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Vulnerability of infrastructures

Examples from energy and transport sectors

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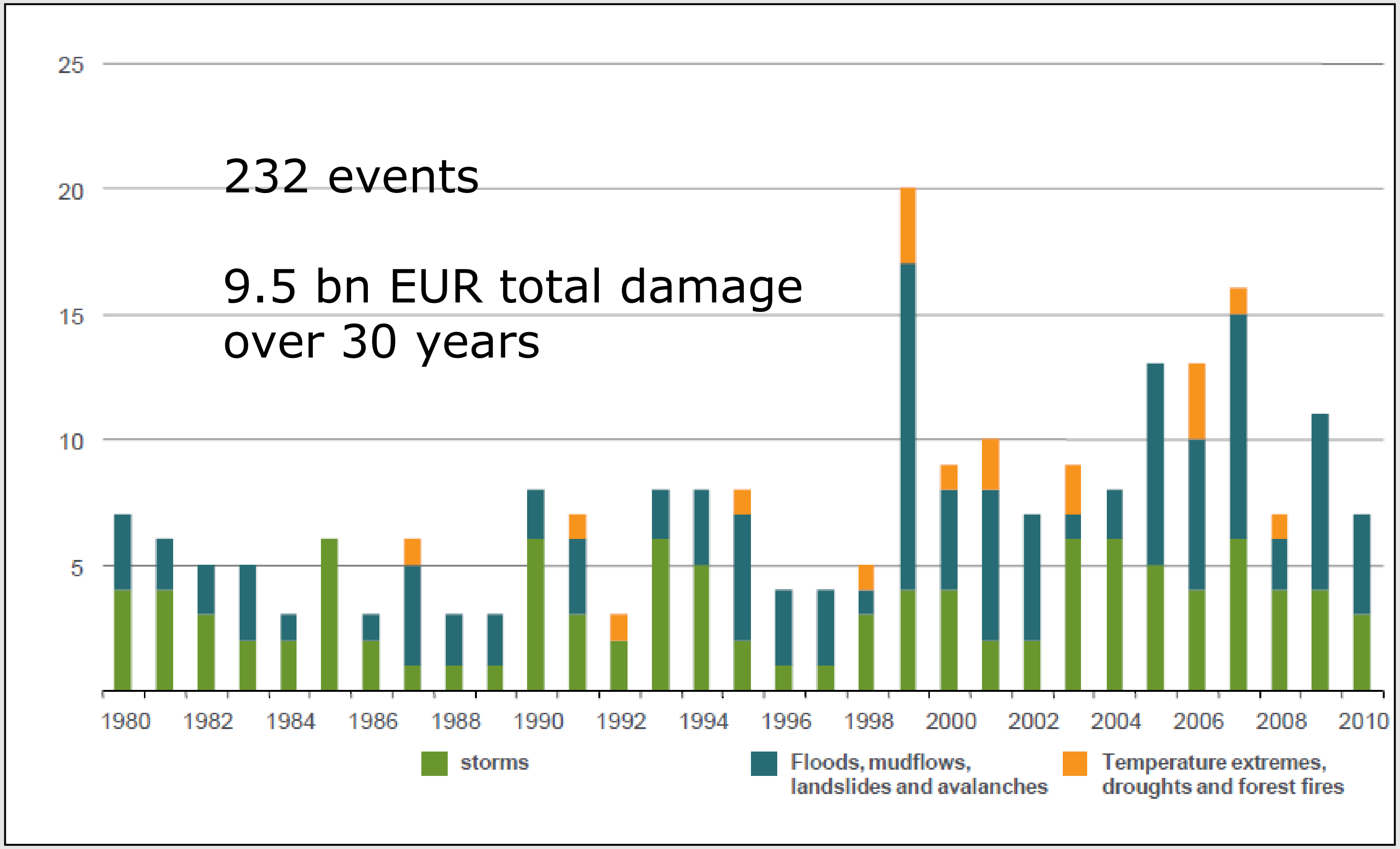
Outline

- **T**ransport (Austrian level – short)
  - Damages and impacts in Austria
  - Approximation of recent cost shares
- **E**nergy (European level – long)
  - Impacts and vulnerabilities
  - Who is mostly effected? (including regional disparities)
  - Hazard chains and how to adapt (who should do what)

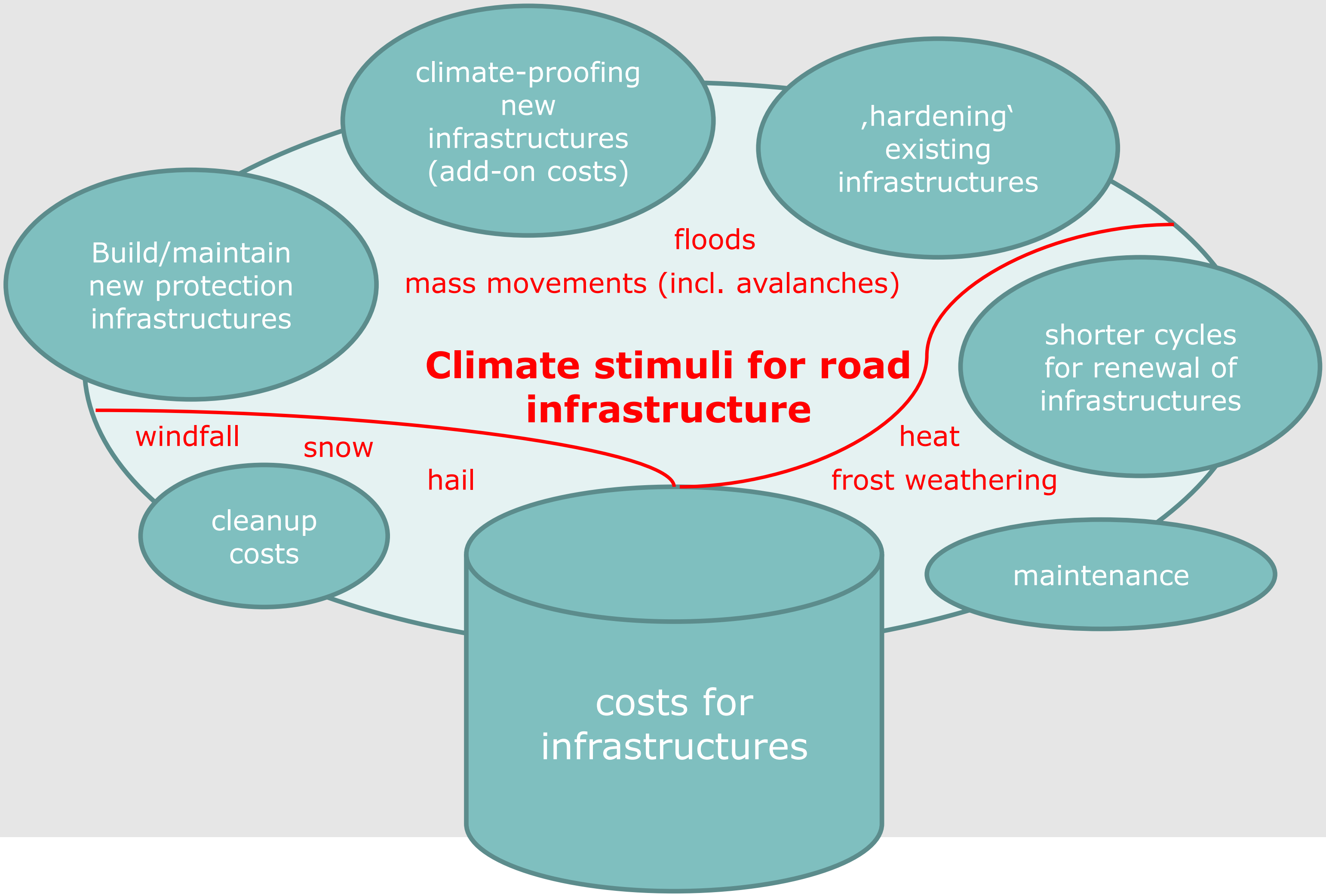
Trend for weather disasters in Austria



Data source and processing: MunichRe/NatCatService

Some examples for transport sector damages

breakdown of climate costs for road infrastructures



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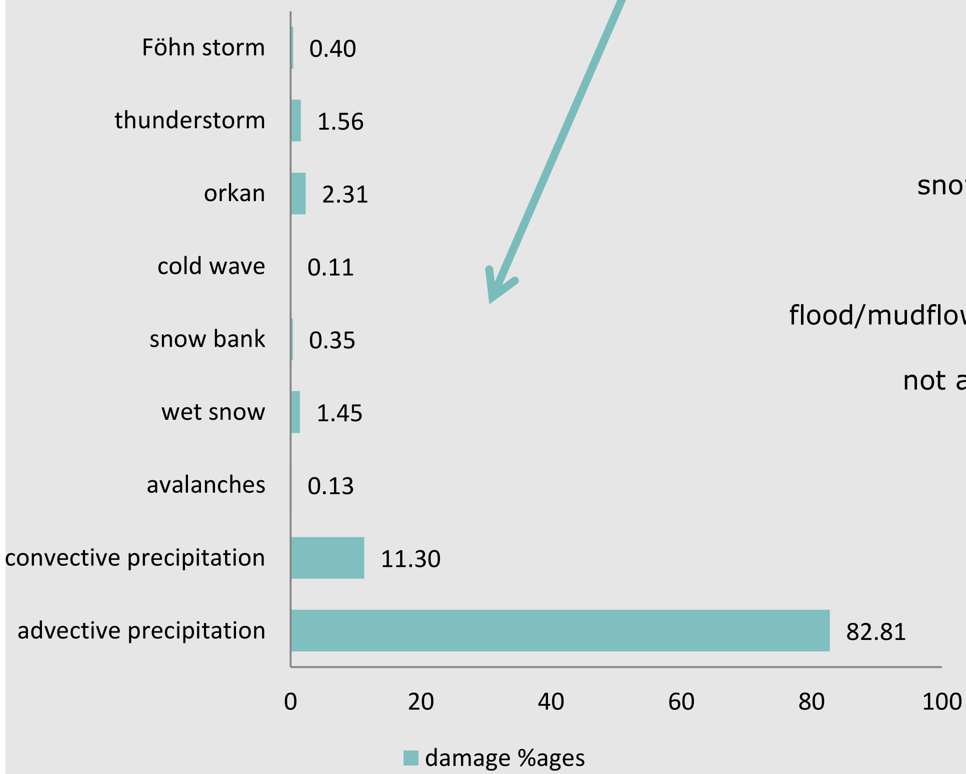
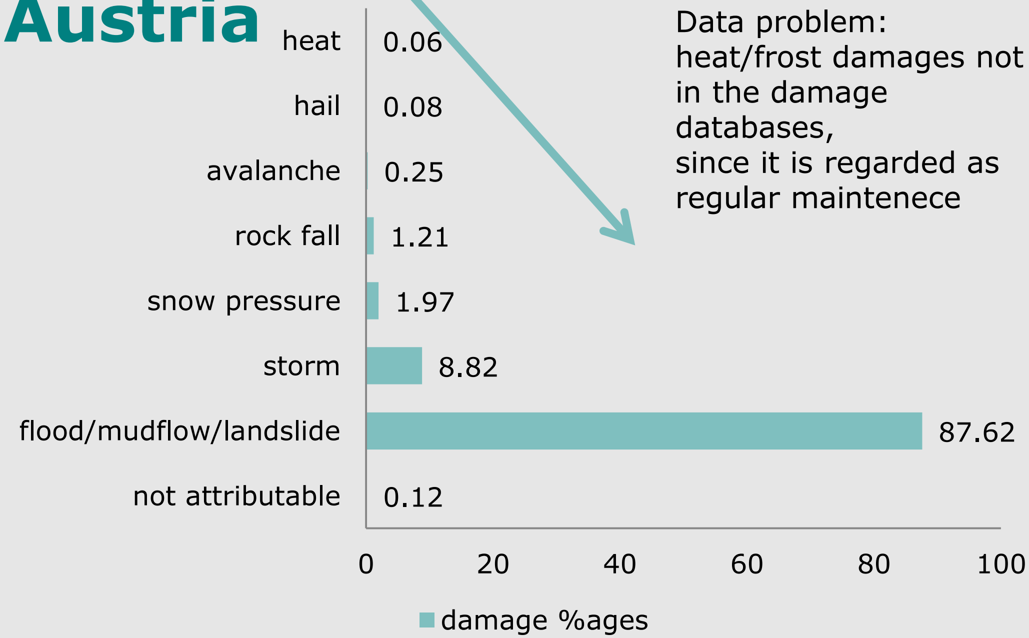
Cost shares for railway and road by type of weather extreme in Austria



cost shares of meteorological extreme events damage categories for Austrian railway (1990-2010). Data source: ÖBB, data processing: BOKU-Met. n= 1383 events (1990-2009)



Data problem:
heat/frost damages not in the damage databases,
since it is regarded as regular maintenece

cost shares of climate damage categories for the provinces Styria (January 2008 to December 2011) and Salzburg (June 2007 to December 2011). Data source: provincial governments of Styria/Salzburg. n = 1444 events (2007-2011)

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An approximation of transport and energy sector direct damage costs in contrast to overall large-scale event costs

	Large-scale event damages MunichRe Austria	Street infrastructure damages Salzburg	Street infrastructure damages Styria	Street infrastructure damages Vorarlberg	Street infrastructure damages Tyrol	Railway infrastructure damages ÖBB Austria
Reference period	1980-2010	2008-2010	2008-2011	2005-2010	2005-2011	1990-2010
Average annual damages in million EUR	**299,35**	5,04	2,45	4,85	4,28	6,44
Upscaled street damages		For the four provinces the sum of average annual damages for provincial roads is almost 16,62 million EUR. Thus, an upscaling (+national highway network and +missing provinces) to national level could be assumed at about **50 million EUR**				

Preface – Energy infrastructures

- **Electricity** generation and distribution is at the core of energy sector adaptation to CC due to
  - most vulnerable infrastructure
  - raising share in final energy consumption
- 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)
- Climate risks, state of energy infrastructure and recent policy frameworks make it necessary to mainstream/start adaptation a.s.a.p.
- Mainstreaming potential for adaptation does exist within 20-20-20 goals/European energy policy/mitigation policy

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)
- 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

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

- Indirect impacts via accelerated **demand** (climate-change triggered e.g. during **heat waves**) on transmission infrastructures (likelihood for flash-over increases for overloaded lines)
- **Higher temperatures and low water** levels cause threefold effects:
  - lower capacity of **transmission** lines,
  - lower efficiency of thermal/nuclear power **plants** and
  - higher seasonal **demand** peaks)
- **heat waves and droughts are/will further be a core challenge for the European energy system**!

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)

Who is mostly 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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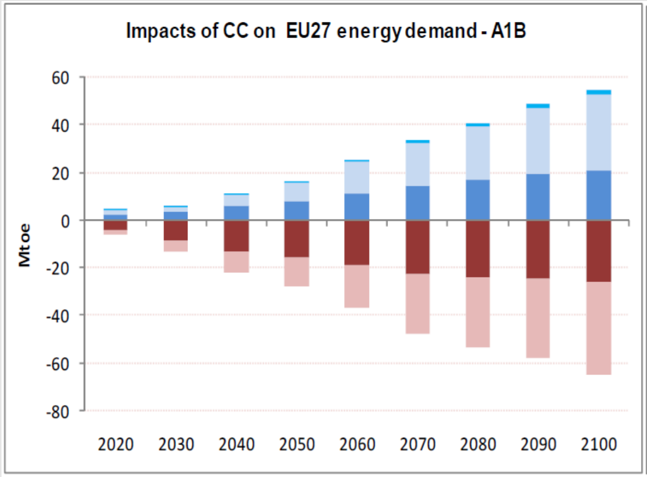
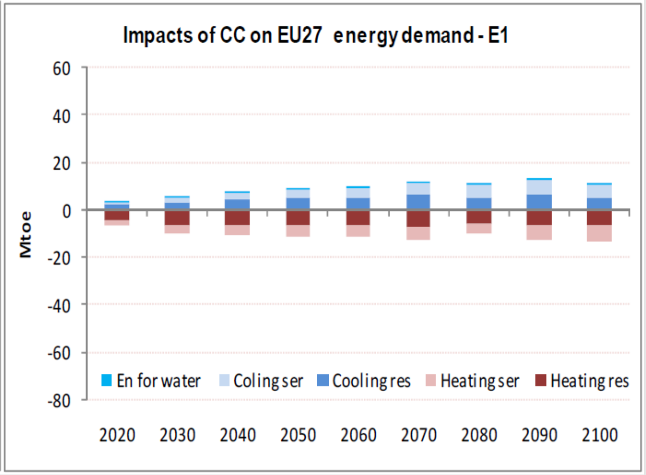
Regional disparities I

The **demand case** of Southern Europe:

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



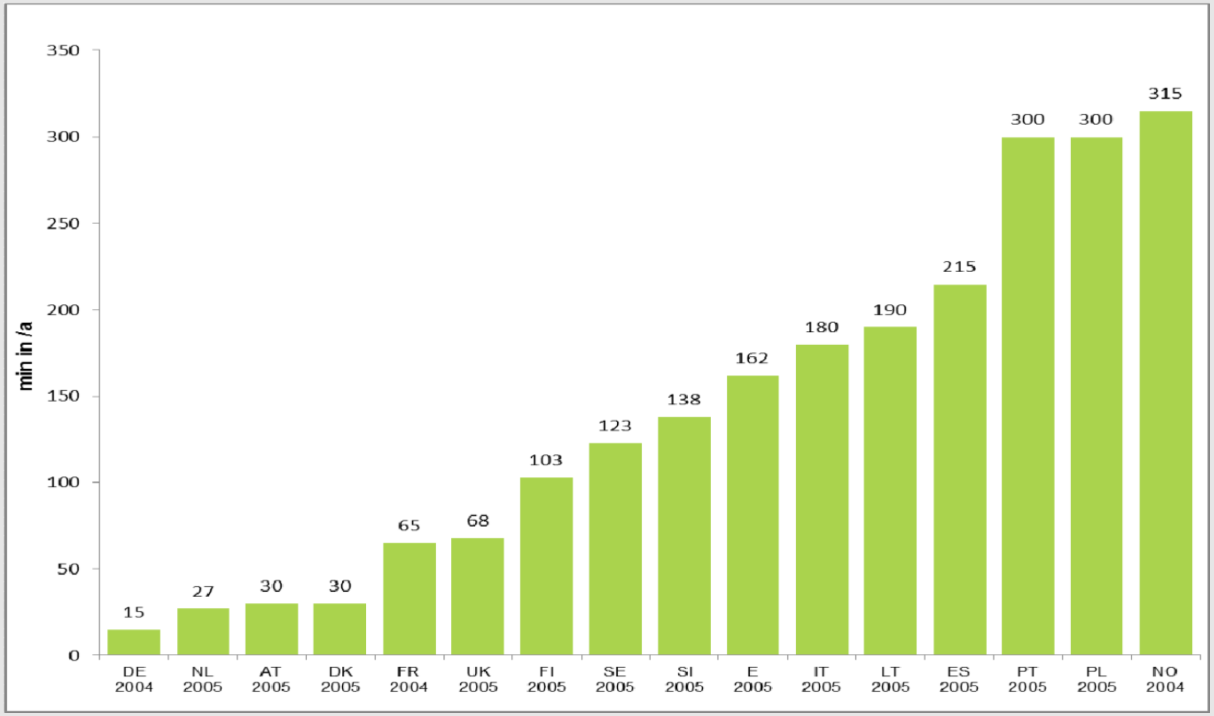


Comparison of additional cooling demand and saved heating demand for IPCC **A1B** and **E1** emission scenarios. En for water stands for surplus energy needs for water treatment, ser stands for service sector, res for residential sector.
Source: POLES model, LEPII-EDDEN, ClimateCosts after Mima, Criqui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

Regional disparities II

The case of Southern and Eastern Europe:

Black-Out statistics

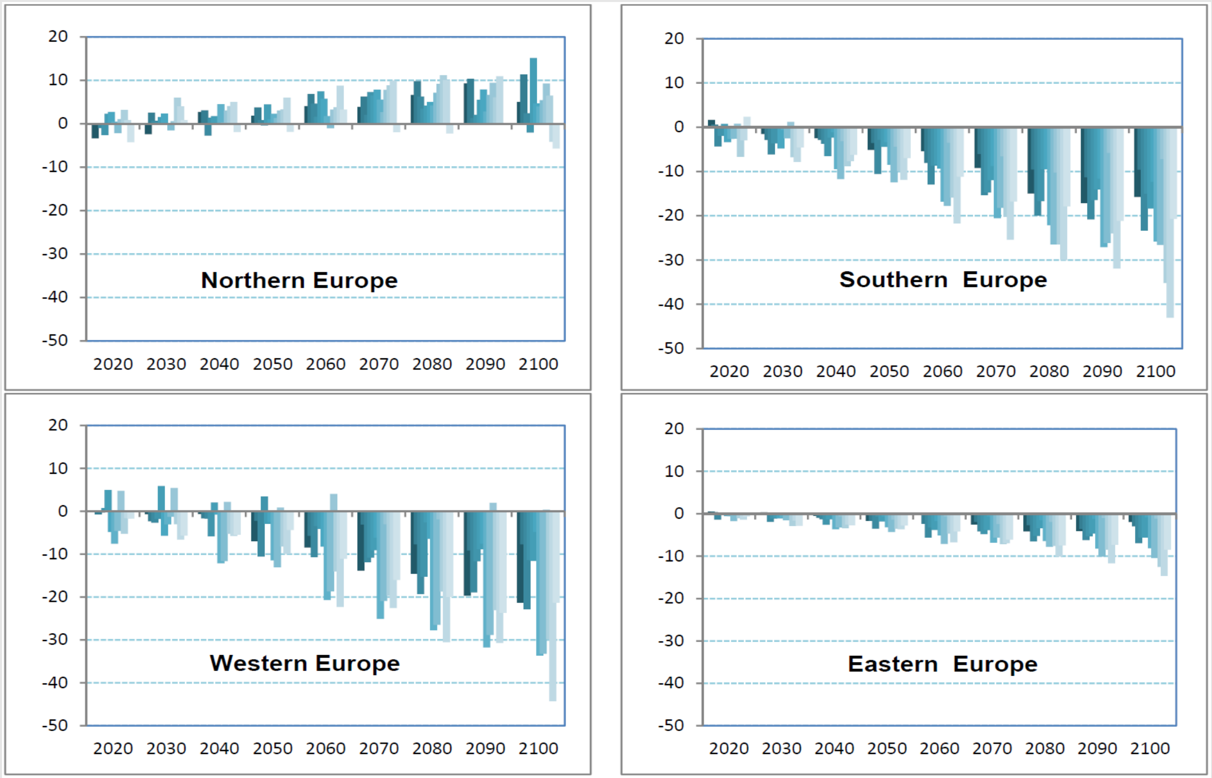


annual per capita average minutes without electricity. Source: CEER (2005/2008).
Note that more recent data has not been collected with a common method.

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)

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Example for a future hazard cascade

- Climatological cascade: Long summers ⏩extended heat waves ⏩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
- 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, thunderstorms and mass movements hits the overloaded Alpine transmission grid ⏭flash-over and/or heavy mudflows at two major trans-Alpine highest V-lines⏩black-out at European scale

4 main targets for adaptation in the energy sector

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 [synergies with mitigation targets!]
4. Enable further storage capacities as crucial buffers for the European energy market and to allow for higher shares of RE [synergies with mitigation targets!]

Who should do what to adapt? Private sector responsibilities

TSOs/DSOs:

- Detect vulnerable hot spots in the grid infrastructure
- Retrofit the existing transmission/distribution grid infrastructure
- Build sufficient redundancies
- Install underground cables at vulnerable grid hot spots

Energy companies:

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

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

National policy:

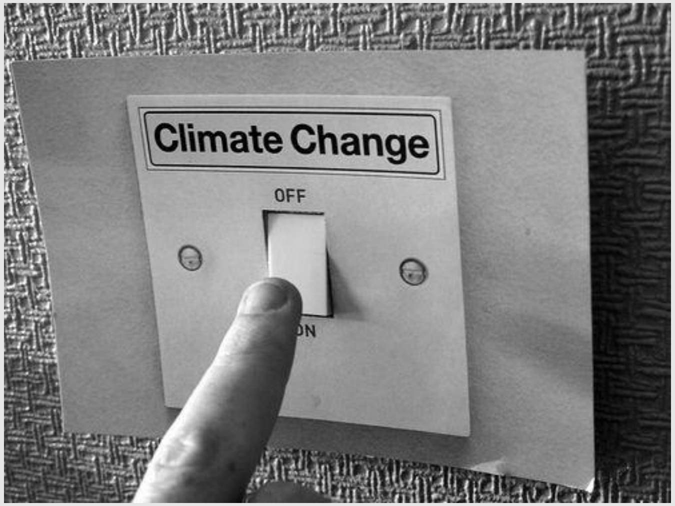
- Elaborate adaptation strategies for the energy sector and support the implementation of measures against a regional background of expected climate impacts
- Ensure that envisaged mitigation targets and according energy mixes are climate-proofed
- Promote energy efficiency and sufficiency by fiscal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

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



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