Smart Cities – NTNU-DTU Meeting

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Agenda (draft)

- Joint H2020, N5T, ... applications
- Demand Response in Cities and Districts
- Smart Campus initiative and collaboration (a follow up on the joint NTNU - TU-Berlin - DTU Workshop we had on DTU in February).
- Should we aim at having a joint (Big) Data Management Systems for Smart Cities (as a follow up on some joint initiatives)?
- ZEN and CITIES project - status and collaborations
- Project Smart Cities 2030
Zero Emission Smart Campus Areas

- Indoor climate, energy levels, etc.
- Compare different data levels between the campuses
- Interfaces for operators
- Interfaces for users
Demand Response

- We have demonstrated a large potential in Demand Response. Automatic solutions and end-user focus important.
- Controllers for building heat/comfort can focus on:
  - Peak Shaving
  - Smart Grid demand (like ancillary services needs, ...)
  - Energy Efficiency
  - Cost Minimization
  - Emission Efficiency
- We see large problems with tax and tariff structures in many countries (eg. Denmark).
Figure 4: Six characteristics of the demand response to a step increase in electricity price. \( \tau \): The delay from adjusting the electricity price and seeing an effect on the electricity demand, equal to approximately 0.5 here. \( \Delta \): The maximum change in demand following the price change, in this case close to 0.2. \( \alpha \): The time it takes from the change in demand starts until it reaches the lowest level, approximately equal to 0.5 here. \( \beta \): The total time of decreased electricity demand, roughly equal to 2 here. \( A \): The total amount of decreased energy demand, given by the green-shaded area. \( B \): The total amount of increased energy demand, given by the grey-shaded area.
Labelling proposal
for energy, price and emission based labelling

The test consists of the following steps:

1. Let $\lambda_t$ be the price of electricity at time $t$.

2. Simulate the control of the building *without considering* the price, and let $u^0_t$ be the electricity consumption at time $t$.

3. Simulate the control of the building *considering* the price, and let $u^1_t$ be the electricity consumption at time $t$.

4. The total operation cost of the price-ignorant control is given by $C^0 = \sum_{t=0}^{N} \lambda_t u^0_t$.

5. Similarly, the operation cost of the price-aware control is given by $C^1 = \sum_{t=0}^{N} \lambda_t u^1_t$.

6. $1 - \frac{C^1}{C^0}$ is the result of the test, giving us the fractional amount of saved money.

This test is inspired by minimizing total costs for varying electricity prices, but in general $\lambda_t$ could just represent one's desire to reduce electricity demand at time $t$. 
Flexibility Represented by Saturation Curves (for market integration using block bids)
Smart CITIES Data Management System

Xiufeng Liu, Per Sieverts Nielsen, Alfred Heller, Alexander Turecz
Smart City Data & Characteristics

- **Data Types:**
  - City info., GPS, Traffic, Mobile, LBS, Environment and Climate data, Social activity, IoT, etc.

- **Data Characteristics:**
  - Heterogeneous data sources
  - Featured with big data:
    - Variety (varied/complex formats/types/meanings):
    - Volume: Very large data volumes
    - Velocity: Data arrives very fast (data streams)
  - Temporal-spatial data
    - Fine granularity
    - Multi-dimensions
CITIES Data Platform

• Data security assurance
  – Data anonymization (e.g., for sensitive data)
  – Secured data management (VM-based environment/private ownCloud)

• Quality assurance
  – Data cleansing/quality checking

• Data fusion
  – Open data platform
  – Linked data
CITIES Data Platform
Components of CITIES Data Platform
Topics

- Energy systems
- Data analytics
- Policy and regulations
  - Water
  - Cloud-based solutions
  - Mobility
  - Markets
  - Smart buildings
Smart Cities 2030
Test Center for Intelligent and Integrated Energy Systems
Test i et mini samfund beliggende på 40 Hektar naturgrund
- Test i et fungerende driftsmiljø bestående af mange forskellige typer bygninger

Ældre bygninger:
1. Møllen: Urban Farmning
   1. Bygning 228 m²
   2. Bygning 590 m²
   3. Bygning 290 m²
   4. Bygning 230 m²
   5. Bygning 155 m²
2. Privathus, 183 m²
3. Privathus, 153 m²
4. Privathus, 166 m²
5. Gård 140 m²
6. Gårde 4-længer 231 m²
7. Rækkehuse 140 m²
8. Rækkehuse 130 m²
9. Depot 140 m²
10. Kontor 110 m²
11. Lager 450 m²
12. Erhverv produktion 450 m²
13. Privat hus 160 m²
14. Vin gården 110 m²
   1. Erhverv 70 m²
   2. Produktion Vin 25 m²
   3. Kelterem 5 m²
   4. Klimarum cafe 10 m²
15. Shelter 60 m²

Nye bygninger:
1. Smart City 2030
   1. Urban Farmning
   2. Rækkehuse
   3. Parcel huse
   4. Kollegie værelser
   5. Undervisningsbygning
   6. Laboratorier
2. Center Danmark 4800 m²
3. Ny Gudsøgårds 2600 m²
   1. Privat hus 280 m²
   2. Erhverv 280 m²
   3. Stall 280 m²
   4. Ridehal 1700 m²
   5. Produktion Gødning
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 the wind power production was more than 100 pct of the power load.
July 10th, 2015 more than 140 pct of the power load was covered by wind power
Wind integration in Denmark

**Power right now**

Measured in MW:

- Central power stations: 1.315
- Local CHP plants: 298
- Wind turbines: 3.951
- Solar cells: 0
- Net exchange export: 2.096
- Electricity consumption: 3.469
- CO2 emissions: 164 g/kWh

**LEGEND**

- Jutland - Sweden
  - Exports: 332 MW
- Zealand - Sweden
  - Exports: 1.026 MW
- Bornholm - Sweden
  - Exports: 16 MW
- Jutland - Norway
  - Exports: 1.530 MW
- Jutland - Germany
  - Imports: 473 MW
- Zealand - Germany
  - Imports: 336 MW
- The Great Belt
  - 590 MW

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From large central plants to Combined Heat and Power (CHP) production

1980

Today

From a few big power plants to many small combined heat and power plants – however most of them based on coal

DK has enough excess heat to cover most of the need for heating .... but ...

CITIES
Centre for IT Intelligent Energy Systems

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