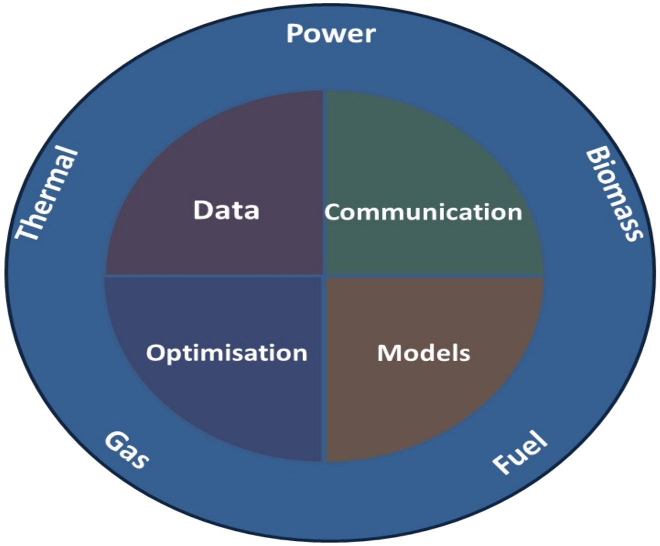
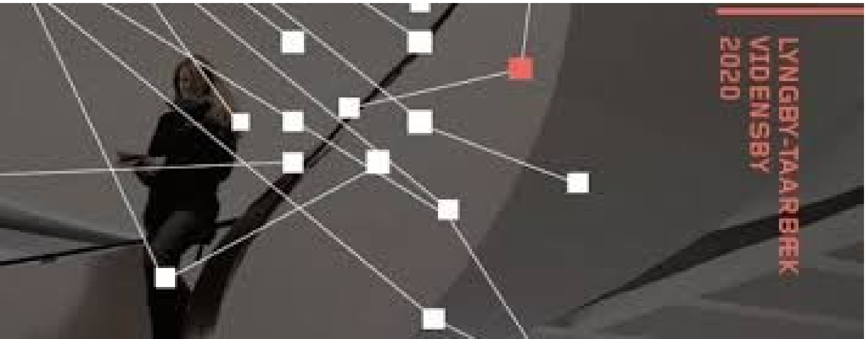
Smart Cities



Solutions for a fossil-free future

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



Henrik Madsen, Alfred Heller,
Ivan Herrmann, Niamh O'Connell,

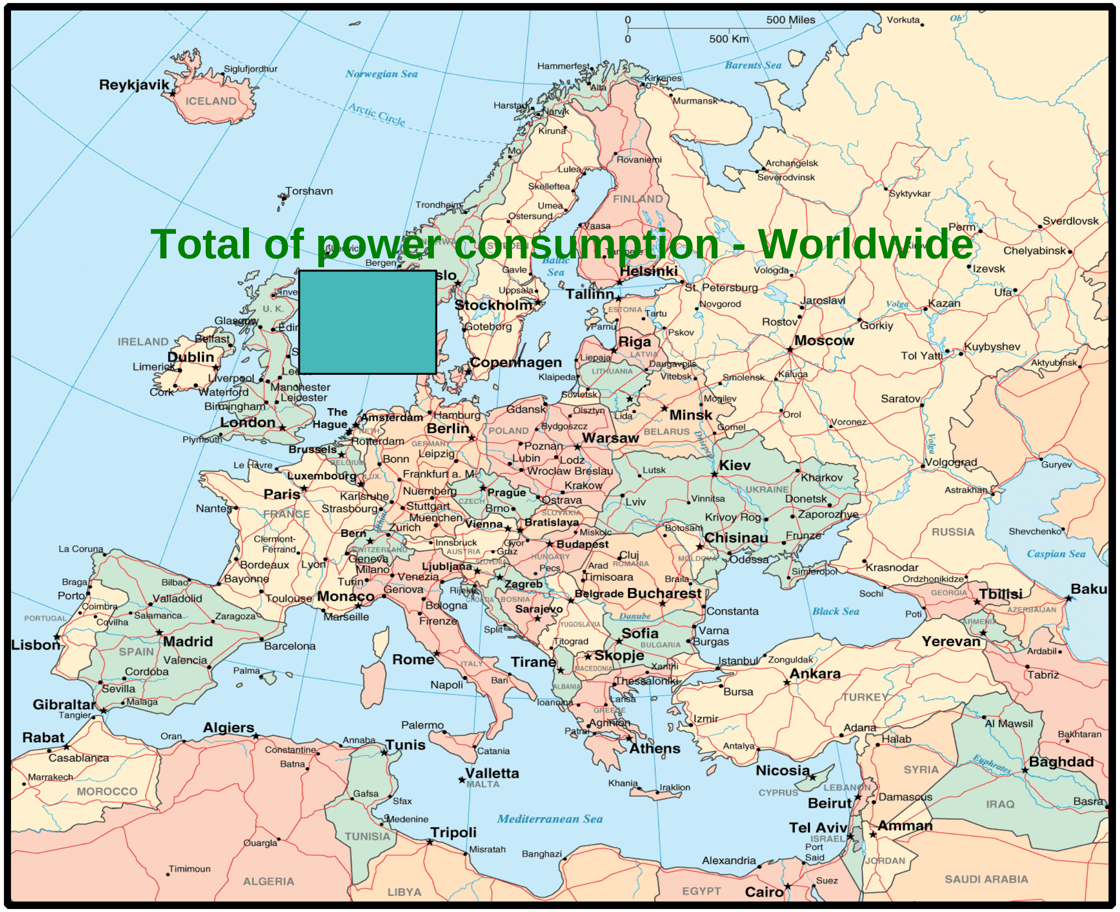
Background and Motivation

Potentials for renewable energy

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

Potentials for renewable energy

- **Scenarie:** We want to cover the worlds entire need for power using wind power.
- How large an area should be covered by wind turebines?
- **Conclusion**: Use intelligence ....
- Calls for **Smart Cities** Solutions.

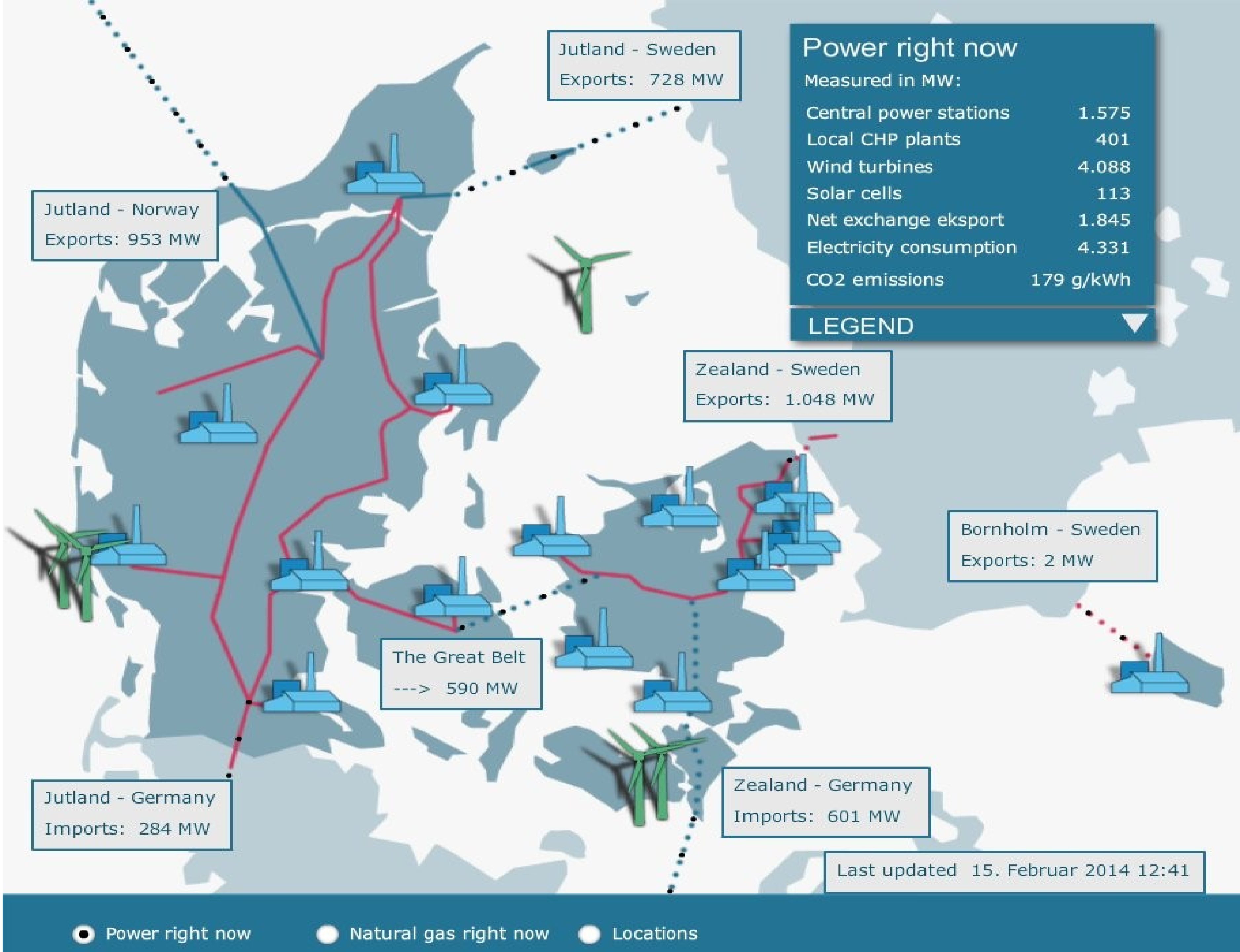


Status: Wind Power in Denmark

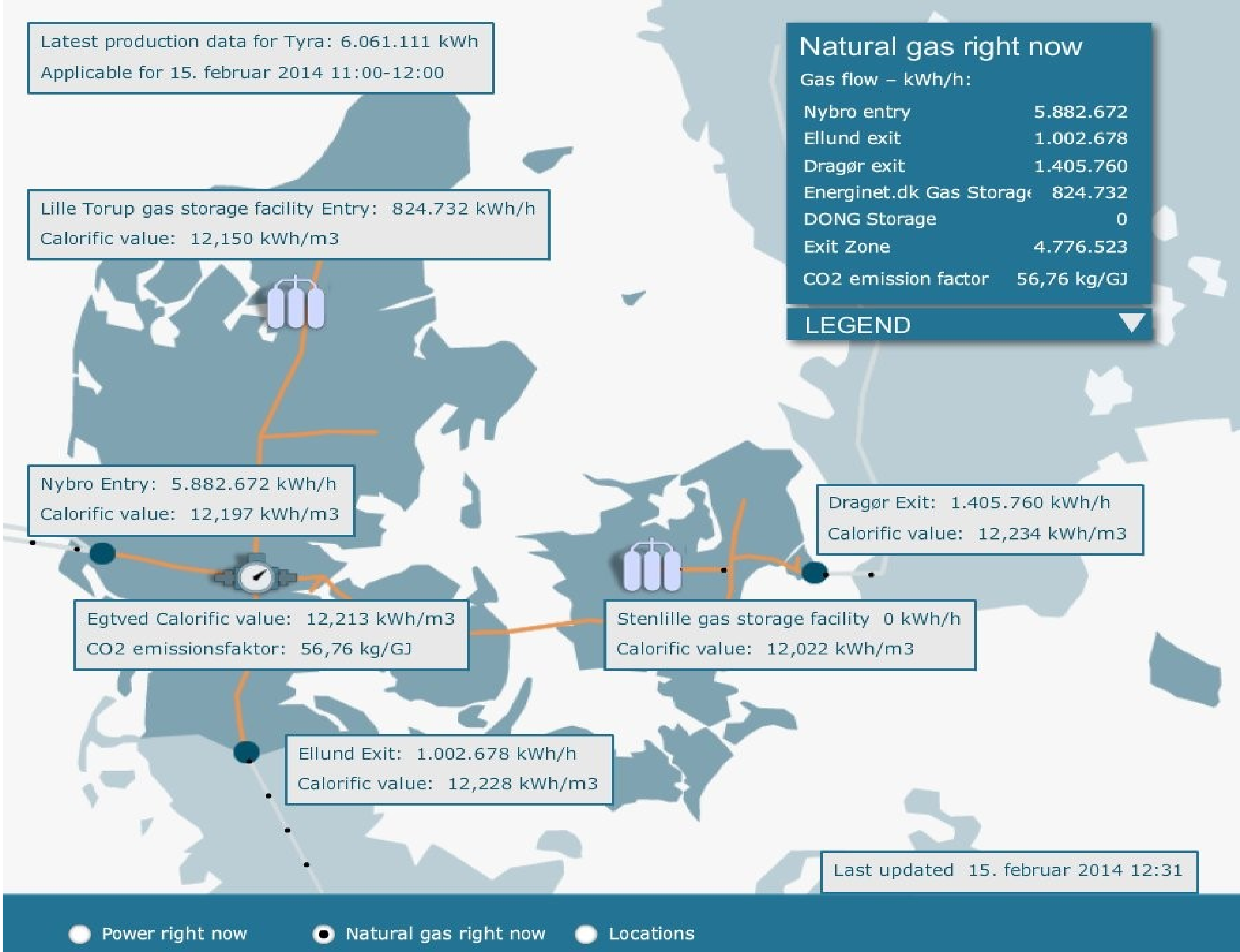
Notice – wind only:

Key figures for wind power*

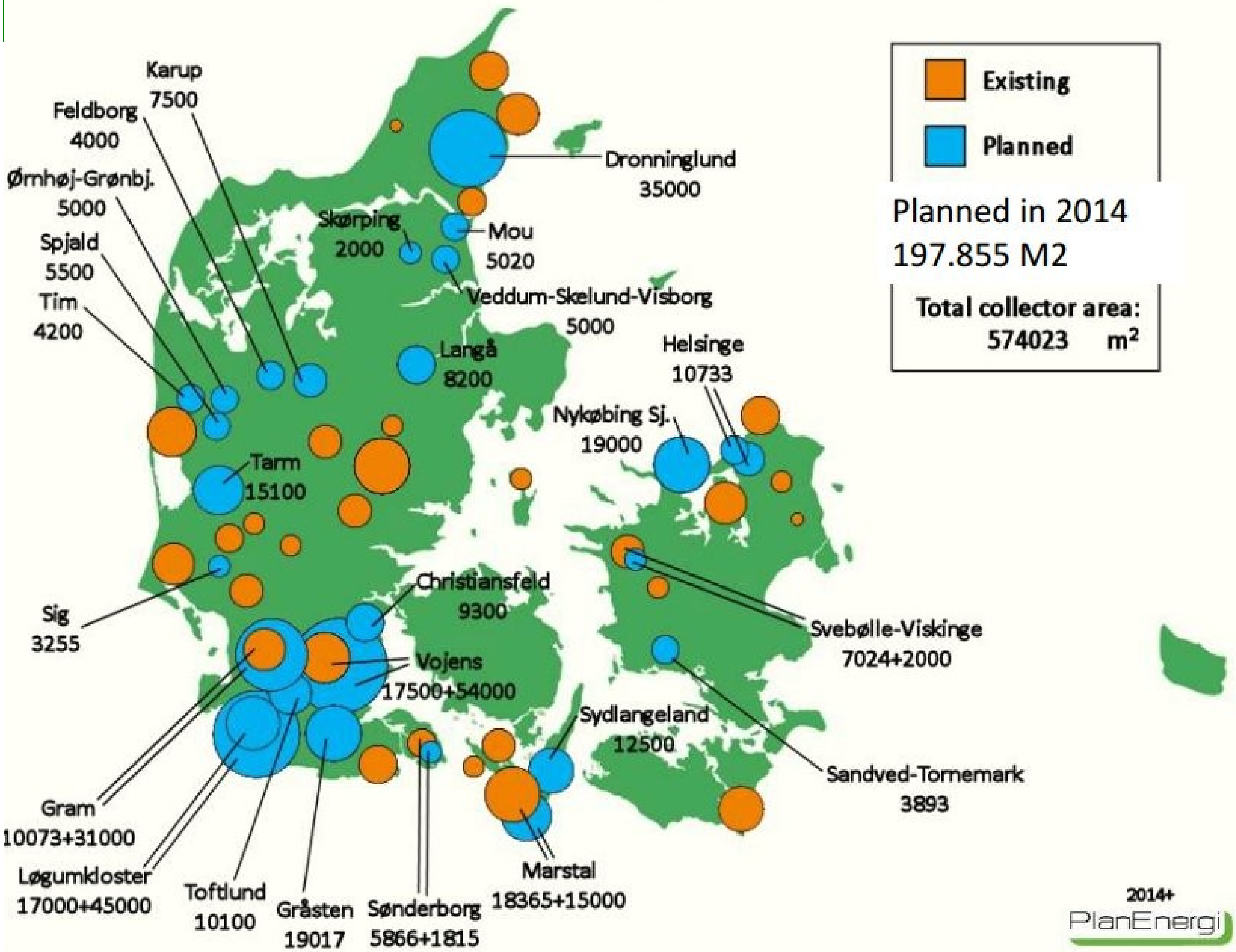
	2013	2012
Wind power generation	11.1 billion kWh	10.3 billion kWh
Electricity consumption (including loss in the electricity grid)	33.5 billion kWh	34.1 billion kWh
Wind power share of electricity consumption the entire year	33.2%	30.1%
Wind power share of electricity consumption in December	54.8%	33.5%
Wind power capacity at the end of the year	4,792 MW	4,166 MW
Energy content of the wind	Approx. 93% of a standard year	Approx. 102% of a standard year



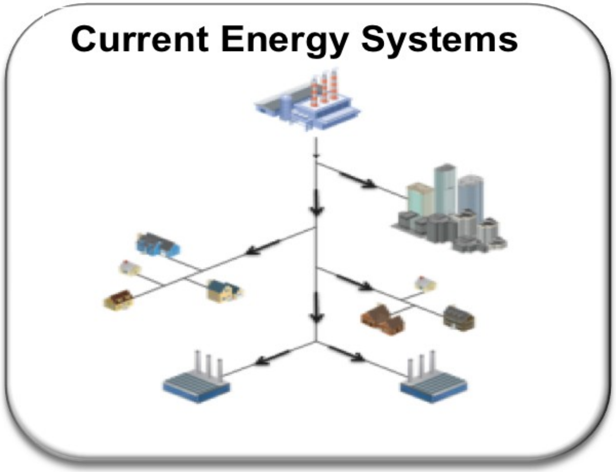
Power right now
Measured in MW:
Central power stations 1.575
Local CHP plants 401
Wind turbines 4.088
Solar cells 113
Net exchange eksport 1.845
Electricity consumption 4.331
CO2 emissions 179 g/kWh
LEGEND
Jutland - Sweden
Exports: 728 MW
Jutland - Norway
Exports: 953 MW
Zealand - Sweden
Exports: 1.048 MW
Bornholm - Sweden
Exports: 2 MW
The Great Belt
---> 590 MW
Jutland - Germany
Imports: 284 MW
Zealand - Germany
Imports: 601 MW
Last updated 15. Februar 2014 12:41
Power right now
Natural gas right now
Locations

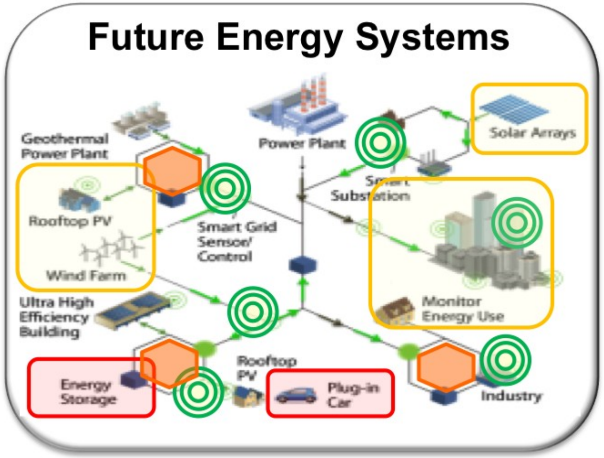

Latest production data for Tyra: 6.061.111 kWh
Applicable for 15. februar 2014 11:00-12:00
Natural gas right now
Gas flow – kWh/h:
Nybro entry 5.882.672
Ellund exit 1.002.678
Dragør exit 1.405.760
Energinet.dk Gas Storag 824.732
DONG Storage 0
Exit Zone 4.776.523
CO2 emission factor 56,76 kg/GJ
LEGEND
Lille Torup gas storage facility Entry: 824.732 kWh/h
Calorific value: 12,150 kWh/m3
Nybro Entry: 5.882.672 kWh/h
Calorific value: 12,197 kWh/m3
Dragør Exit: 1.405.760 kWh/h
Calorific value: 12,234 kWh/m3
Egtved Calorific value: 12,213 kWh/m3
CO2 emissionsfaktor: 56,76 kg/GJ
Stenlille gas storage facility 0 kWh/h
Calorific value: 12,022 kWh/m3
Ellund Exit: 1.002.678 kWh/h
Calorific value: 12,228 kWh/m3
Last updated 15. februar 2014 12:31
Power right now
Natural gas right now
Locations

Solar district heating in Denmark



Transition in the Energy World





The rapidly changing energy world calls for a the next generation of tools for simulation, planning, optimization, decision support, control and operation in Cities. These tools calls for research focusing on:

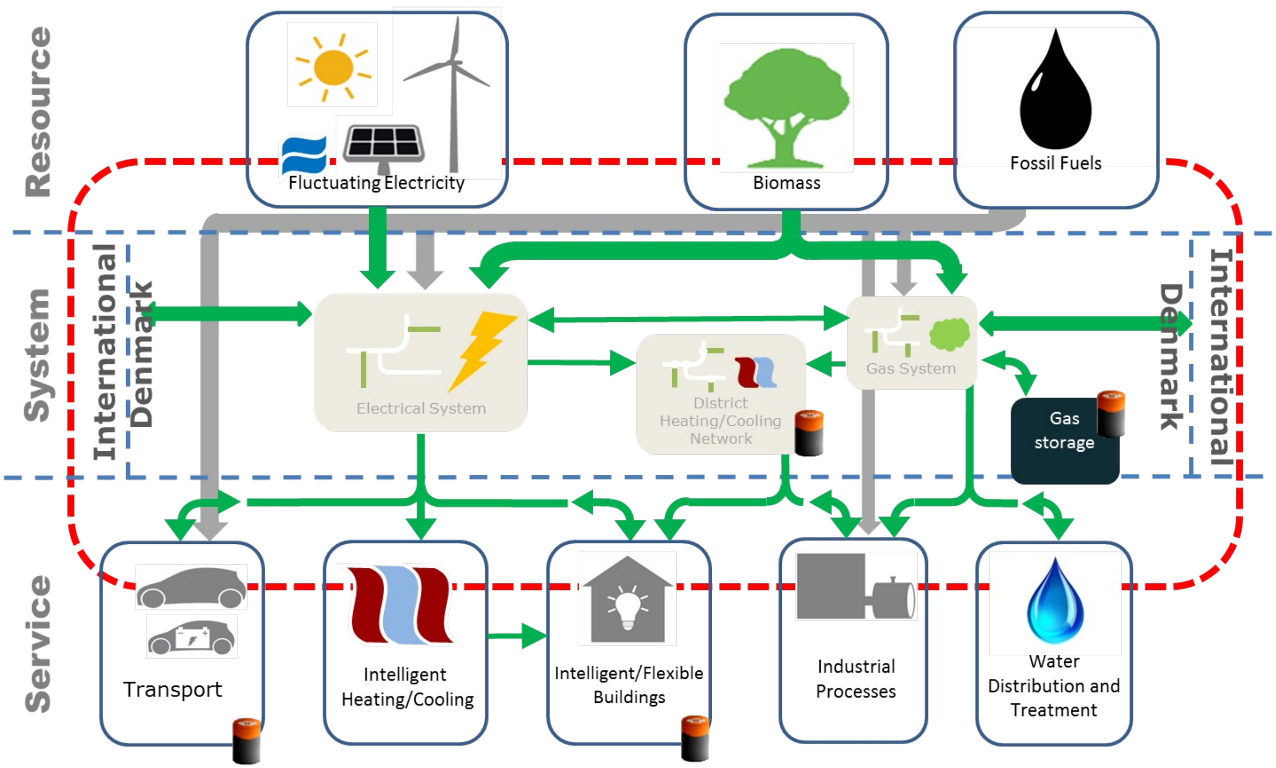
- Increasing penetration of variable RE in Cities
- Increasing ultra high energy efficiency buildings and controllable loads
- New data, information, communications and controls
- Electrification of transportation and alternative fuels
- Enable (virtual) energy storage by energy systems integration
- Interactions between electricity/thermal/fuels/data pathways
- Increasing system flexibility and intelligence

Project Ideas

Background, Concepts, Methodology, Objectives and Partners

Concept

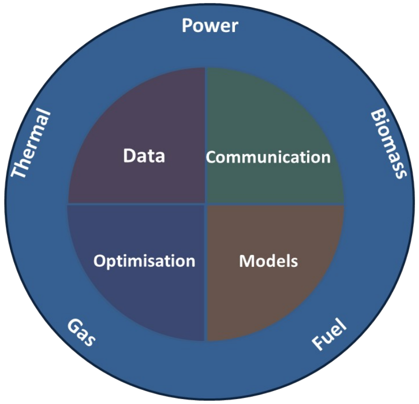
Integration based on *ITC solutions* leading to methods for *operation* and *planning* for future energy systems in cities



CITIES – Hypothesis

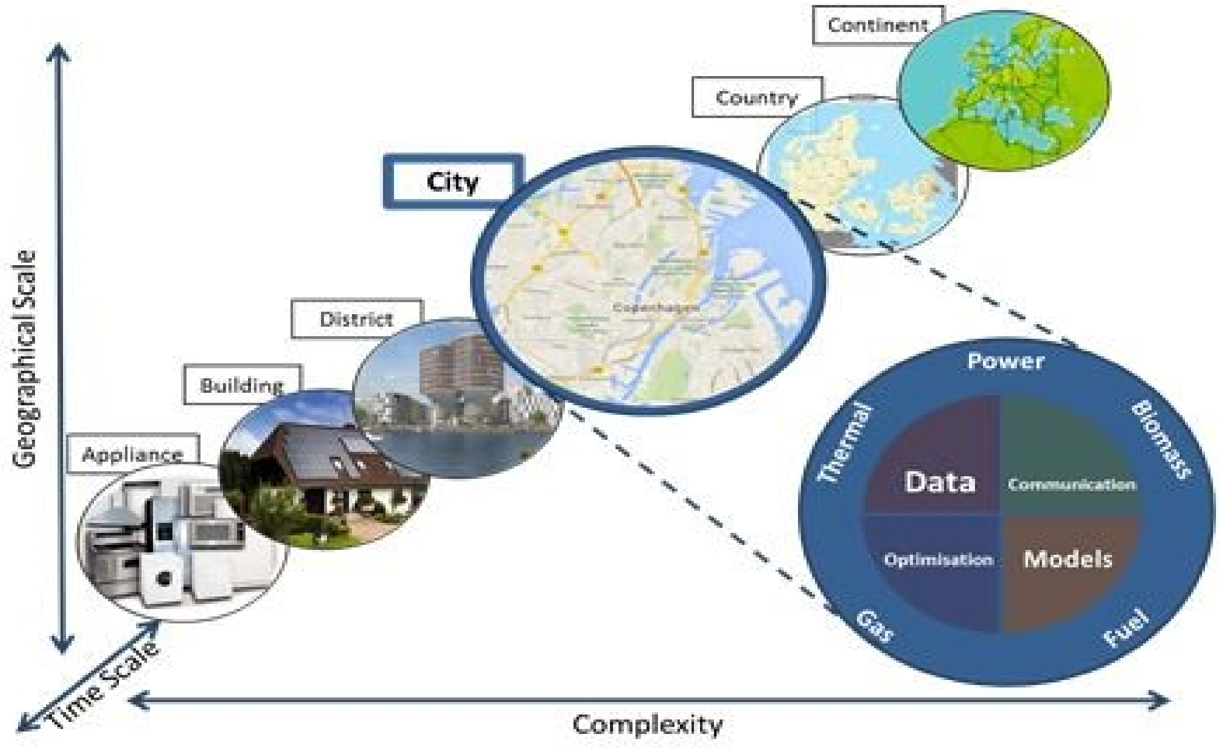
The **central hypothesis** of CITIES is that by **intelligently integrating** currently distinct energy flows (heat, power, gas and biomass) in urban environments we can enable very large shares of renewables, and consequently obtain substantial reductions in CO2 emissions.

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

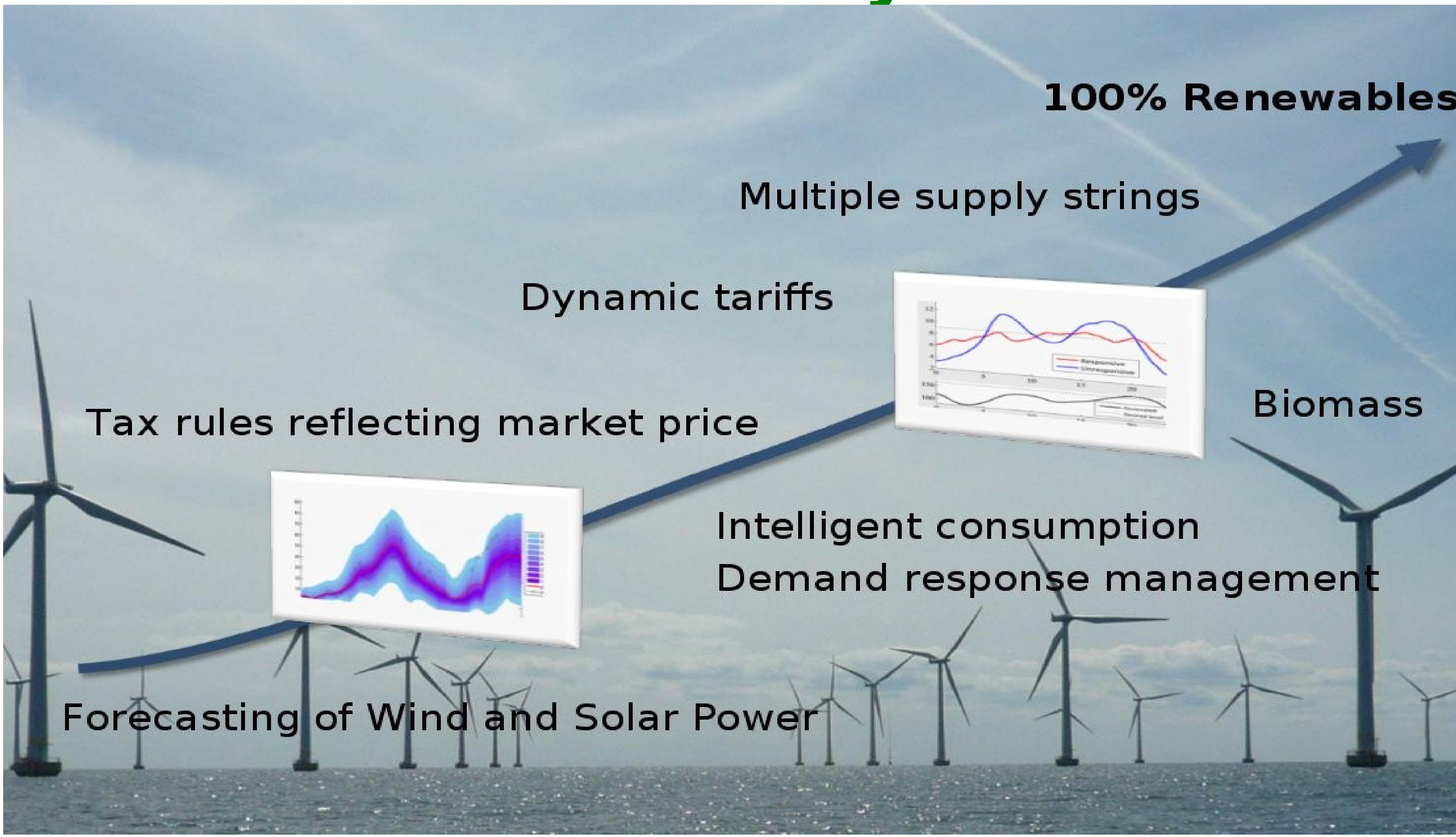


Scientific Objectives

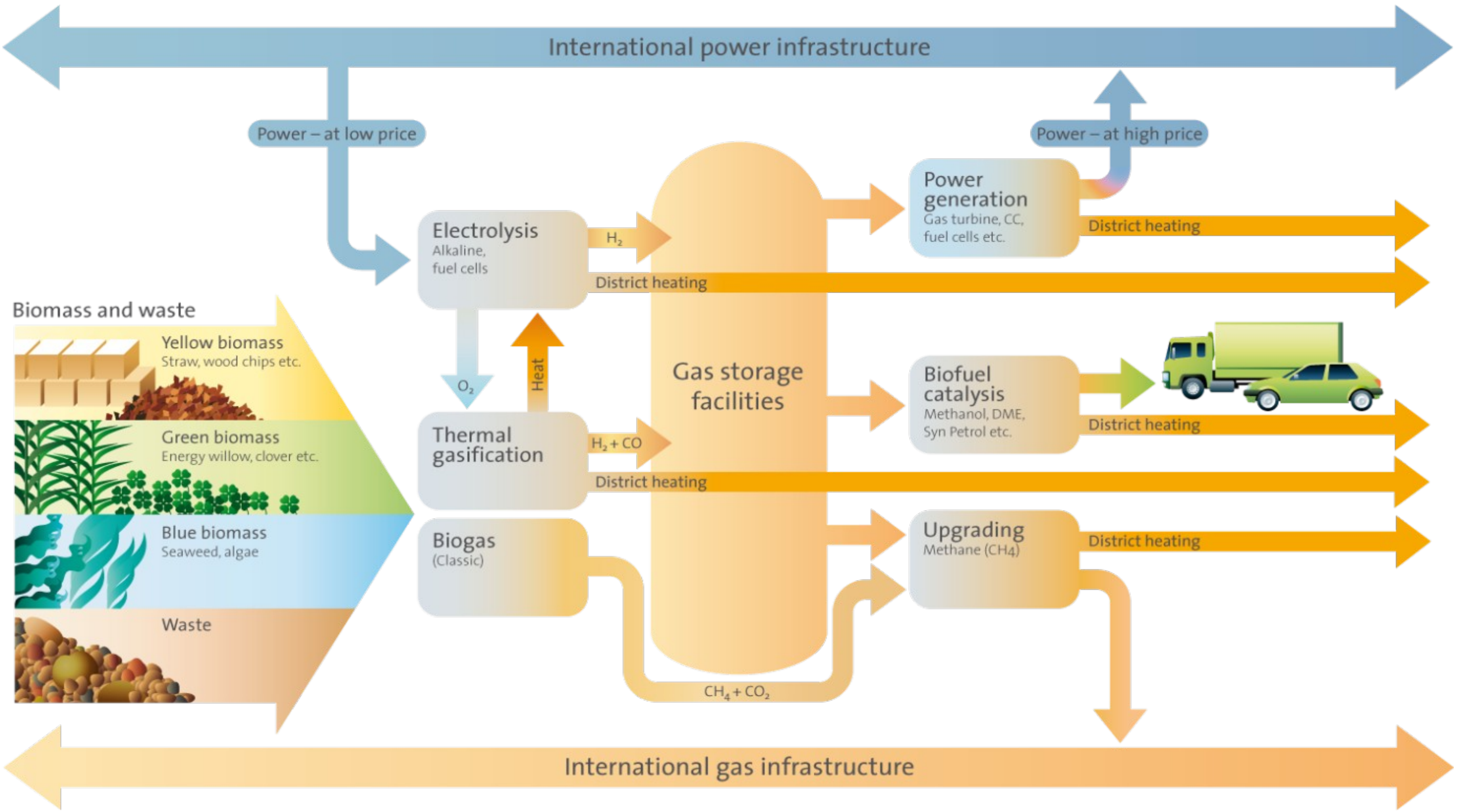
To establish methodologies and ITC solutions for design and operation of integrated electrical, thermal, fuel pathways at all scales



Measures to activate flexibility

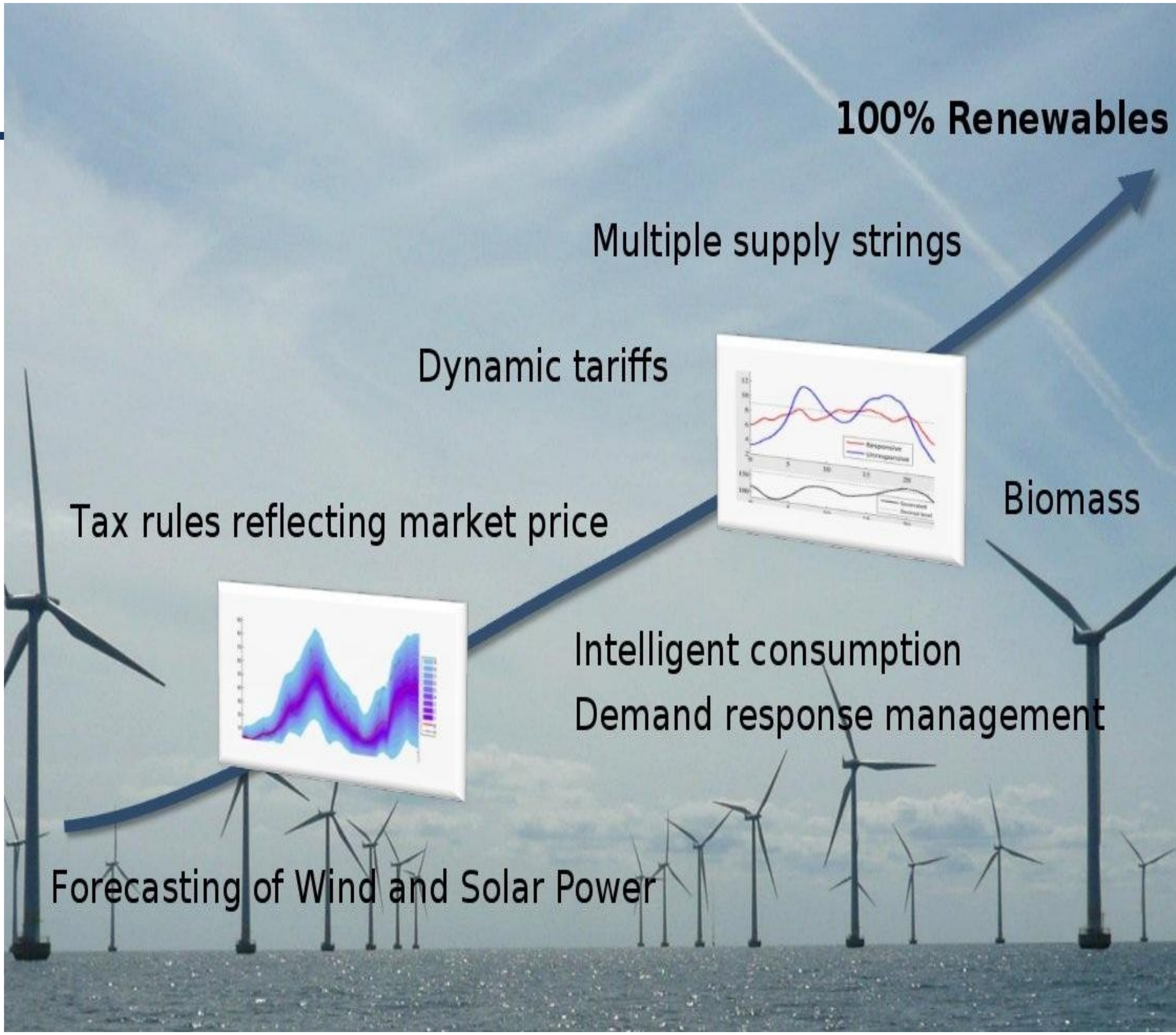


Interactions between power, gas, DH, and biomass systems

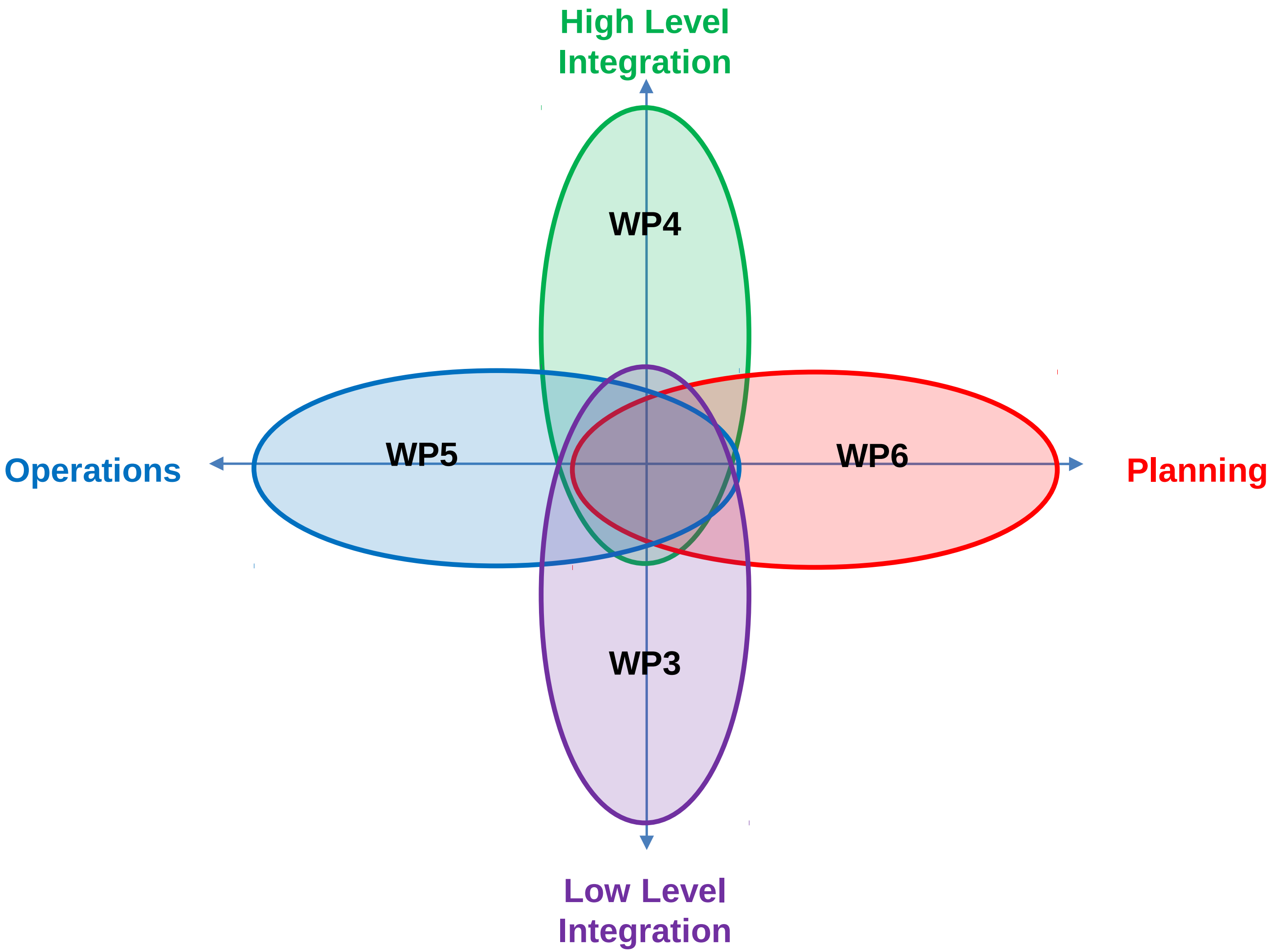


Societal Objectives

To establish methods and realistic scenarios for ultimately achieving independent from fossil fuels by harnessing the latent flexibility of energy systems in Cities through *intelligence, integration*, and *planning*.



Energy Systems Integration and Management



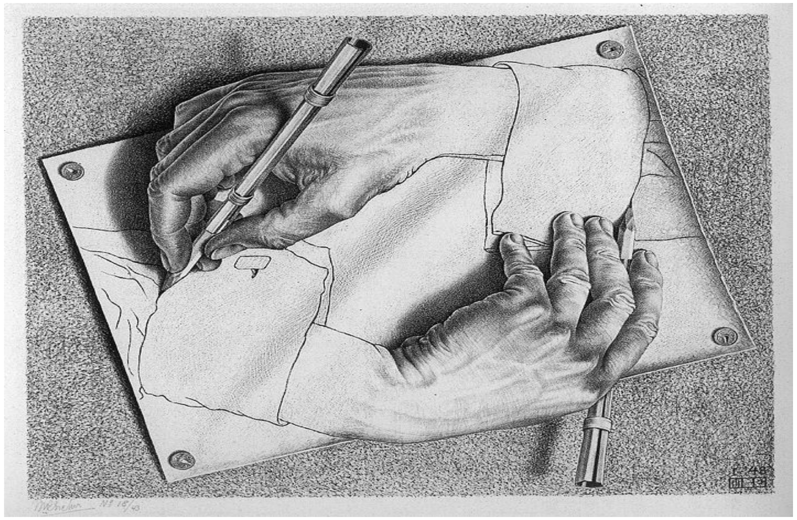
Key Outcomes

Key Outcomes

- Operational methods and scenarios for energy systems integration and management, paving scenarios towards a fossil free future
- Component level, modular and aggregate models of energy supply, consumption, and transmission, suitable for simulation, control and optimisation frameworks
- Market structures that support energy systems integration
- Modular forecasting and control models for a variety of energy system components, including their interactions
- Integration of short-term operational models in models for long-term planning.
- Models of energy consumption and production accounting for their stochastic and dynamic features.
- Methods for controlling energy consumption and demand side management.
- CITIES is aiming at being a leading knowledge centre for Smart Cities development and operational tools.
- Synergies with existing and new smart cities development projects
- .... **a couple of examples follows ...**

Energy Labelling of Buildings

- Today building experts make judgements of the energy performance of buildings based on drawings and prior knowledge.
- This leads to 'Energy labelling' of the building
- However, it is noticed that two independent experts can predict very different consumptions for the same house.



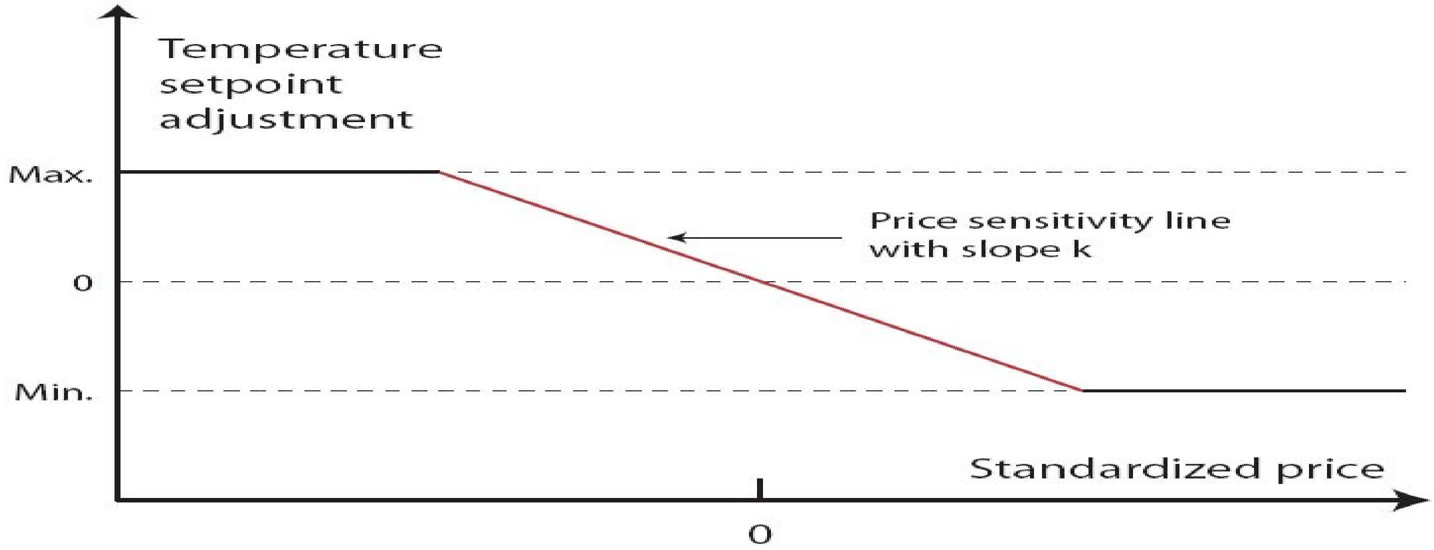
Results

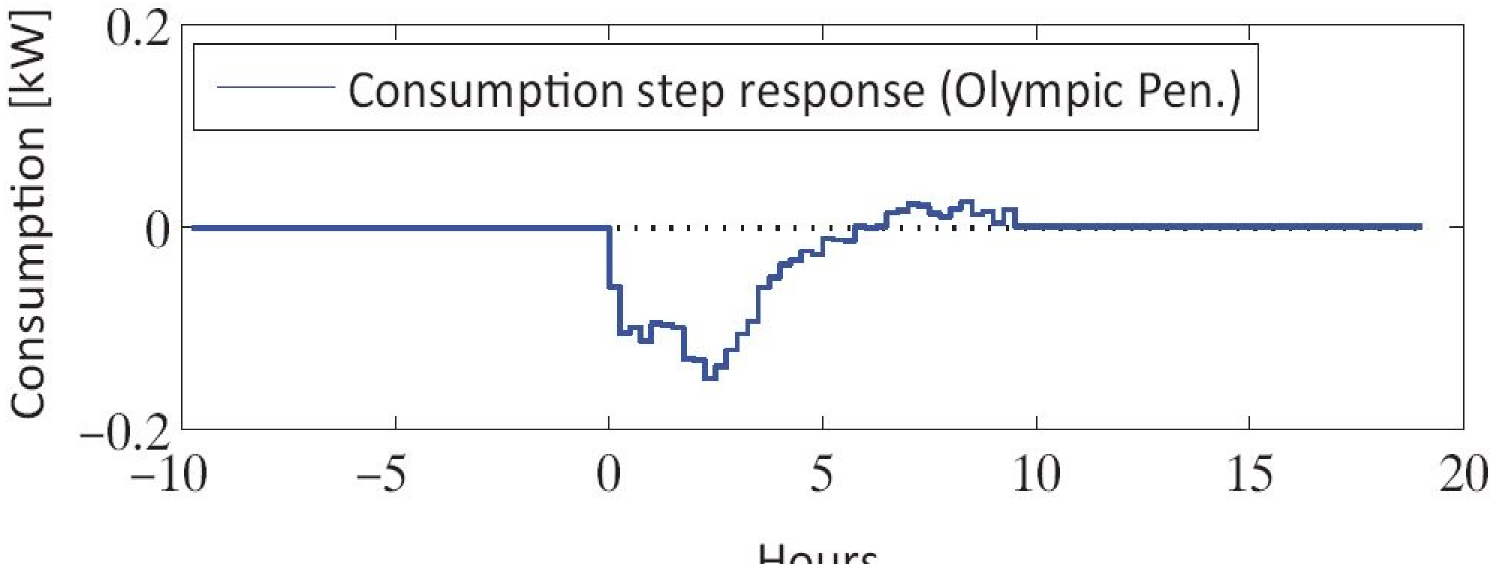
	UA	σ_{UA}	$\mathrm{gA}^{\max}$	$\mathrm{wA}_E^{\max}$	$\mathrm{wA}_S^{\max}$	$\mathrm{wA}_W^{\max}$	T_i
	W/°C		W	W/°C	W/°C	W/°C	°C
4218598	211.8	10.4	597.0	11.0	3.3	8.9	23.6
4218600	98.7	10.8	-96.2	23.6	10.1	13.0	22.3
4381449	228.2	12.6	1012.3	29.8	42.8	39.7	19.4
4711160	155.4	6.3	518.8	14.5	4.4	9.1	22.5
4711176	178.5	7.3	800.0	1.9	-7.6	8.5	26.4
4836681	155.3	8.1	591.0	39.5	28.0	21.4	23.5
4836722	236.0	17.7	1578.3	4.3	3.3	18.9	23.5
4986050	159.6	10.7	715.7	10.2	7.5	7.2	20.8
5069878	144.8	10.4	87.6	3.7	1.6	17.3	21.8
5069913	207.8	9.0	962.5	3.7	8.6	10.6	22.6
5107720	189.4	15.4	657.7	41.4	29.4	16.5	21.0

CITIES solution
Use of data from Smart Meters

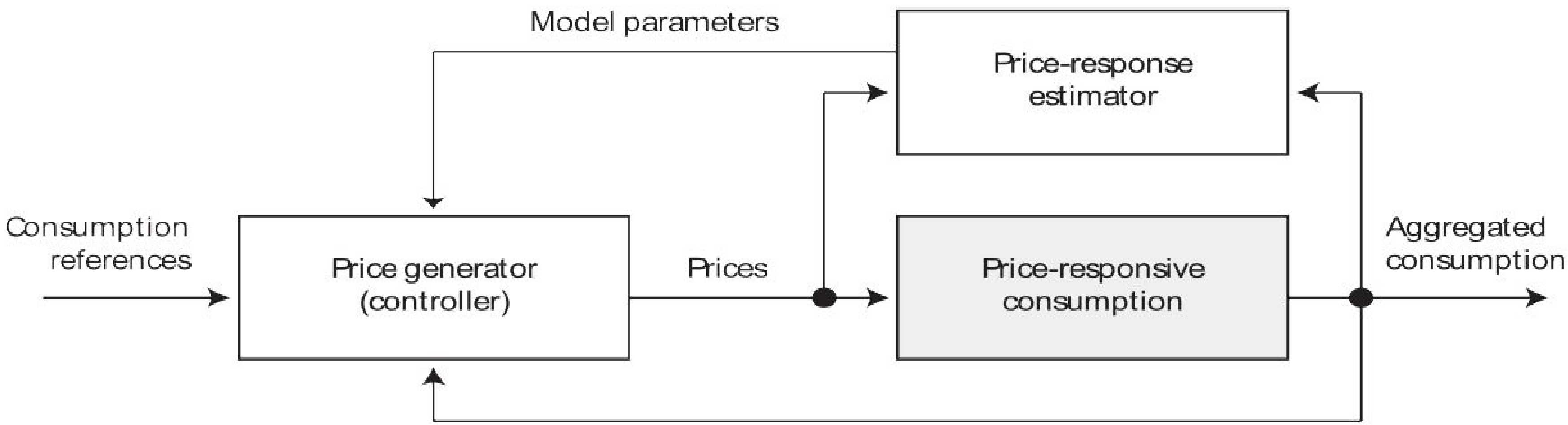
- Automatic energy labelling
- Screening for identifying buildings with a low energy efficiency
- Recommendations:
  - Should they replace the windows?
  - Or put more insulation on the roof?
  - Or tighten the building?
  - Should the wall against north be further insulated?
  - ......
- Better control of the heat supply
- Methods for demand side management

CITIES Solution: Demand Side Management





Control of Energy Consumption



Contracts / Products

Partners

Danish Partners

AALBORG UNIVERSITET
AD NYE VEJE
ENFOR
Forecasting and Optimization for the Energy Sector
DANSK ENERGI
DTU
DONG energy
ENERGINET/DK
HALDOR TOPSØE
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RAMBØLL
Ea Energy Analyses
NEAS ENERGY
GRØN ENERGI
FREDERIKSSUND KOMMUNE
DFF|EDB
Dansk Fjernvarme
LEAN ENERGY CLUSTER
DI
Dansk Industri
GRUNDFOS
EMT NORDIC
KØBENHAVNS KOMMUNE
EMD International A/S
Horsens Varmeværk
SYD ENERGI
Bright Green Business
ProjectZero
EURISCO
RESEARCH & DEVELOPMENT
Fjernvarme Fyn
AARHUS KOMMUNE
Danfoss
HØJE TAASTRUP
fjernvarme amba
TEKNOLOGISK INSTITUT

International Partners

Thanks to DSF

(DSF – 1305-00027B)

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