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Artificial Intelligence and Computer Science for Smart 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!*

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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?

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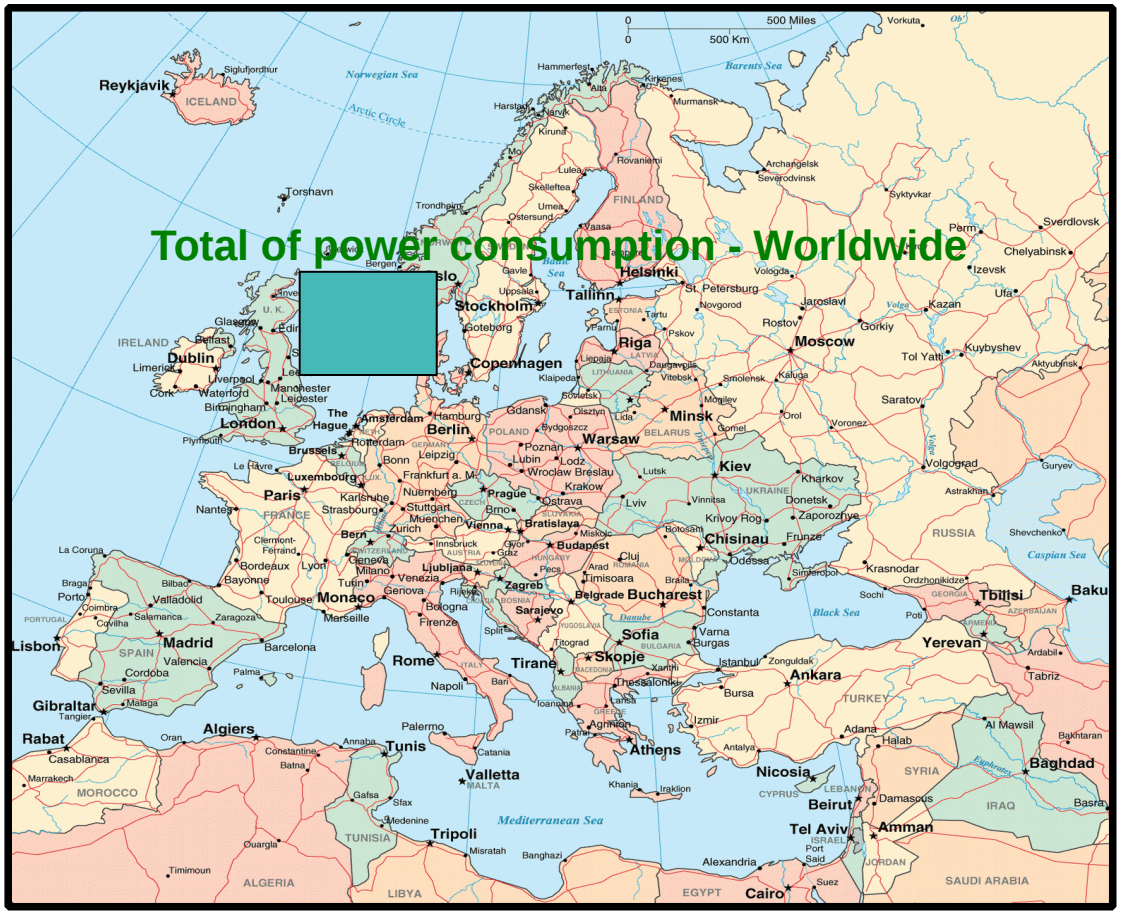
Potentials and Challenges for renewable energy

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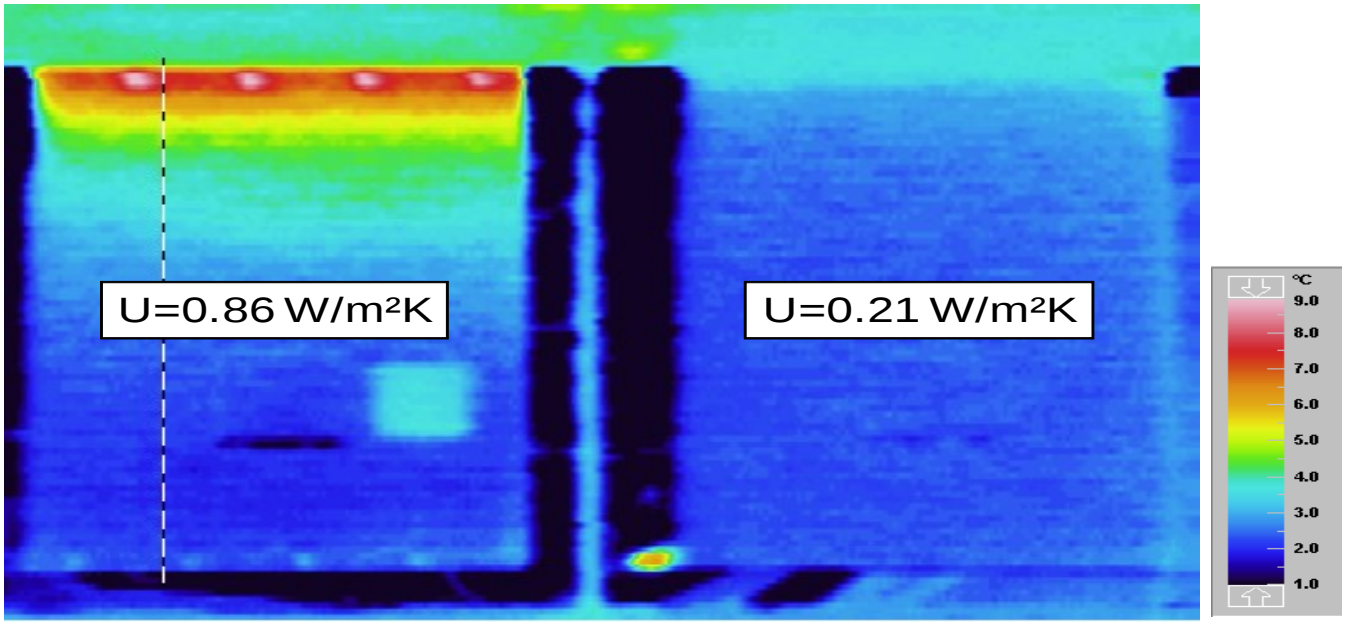
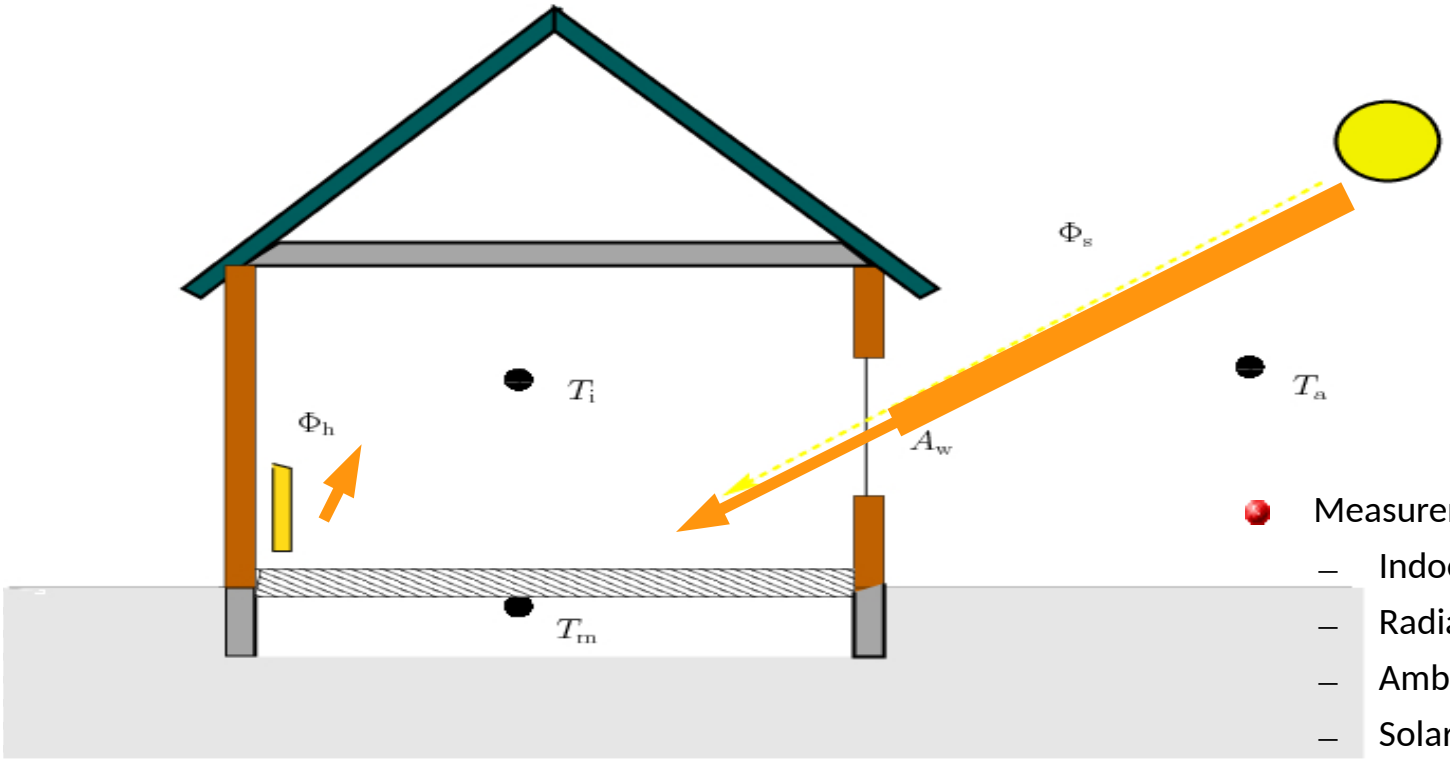
Example

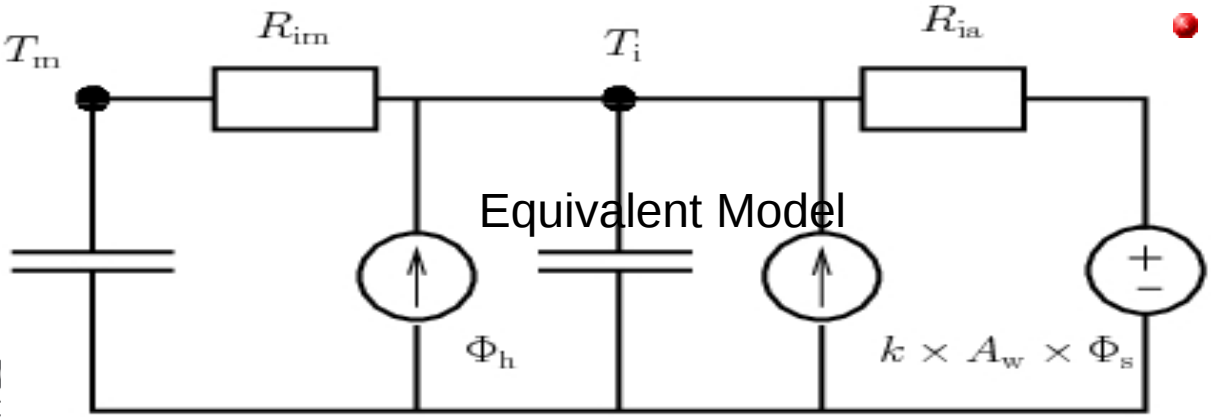


Consequence of good or bad workmanship (theoretical value is U=0.16W/m2K)

Model for the 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

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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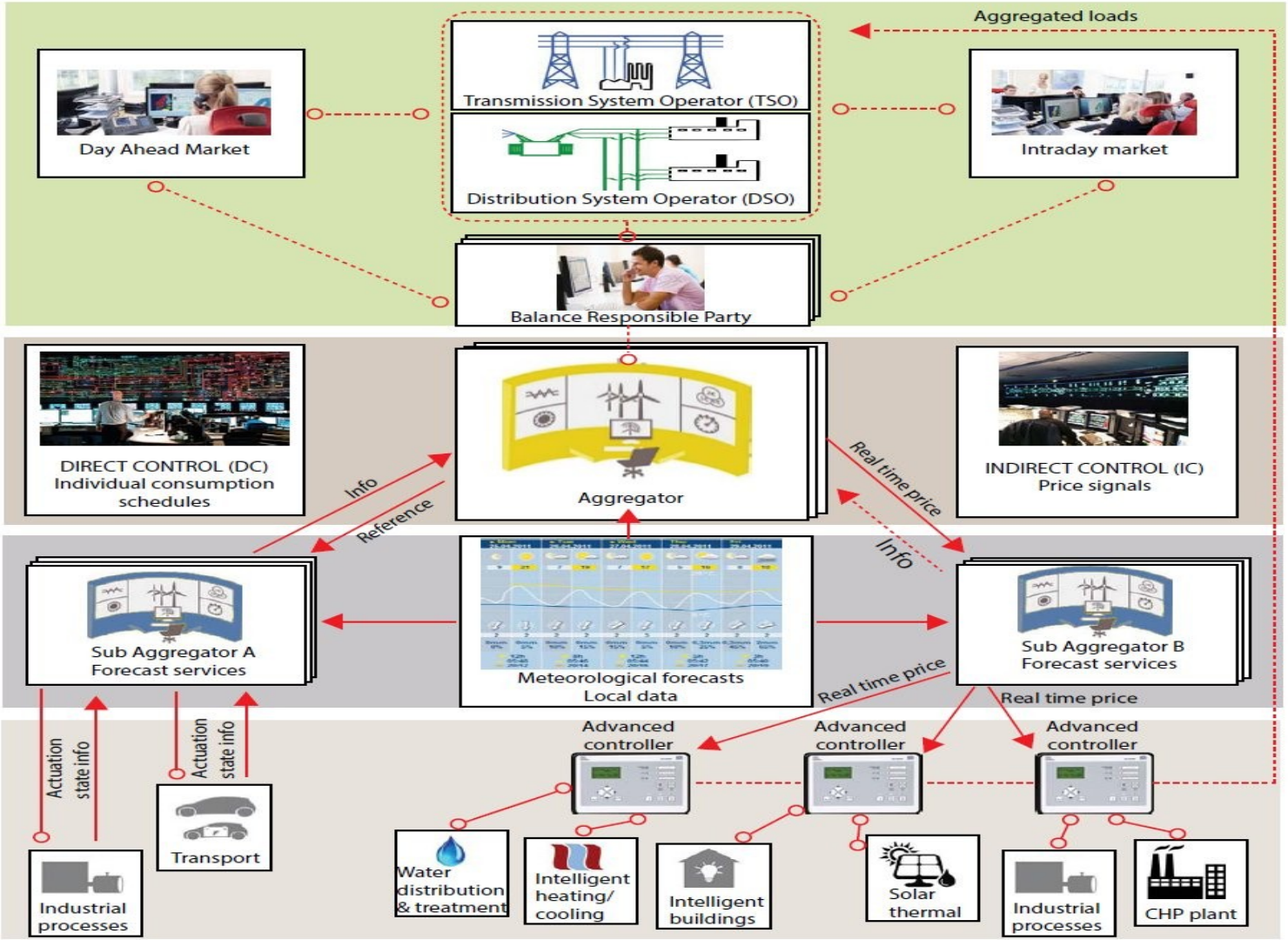
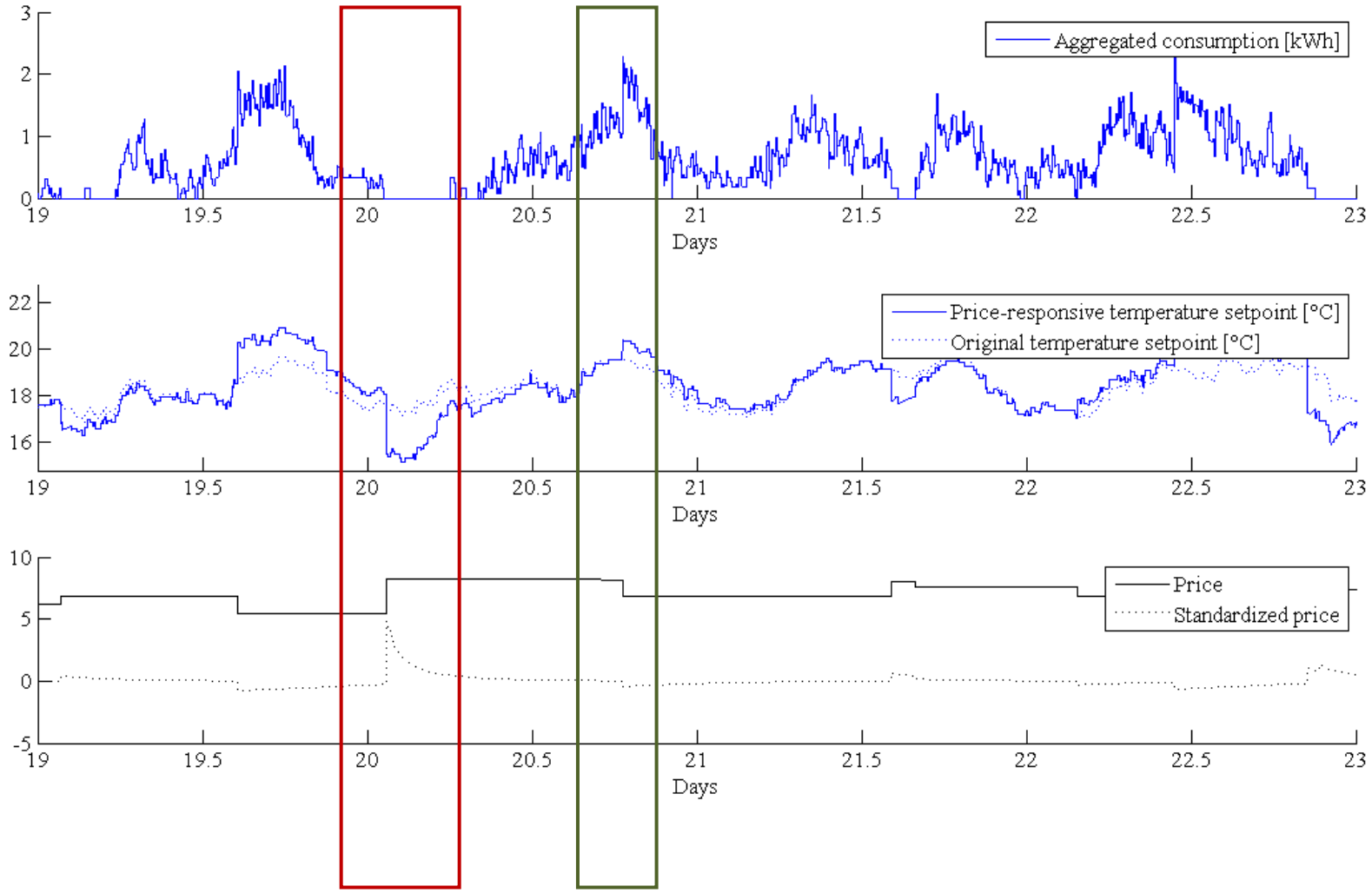
Smart-Energy OS

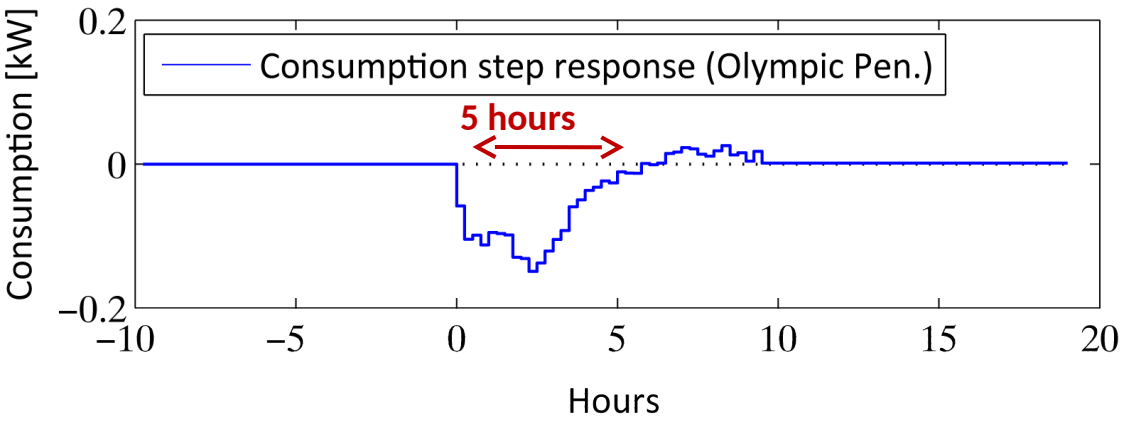


Aggregation (over 20 houses)

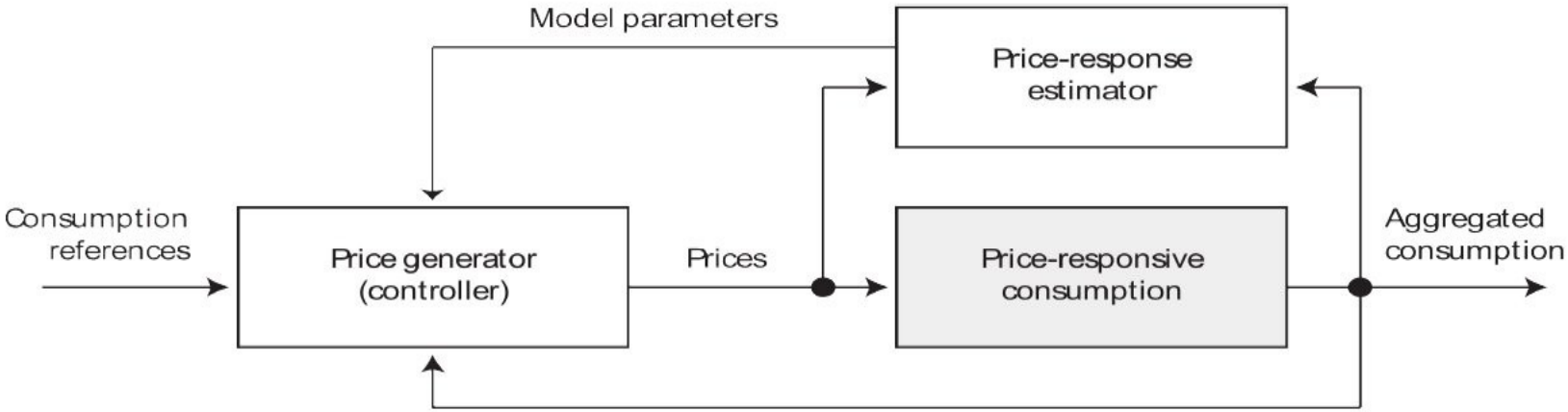


Response on Price Step Change

Olympic Peninsula



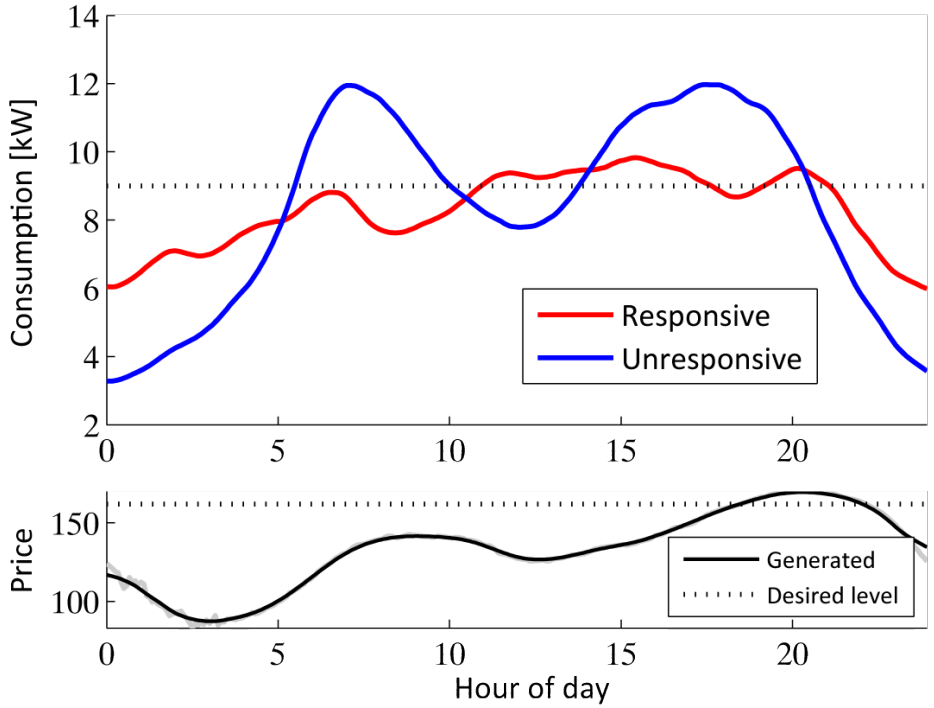
Control of Energy Consumption



Control performance

Considerable **reduction in peak consumption**

Mean daily consumption shift



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Case study No. 3

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

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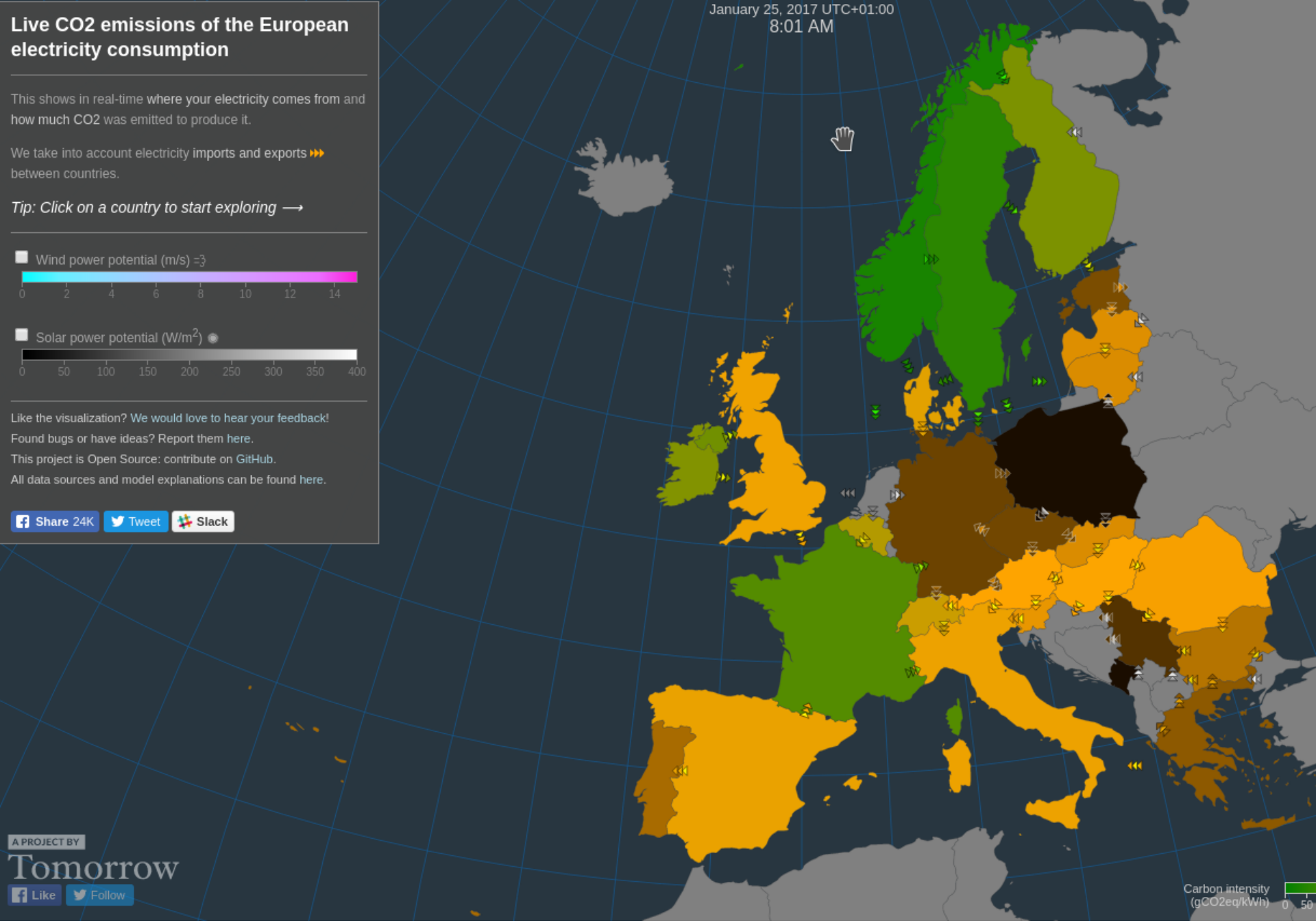
Live CO2 emissions of the European electricity consumption
This shows in real-time where your electricity comes from and how much CO2 was emitted to produce it.
We take into account electricity imports and exports between countries.
Tip: Click on a country to start exploring ⟶
Wind power potential (m/s)
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
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January 25, 2017 UTC+01:00
8:01 AM
A PROJECT BY
Tomorrow
Like
Follow
Carbon intensity (gCO2eq/kWh)
0 50

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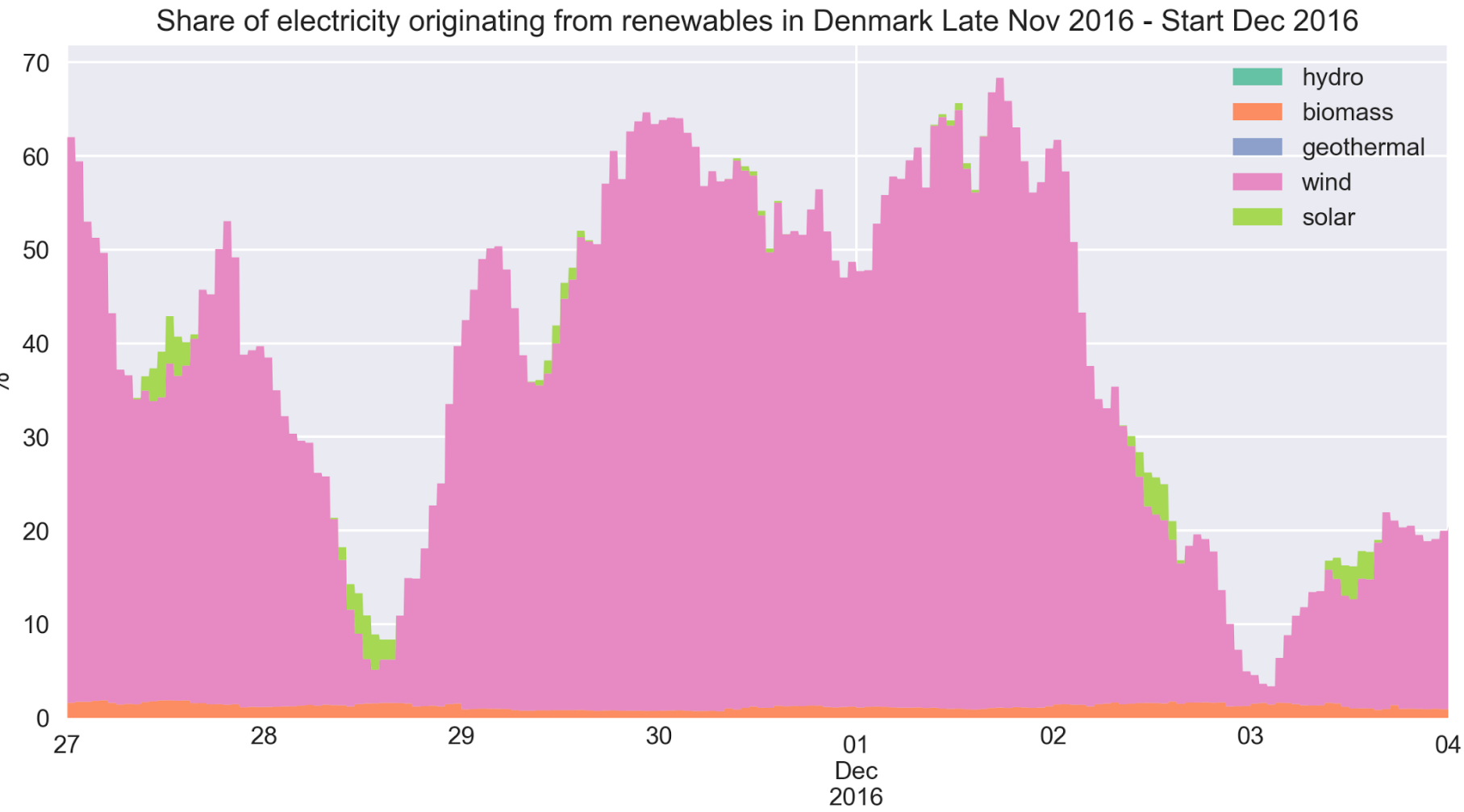

Source: pro.electicitymap.

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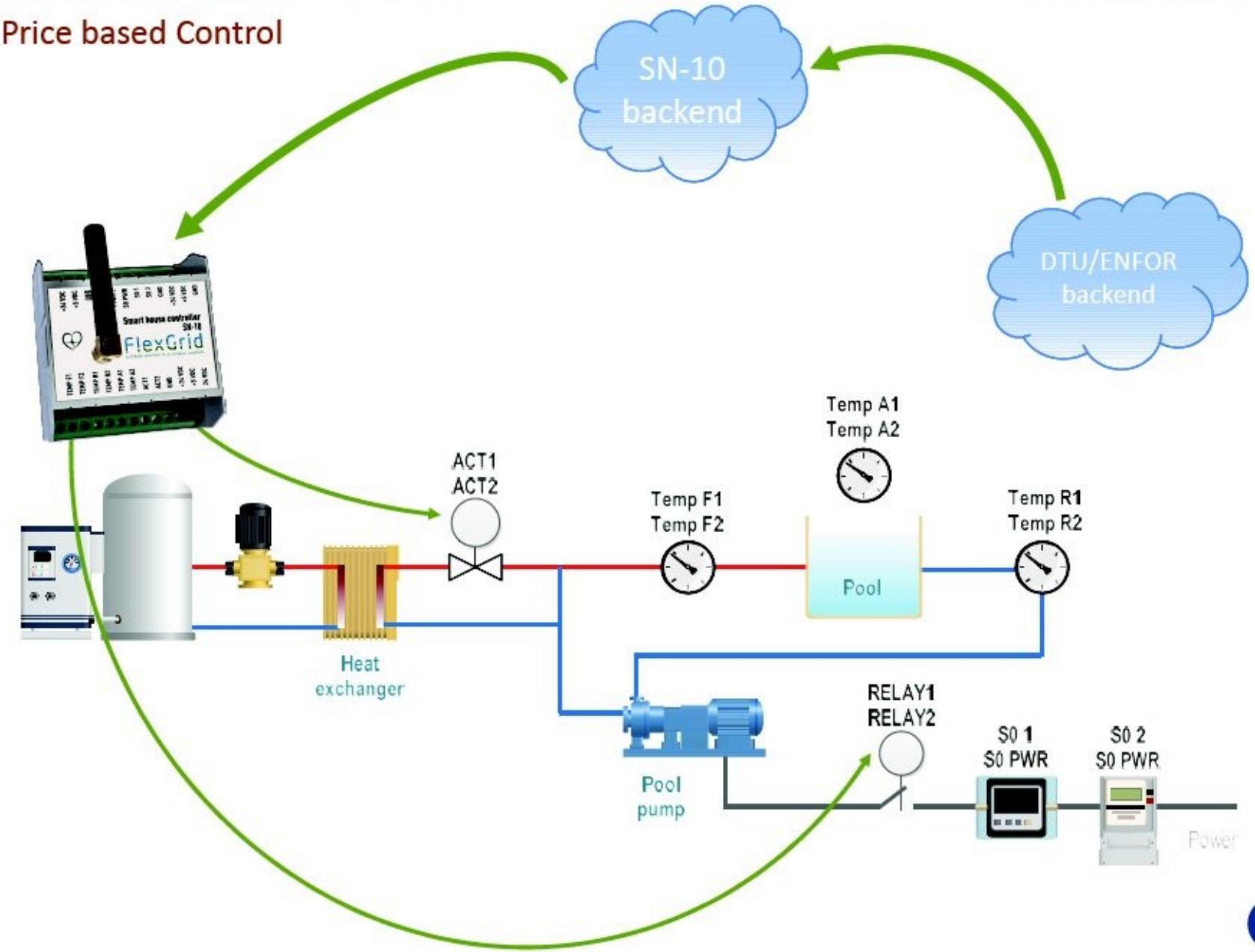
How does it work?

Price based Control



Example: CO2-based control

Summary

- A procedure for data intelligent control of energy systems, using the Smart-Energy OS setup, is 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, and 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.


Your global warming impact
Electricity
Car
Vegetables
Meat
Airplanes

Tomorrow