ENVIRONMENT AGENCY AUSTRIA **umweltbundesamt**

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Sharing Best Practices to Protect Electricity Networks from Natural Disasters

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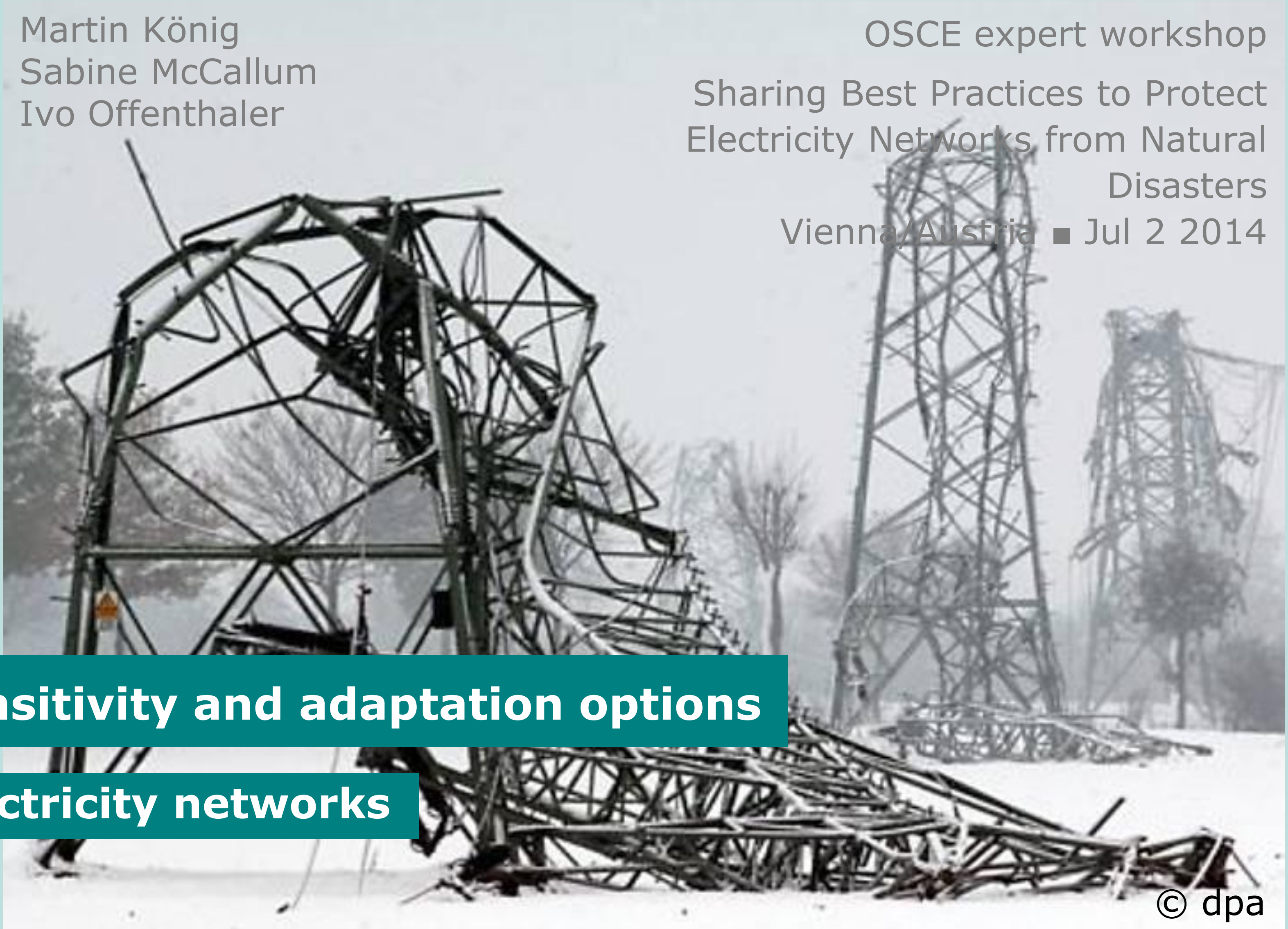

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CC sensitivity and adaptation options for electricity networks

Background

- Electricity generation and distribution is at the core of energy sector adaptation to CC as it is the most vulnerable part of the energy system
- The energy sector as such has not yet been in the focus of adaptation mainly due to mitigation commitments and nuclear policy debate (e.g. phase-out in Germany)
- Emerging climate risks, state of energy infrastructure and policy frameworks make it necessary to start adaptation a.s.a.p. European adaptation strategy includes climate resilience of e-grid
- Mainstreaming potential for adaptation does exist within 20-20-20 goals/European energy policy/mitigation policy

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Aggregated climate change impacts for Europe’s energy sector 1/2

- Direct physical impacts and damages to **transmission and distribution** grid (including substations and transformers) by extreme events (storm/windfall, precipitation/mass movements/floods, thunderstorms/lightning/flash-over, wet snow deposits and icing)

- Adverse impacts on conventional **supply** facilities caused by extreme weather periods (esp. heat and drought) causing problems for cooling of thermal and nuclear power stations

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Aggregated climate change impacts for Europe’s energy sector 2/2

- Indirect impacts via accelerated **demand** for cooling (climate-change triggered e.g. during heat waves) on transmission infrastructures (likelihood for flash-over increases for overloaded lines)

- Adverse effects of higher temperatures on all three energy system compartments (lower capacity of transmission lines, lower efficiency of thermal/nuclear power plants and higher seasonal demand peaks) -> **heat waves are/will further be a core challenge**!

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Vulnerability is further altered by:

- Increasing interconnection of grid-dependent European internal energy market and thus increasing amounts of transmitted energy/less domestic supply in many regions
- Projected further shift towards increasing electricity demands and according shifts in primary energy consumption
- Increasing share of renewable energy generation, which will entail a more complex pictures of climate threats (e.g. increasing dependency from solar irradiation, wind velocities, river run-off regimes)

Impacts of changing climate parameters on different energy supplies

Technology	Δ air temp.	Δ water temp.	Δ precip.	Δ wind speeds	Δ sea level	Flood	Heat waves	Storms
Nuclear	1	2		-	-	3	1	-
Hydro	-	-	2	-		3	-	1
Wind (onshore)	-	-	-	1	-	-	-	1
Wind (offshore)	-	-	-	1	3	-	-	1
Biomass	1	2	-	-	-	3	1	-
PV	-	-	-	-	-		1	1
CSP	-	-	-	-	-	1	-	1
Geothermal	-	-	-	-	-	1	-	-
Natural gas	1	2	-	-	-	3	1	-
Coal	1	2	-	-	-	3	1	-
Oil	1	2	-	-	-	3	1	-
Grids	3	-	-	-		1	1	3

Note: 3 = Severe impact, 2 = Medium impact, 1 = Small impact, - = No Significant impact;

Source: Rademaekers et al. (2011)

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Who is most affected?

- Citizens and companies as energy consumers, whose activity is threatened by weather-induced black outs (threatened security in energy supply)
- TSOs and DSOs as the (in some countries rather old) infrastructure (explicitly for the usually less robust distribution grid) is threatened by extreme events – sometimes in critical conjunction with high demand (cf. black out 2003 in IT/CH as one example)
- Energy suppliers with a high share of vulnerable supplies – i.e. water intensive energy supply (i.e. for cooling thermal plants as well as for run-off plant-generated hydropower)

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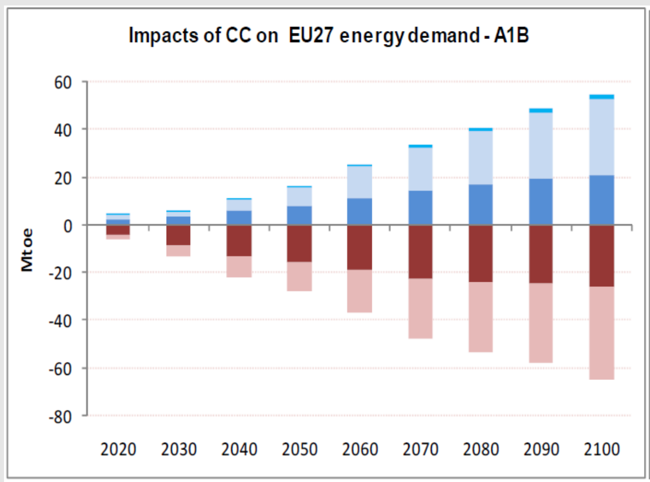
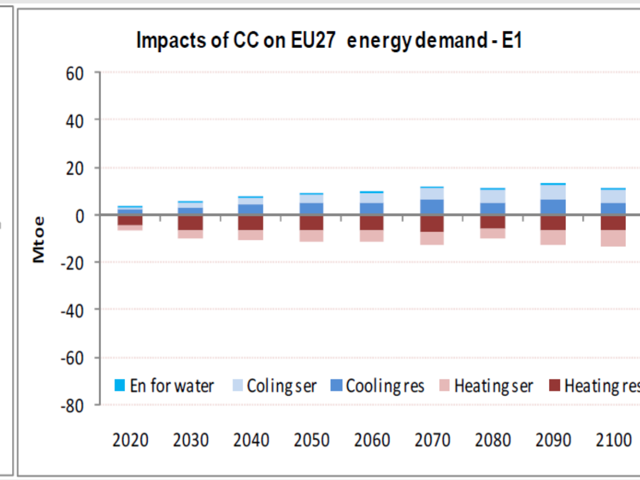
Regional disparities I

The case of Southern Europe:

- Insufficient domestic supply (e.g. Italy)
- Resulting high import dependency
- Most effected by energy demand for cooling (↑) and least for heating (↓)
- Most effected by heat waves and droughts with cooling water problems



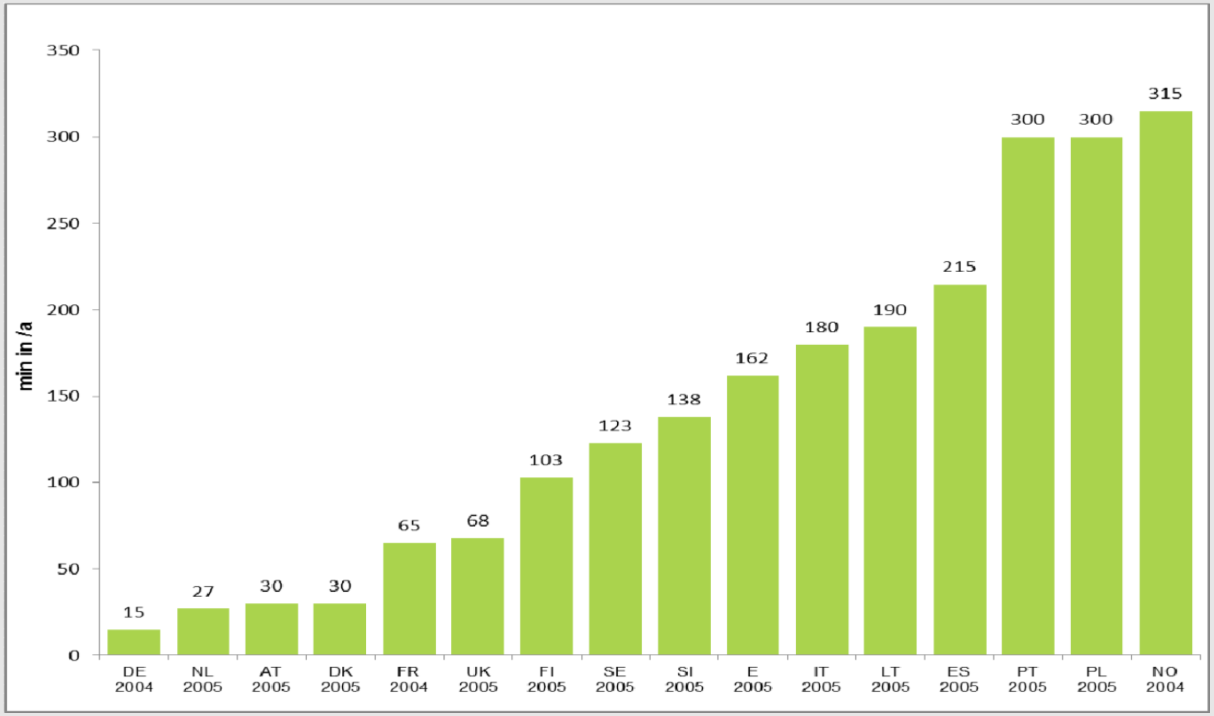


Comparison of additional cooling demand and saved heating demand for IPCC A1B and E1 emission scenarios.
En for water stands for surplus energy needs for water treatment, ser stands for service sector, res for residential sector.
Source: POLES model, LEPII-EDDEN, ClimateCosts after Mima, Criqui and Watkiss (2012)

Regional disparities II

The case of Southern and Eastern Europe:

Black-Out statistics



per capita average minutes without electricity. Source: CEER (2005/2008).
Note that more recent data has not been collected with a common method.

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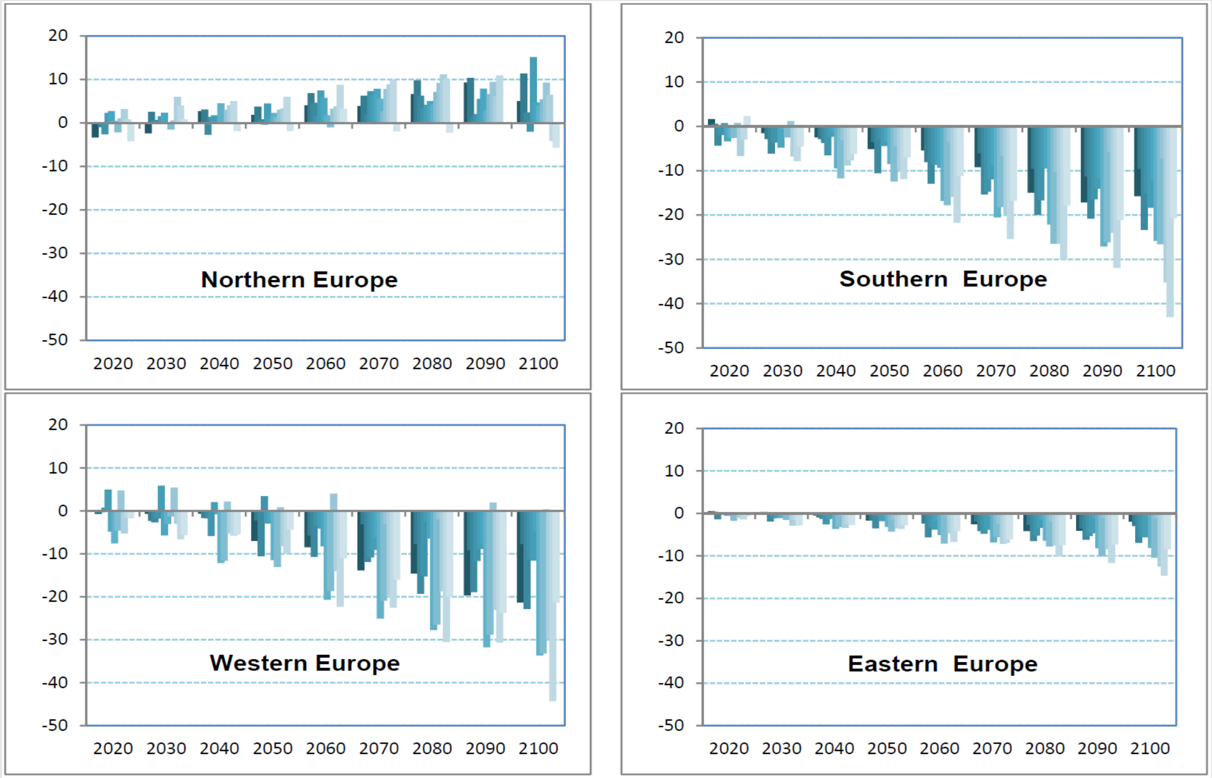
Regional disparities III

The case of Southern, Western and Eastern Europe:

Shrinking hydropower potential in forthcoming decades



hydropower generation in TWh modelled for A1B emission scenario using different GCMs.
Source: Mima, Criqui and Watkiss (2012)

Example for a future hazard cascade

- Climatological cascade: Long summers ⏩extended heat waves (cf. 2003) ⏩high electricity demand/insufficient domestic supply in Southern Europe
- Meteorological cascade: persistent high pressure over Central and Southern Europe ⏩Tmax>30°C/Tmin>20°C for more than 2 weeks ⏩droughts and low water levels/poor cooling water T-quality
- Energy meteorological cascade: shrinking cooling water supply for conventional power stations + air conditioning triggered peak demand ⏩heavy loads in major North-South transmission lines
- 'End of season' cascade: Atlantic Low pressure system hits Western and later Central and Eastern Europe ⏩extreme precipitation and mass movements the overloaded Alpine transmission grid ⏭flash-over at Silz-Soazza line ⏭Lukmanier line hit by heavy mudflows ⏩black-out at European scale

4 main targets for adaptation

1. Ensure safe transmission and distribution in a changing climate
2. Safeguard climate-proofed energy supply
3. Cut-off seasonal (climate-induced) demand peaks threatening supply and transmission
4. Enable further storage capacities as crucial buffers for the European energy market and to allow for higher shares of RE

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Who should do what to adapt?

TSOs/DSOs:

- Detect vulnerable hot spots in the grid infrastructure
- Retrofit the existing transmission/distribution grid infrastructure
- Expensive (need for PPP): Build sufficient redundancies
- Expensive (need for PPP) and not suitable in urban areas as heat release critical: Install underground cables at vulnerable grid hot spots

Energy companies:

- Detect vulnerable power plants/energy supplies
- Invest in energy meteorology databanks, forecasts, early warning, ...
- Climate-proof power plants and envisaged energy mix
- Install ex post measures (e.g. flood protection, promote erosion control in hydropower catchments)

Who should do what to adapt?
Role for Policy makers – National level

National policy:

- Elaborate adaptation strategies for the energy sector and support the implementation of measures against a regional background of expected climate impacts
- Ensure that envisaged mitigation targets and according energy mixes are climate proofed (together with energy companies)
- Promote energy efficiency and sufficiency by fiscal measures (e.g. taxing) in order to cut off demand peaks

Who should do what to adapt?
Role for Policy makers – European level

European policy:

- Set a clear focus on the European (TEN-E/CEF) transmission grid safety, sufficient redundancies and cross-border connections (cf. TEN-E guidance and priority axes as well as funding guidelines for projects under TEN-E/CEF)
- Promote research on energy sector vulnerability, measures to increase energy sector resilience (e.g. invest in research on alternative storage technologies) and climate-proofing RE supply (via EU Framework Programme for RTD)
- Mainstream adaptation of concrete measures into mitigation policies in order to cut-off peak demands during e.g. heat waves (cf. EU energy efficiency Directives)

➢ NOTE: For all concrete measures in the energy sector, PPP is an essential key to success

Some concrete measures for TSOs/DSOs I

- Install additional network capacities with special focus on volatile base load countries and regions. Especially regions with high potential and future dependence on non-base load capable renewable energy sources ((e.g. North Africa -> Solar Energy (cf. DESERTEC) or North Sea (offshore wind parks) (cf. ENTSOE 2010)) have to be taken into account. (cf. e.g. EDSO-SG). Make use of existing power pole infrastructure wherever possible.
- Install additional network capacities with special regard on countries and regions with high storage potential (e.g. Norway and Austria -> pumped storage units) (cf. ENTSOE 2010) [Yet, water pumping storage capacities have the highest efficiency]. Make use of existing power pole infrastructure wherever possible.

Some concrete measures for TSOs/DSOs II

- Detect vulnerable hot spots in the grid which are exposed especially to
  - Mass movements
  - Storms
  - Floods
  - Overheating
  - Icing and wet snow deposits
- Install underground cables at vulnerability hot spots [expensive, costs may exceed 10 times the costs of ordinary overhead transmission, also the conductivity of underground cables is limited due to fast warming and additional cooling facilities necessary]
- Expand aisles through forests to the degree necessary [controversial, but in some explicitly storm-exposed regions possibly unavoidable]
- Put slope stability measures into place (protective forests or technical measures such as terraces and fences)

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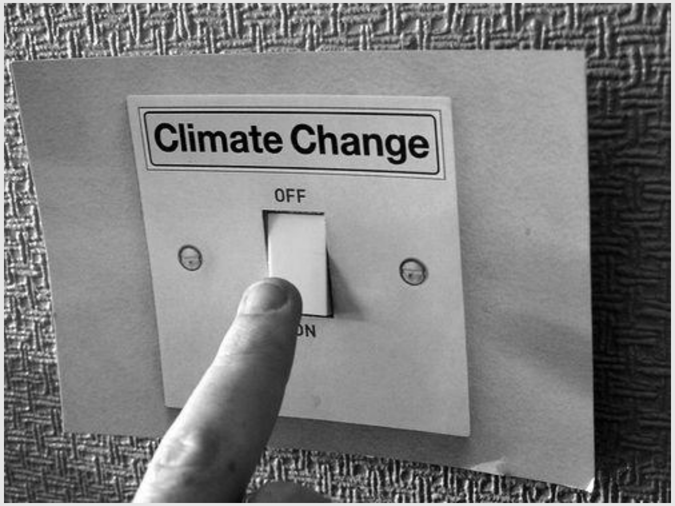
Some concrete measures for TSOs/DSOs III

- Set up early warning systems for energy shortcuts due to
  - high demand (e.g. during heat waves or cold spells leading to overheating of the network due to overuse);
  - extreme events (storm, icing, hail) or periods (droughts lead to low hydropower and usually also wind power, heat waves -> overheating of the transmission cables due to high temperatures).
- (Re-)locate flood-prone transformers and substations to higher/safer ground.
- Support the Establishment of small/regional distribution networks that work independent from large-scale grid infrastructures. Support small and smart projects which go for independent ‘isle solutions’.



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