



Das E-Energy-Leuchtturmprojekt
in der Modellregion Cuxhaven



Modelling the effects of integration in the eTelligence project

IEA DSM Agreement Task XVII Workshop
Sophia Antipolis, 18 May 2011

Dierk Bauknecht and Dr. Matthias Koch
Öko-Institut e.V. Freiburg, Germany

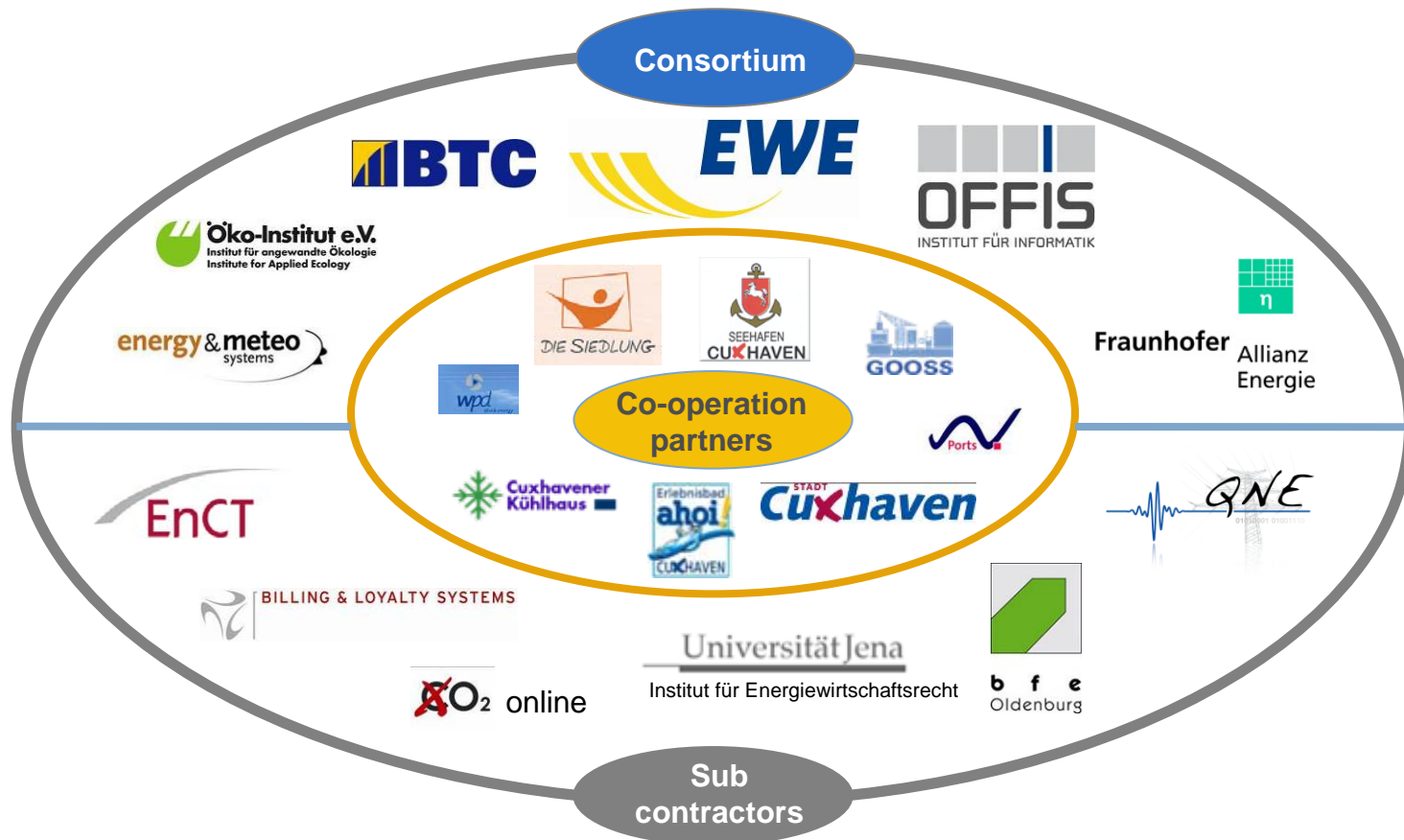
Agenda

- I. The eTelligence project**
- II. Economic and ecological effects of flexibility in the electricity system**
- III. PowerFlex model for quantitative analysis**
- IV. Case study: smart flexibility from electrical cooling**
- V. Conclusions and next steps**

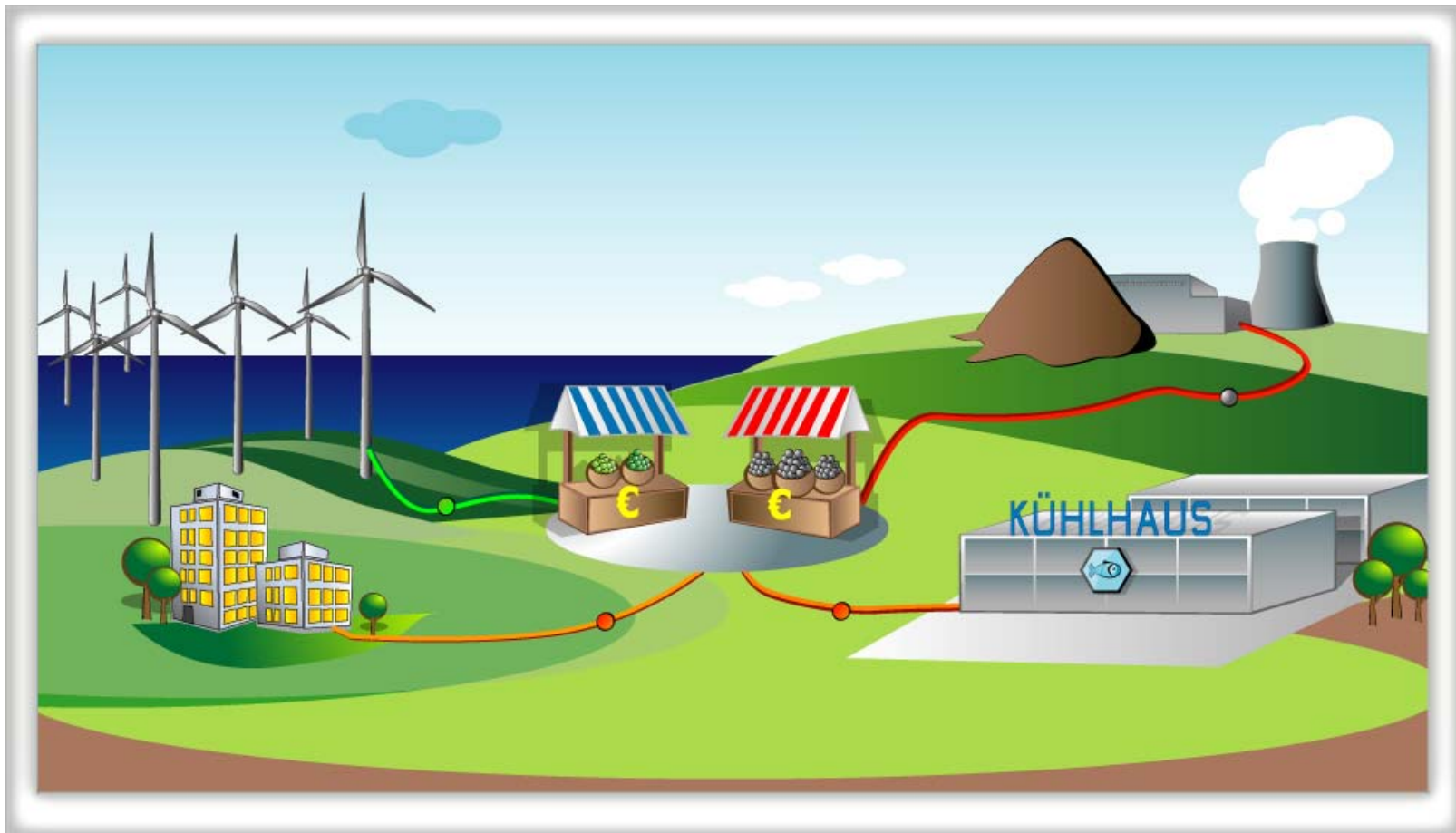
II. The eTelligence project

Who is participating in eTelligence?

- Numerous partners from research and industry are among the project consortium led by EWE.



eTelligence-Scenario



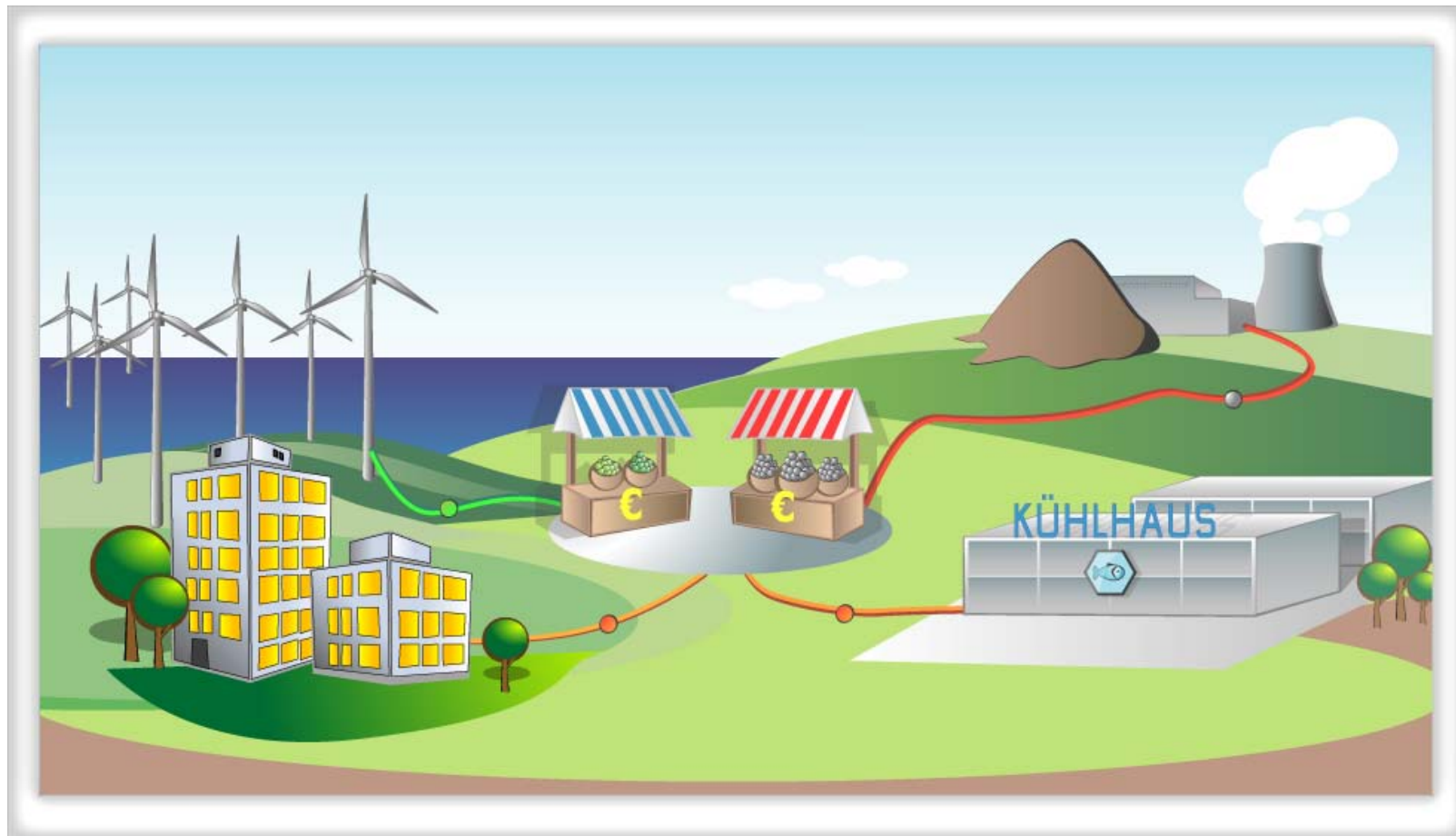
eTelligence-Scenario: Local Generation



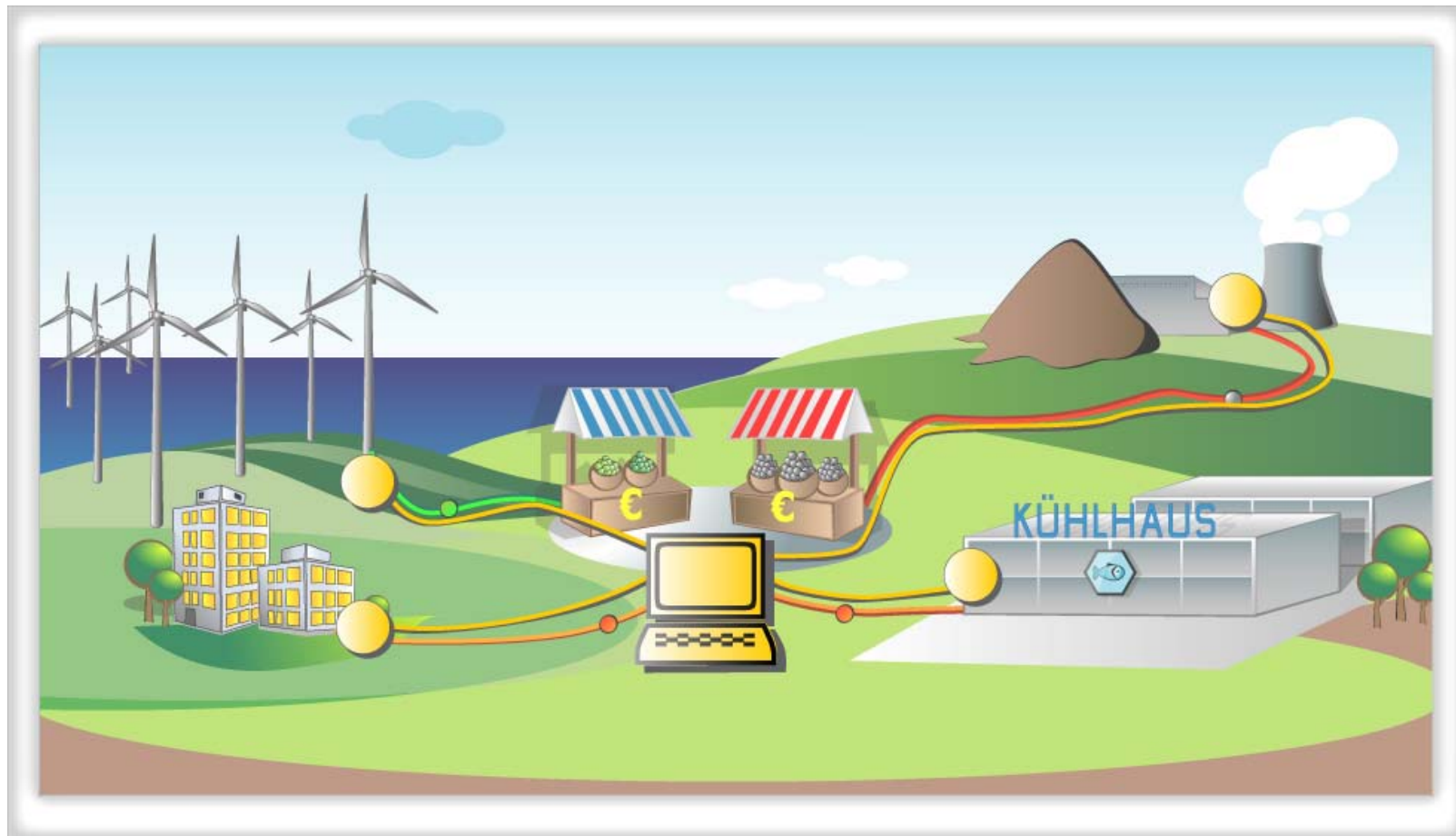
eTelligence-Scenario: Shiftable loads



eTelligence-Scenario: household customers



eTelligence-Scenario: Power Grid and Communication Network



eTelligence-Scenario: The market place



II. Economic and ecological effects of flexibility in the electricity system

Flexibility for integrating intermittent RES

- Increasing demand for flexibility due to renewables
 - short-term fluctuations
 - long-term fluctuations
 - forecasting errors

- Flexibility options today
 - ramping of thermal power plants
 - pump storage plants

- New flexibility options
 - storage power plants (CAES, batteries,...)
 - demand side management (“smart flexibility”)
 - flexibility of renewables and DG (“smart flexibility”)

Economic and ecological effects of (smart) flexibility

- Generation shifts from peak to base load plants
 - Flattened load curve
 - Replacement of conventional balancing capacity

CO₂ ↑ ↓ EURO ↓

- Efficiency increase of conventional plants
 - Reduction of part-load operation of conventional plants

CO₂ ↓ EURO ↓

- Higher system capacity for integrating RES
 - Demand shifts to times of negative residual load
 - Reduction of electricity generation linked with spinning reserve

CO₂ ↓ EURO ↓

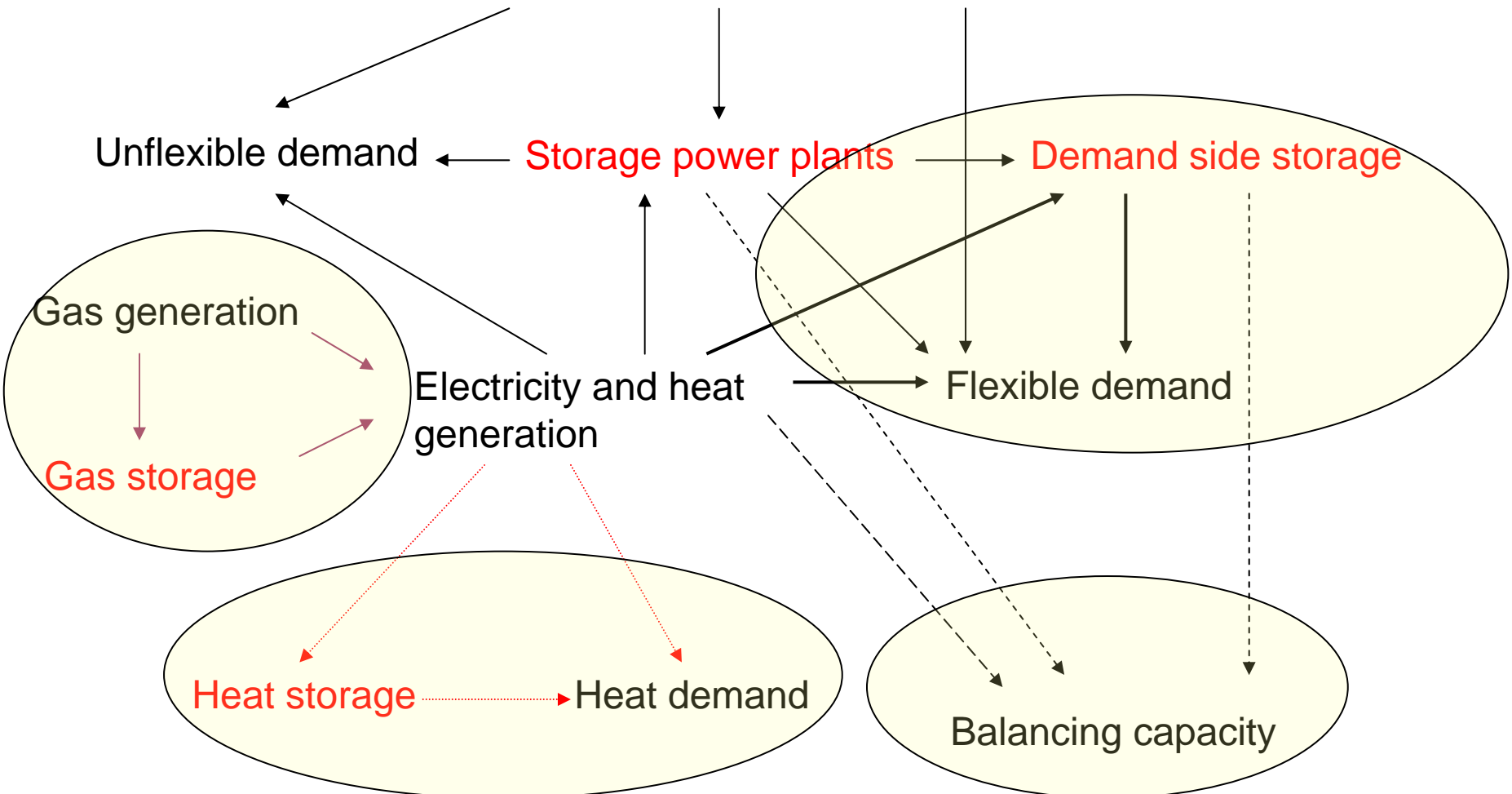
II. PowerFlex model for quantitative analysis

PowerFlex model for quantitative analysis

- Model developed by Öko-Institut
- Mixed-integer, linear optimisation model
 - Minimisation of overall costs
 - Technical and energy economic constraints
 - No network constraints yet
- Dispatch of power plants and flexibility options
- Covering the predefined demand of electricity and balancing capacity
- Optimisation on hourly base for 24 h

Flexibility

Intermittent and must-run electricity generation



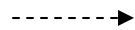
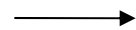
Legend:

Electricity:

Control energy:

Heat:

Gas:



Flexibility mapping in the PowerFlex model

- Thermal power plants > 100 MW
 - Operational status: start-up, part-load, full load
 - Load specific electrical efficiency
 - Load change ratio, start-up and shut-down time
- Thermal power plants < 100 MW
 - Technology specific groups
 - No flexibility restrictions
- Storage power plants
 - Capacity of pumping, storage and generation
- Flexible consumers
 - Electrical capacity, storage capacity, demand profile

III. Case study: flexibility from electrical cooling

Flexibility potential from electrical cooling – Preliminary case study

- **Cold storage warehouses, refrigeration in households and food retailing (no industrial cooling)**
- Represents approx. 5% of German electricity demand
- Flexibility determined by
 - Installed electrical capacity of refrigeration machines
 - Storage volume
 - technology specific temperature interval (1° C to 6° C)
 - COP (Coefficient of performance)
 - Mass and mixture of cooling goods (specific heat capacity)
 - Demand profile: technology specific or standard load profiles
 - Efficiency of storage (assumption 76% like pump storage)

Flexibility potential from electrical cooling – Preliminary case study

	cold storage warehouses	refrigeration equipment	
		households	food retailing
Electrical capacity	180 MW	6.800 MW	1.400 MW
Storage capacity	1.200 MWh	2.500 MWh	280 MWh
Demand	115 MW	2.200 MW	900 MW

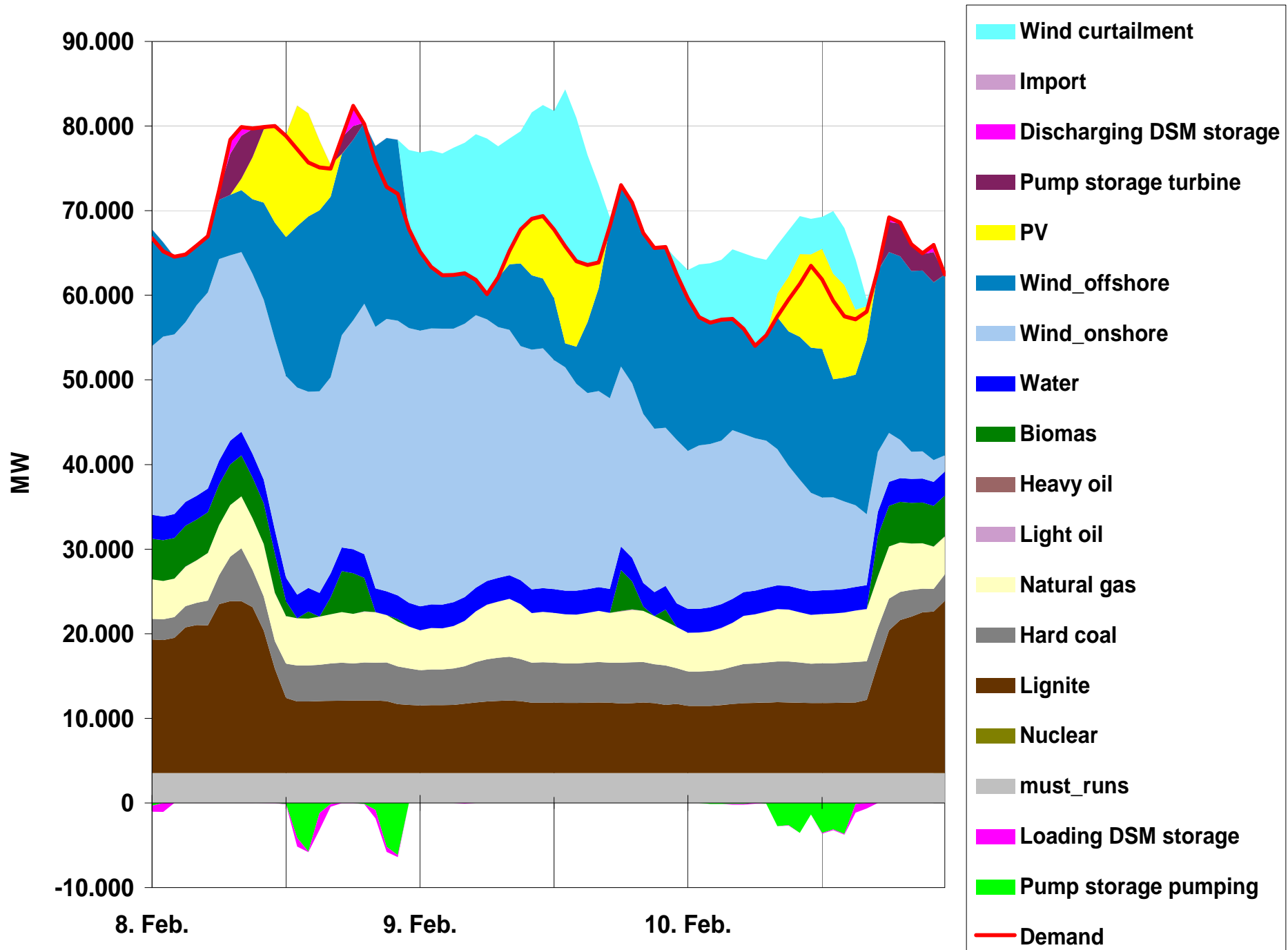
Scenario analysis for flexibility from electrical cooling

● Scenario 2008

- Without additional flexibility:
 - Full integration of electricity from RES
- With additional flexibility:
 - Fuel mix switch from gas and oil to coal and nuclear
 - + 50 GWh thermal (storage losses)
 - Costs: - 8 Mio €, CO₂-emissions: + 40 kt

● Scenario 2030

- Without additional flexibility:
 - - 9 TWh wind (5 % of possible supply)
- With additional flexibility:
 - Fuel switch from gas and oil to coal
 - + 270 GWh wind and biomass
 - + 100 GWh thermal (storage losses)
 - Costs: - 16 Mio €, CO₂-emissions: + 70 kt



● Conclusions

- Smart flexibility increases integration of RES
- Additional flexibility and storage options are needed to fully integrate RES in 2030
- Sensitive input parameter
 - Efficiency of storage / smart flexibility
 - Fuel type switch between base and peak load plants
 - Flexibility and balancing capacity requirements from conventional plants

● Next steps

- Including further flexible consumers
- Implementation of heat and gas storage
- Taking into account results of eTelligence field trial
- Definition of relevant scenarios
- Comparing the whole range of flexibility options
- European perspective

Thank you for your attention!



Co-funded by



Bundesministerium
für Wirtschaft
und Technologie

Öko-Institut e.V.

Dierk Bauknecht and Dr. Matthias Koch

Email: d.bauknecht@oeko.de

Telefon: 0761-452 95-30



Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology