CITIES Update

DTU-NTNU-TUB Workshop

February 6th and 7th, 2017

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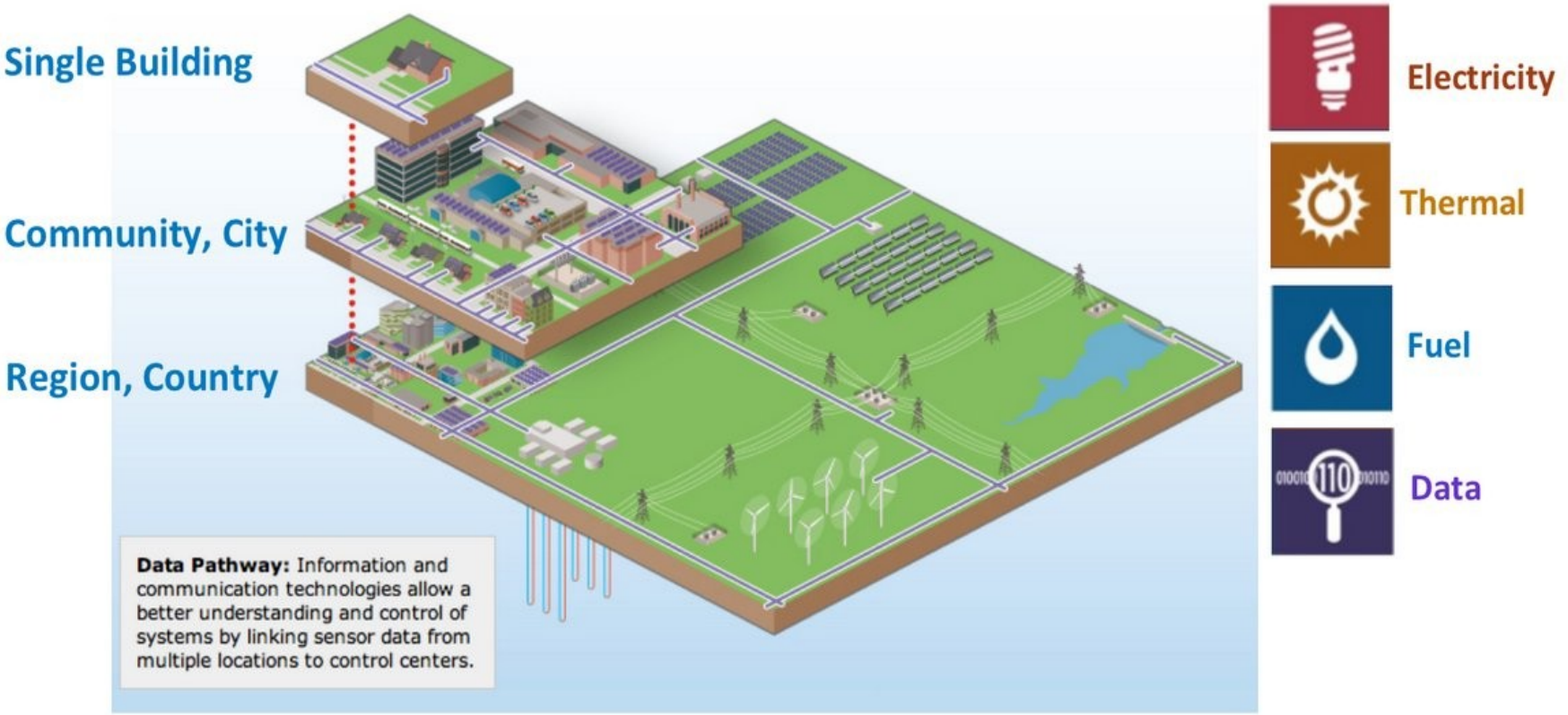
Center Manager

CITIES
Centre for IT Intelligent Energy Systems

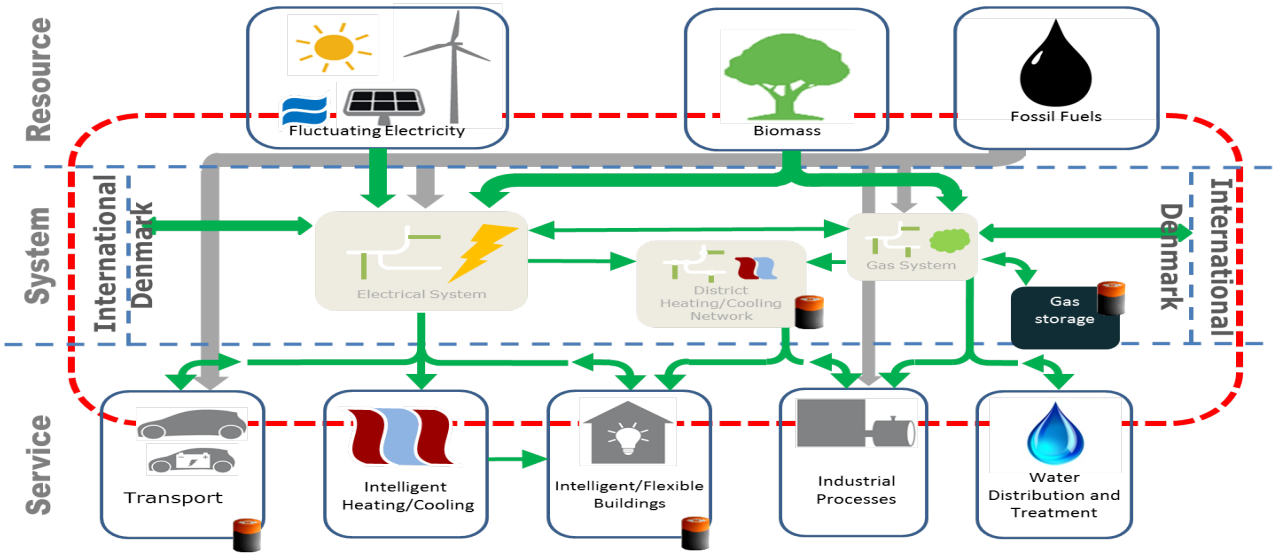
Systems Integration in Smart Cities

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



Concept

Integration based on **data and IT solutions** leading to **models and methods** for ***planning and operation*** of future electric energy systems

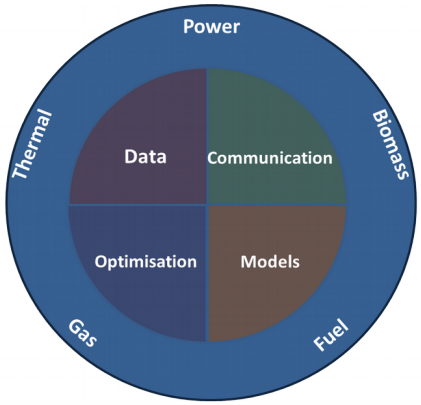


CITIES
Centre for IT Intelligent Energy Systems

Hypothesis

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

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



Scientific Objective

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

Goals
(from the application)

- To educate 11 Phd's and 4.5 PostDocs
- 30-40 journal papers
- 6 PhD summerschool events
- Dissemination through media and broad-audience events
- A dynamic and public website
- Models and strategies for integrated energy systems
- CITIES Innovation Centre (in parallel to CITIES)
- Support activities related to green/smart cities projects
- Establish international networks

Status (1. Dec 2016)

Some statistics (- 1/12 2016):

- Many invited presentations
- Part of national Big Data - and Center of IoT initiatives
- 12 times in the media (2016 only)
- 60+ scientific oriented presentations (2016 only)
- 72 journal papers (34 papers in 2016)

  (wp1:**5**,wp2:**3**,wp3:**1**,wp4:**5**,wp5:**12**,wp6:**3**,wp7:**6**)
- 12 Workshops
- 6 PhD summer/winter-schools
- 3-4 extra PhD's (Indonesia, Malaysia, DSOs, ...)
- Several successful H2020, EUDP, ... applications related to CITIES

  Ex: Smart Cities Accelerator – 48 mill dkk – directly linked to CITIES

Project management

- Homepage www.smart-cities-centre.org
- Twitter (@CITIES_Centre)
- **CITIES Innovation Center** (CIC) (incl. Homepage…)
- International influence:
  - EU Commission (reports and workshops)
  - EU JRC
  - EERA JP ESI
  - Global: iiESI (Summer schools / Meetings / Workshops)
  - Global: IEA (Annex 58, 66, 67 and 71)
- Innovation Networks:
  - INNO SE - CLEAN
  - TI (VE-Net)

International Collaboration

- Our partners – tecnalia, NREL, UCD, Samsung, …
- Member of Advisory Board or Partner in many International Projects;

  The largest being:

  Energy Systems Integration Partnership Programme (ESIPP) – Ireland – 120 mill dkr

  Centre for Energy Systems Integration (CESI) – UK – 300 mill dkr (project partner)

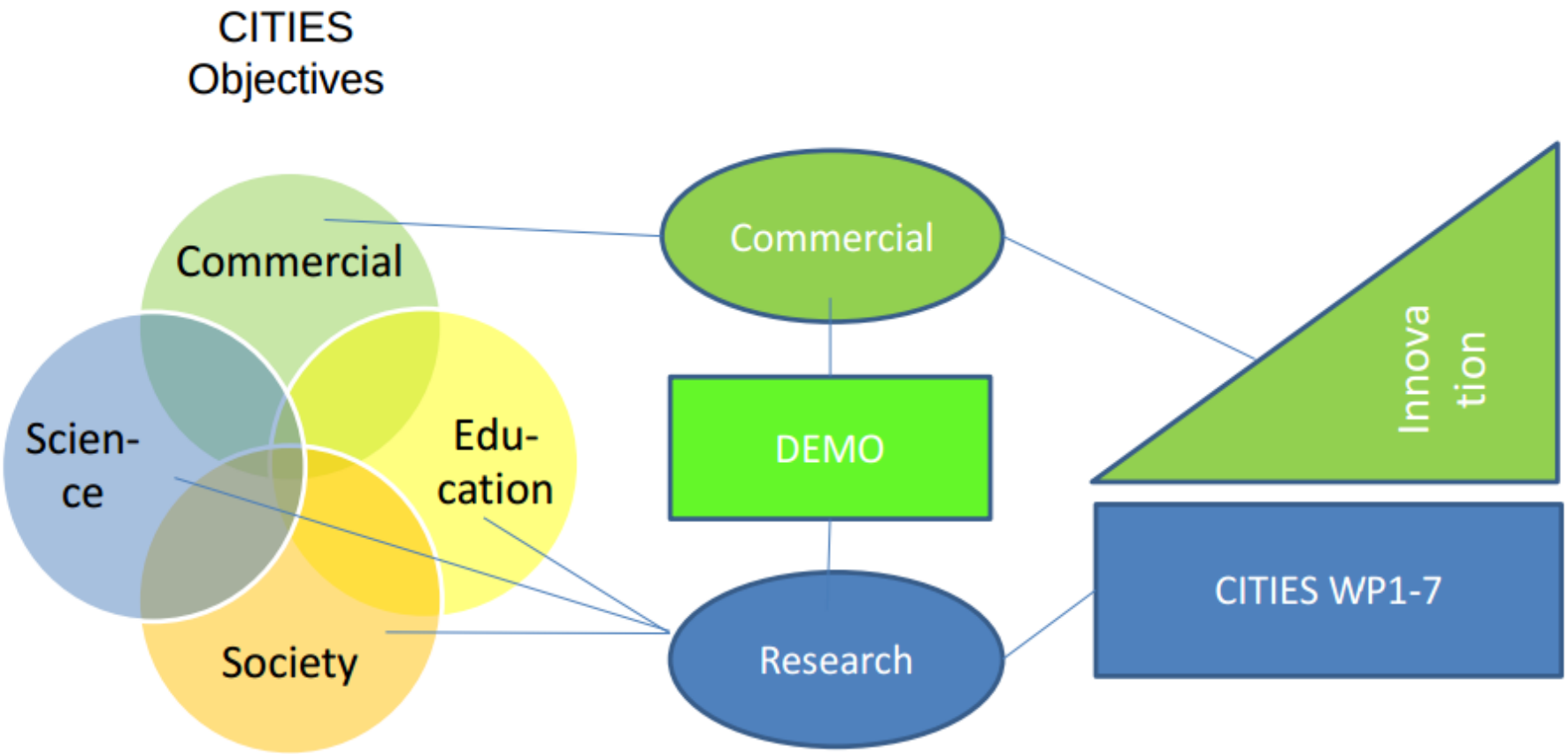
  - Research Centre on Zero Emission Neighbourhoods in Smart Cities (ZEN) – Norway – approx 300 mill NOK
  - In all cases the project has a strong link to CITIES
- Part of UK intiative ‘Mathematics in Energy Systems’
- COST TD1207 ‘Mathematical Optimization in the Decision Support Systems for Efficient and Robust Energy Networks.

CITIES – Demo Projects

- **Purpose: To ensure an efficient and fruitful collaboration between smart cities projects (Sønderborg, Tjæreborg, Frederikssund, Odense, Aarhus, Copenhagen,..), companies, research organisations, and universities.**
- Use test facilities

  (eg. at Tecnalia, NREL, Grundfos, Danfoss, PowerLab.dk/SYSLAB, TI, ...)
- At least two Work Packages must participate
- Linked to new partner projects (EUDP, Innovation Centre, H2020 etc.)
- Linked to external existing and planned Smart Cities projects
- Use of high performance computing facilities (eg. ESIF and DTU-HPC)
- Described on our homepage.

CITIES Innovation Center



Results – some examples

- Software:
  - HPMPC: A toolbox for High-Performance MPC
  - MPC-R: A toolbox for MPC in R
  - CTSM-R: A toolbox for semi-physical modelling in R
- Modelling and Planning tools
  - Modelling tools for aggregated loads
  - Multiple Execution Tool for EnergyPLAN
  - Sifre (Energinet.dk) - incl. tests in Sønderborg
- Hardware
  - SN-10 Smart House Controller
- Data Analytics and Energy Informatics
  - WEB-service for forecasting (load, wind, solar,...)
  - Cloud based model predictive control
  - Smart-Energy Data Management Systems (OS, DATA, REP)

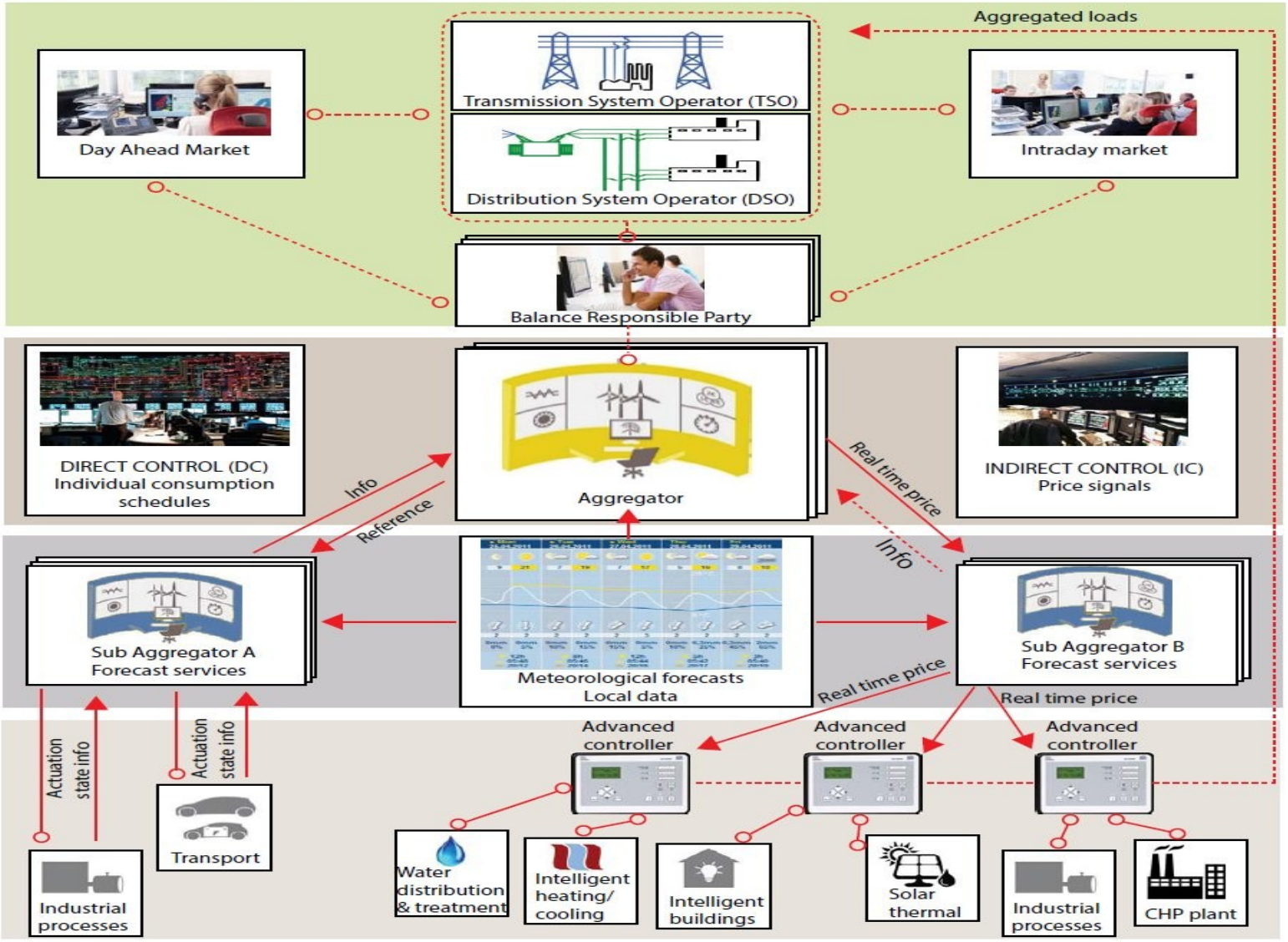
Results
A few examples

CITIES Data Management Systems

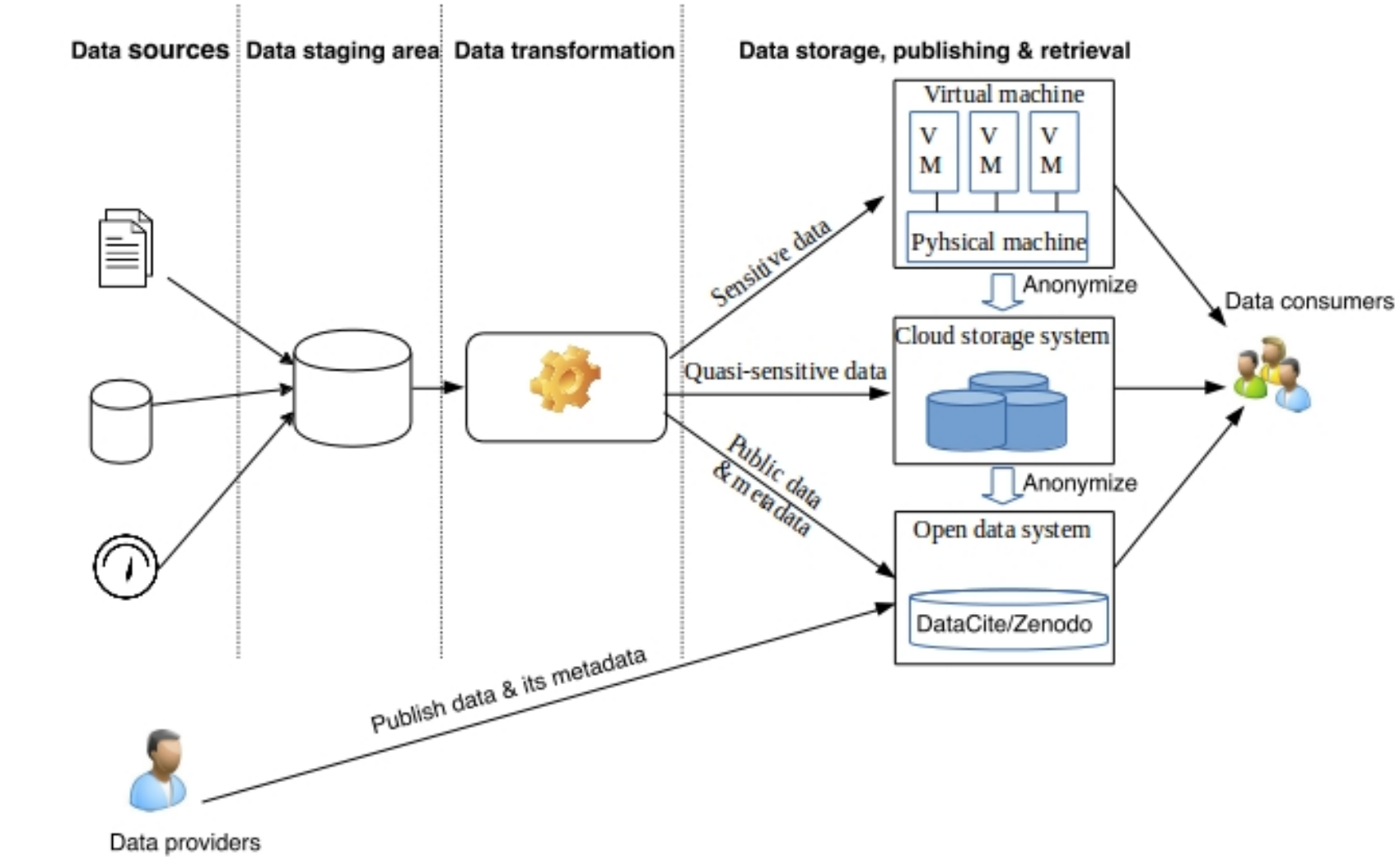
- Smart-Energy Operating-System (SE-OS)
- Smart-Energy Data analytics (SE-DATA)
- Smart-Energy Repository (SE-REP)

We try to refer to the EU Inspire Directive (which will be mandatory from 2020)

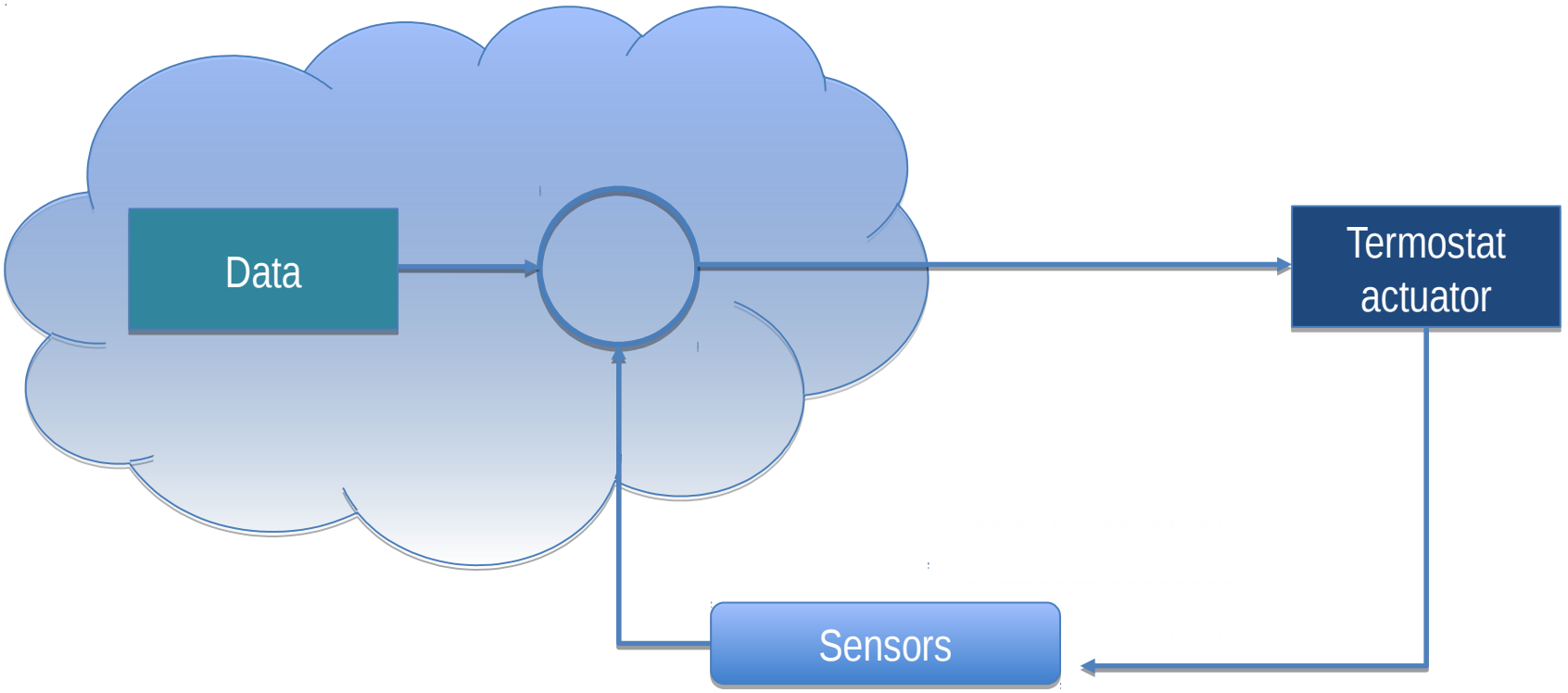
Smart-Energy OS



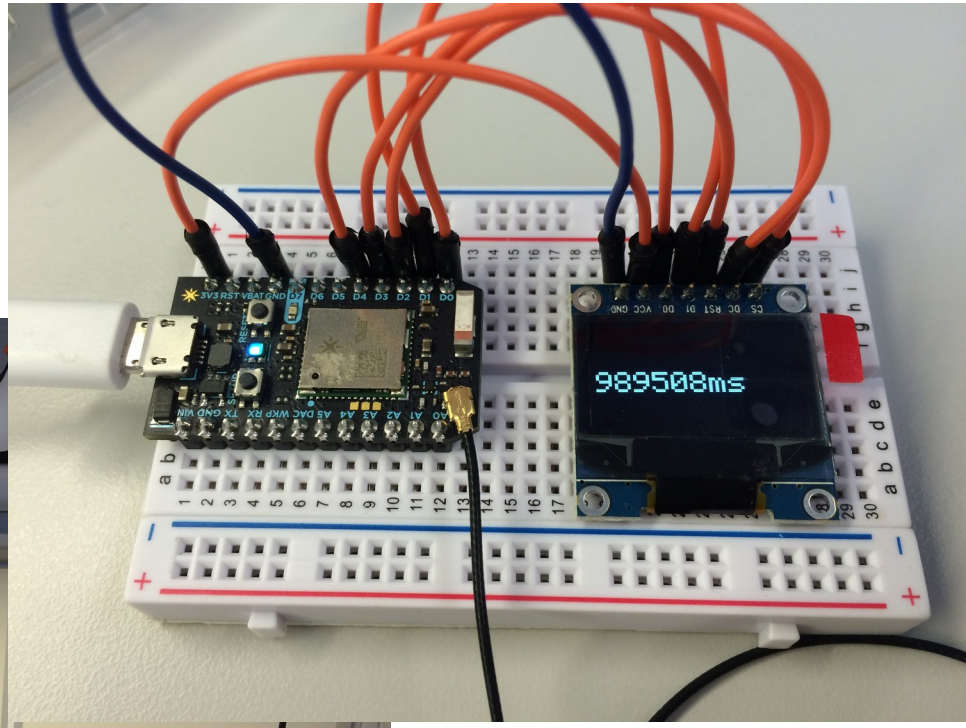
SE Data analytics

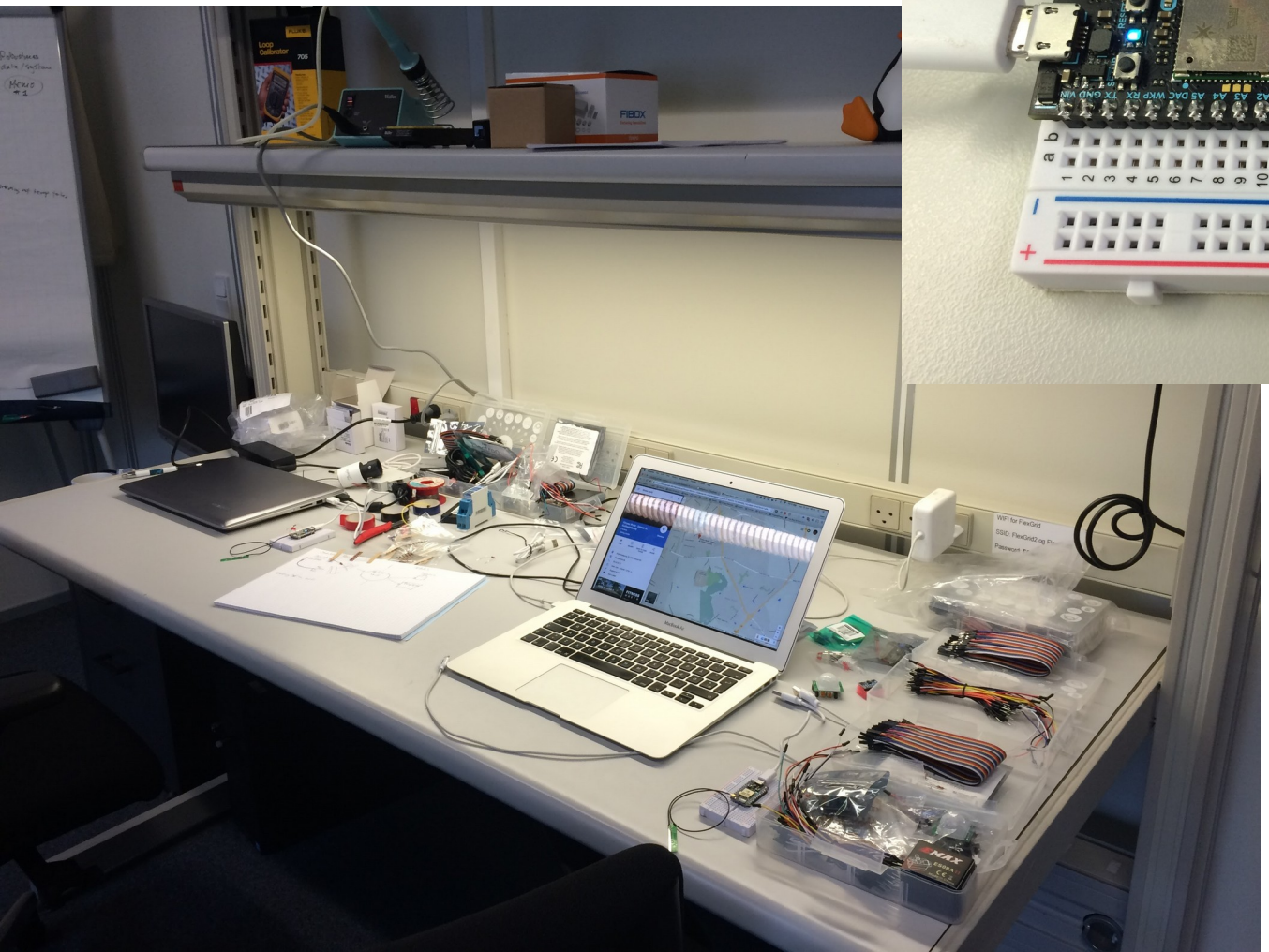


Cloud based control solutions
Control loop design – **logical drawing**

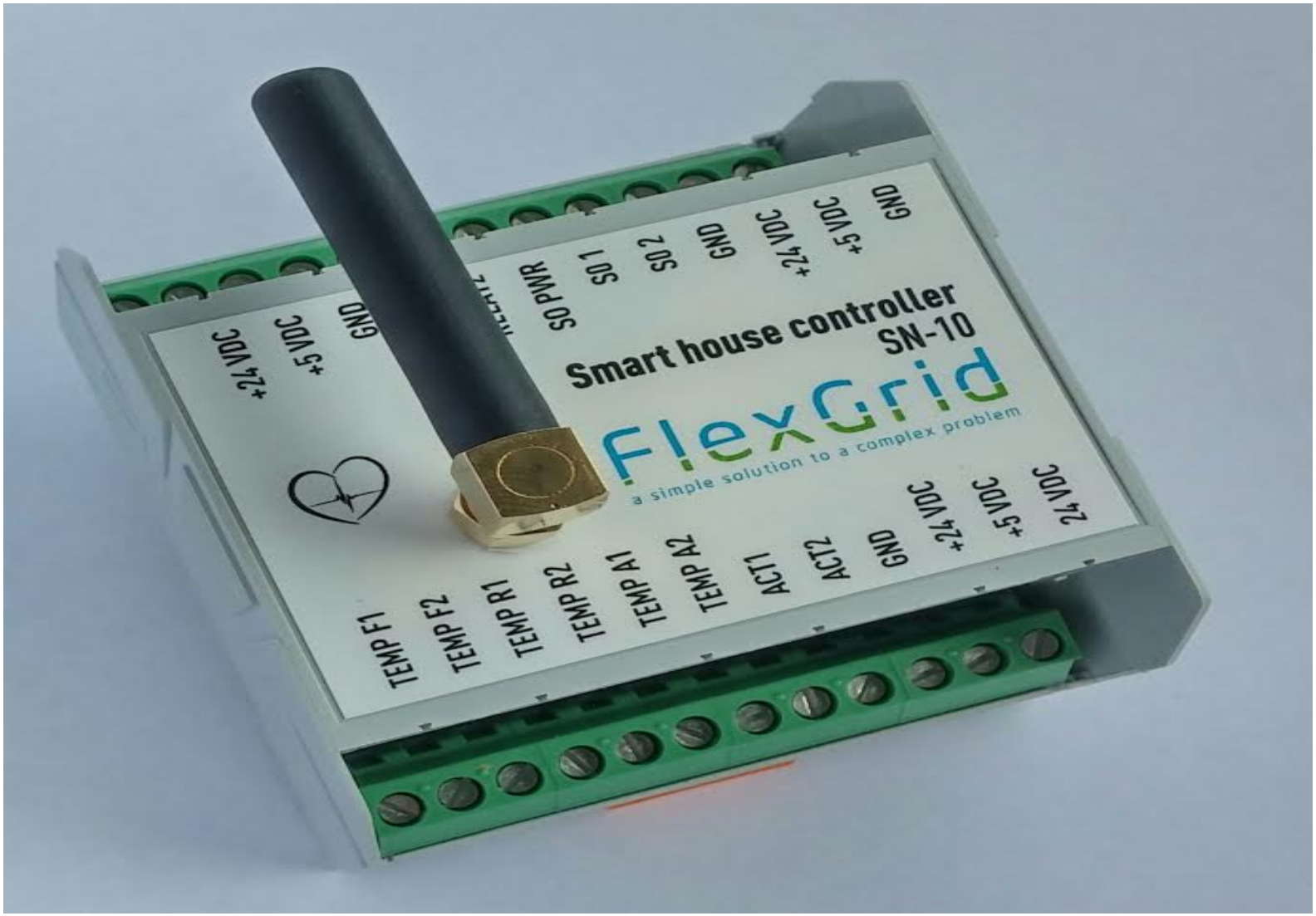


Lab testing ….





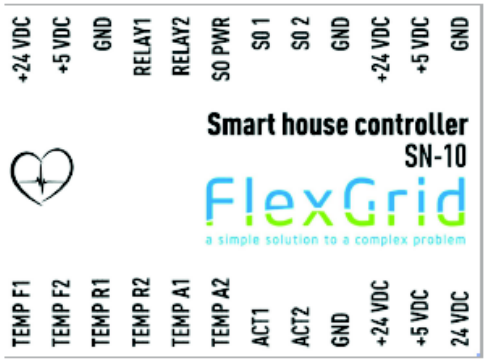
SN-10 Smart House Prototype

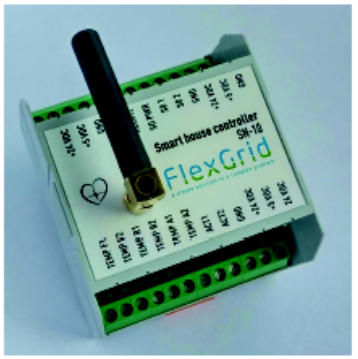


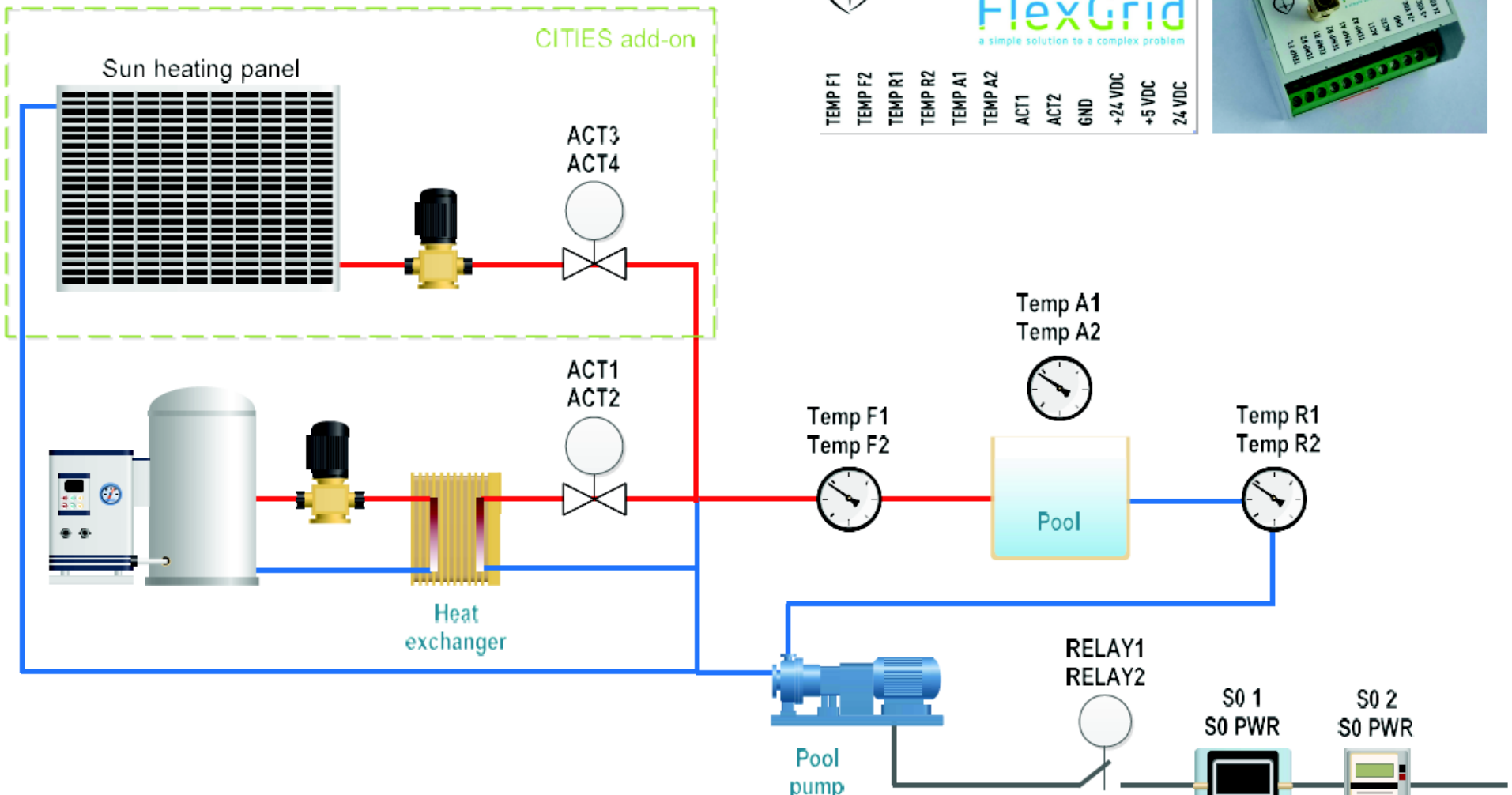
Smart Control of Houses with a Pool

PilotB SN-10 signal overview

revision 1.0 (CITIES add-on)







CITIES

Centre for IT-Intelligent Energy Systems in cities

Demo projects | Solutions | Work Packages | Partners | Events | Communications | Publications | Vacan

CITIES forecasts procedures leads to DTU being at the forefront of solar power

CITIES forecasts procedures leads to DTU being at the forefront of solar power according the Technoligist.eu.

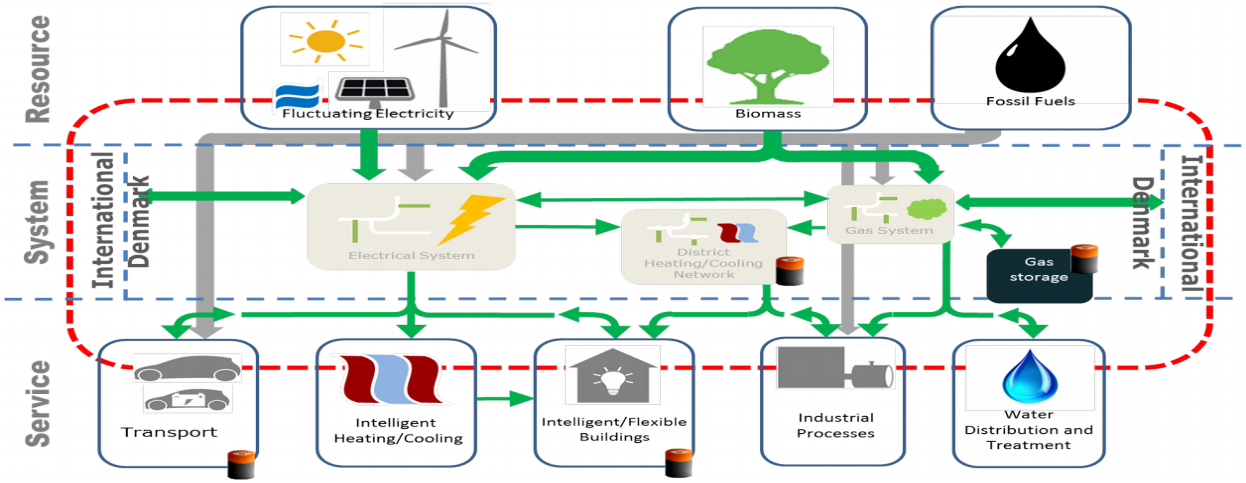
TECHNOLOGIST
INNOVATION. EXPLAINED.

Denmark at the forefront of solar power

DTU TECHNOLOGIST ONLINE SEP 10, 2016

A production plan for solar power.

(Virtual) Storage Solutions
CITIES Demo Projects / Conclusions



- **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

Plans

Plans

- Establish *CITIES Innovation Center*
- New (extra) PhDs and Post Docs
- Provide a tool box for smart energy systems / smart cities
- Focus on planning (tools, methodologies, ..) (WP4, WP6, WP7)
- Focus on interaction with gas systems (WP1, WP2, WP5)
- Focus on / discuss new market structures (WP4, WP5, WP6)
- Definition and initialization of (more) Demo Projects
- Libraries for Model Predictive Control
- Cloud based solutions for aggregation, forecasting and control
- Interaction with the Commission (eg. using workshops)
- Interaction with DoE (mostly via iiESI)
- Data ownership and security

CITIES INNOVATION CENTER

Integrated energy systems powered by intelligent data

Search ...

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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