Data Intelligence is Key to Energy Efficient and Flexible Energy Systems

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Quote by B. Obama at the Climate Summit in New York in 2014:

*We are the **first generation** affected by climate changes,*

*and we are the **last generation** able to do something about it!*

Potentials and Challenges for renewable energy

- **Scenario**: We want to cover the worlds entire need for power using wind power.
- How large an area should be covered by wind turbines?

Potentials and Challenges for renewable energy

- **Scenario:** We want to cover the worlds entire need for power using wind power
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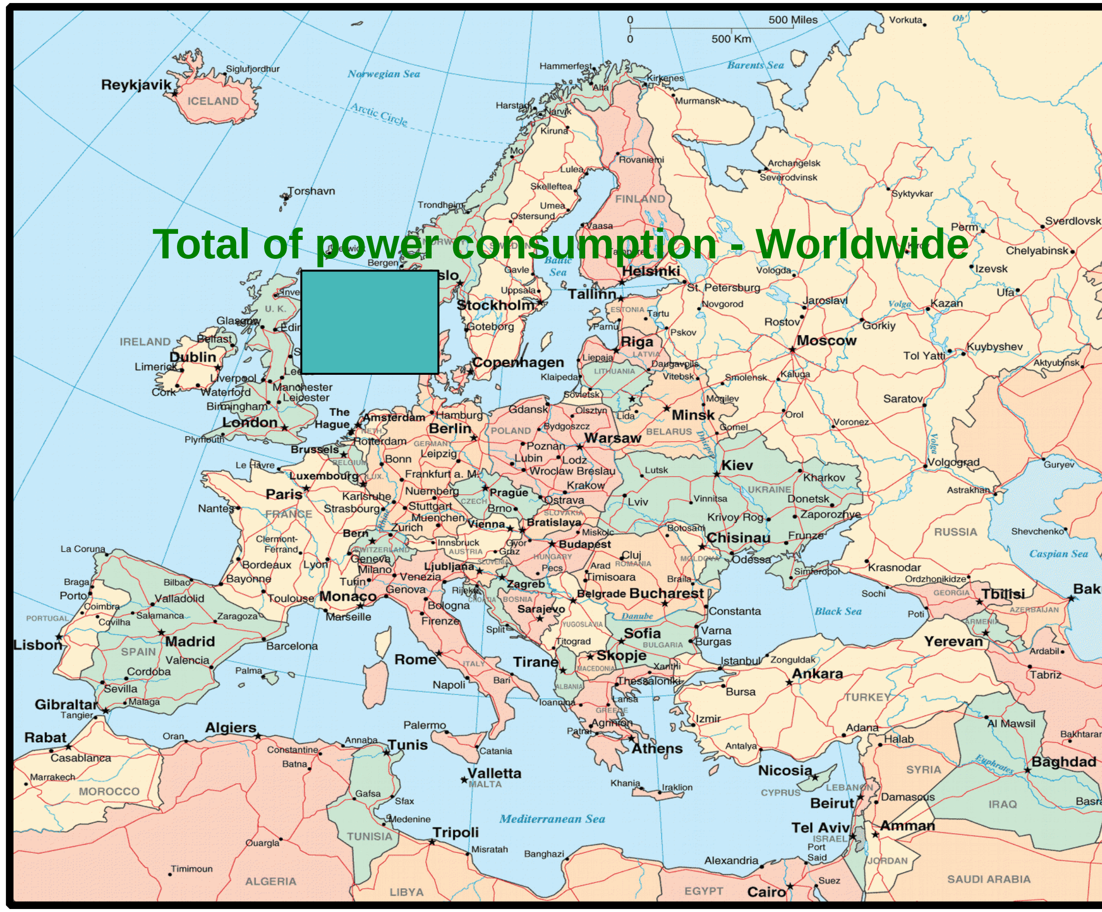
- **Conclusion**: Use intelligence ....
- Calls for **IT / Big Data / Smart Energy/Cities Solutions/** **Data Intelligent and Integrated Energy Systems**



Case Study No. 1

Thermal Performance Characterization of Buildings using (Smart) Meter Data

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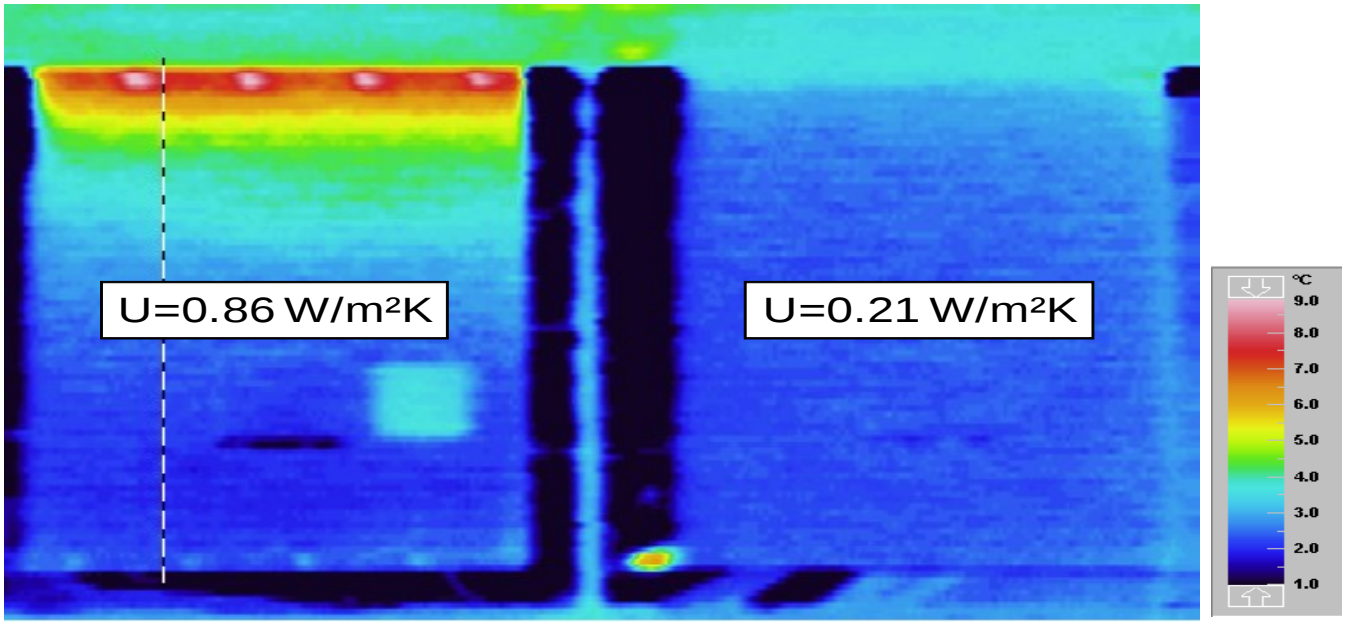
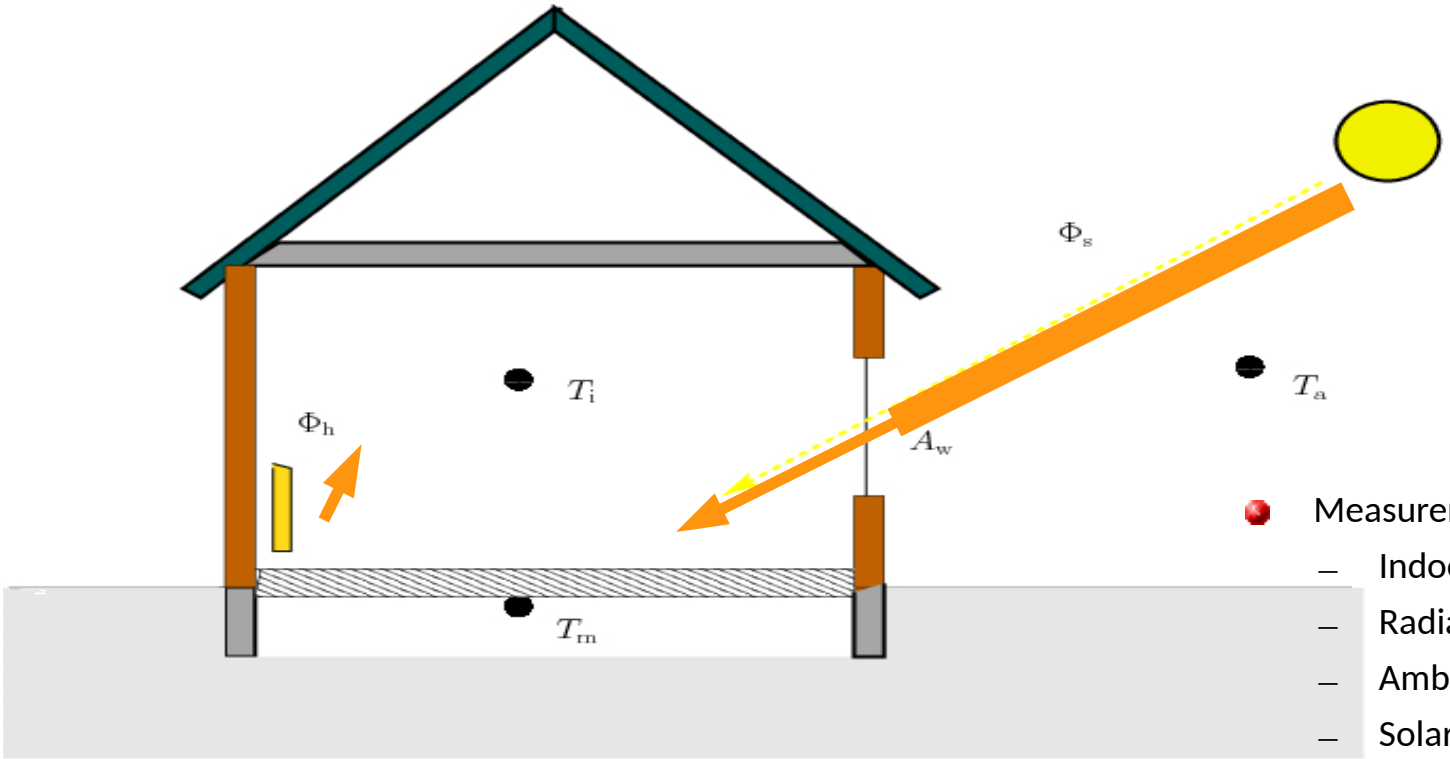
Example

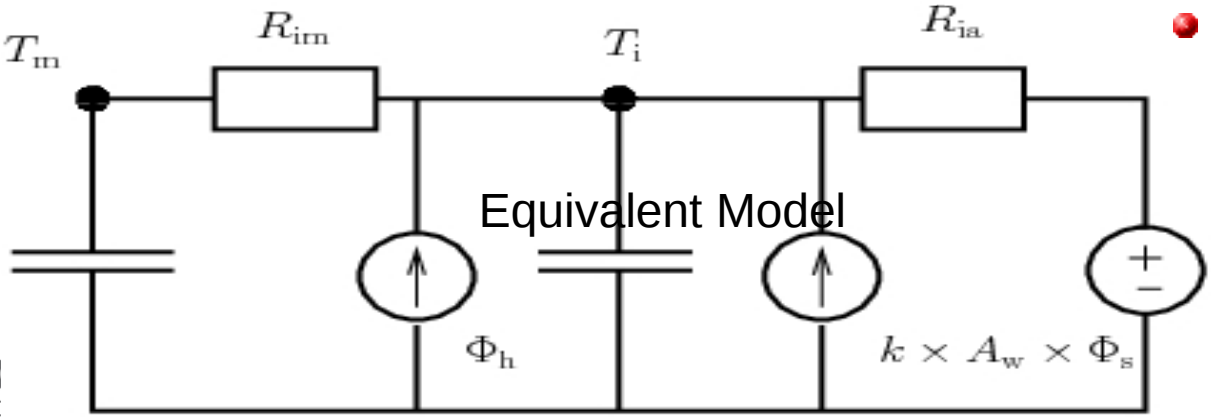


Consequence of good or bad workmanship (theoretical value is U=0.16W/m2K)

Model for heat dynamics



- Measurements:
  - Indoor air temp
  - Radiator heat sup.
  - Ambient air temp
  - Solar radiations
- Hidden states are:
  - Heat accumulated in the building
  - *k*: Fraction of solar radiation entering the interior



Equivalent Model

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Results

	UA W/°C	σ_{UA}	gA^{max} W	wA_E^{max} W/°C	wA_S^{max} W/°C	wA_W^{max} W/°C	T_i °C	σ_{T_i}
4218598	211.8	10.4	597.0	11.0	3.3	8.9	23.6	1.1
4381449	228.2	12.6	1012.3	29.8	42.8	39.7	19.4	1.0
4711160	155.4	6.3	518.8	14.5	4.4	9.1	22.5	0.9
4836681	155.3	8.1	591.0	39.5	28.0	21.4	23.5	1.1
4836722	236.0	17.7	1578.3	4.3	3.3	18.9	23.5	1.6
4986050	159.6	10.7	715.7	10.2	7.5	7.2	20.8	1.4
5069878	144.8	10.4	87.6	3.7	1.6	17.3	21.8	1.5
5069913	207.8	9.0	962.5	3.7	8.6	10.6	22.6	0.9
5107720	189.4	15.4	657.7	41.4	29.4	16.5	21.0	1.6
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Perspectives

- Identification of most problematic buildings
- Automatic energy labelling
- Recommendations:
  - Should they replace the windows?
  - Or put more insulation on the roof?
  - Or tigthen the building?
  - Should the wall against north be further insulated?
  - .....
- Better control of the heat supply (.. see later on ..)

Perspectives (2)

"Skat, jeg kan se på k-værdierne, at vinduerne skal pudses"

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Case study No. 2

Control of Power Consumption using the Thermal Mass of Buildings (Peak shaving)

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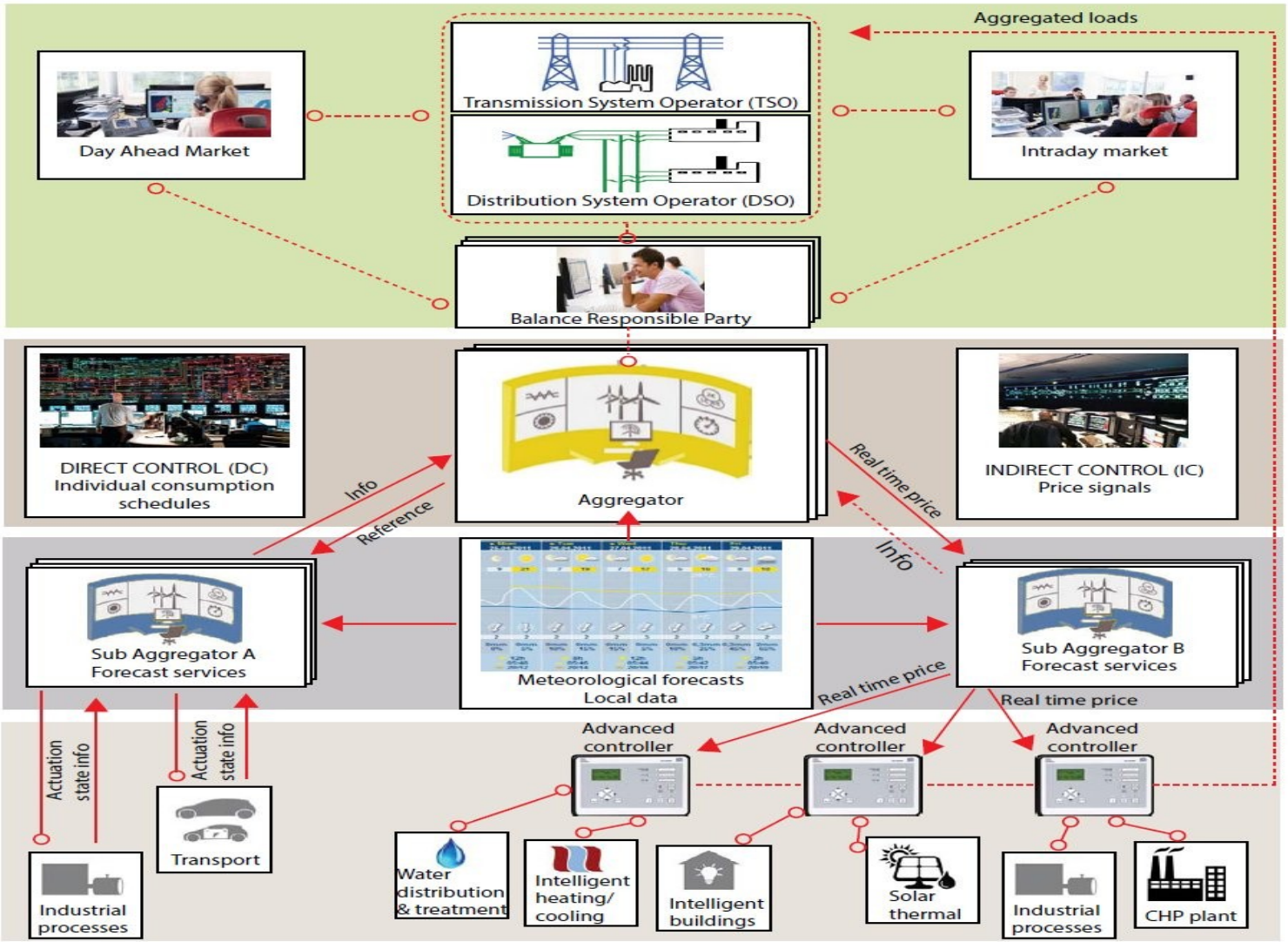
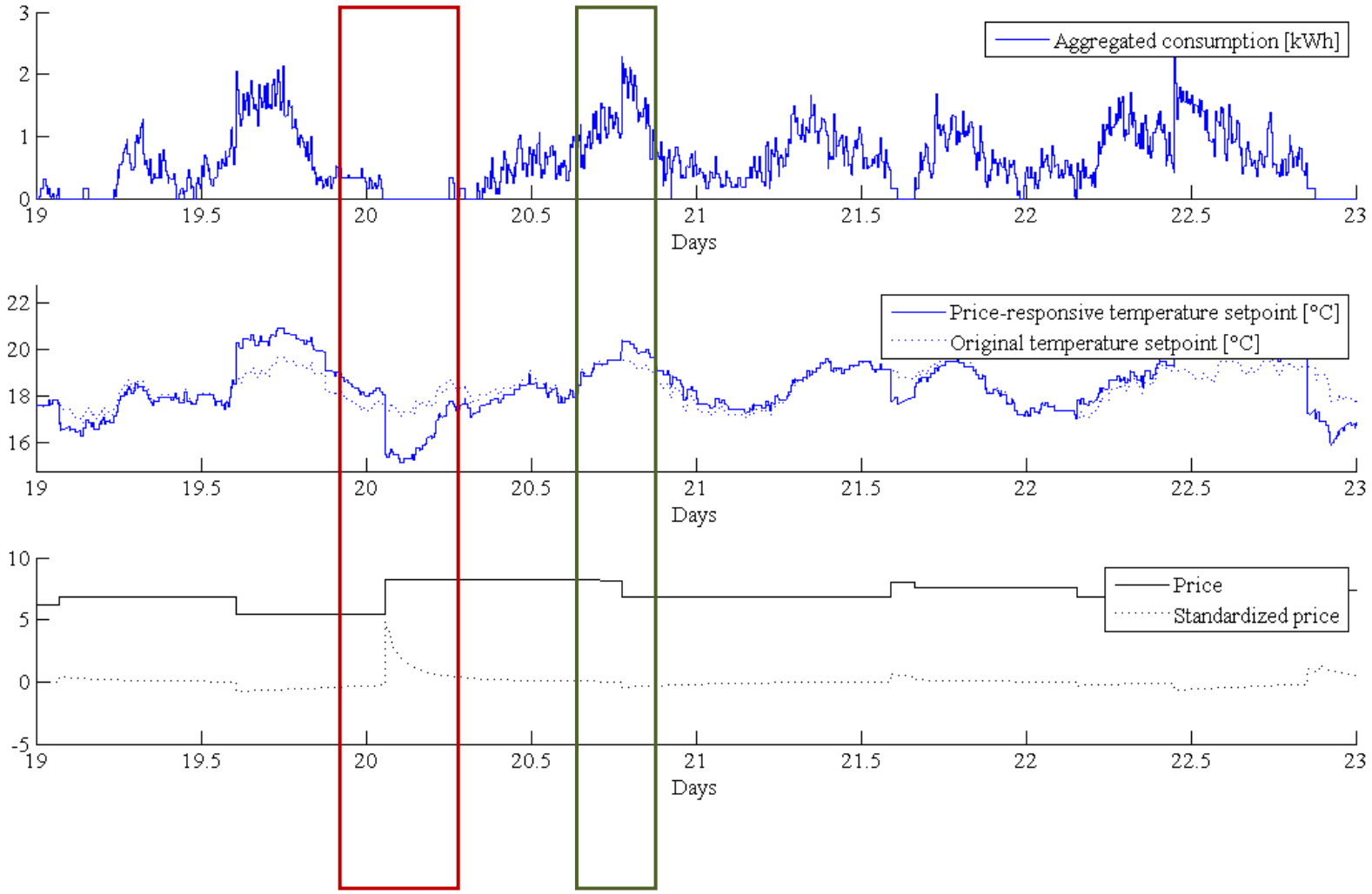
Smart-Energy OS

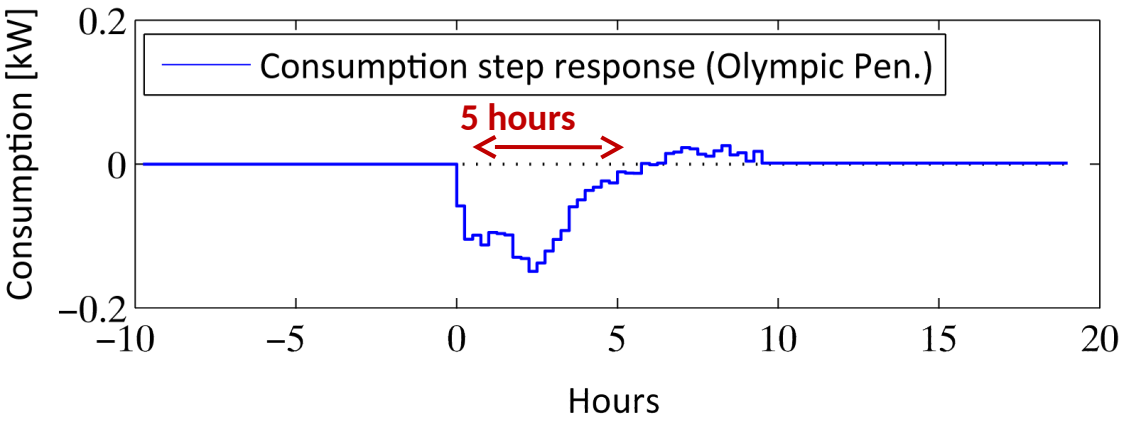


Aggregation (over 20 houses)

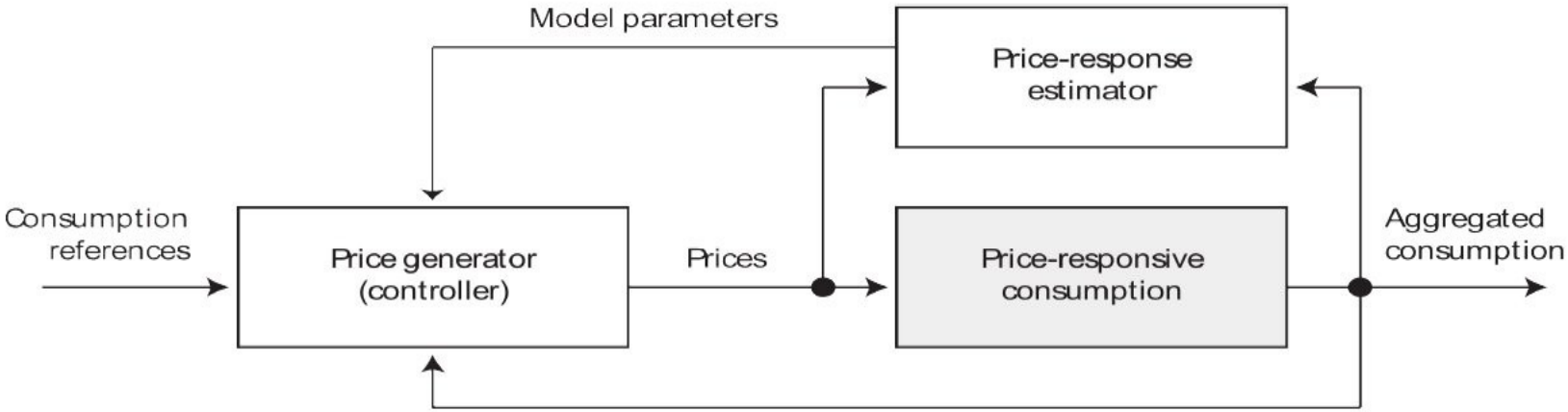


Response on Price Step Change

Olympic Peninsula



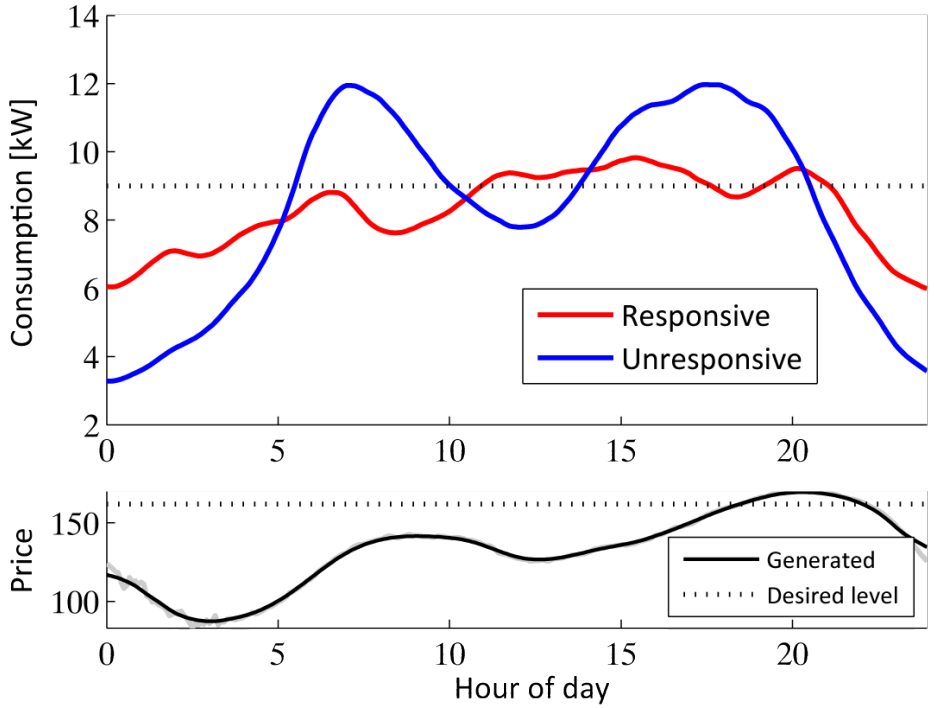
Control of Energy Consumption



Control performance

Considerable **reduction in peak consumption**

Mean daily consumption shift



Flexibility Function and Penalty Signals

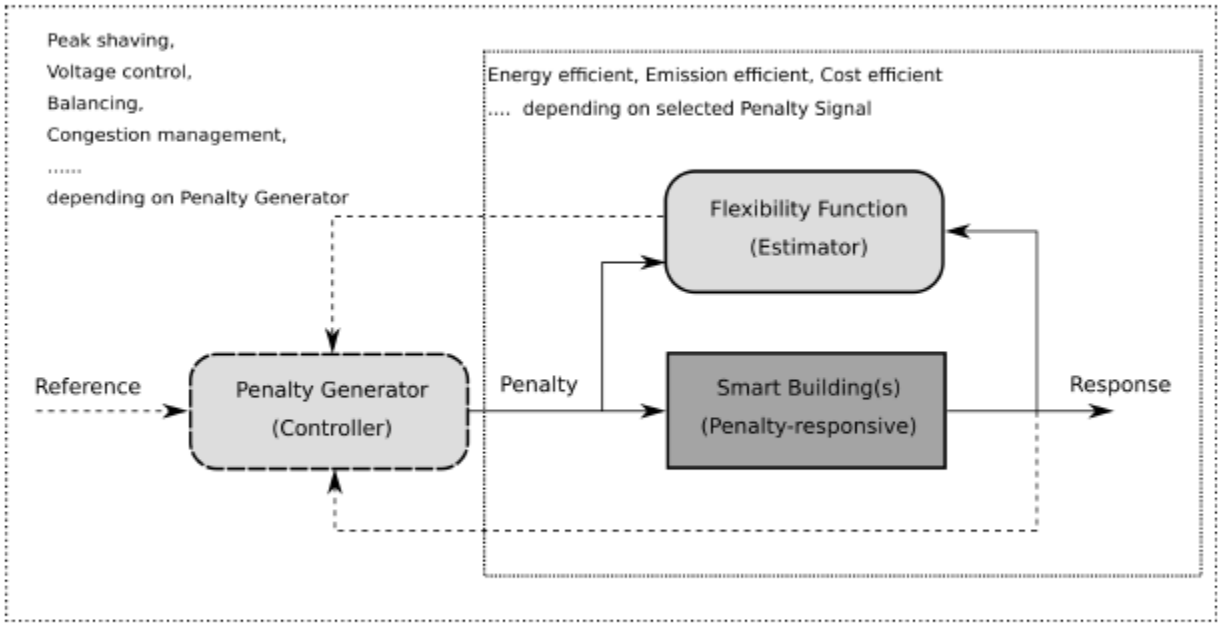


Figure 8: Smart buildings and penalty signals.

Penalty Function (examples)

- **Real time CO_2.** If the real time (marginal) CO_2 emission related to the actual electricity production is used as penalty, then, a smart building will minimize the total carbon emission related to the power consumption. Hence, the building will be *emission efficient*.
- **Real time price**. If a real time price is used as penalty, the objective is obviously to minimize the total cost. Hence, the building is *cost efficient*.
- **Constant**. If a constant penalty is used, then, the controllers would simply minimize the total energy consumption. The smart building is, then, *energy efficient*.

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Case study No. 3

Control of Heat Pumps
Summer Houses with a Swimming Pool
(CO2 minimization)

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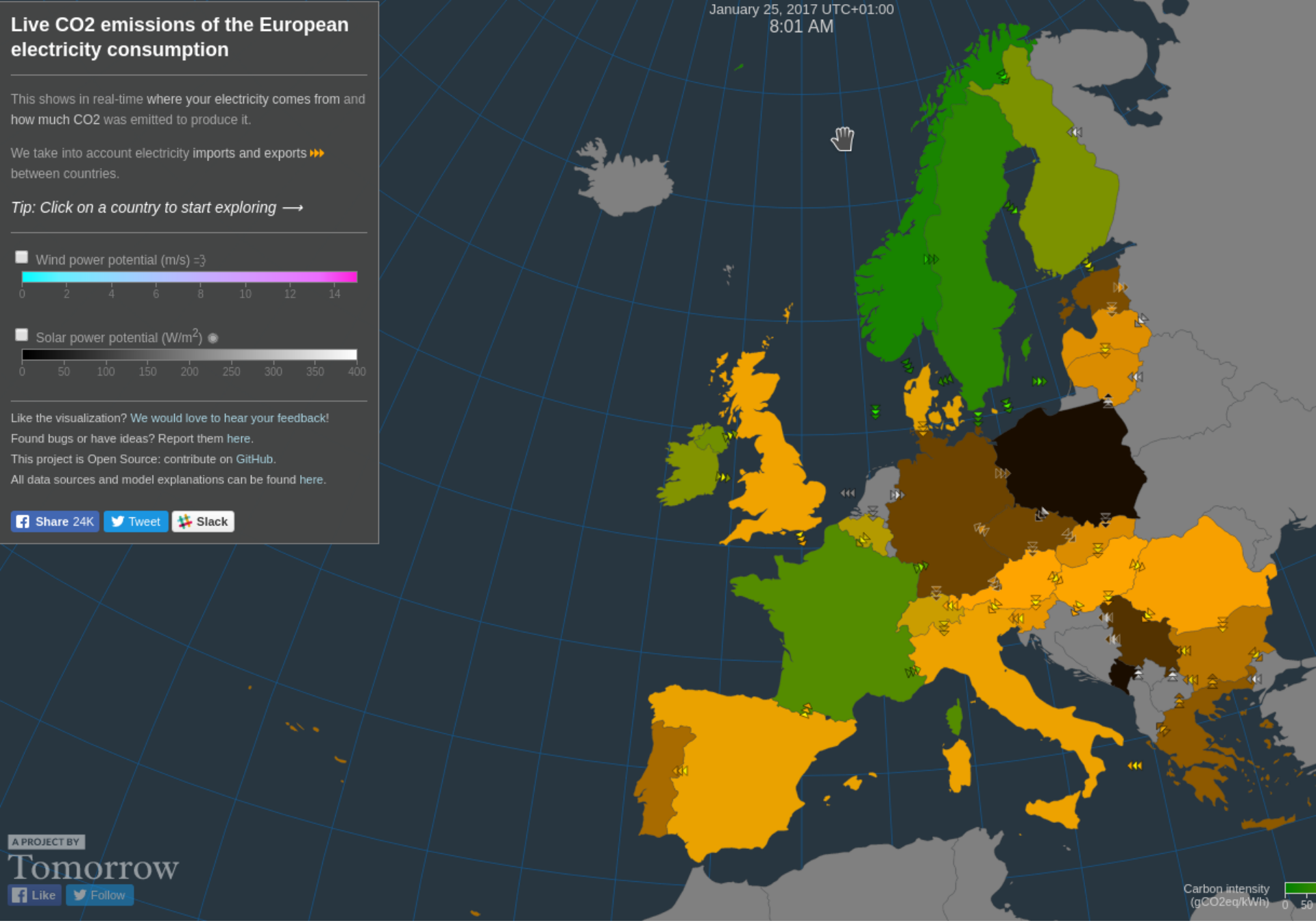
Live CO2 emissions of the European electricity consumption
This shows in real-time where your electricity comes from and how much CO2 was emitted to produce it.
We take into account electricity imports and exports between countries.
Tip: Click on a country to start exploring ⟶
Wind power potential (m/s)
0 2 4 6 8 10 12 14
Solar power potential (W/m2)
0 50 100 150 200 250 300 350 400
Like the visualization? We would love to hear your feedback!
Found bugs or have ideas? Report them here.
This project is Open Source: contribute on GitHub.
All data sources and model explanations can be found here.
Share 24K
Tweet
Slack
January 25, 2017 UTC+01:00
8:01 AM
A PROJECT BY
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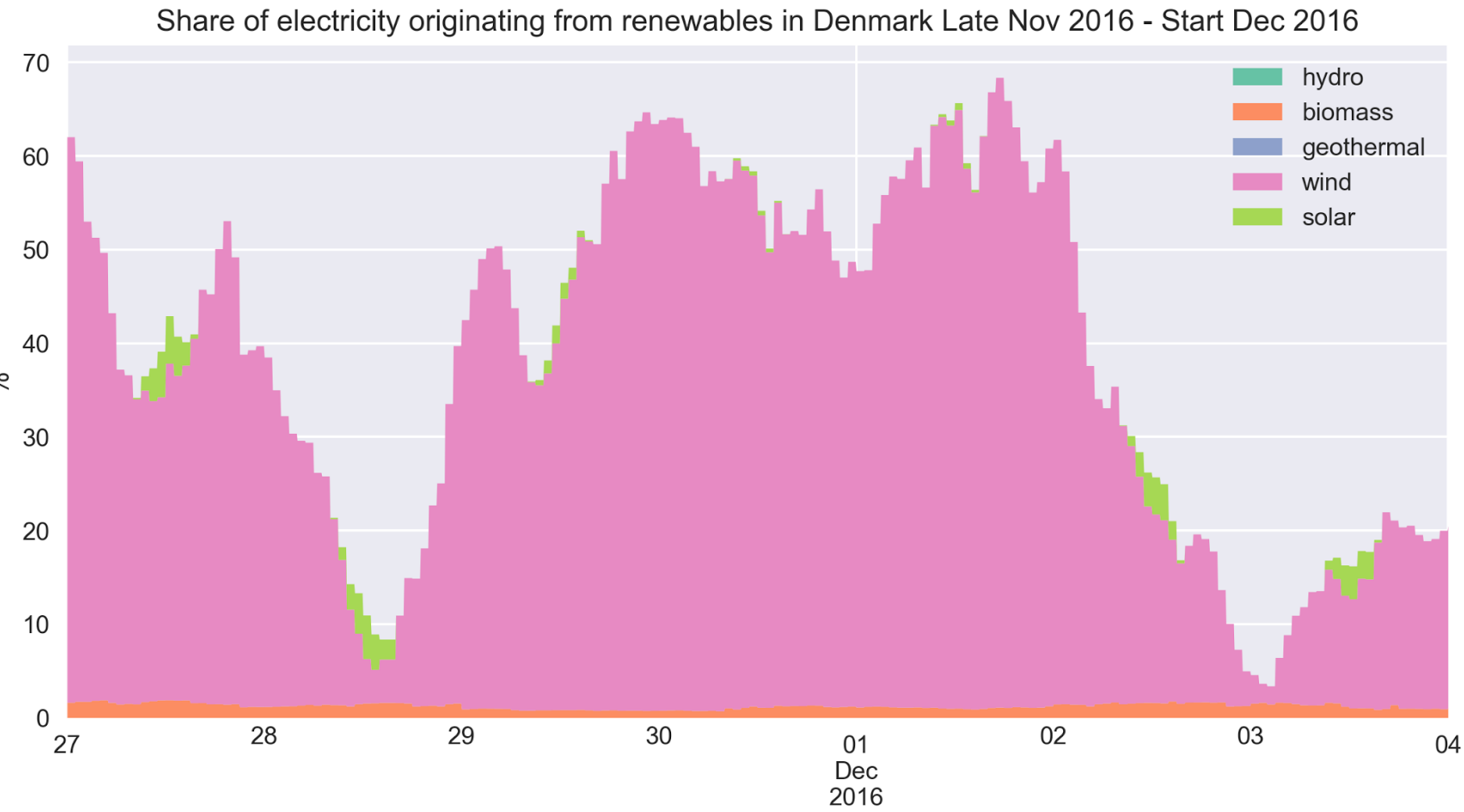
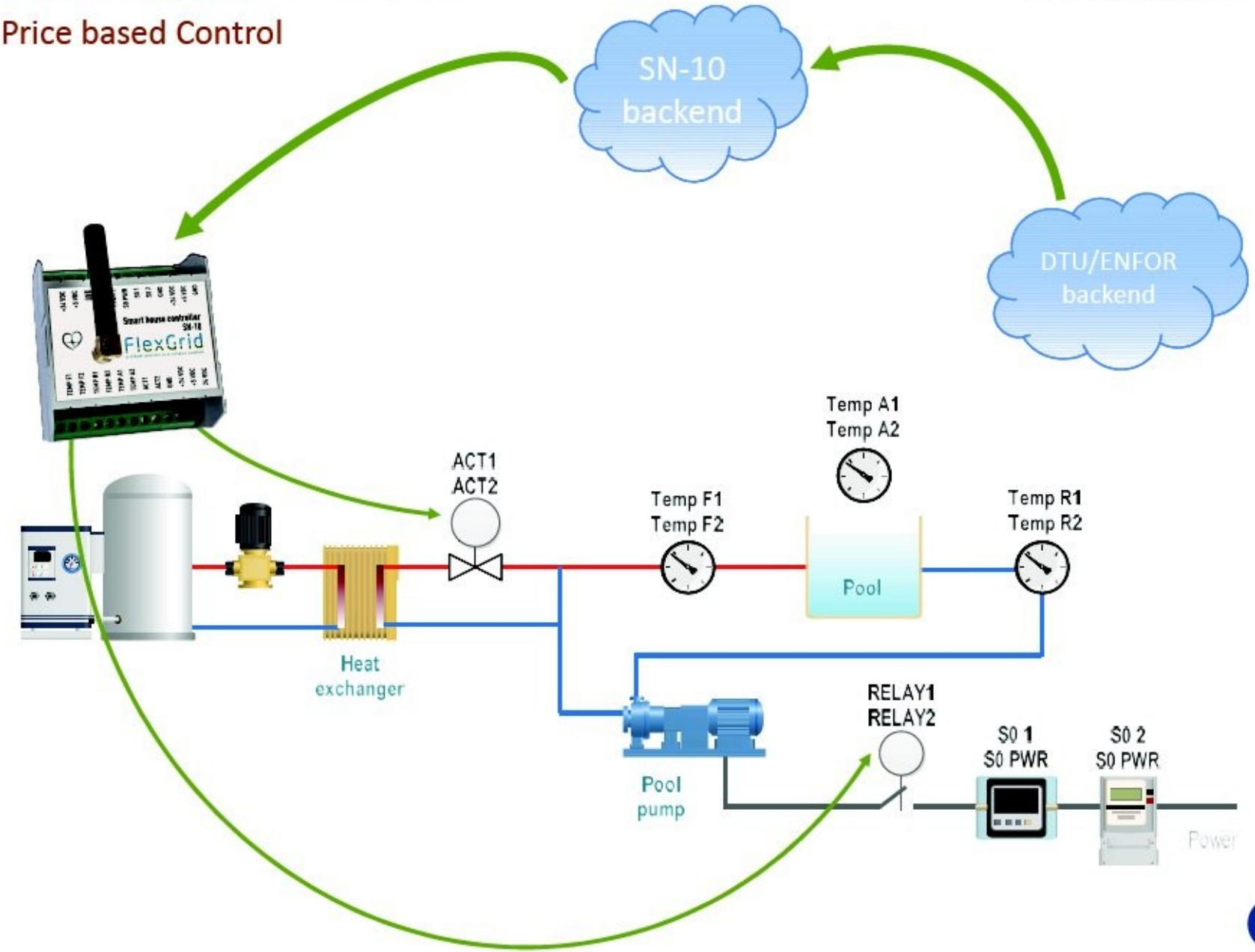
Like
Follow
Carbon intensity (gCO2eq/kWh)
0 50



Source: pro.electicitymap.

How does it work?

Price based Control



Example: CO2-based control

Summary

- Methods for data intelligent control of energy systems, using the Smart-Energy OS setup, are suggested.
- The controllers can provide
  - Energy Efficiency
  - Cost Minimization
  - Emission Efficiency
  - Peak Shaving
  - Smart Grid demand (like ancillary services needs, …)
- We have demonstrated a large potential in Demand Response. Automatic solutions as well as end-user focus are important
- We see large problems with the tax and tariff structures in many countries (eg. Denmark).
- Markets and pricing principles need to be reconsidered.