Energy Storage – ‘just’ one solution to provide flexibility

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The Energy landscape is about to change …

- Europeanization. Large power plants move away from load centers requiring more cross border transmission
- Decentralization. Large numbers of small scale power generators will be installed, mainly based on RES

2010 2030 2050

… and will result in more uncertainty, everywhere

- Electrification (fuel shift). Energy demand will result in greater dependence on power quality and security of supply
- Uncertainty. More fluctuation in supply and in demand will result in less predictable power flows, and e.g. need for energy storage
- Prosumers, consumers become producers. That will affect power flow and energy market, and might require development of new market mechanisms

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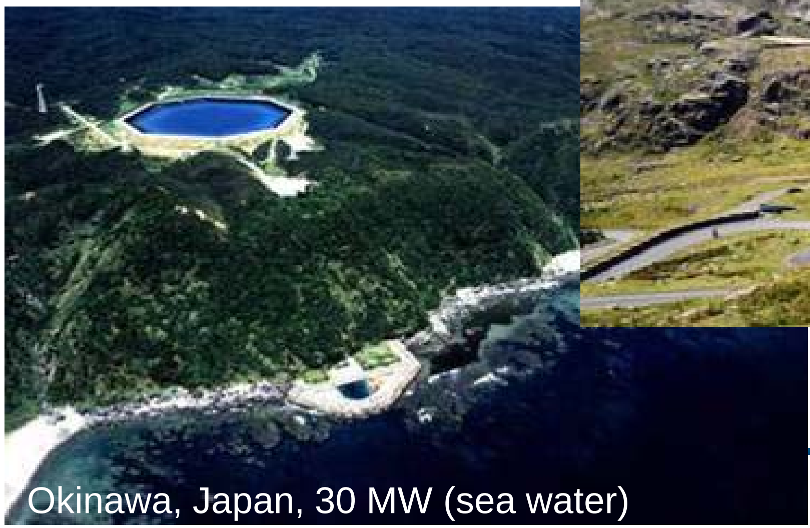
Combination of electricity storage and wind energy seems logical

- Electricity storage is well-established practice
  - Already in 1999 the EU had 32 GW capacity of pumped storage out of a total of 188 GW of hydropower and representing 5.5% of total electrical capacity in the EU (90 GW worldwide), but percentage is decreasing
  - Wide variety of (mainly small-scale) storage applications
- Storage can add various values to the energy business


Okinawa, Japan, 30 MW (sea water)

Scope and background of recent E-storage study

- **Necessity of large-scale energy storage (“20-20-20” goals)**
  - Maximise share of electricity from renewable energy sources
  - Increase efficiency of electricity generation
    => reduce consumption of primary fossil fuels
  - Reduce CO_2 emissions
  - Decouples supply from demand
- **Value and Benefits of large-scale energy storage**
  - Reduce costs of generation
  - Potential income for LSES from operation in the market
- Focus on year 2020, supplementary calculations for 2030 and 2050

To be seen in context of various other studies
(Ummels, AES, Frontier, EZ, ECN etc.)

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Approach and assumptions

Main assumptions and data sources

Generation Structure	• UCTE / Europrog2007 / IEA Greenpeace (profiles for RES) • Own adjustment for wind development in the Netherlands partially hourly
Network Representation	Simplified representation of UCTE-grid incl. potential extensions • Remaining countries aggregated to one single node • Representation of big countries by several regions
Load	• Hourly Profiles: Historical Data from national sources (2008) • Growth: UCTE / Europrog2007
Fuel and CO_2 Prices	• Region-specific transport costs (coal, HFO,..) and identical fuel prices (UR,..) • Linear increase of CO2 prices until 2030
Reserves	• Consideration of all four reserves types for Core Countries (NL, BE, DE) • Partially aggregation for FR, NORDEL, UK • Locational restrictions of reserve assignments

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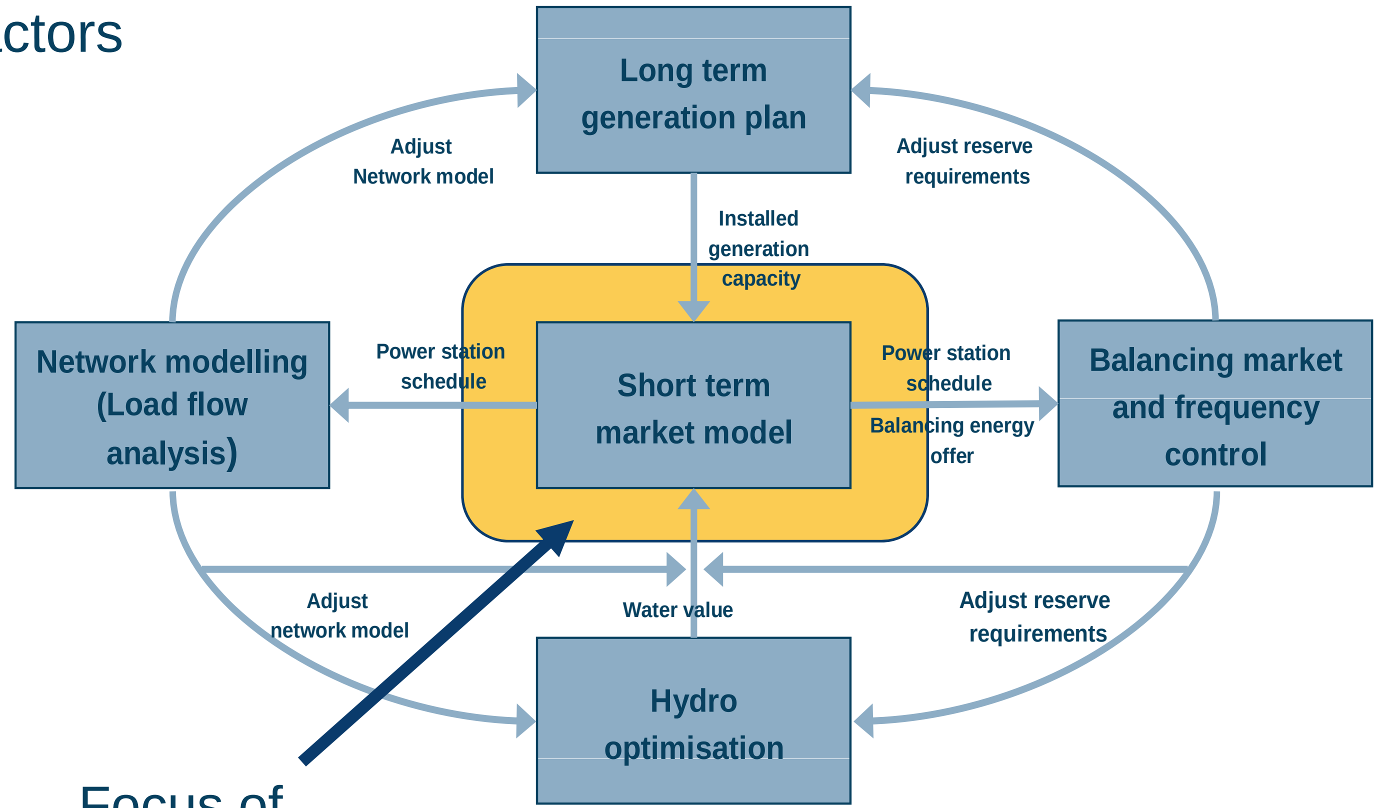
Specific assumptions

Need to consider various parameters

- Important input factors
  - Regional Grid
  - Cogeneration
  - Wind
  - Reserves
  - Hydro



Focus of recent study

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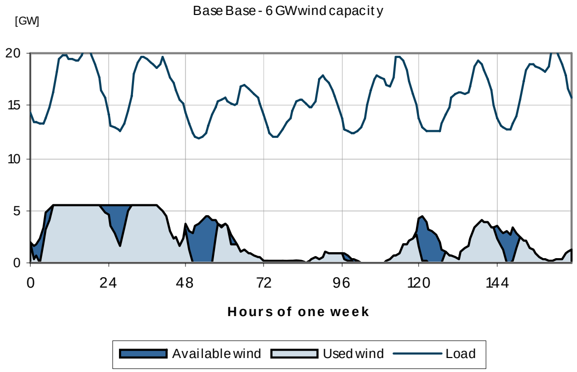
Value & necessity of large-scale storage

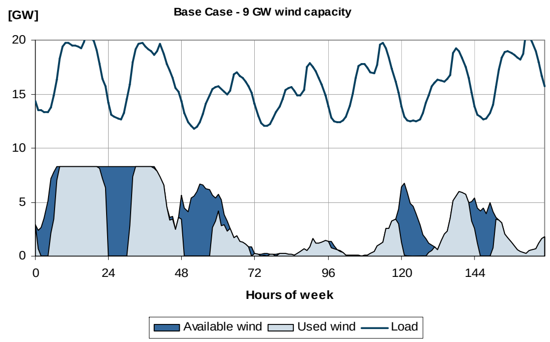
Relation to level of wind power

- Curtailment of wind power may already occur at 6 GW of wind power
- Problems quickly increase as installed capacity grows
- May result in continued curtailment of wind power over several days
- Approx. 6.4% (1.5 TWh) of wind energy lost in base case in 2020
- Sensitive to variations in wind, must-run capacity and load

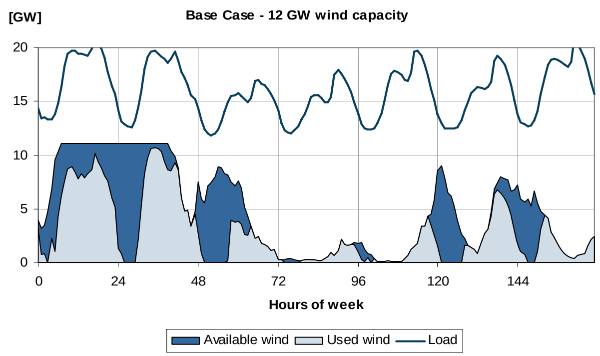
6 GW



9 GW



12 GW



Value & necessity of large-scale storage

Reduced CO_2 emissions and generation costs due to LSES

- Addition of large-scale energy system clearly decreases specific emissions, annual savings of 1.25 million tons in base case
- LSES generally allows savings of generation costs in the NL
- Absolute savings partially compensated by increasing production - but specific costs decrease in all cases
- Overall volume remains limited: several tens of M€/a

Potential income of LSES

- Revised generator offers result in annual net revenues for LSES of approx. 100 M€ (energy and reserves)
  - Significant share earned in few weeks with curtailment
  - Strongly influenced by assumed pricing of wind power (competitive vs. 100 €/MWh subsidies)

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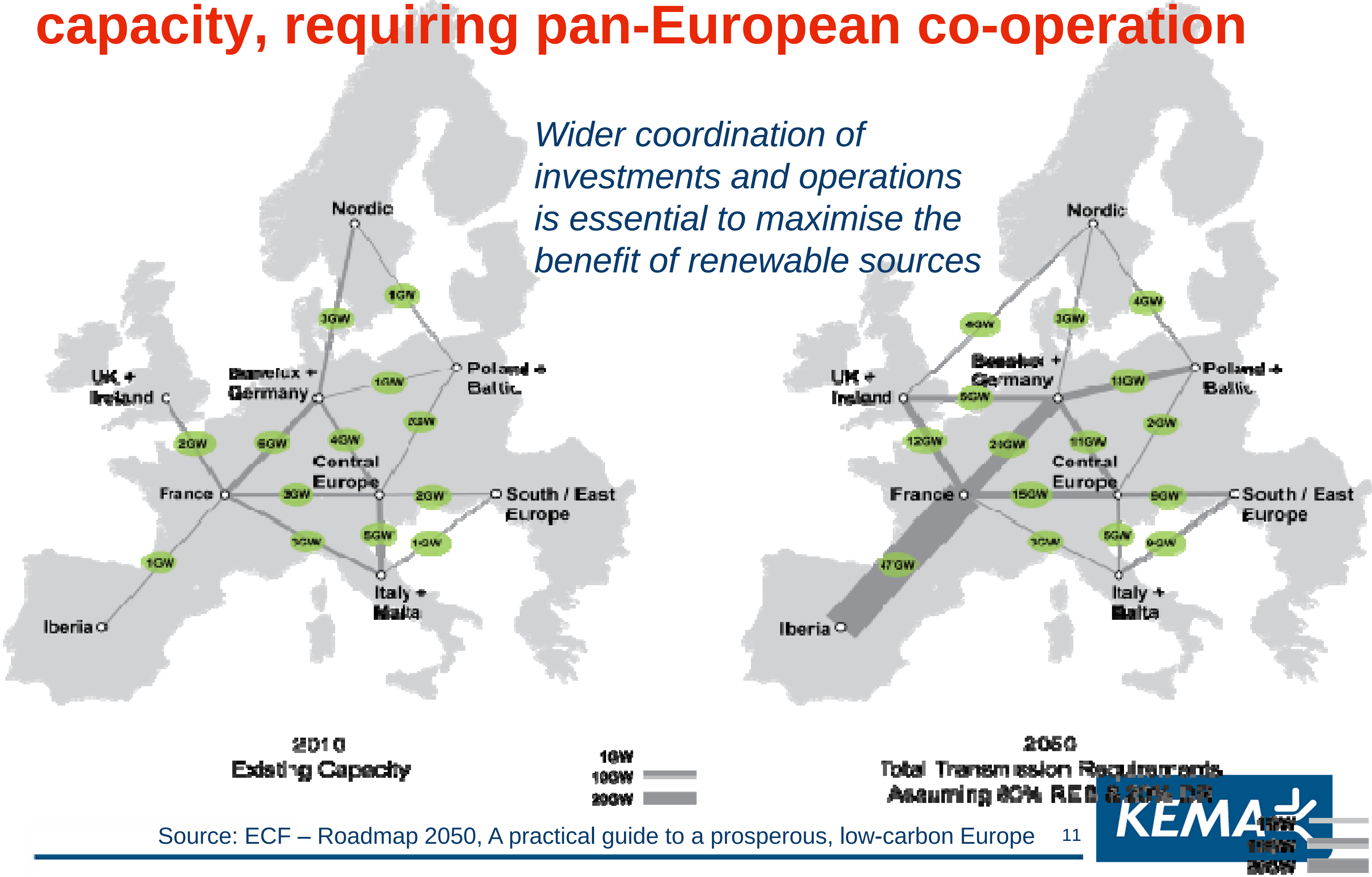
Value & necessity of large-scale storage

Sensitivity of input parameter on Base Case

Load	⇓ by 5% in NL	⇓ Wind utilisation (- $^1/_3$)
Wind Capacity	⇑ From 9 GW to 12 GW	⇑ Wind curtailment (> factor 2)
Must-Run Commitment	⇓ by 10% (e.g. CHP)	Similar impact to 2,000 MW LSES
Interconnection	⇑ "NorNed-2" (2,000 MW)	Higher benefits than LSES, but cannot prevent curtailment
Storage Volume	⇓ From 16 GWh to 4 GWh	⇓ Savings (< 50%)
Round-Cycle Efficiency	⇓ From 75% to 60%	⇓ Wind utilisation

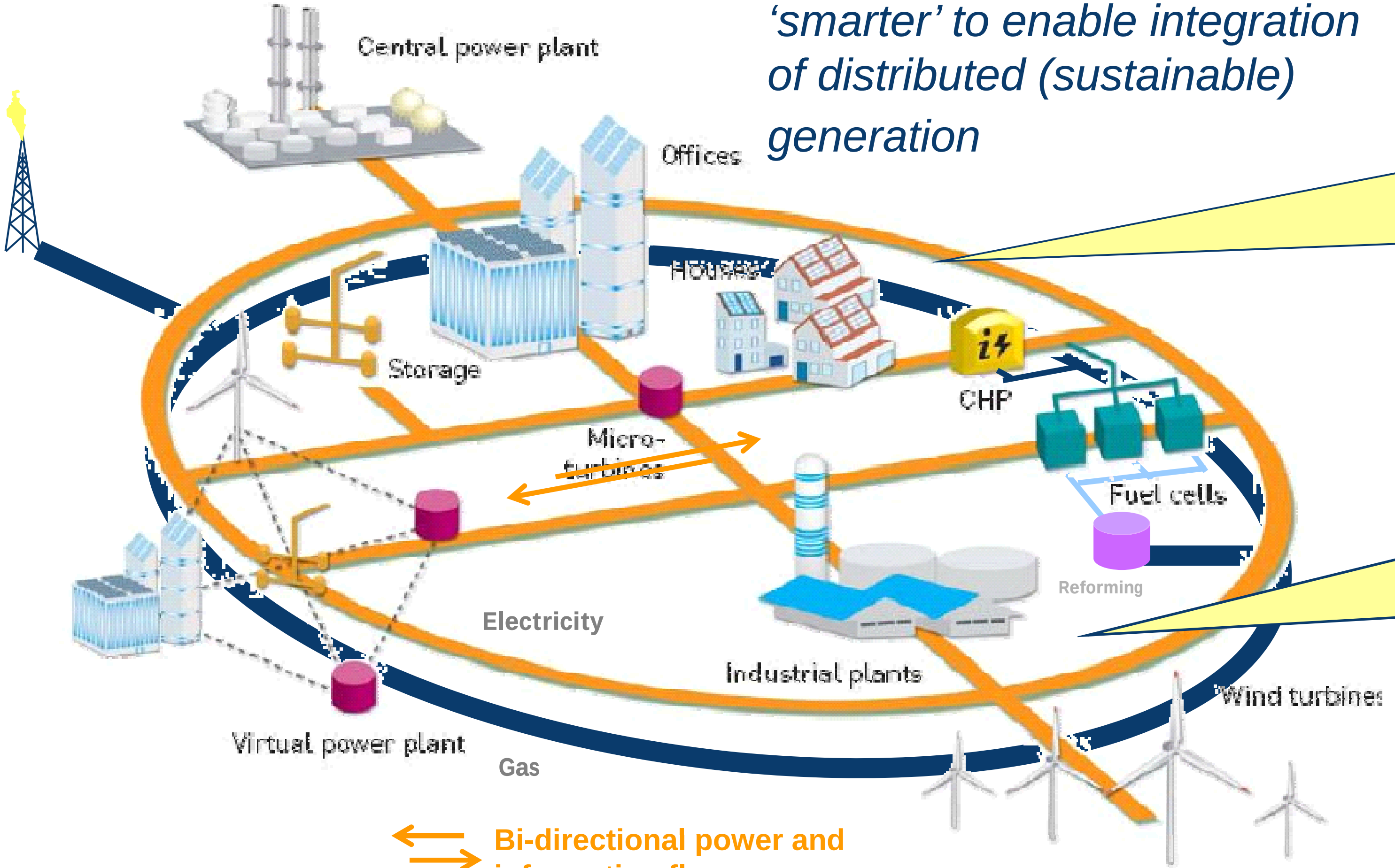
Alternative solution A: increase interconnection capacity, requiring pan-European co-operation

Wider coordination of investments and operations is essential to maximise the benefit of renewable sources



Alternative B: Integration of distributed energy and new services locally

Distribution grids should be 'smarter' to enable integration of distributed (sustainable) generation



Some challenges: less predictable generation, less predictable load, network overload risk, …

New services can be offered: real time pricing, local energy storage, smart charging, …

Bi-directional power and information flows

Concluding remarks

- Transition towards a low-carbon energy system will require more flexibility of our system
- A number of alternatives are possible, and (almost) available
  - Energy storage
  - More interconnection capacity
  - Integration of RES on a distribution level
  - More flexible power generation
- We need more than technology though as a radical new vision for our energy system is needed, and active involvement of end-users

Thank you for your attention

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