

# Technological Possibilities and Challenges for Smart Cities



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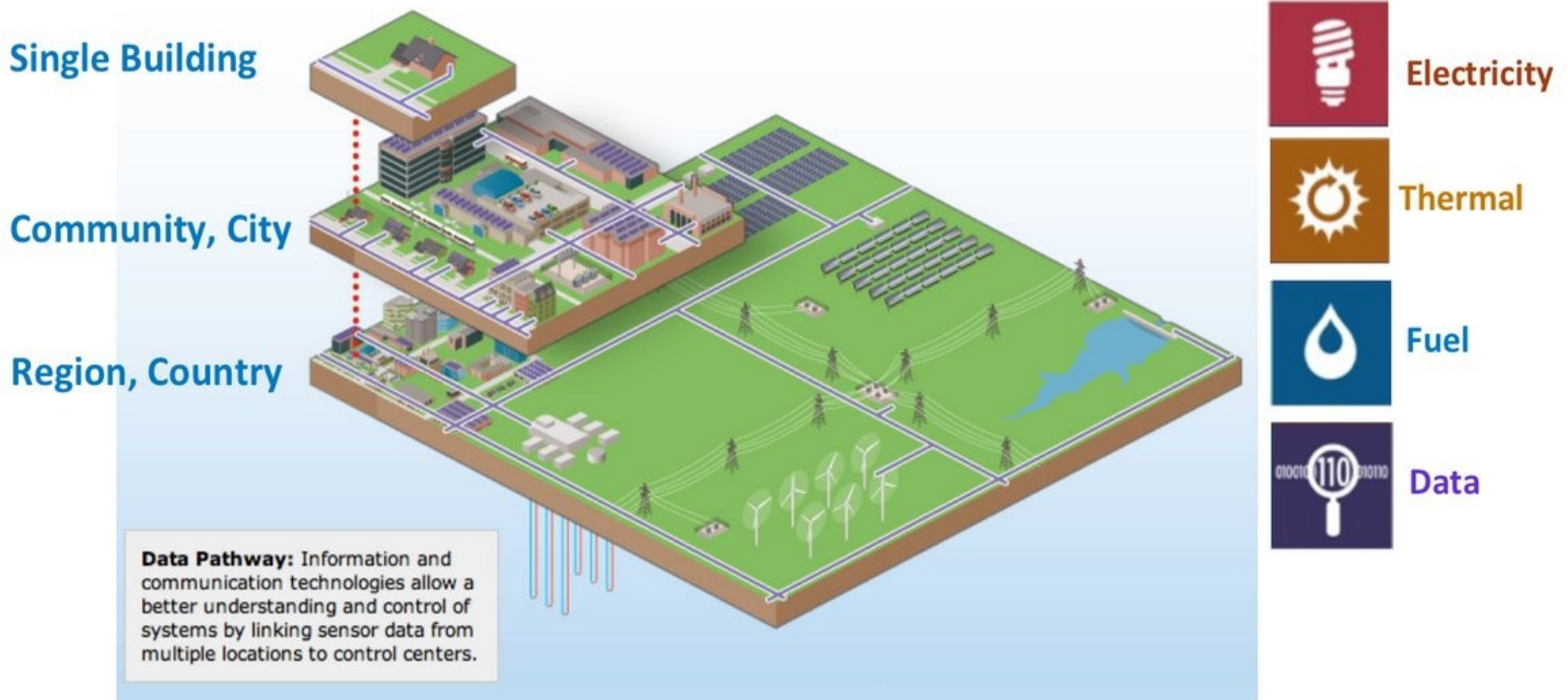
# Smart Cities Projects

- CITIES – Center for IT-Intelligent Energy Systems in Cities (DK+US+Korea+Spain+...)
- Smart City Accelerator (DK+S – Greater Copenhagen)
- Cities Innovation Center (DK)
- Smart Water Cities (DK)
- Zero Energy/Emission Buildings (N)
- Zero Emission Neighbourhoods in Smart Cities (N)
- Joint DTU – NTU (Singapore) Smart Cities Initiative (16 PhDs)
- CESI National Centre (UK)
- EERA Joint Programme for Smart Cities (EU)
- Int. Institute for Energy Systems Integration (US)



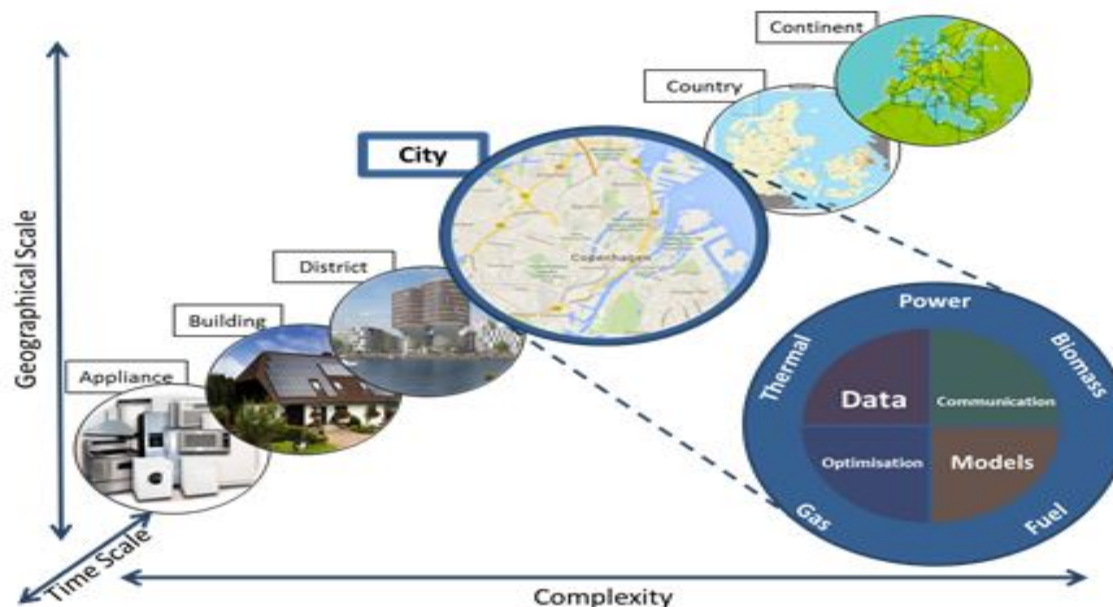
# Systems Integration in Smart Cities

**Energy system integration (ESI)** = the process of optimizing energy systems across multiple pathways and scales



# Temporal and Spatial Scales

The **Smart-Energy Operating-System (SE-OS)** is used to develop, implement and test of solutions (layers: data, models, optimization, control, communication) for **operating flexible energy systems** at **all scales** with a focus on **Smart Cities**.



# Greater Copenhagen (Øresund Region)

- More than 3.8 mill people
- More than 150.000 university students
- Leading companies in relation to Energy (Vestas, Siemens, EON, Vattenfall, DONG, ...)
- The cities here want to play an active role in the transition to a zero-CO2 future
- Copenhagen CO2 free by 2025
- Malmö CO2 free by 2030



# Smart Cities Accelerator

Interreg-Øresund/Kattegat/Skagerrack programme (EU structural funds)

***"Smart Cities Accelerator gathers central municipalities and academic institutions in Greater Copenhagen in a close collaboration that will focus on energy optimisation away from fossile fuels towards more renewables energy sources. The project integrates development of sustainable solutions and datasets of various energy systems along with insight into citizens behavioral patterns, legal matters and learning of school children. The aim is to create more sustainable solutions at the level of local athorities.***

10 Public partners // 4 academic institutions, 5 cities: and 1 central heating company

- Sweden: Malmö, Lund, Båstad, Lund Universitet (3), Malmö Högskole
- Denmark: Copenhagen, Høje Taastrup, Høje Taastrup Central Heating, University of Copenhagen (2), DTU (3)

Budget:

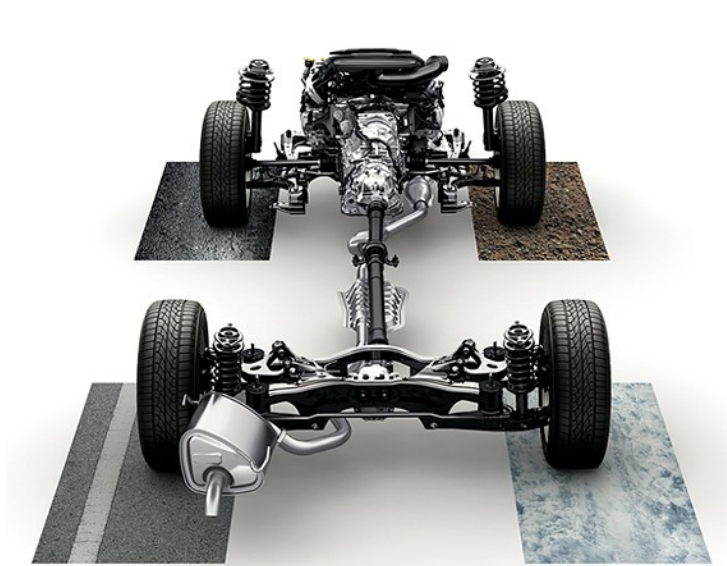
6.468.035 Euro

Period

- 1. September 2016 – 31. August 2019

# Digitally more advanced – Mechanically less complicated

Courtesy of Niels Lassen



***Fossil fuel car – 2000+ moving parts in driveline  
Numerous «wear points» - points where moving parts  
grind against each other and lubrication and service is  
needed  
5 year warranty***

***Electric car – 20 moving parts in  
driveline  
Only 2 «wear points» (in gear box)  
Unlimited mile warranty***

# Digital revolution

Courtesy of Niels Lassen

Google



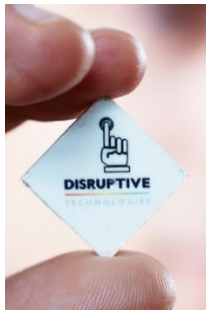
*When we use their product, they gather information on how we use it, our preferences etc.*

*Crucial information regarding how the product can be further developed*

*The «Internet Of Things» (IoT), and Sensor Technology enables us to do the same for Buildings and Cities using Big Data Analytics*

# Collect data on three levels

Physical environment

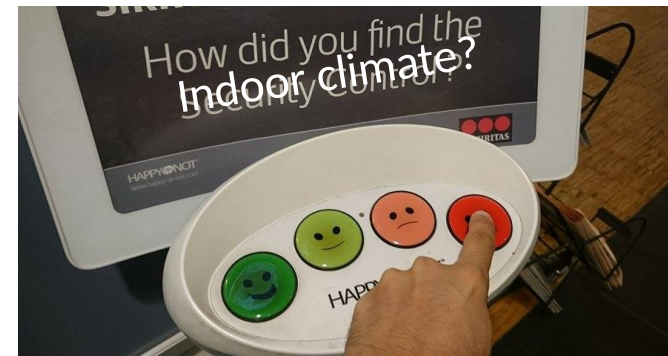


Sensed environment



Smartphone or room tablet

Total user satisfaction



Measurement of user satisfaction at entrance door

**By using a simple system for data collection via existing room automation systems, new smart sensors, smart phones with IoT and cloud computing we can achieve a high degree of accuracy for the automation system. Collecting data about the indoor environment and user at the same time**

# Big Data value chain

## Sense

### Data Origins

The Internet, sensors, machines, etc.

## Think

### Data Collection

Web log, sensor data, images/audio, RFID and videos, etc.

### Data Storage

Technologies supporting data storage

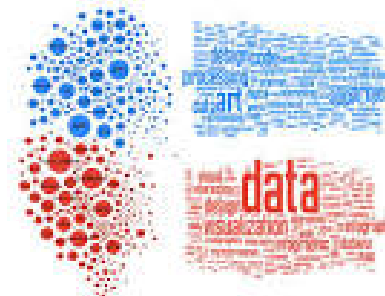
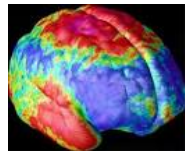
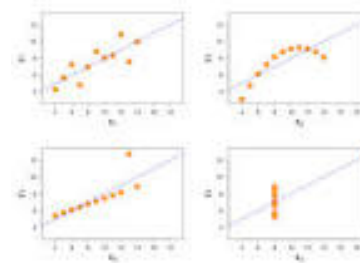
## Act

### Analytics:

Predictive analytics, patterns in data, decision making

### Consumers:

Business processes, humans, and applications



# BIG DATA: What can we do?

## Domain / application areas

Energy

Transport

Water

... and other applications

Collection of data, eg sensors on individuals (eg RFID or image analysis)

Storage, manipulation, real-time data

Establishing a dynamic Big Data cloud

Structuring data, distributed data and data-sharing

Merging and integration of databases

Optimisation/speed-up algorithm functionality and lower cost of calculation

Pattern recognition, machine learning, artificial intelligence, query-algorithms

Multivariate analysis and advanced statistics and data analysis

Privacy/ethics regarding data

Visualisation of data wrt decision support

Targeted projects

Generic Big Data  
problem topics

Platform project

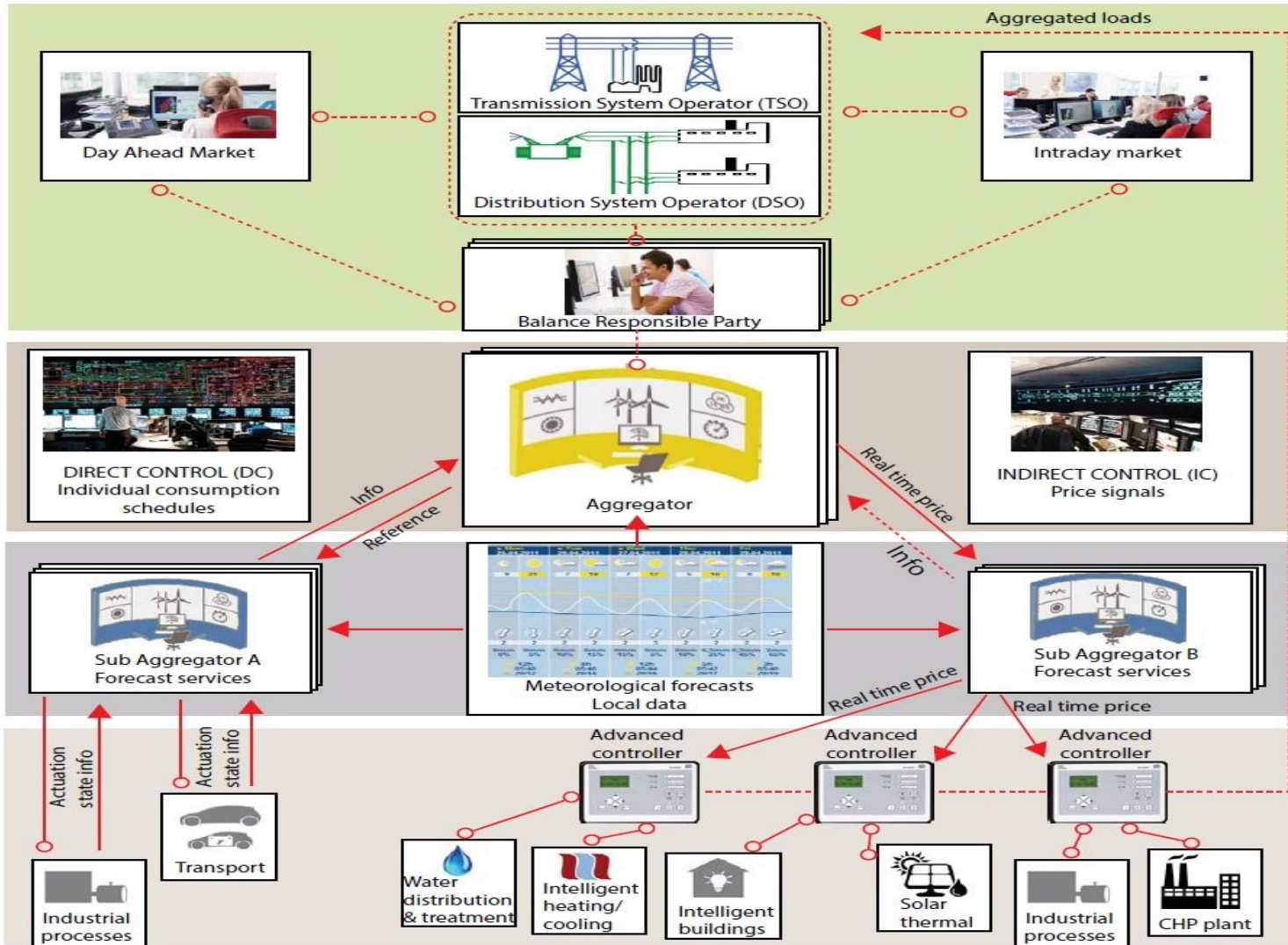


# Perspectives for using data from Smart Meters

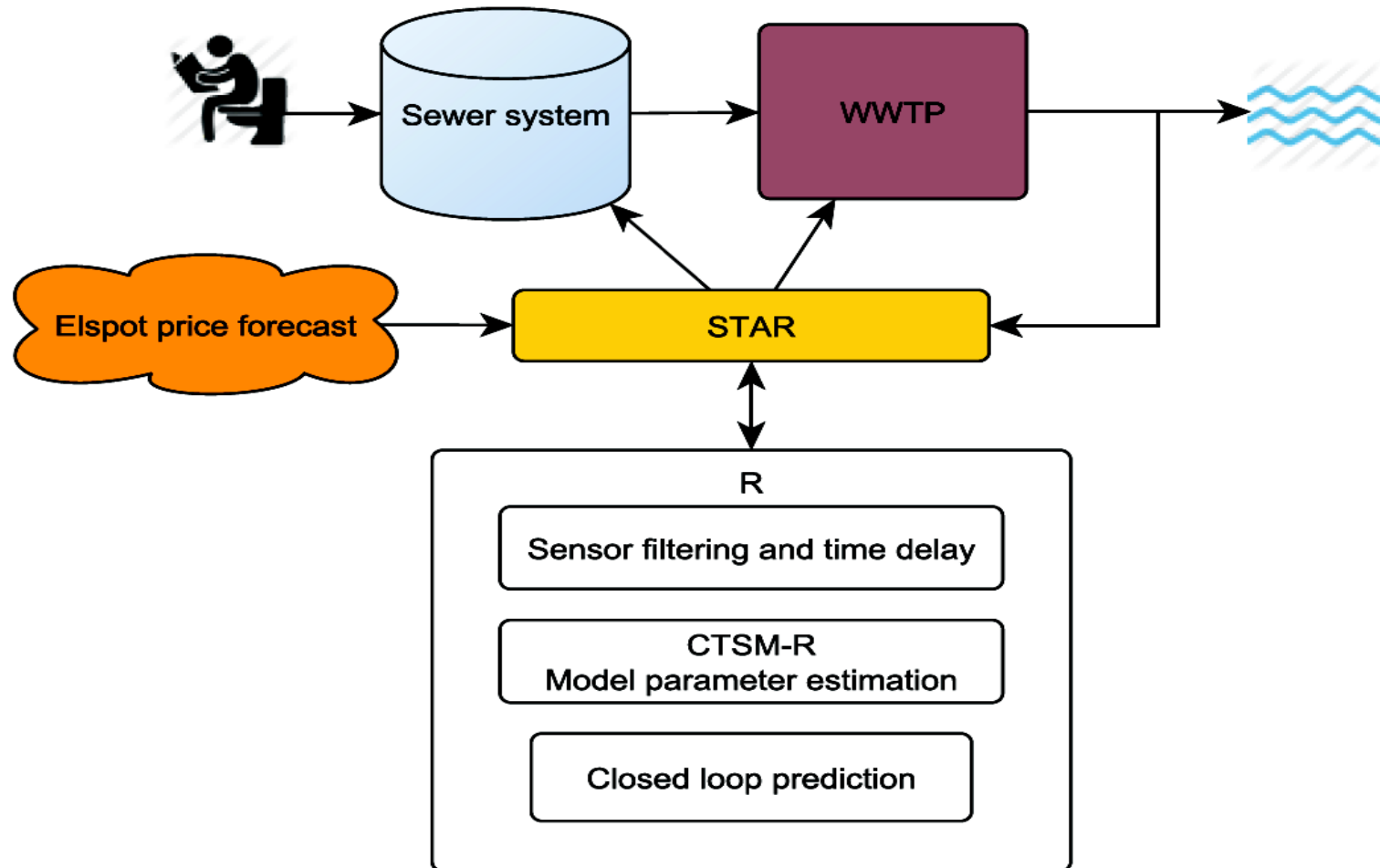
- Reliable Energy Signature.
- Energy Labelling
- Time Constants (eg for night set-back)
- Proposals for Energy Savings:
  - Replace the windows?
  - Put more insulation on the roof?
  - Is the house too untight?
  - .....
- Optimized Control
- Integration of Solar and Wind Power using DR



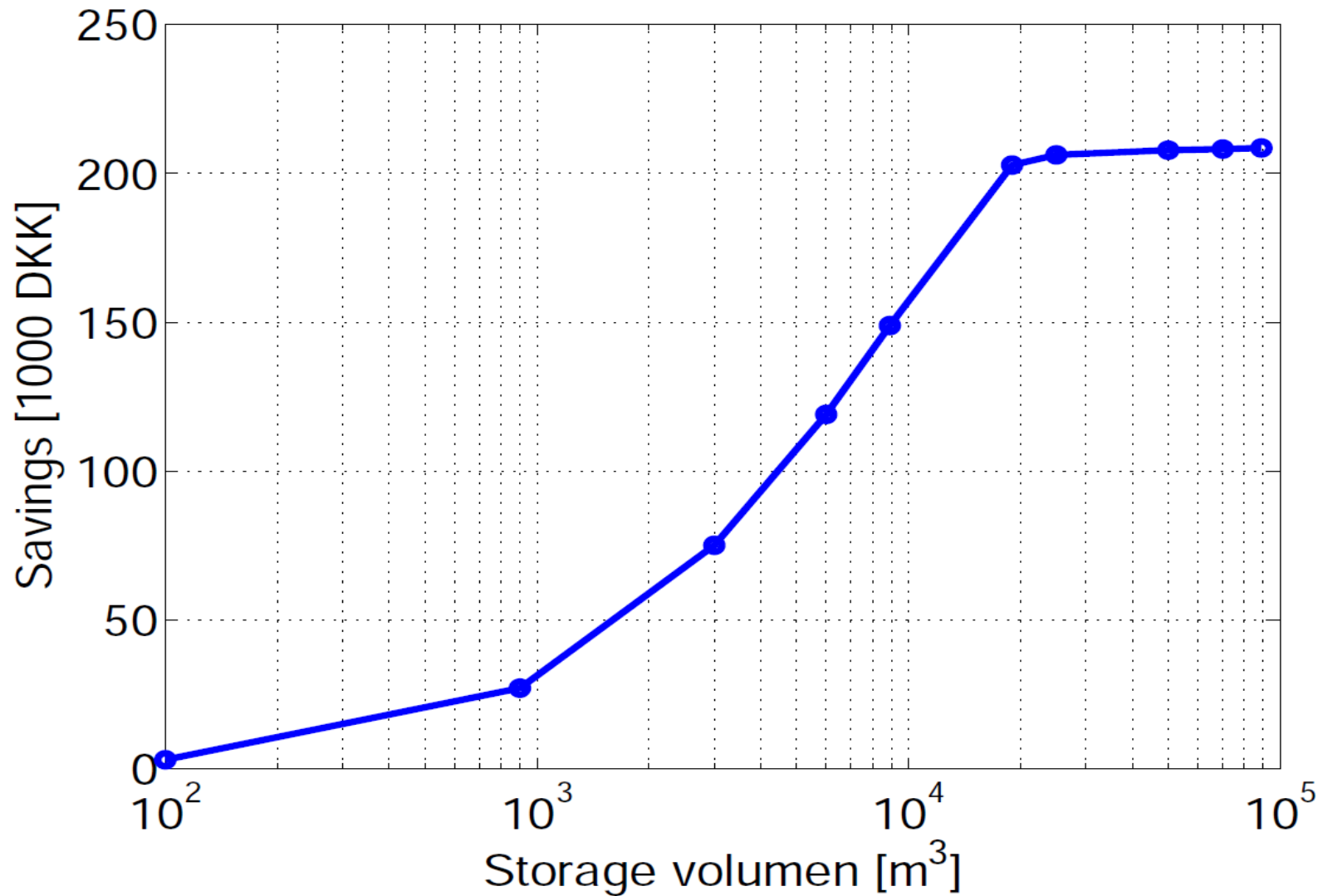
# Smart-Energy OS for Smart Cities



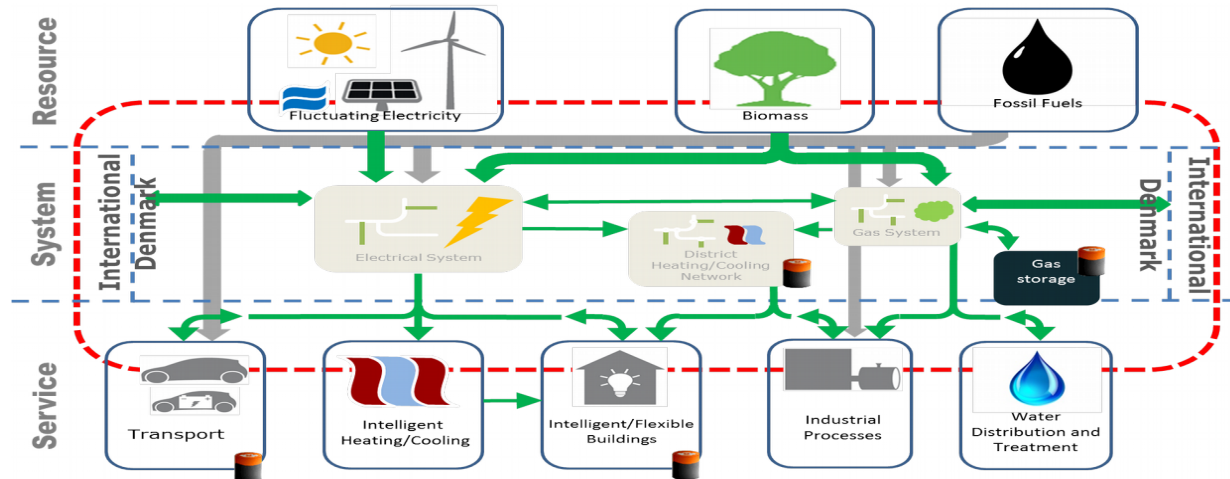
# Energy Flexibility in Wastewater Treatment



# Sewer System Annual Elspot Savings



# (Virtual) Energy Storage Solutions



## Flexibility (or virtual storage) characteristics:

- Supermarket refrigeration can provide storage 0.5-2 hours ahead
- Buildings thermal capacity can provide storage up to, say, 5-10 hours ahead
- Buildings with local water storage can provide storage up to, say, 2-12 hours ahead
- District heating/cooling systems can provide storage up to 1-3 days ahead
- DH systems with thermal solar collectors can often provide seasonal storage solutions
- Gas systems can provide seasonal/long term storage solutions

# ● 2017: Key Exponential Technologies

- Use of (smart) meters and many sensors
- Big Data, IoT, IoS Technologies
- Systems of Systems
- Aggregation (on all scales)
- Intelligent Data Analytics / Artificial Intelligence
- Community Driven Solutions
- Open Data / Open Source Solutions
- (Virtual) Energy Storage
- Energy flexible automated manufacturing / Robotics
- eMoney / eFinance
- 3D printing and visualization





# CITIES INNOVATION CENTER

Integrated energy systems powered by intelligent data

[100% BY 2050](#)[ABOUT US](#)[TOPICS](#)[PROJECTS](#)[EVENTS](#)[PARTNERS](#)

We pioneer the green transition in a unique partnership with the industry, academia and state-actors.

100% renewable urban energy systems, is 100% possible. We are actors from the Danish industry, academia and public sector pioneering the green transition through integrated energy systems powered by intelligent data. Join us now for a safer and greener future.

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**CITIES**

Centre for IT Intelligent Energy Systems

**Smart Greater Copenhagen, Region H, Febr. 2017**

# Conclusion

- Intelligent Energy Systems in Smart Cities can provide virtual storage solutions (... less need for physical storage and batteries)
- District heating (or cooling) systems can provide flexibility on the essential time scales (up to a few days)
- We have enough waste heat to cover the entire need for heating (but ... !)
- Greater Copenhagen area has a unique existing infrastructure
- Focus on the 2017 trends ... (see previous slide)
- We see a large potential in Demand Response. Automatic solutions, price based control, and end-user focus are important
- We see large problems with the tax and tariff structures. Coupling to prices for carbon capture could be advantageous.
- Markets and pricing principles need to be reconsidered; we see an advantage of having a physical link to the mechanism (eg. nodal pricing, capacity markets)

## Conclusion (2)

- Smart Cities is a part of a Smart Society
- A huge potential in the use of (smart) meter data
- It is our impression that by intelligent energy systems integration in cities we could rather easily obtain a fossil-free society, however ....
- We need stronger decision makers ... and Smart Cities triple helix demonstrations



**Thanks for  
your attention !**

**... a new center**

 **Big Data•DTU**  
Center for Data Science and Engineering

**[www.BigData.DTU.dk](http://www.BigData.DTU.dk)**

