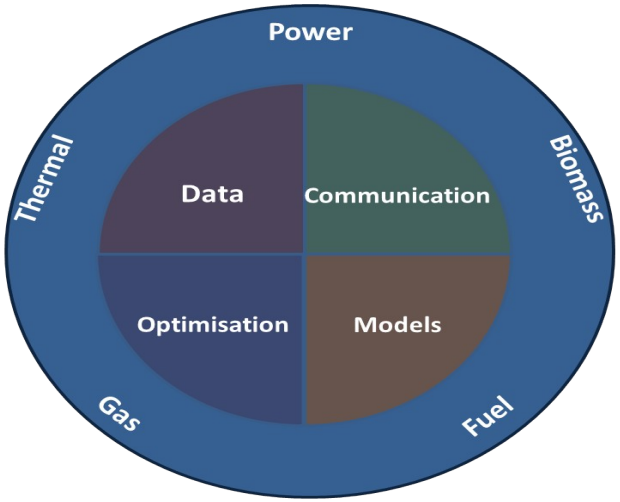
Energy Systems Integration



Henrik Madsen, DTU Compute

http://www.henrikmadsen.org

http://www.smart-cities-centre.org

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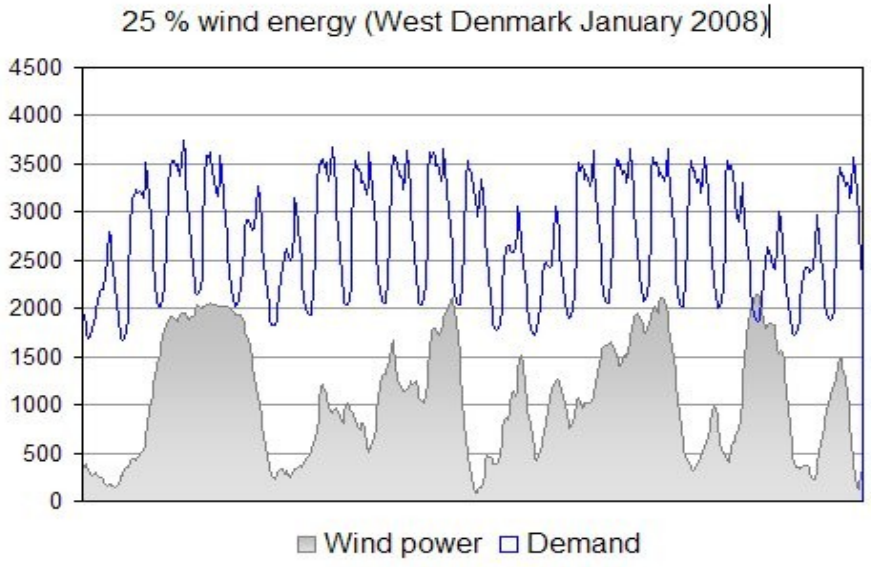
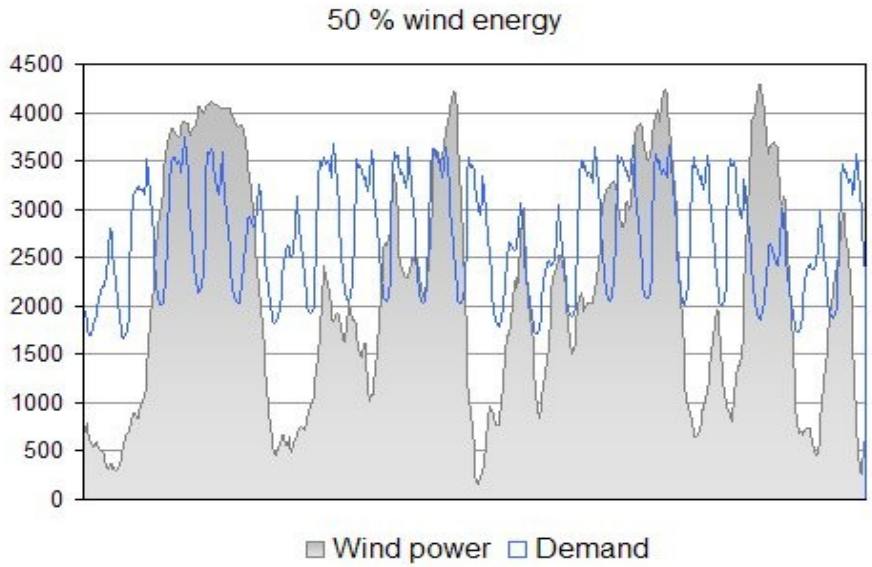
The Danish Wind Power Case

.... balancing of the power system



In 2008 wind power did cover the entire demand of electricity in 200 hours (West DK)



In 2015 more than 42 pct of electricity load was covered by wind power.

For several days in 2014 the wind power production was more than 120 pct of the power load.

July 10th, 2015 more than 140 pct of the power load was covered by wind power

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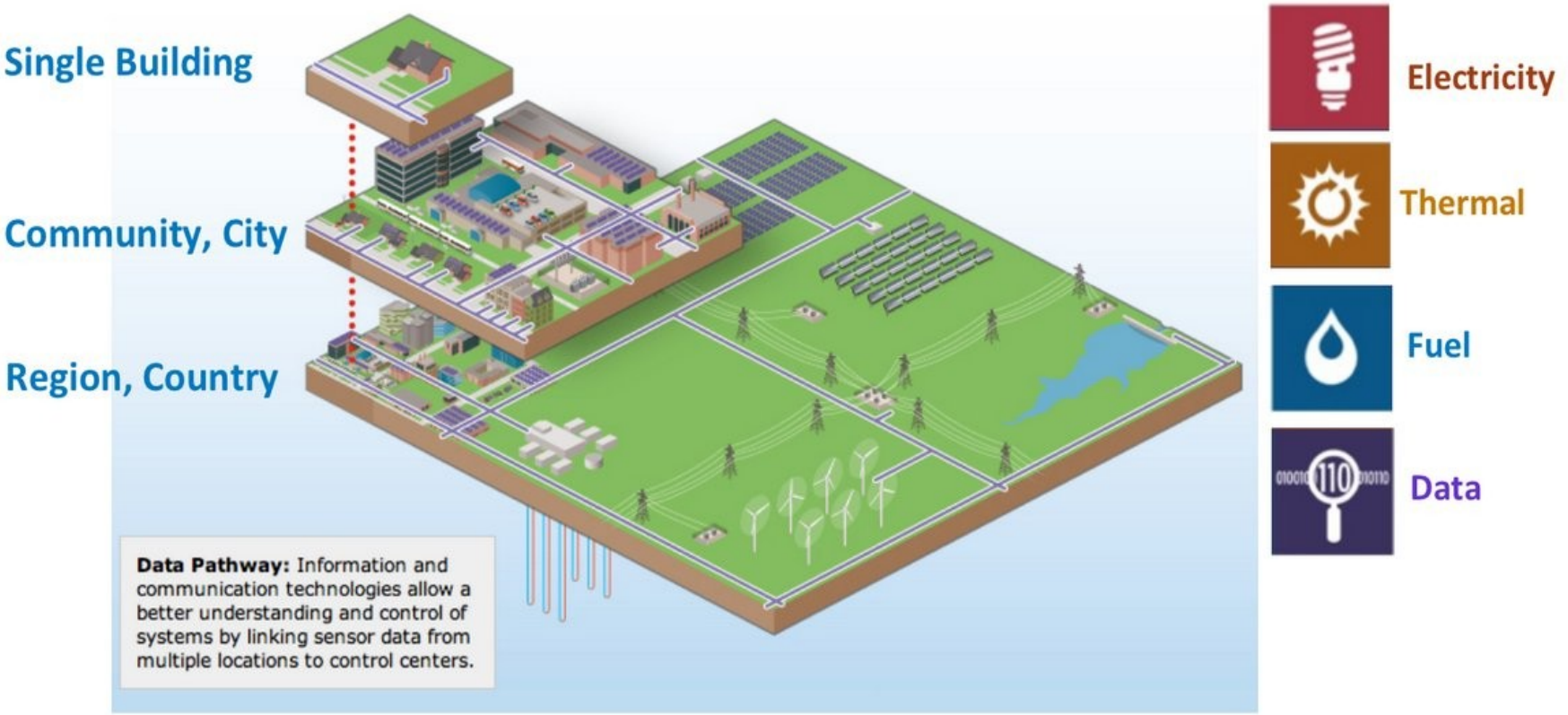
Energy Systems Integration

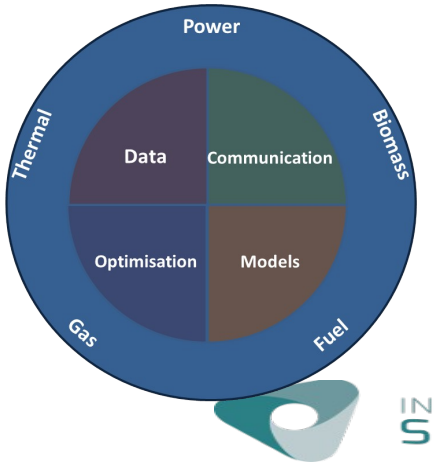
Energy system integration (ESI) = the process of optimizing energy systems across multiple pathways and scales



ESI – Hypothesis

The **central hypothesis of ESI** is that by **intelligently integrating** currently distinct energy flows (heat, power, gas and biomass) in we can enable very large shares of renewables, and consequently obtain substantial reductions in CO2 emissions.

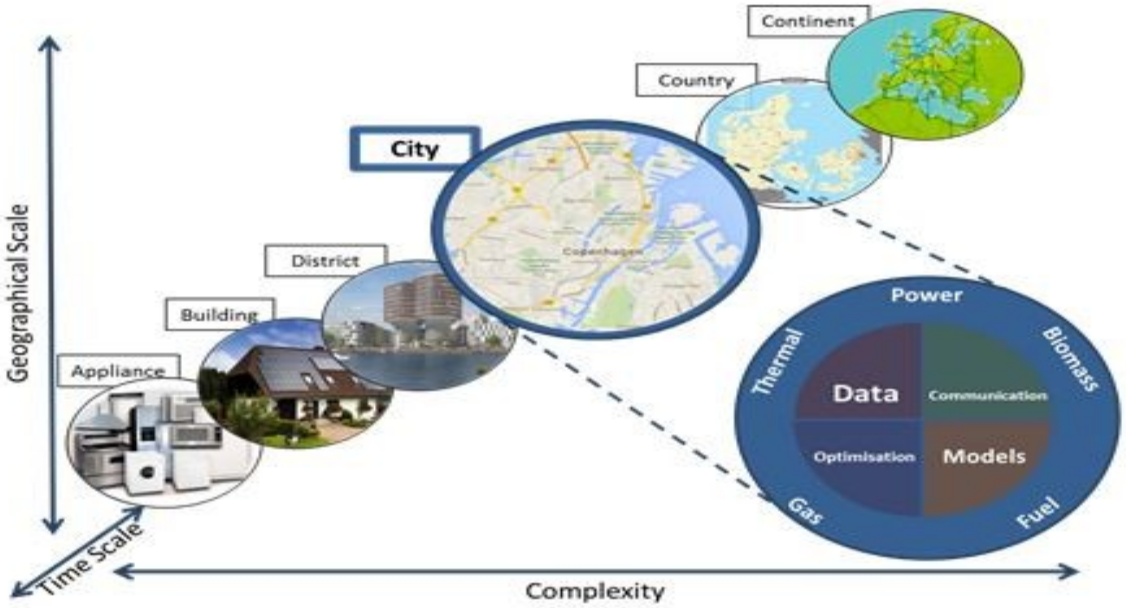
Intelligent integration will (for instance) enable lossless ‘virtual’ storage on a number of different time scales.



Intelligent Integration and CITIES

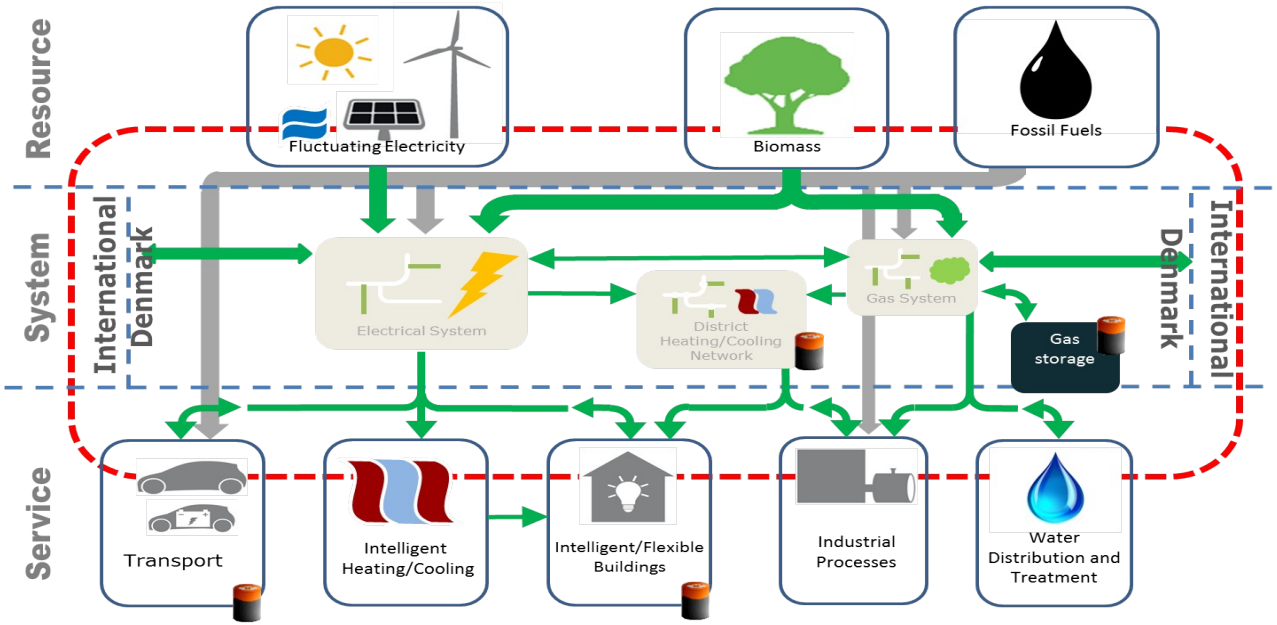
Center for IT-Intelligent Energy Systems (CITIES) is establishing ICT solutions for **design and operation of integrated electrical, thermal, fuel pathways at all scales**.

CITIES is the largest Smart Cities and ESI research project in Denmark – see http://www.smart-cities-centre.org .

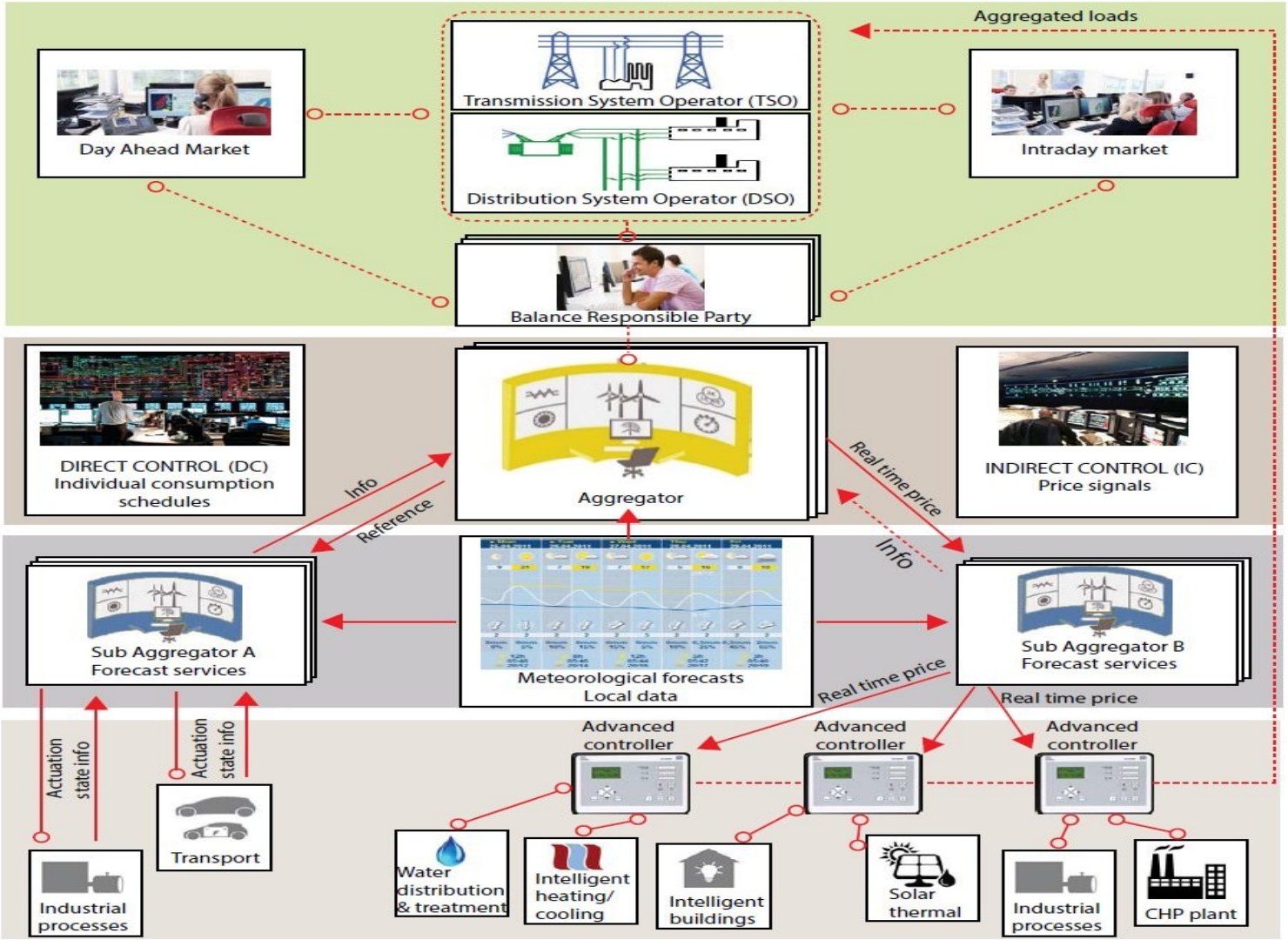


ESI – Concept Challenges

Energy Systems Integration using data and IT solutions leading to **models and methods for planning and operation of future electric energy systems.**

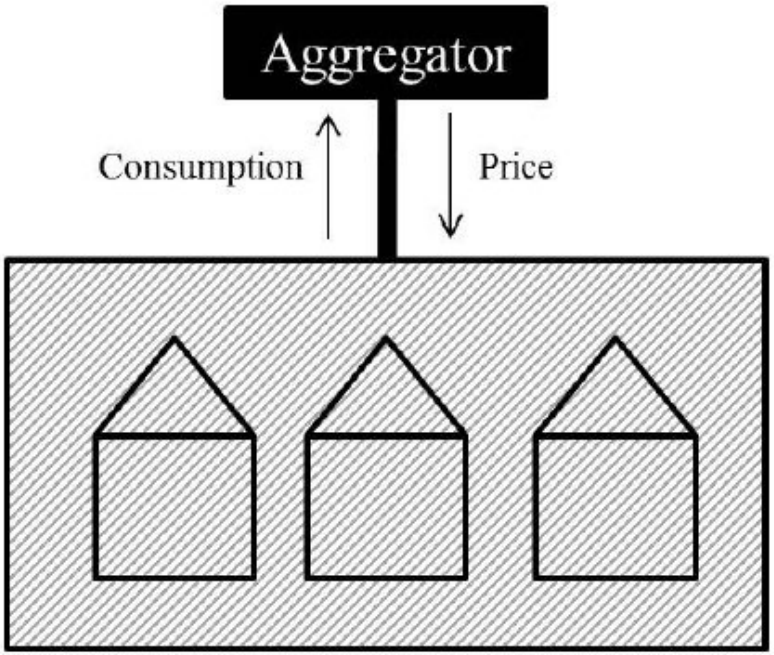


Energy-System OS

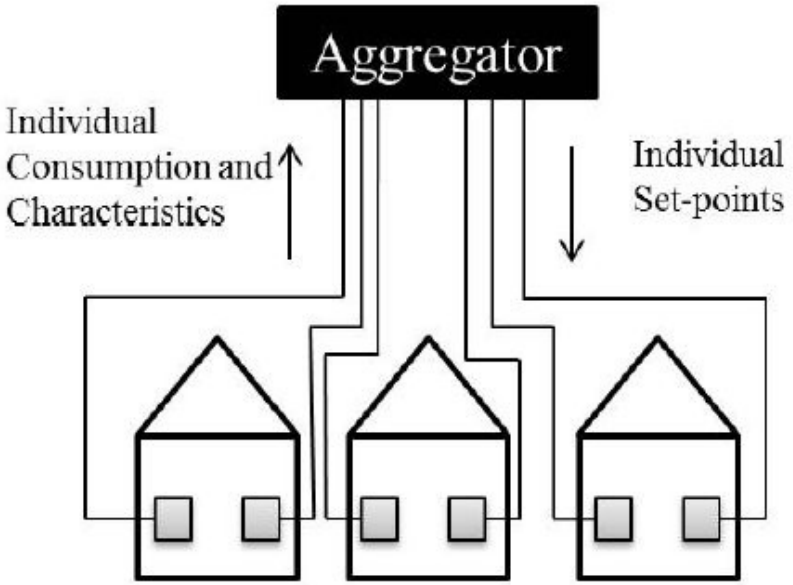


Direct and Indirect Control

For DC info about individual states and constraints are needed

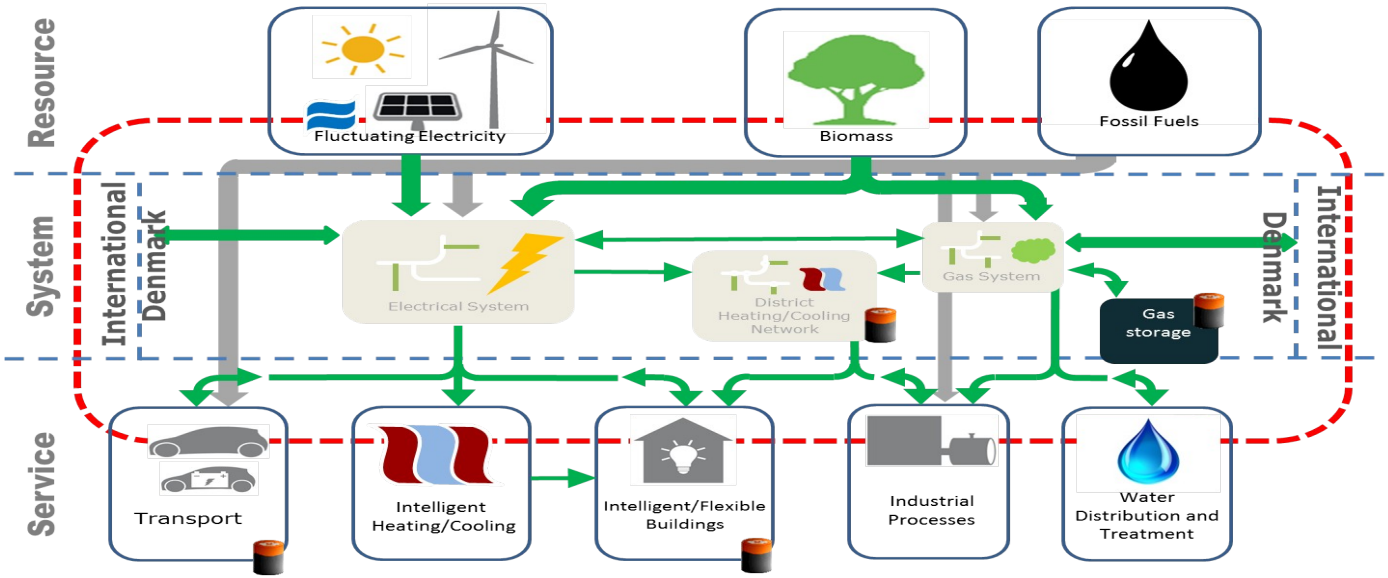


(a) Indirect control



(b) Direct control

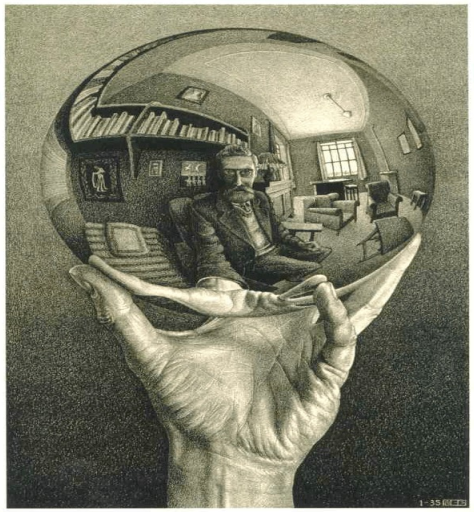
Example: Storage by Energy Systems Integration



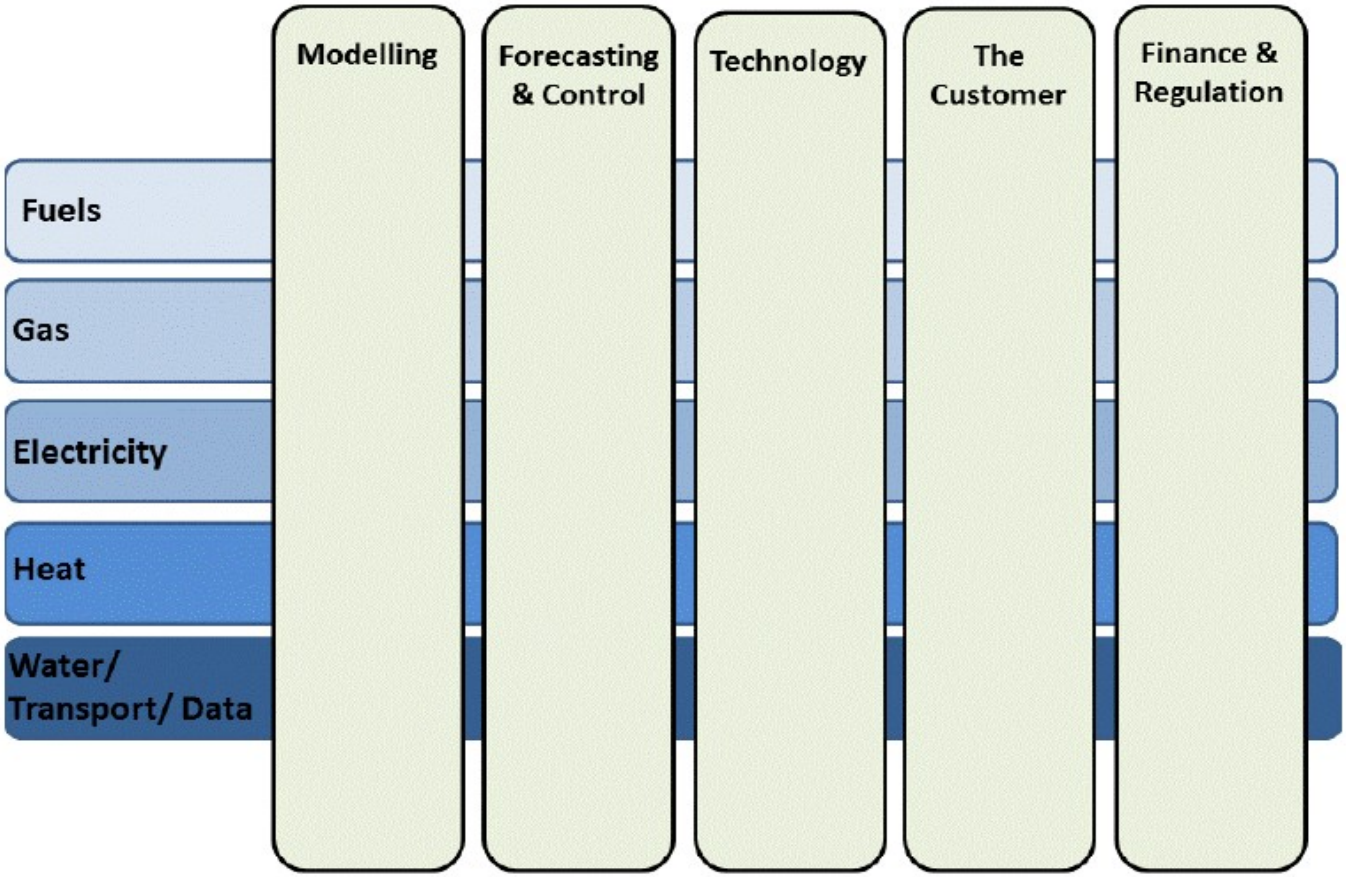
- **Denmark (2014) : 48 pct of power load by renewables (> 100 pct at some days in January)**
- **(Virtual) storage principles:**
  - Buildings can provide storage up to, say, 5-12 hours ahead
  - District heating/cooling systems can provide storage up to 1-3 days ahead
  - Gas systems can provide seasonal storage

Examples:
ESI Projects in CITIES

- Control of WWTP (ED, Kruger, ..)
- Heat pumps (Grundfos, ENFOR, ..)
- Supermarket cooling (Danfoss, TI, ..)
- Summerhouses (DC, Nyfors, ..)
- Green Houses (NeoGrid, ENFOR, ...)
- CHP (Dong, Fyns Fjernvarme, ...)
- Industrial production
- VE (charging)
- .....



News (DTU Compute is leading):
ESI Joint Program in EERA



Thanks for your attention!

For more information:

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