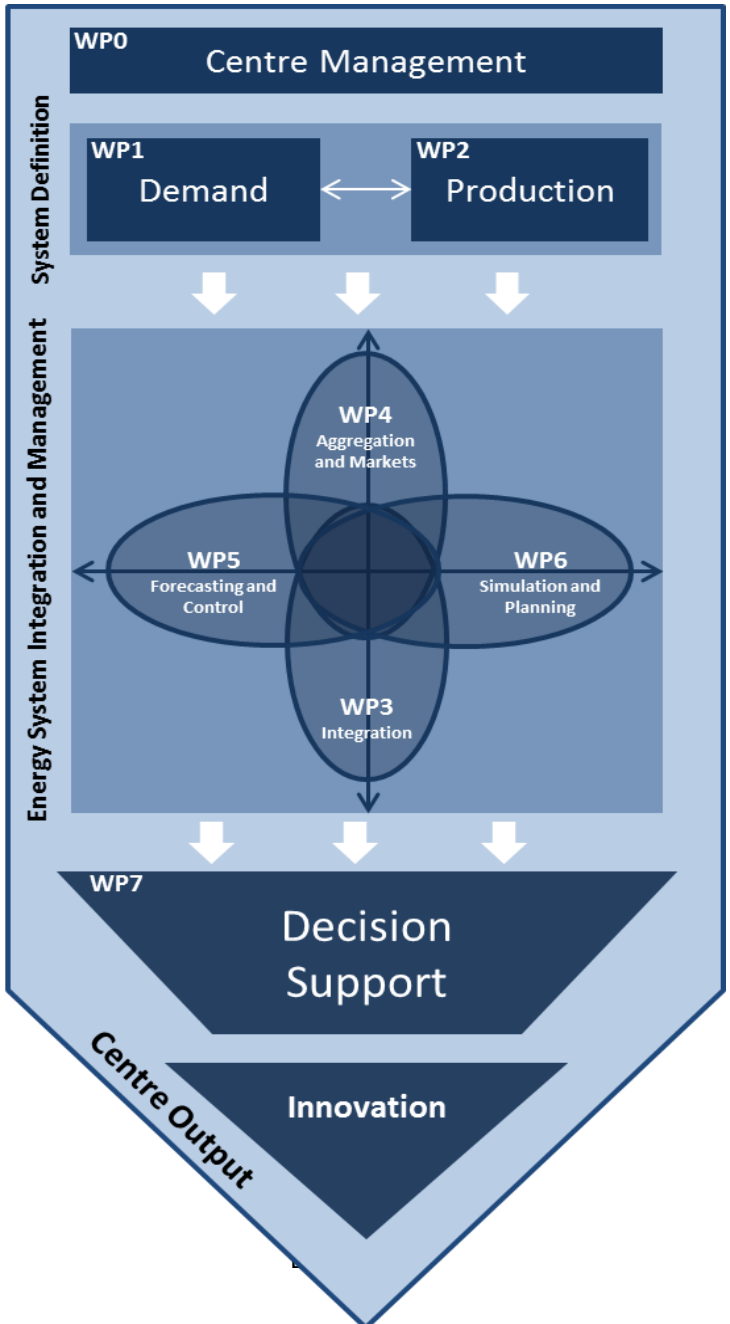


COMMERCIAL OBJECTIVES

The commercial perspective of CITIES is to identify and establish solutions which can form the background for business opportunities within the smart cities environment.



CITIES RESEARCH STRUCTURE



WORK PACKAGES

WP1 *Energy Services and Demand*: Characterize and model energy services and demand in cities, and their geographical and temporal variations

WP2 *Energy Supply, Transmission, Storage and Conversion*: Characterize energy supply, transmission, storage and conversion possibilities and identify opportunities for increased efficiency and flexibility

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WP3 *Intelligent Energy Systems Integration [Low Level Integration]*: Optimize the interactions and synergies between individual system components

WP4 *Intelligent Aggregation and Markets [High Level Integration]*: Develop aggregate models and market structures for city level systems (and subsystems)

WP5 *Forecasting and Control [Short Term/Operational]*: Develop tools for short term (probabilistic) forecasting and control of integrated energy systems with flexible geographic scope

WP6 *Simulation and Planning [Long Term/Planning]*: Develop long term simulation platform for system planning. Focus on longer term energy planning scenarios and methodologies

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WP7 *Decision Making Models and Support Systems*: Methods and tools to assist private and public agents in making "good" decisions to fully benefit from Smart Cities and guarantee a proper city development

DANISH ACADEMIC PARTNERS

Technical University of Denmark

- **DTU Compute - Prof. Henrik Madsen** & Assoc. Prof. Juan Miguel Morales Gonzalez & Assoc. Prof. John Bagterp
- **DTU Civil Engineering -** Prof. Carsten Rode & Assoc. Prof. Alfred Heller
- **DTU Electrical Engineering -** Prof. Pierre Pinson & Senior Researcher Per Nørgård
- **DTU Management Engineering –** Prof. Kirsten Halsnæs & Senior Researcher Dr Per S Nielsen
- **DTU Energy Conversion and Storage -** Dr. Allan Schrøder Pedersen

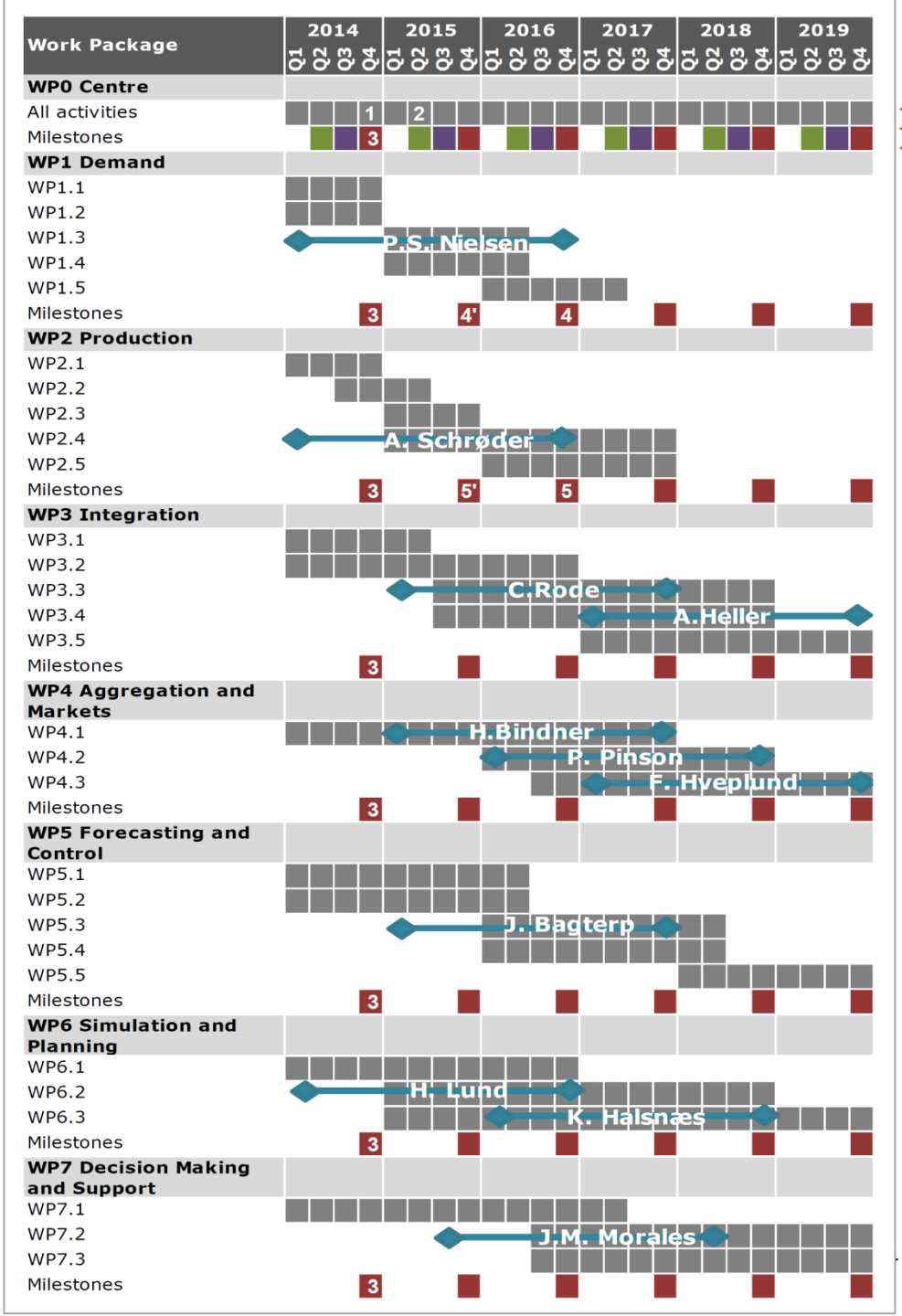
Aalborg University

- **Department of Development and Planning –** Prof. Brian V. Mathiesen & Prof. Henrik Lund
- **Department of Civil Engineering -** Prof. Per Heiselberg

TIMELINE

Gannt diagram showing

- Work packages
- PhD's and PostDocs and their supervisors
- Milestones:
  - PhD summer schools
  - Annual conferences
  - Steering group meetings
  - International advisory board meeting



OVERARCHING HYPOTHESIS FOR WP3 - INTELLIGENT ENERGY SYSTEMS INTEGRATION

- We cannot achieve a non-fossil society only by optimizing the individual buildings.
- We need to analyse buildings in a community/ society context looking to how energy is (PTSC):
  - Produced,
  - Transmitted,
  - Stored
  - Converted

Mette Mylin Danish Energy Agency

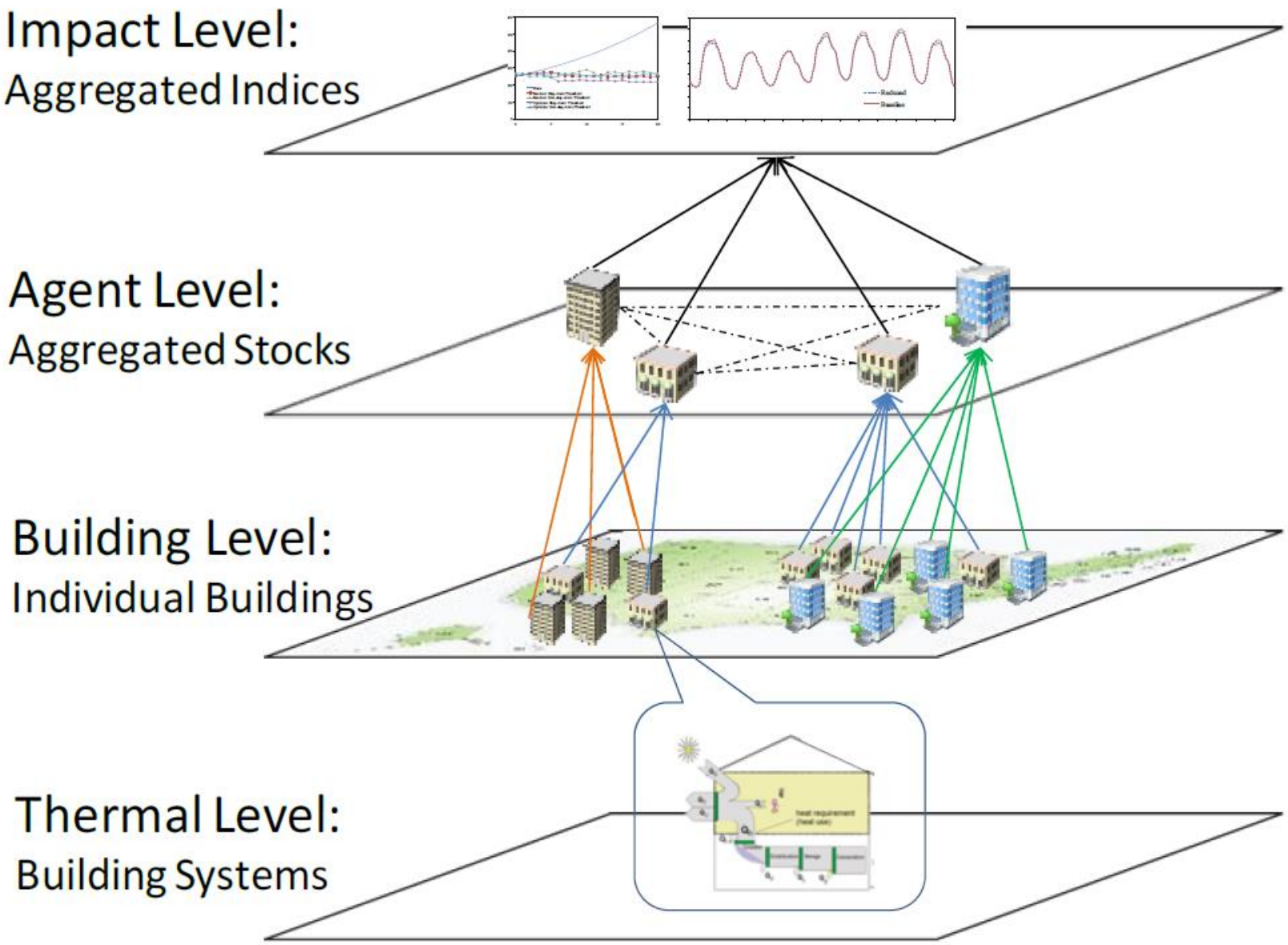
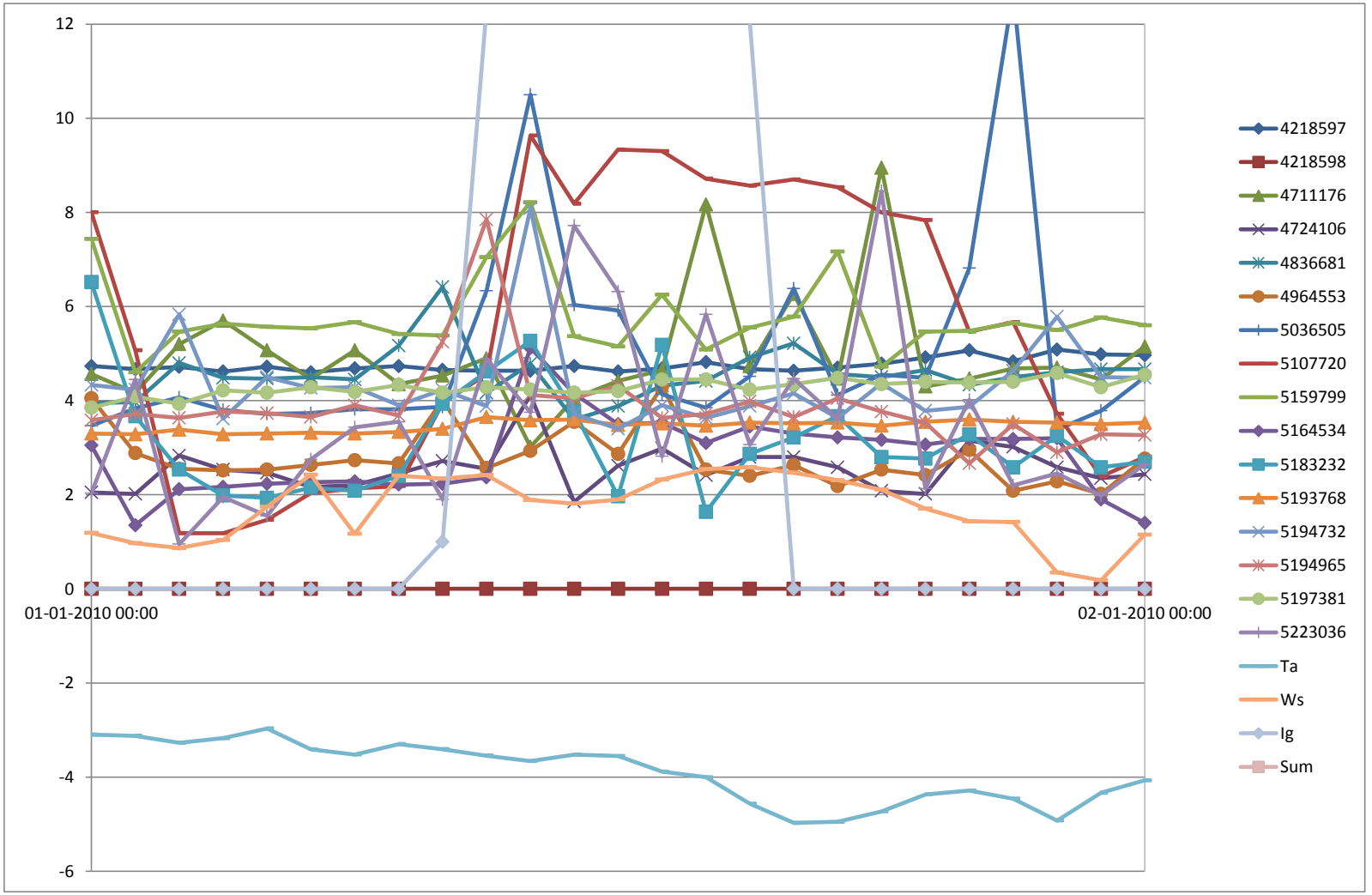


Figure 1 Four Levels of Aggregation

Zhao, Ignacio and Augenbroe, 2011

16 HOUSES IN SØNDERBORG, 1 JAN. 2010



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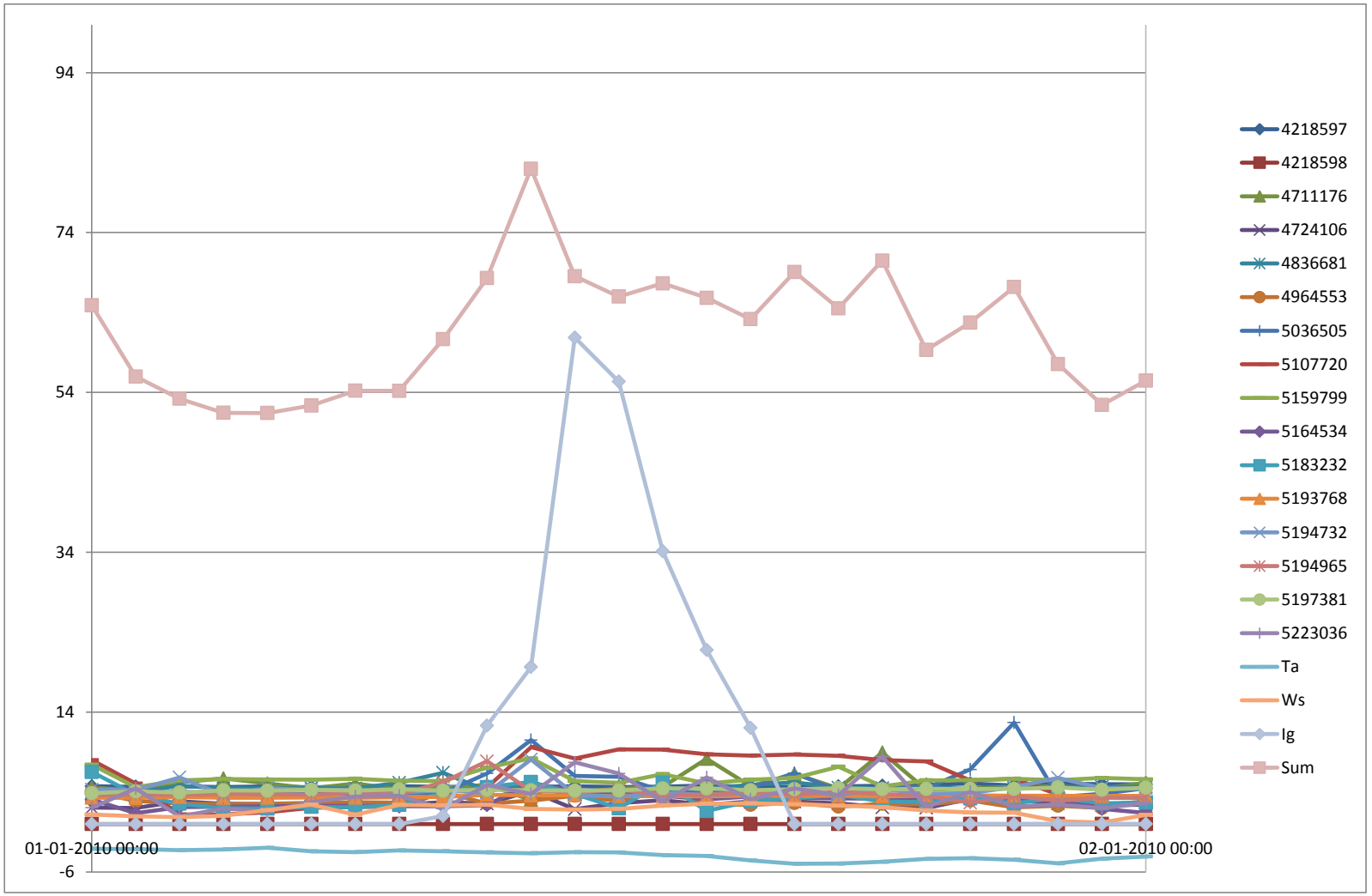

CITIES – TEST FACILITIES

- Kubic (Tecnalia)
- Ireland
- PowerLab.dk (SYSLAB/Bornholm)
- Grundfos' test buildings
- Danfoss' test facity for supermarket cooling
- DTU's test houses (e.g. Sisimiut)
- ESIF - Energy Systems Integration Facility (NREL)

+ A number of Smart Cities projects:

    ProjectZero

    Nordhavn

    Vinge

    …

KEY OUTCOMES

- Operational methods and scenarios for energy systems integration and management, paving scenarios towards a fossil free future
- Component level, modular and aggregate models of energy supply, consumption, and transmission, suitable for simulation, control and optimisation frameworks
- Market structures that support energy systems integration
- Modular forecasting and control models for a variety of energy system components, including their interactions
- Integration of short-term operational models in models for long-term planning.
- Models of energy consumption and production accounting for their stochastic and dynamic features.
- Methods for controlling energy consumption and demand side management.
- CITIES aims to become a leading knowledge centre for Smart Cities development and operational tools.
- Synergies with existing and new smart cities development projects

INNOVATION CENTRE

- Development of ideas for business opportunities in partnership with the energy sector, business partners and decision makers.
- Development of new methods for aggregation, forecasting and control for future energy systems (e.g. low temp. district heating)
- Development of methods related to Energy Informatics (Eg. Use of Smart Meter data for identifying potentials for energy savings)
- Development of products such as apps and other software tools to suit niche applications revealed through CITIES research

Key partners: Dansk Industri, Lean Energy Cluster, VE-net (TI)


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Photo: Egil Borchersen