Climate and Energy Systems

Christoph Töglhofer

Wegener Center
www.wegcenter.at

CZ.AT Winter School

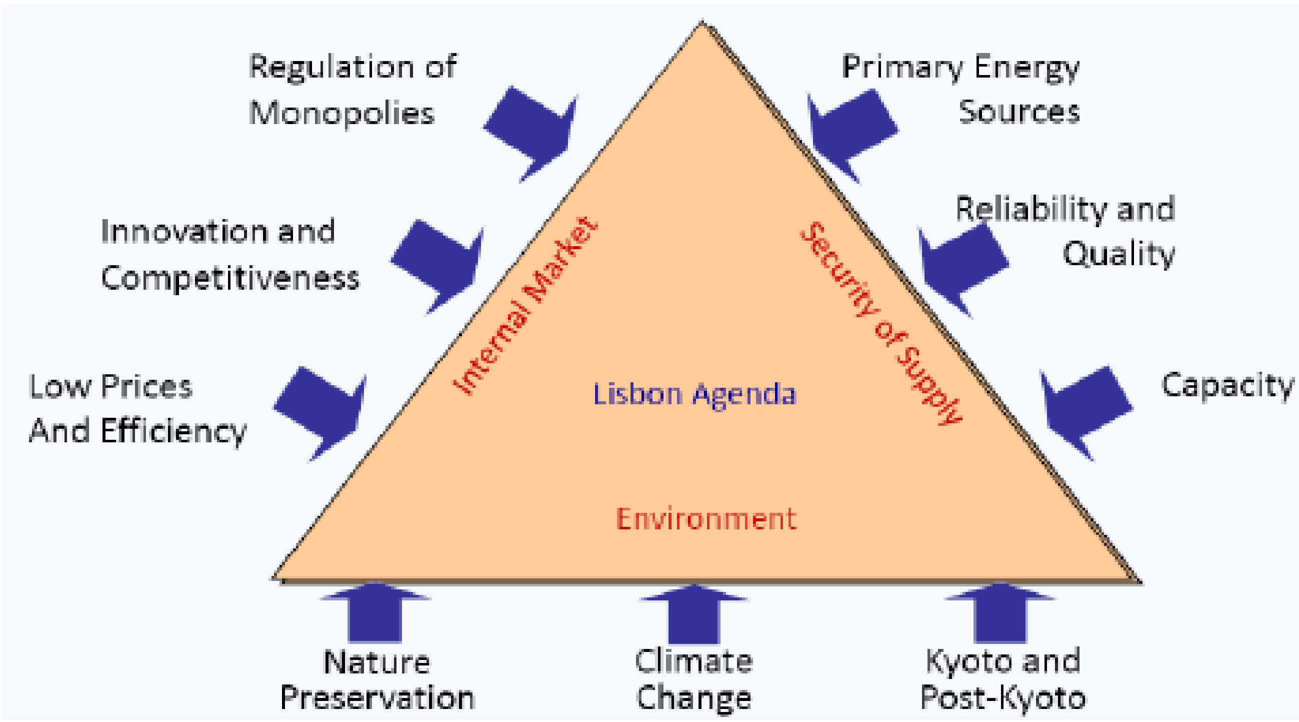
9.2.2012

The importance of climate (change) in energy systems...

- **There is no doubt that climate change is currently the key driver in Energy Research**
  - **Mitigation**
  - Impacts & Adaptation

...but there are other objectives too

➤ Energy Policy in the European Union:



Source: Bellmans (2009) in: Bigano et al. (2009)

OUTLINE

- **1: Climate change**
- **2: Climate and energy systems**
  - **Supply side risks**
  - **Demand side risks**
- **3: Climate change mitigation**

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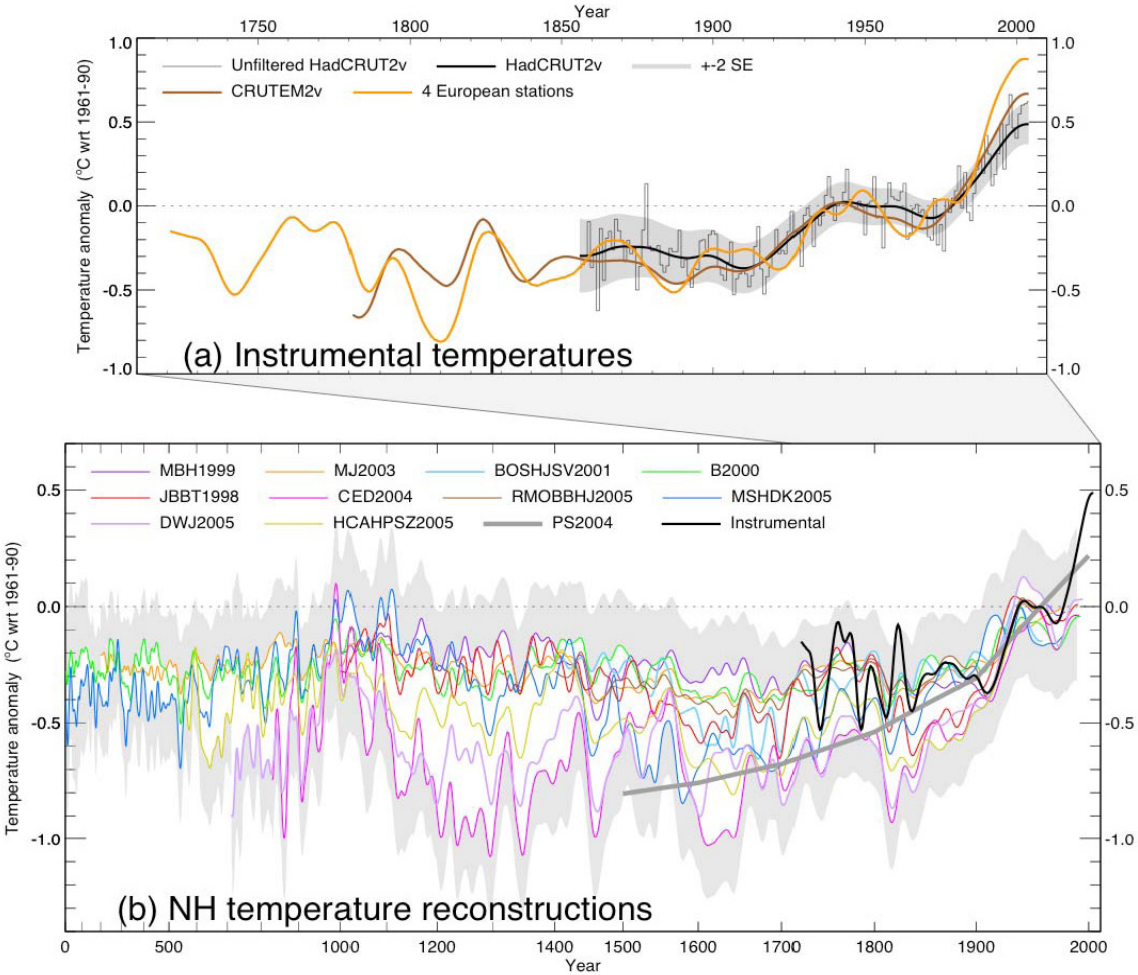
medium climate development



The last millenium:

A lot of „hot air“ in scientific discourse but still the same conclusion: the planet is heating up

(Source: Jansen, Overpeck et al., 2005)

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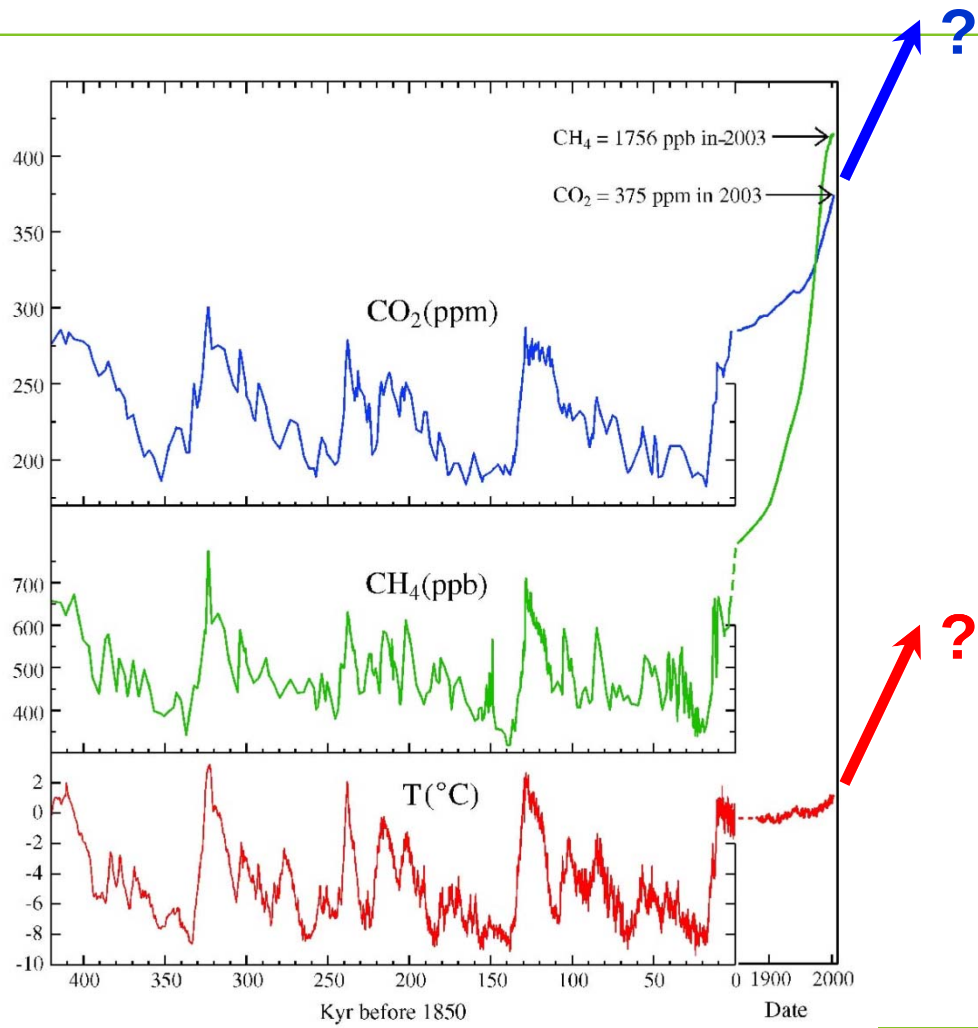
medium climate development



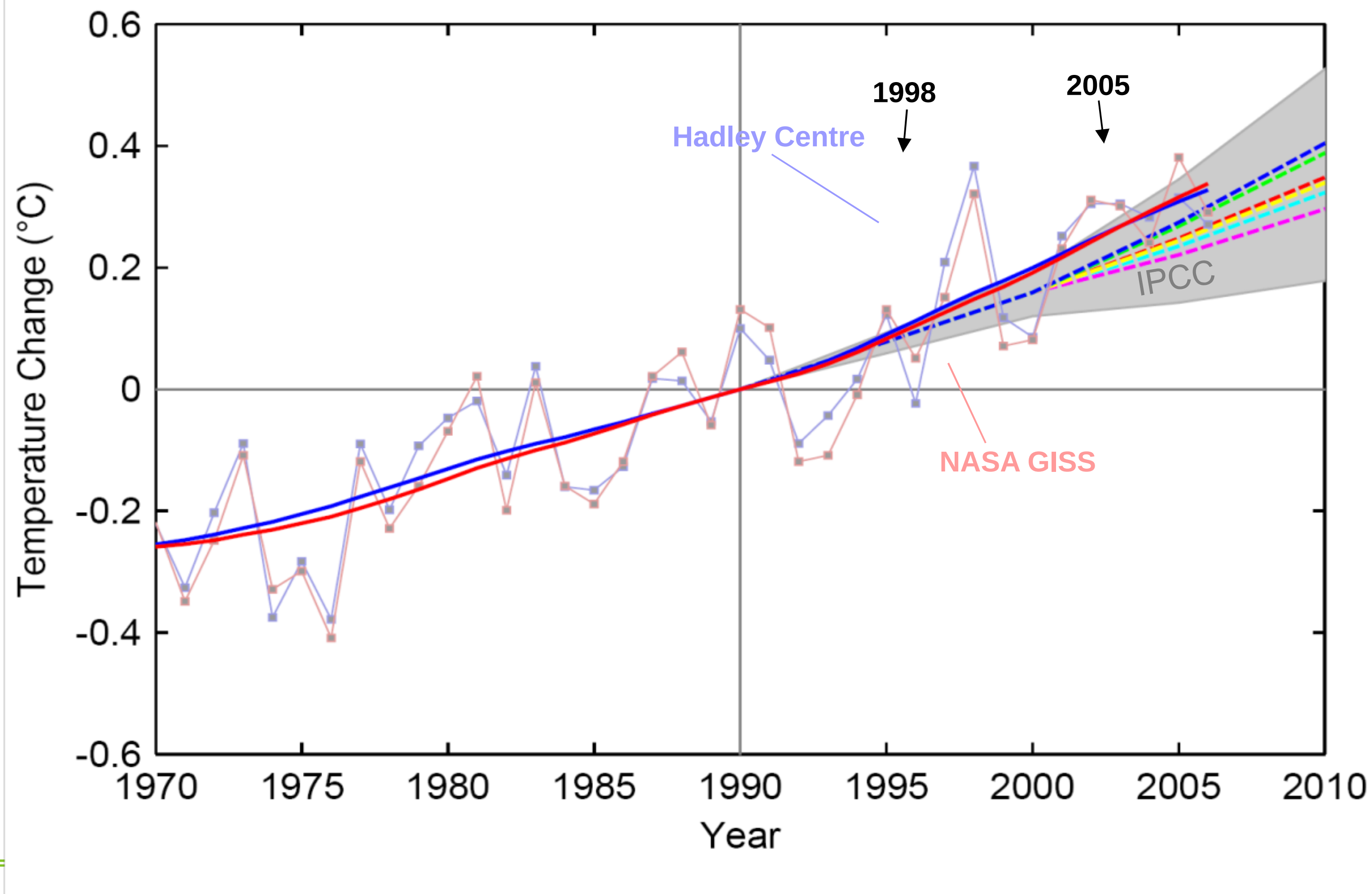
Quo Vadis, earth climate?

After a million years of „well behaved“ oscillations up to the unknown

(Source: Hansen, 2005; on the basis of Petit et al., 1999)

Observed Warming

Climate change projections 1990-2006 from the year 1999 vs. measurements up to 2006



Source: Rahmstorf, Cazenave, Church, Hansen, Keeling, Parker and Somerville (Science 2007)

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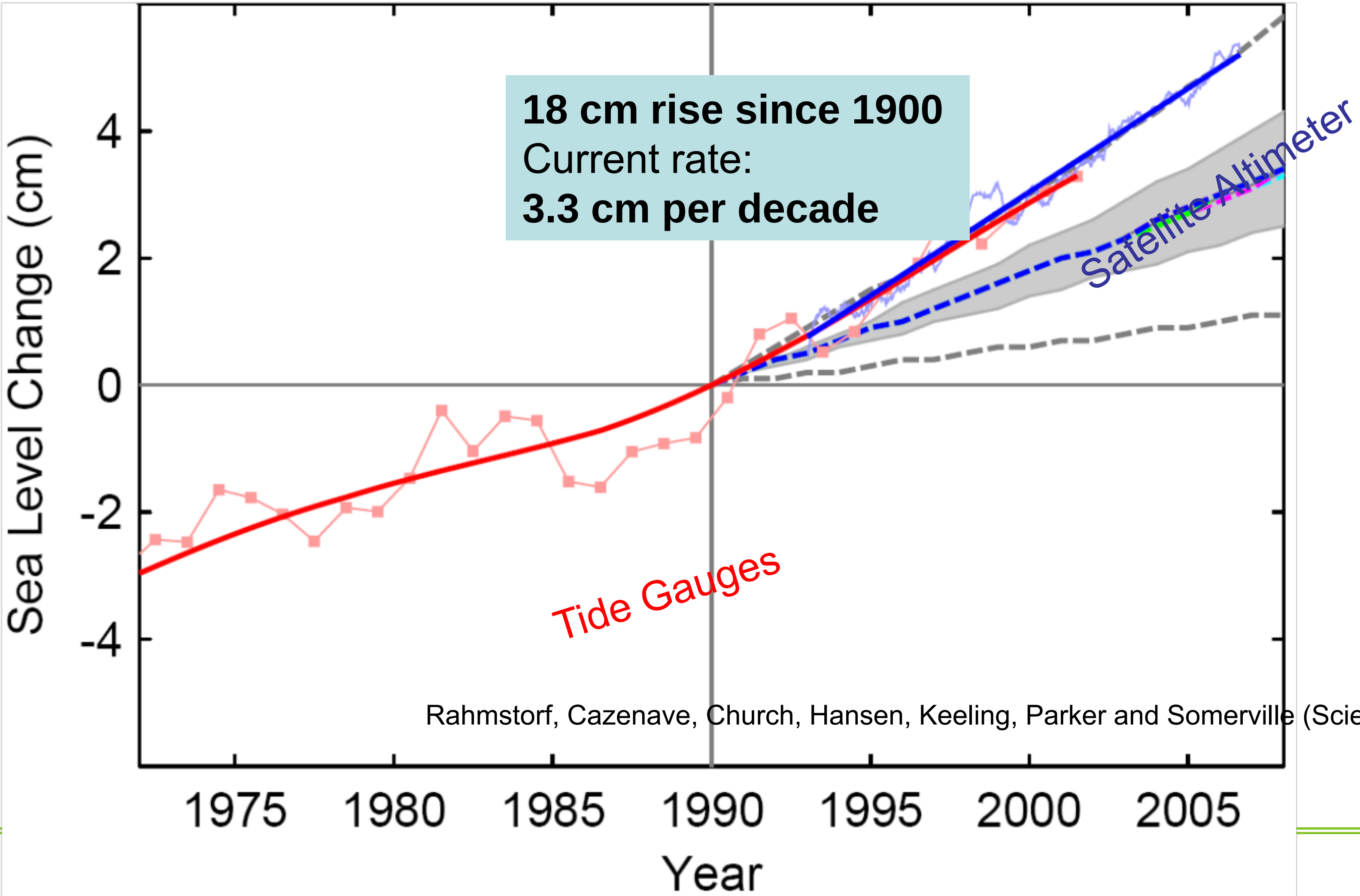
Observed Sea Level Rise

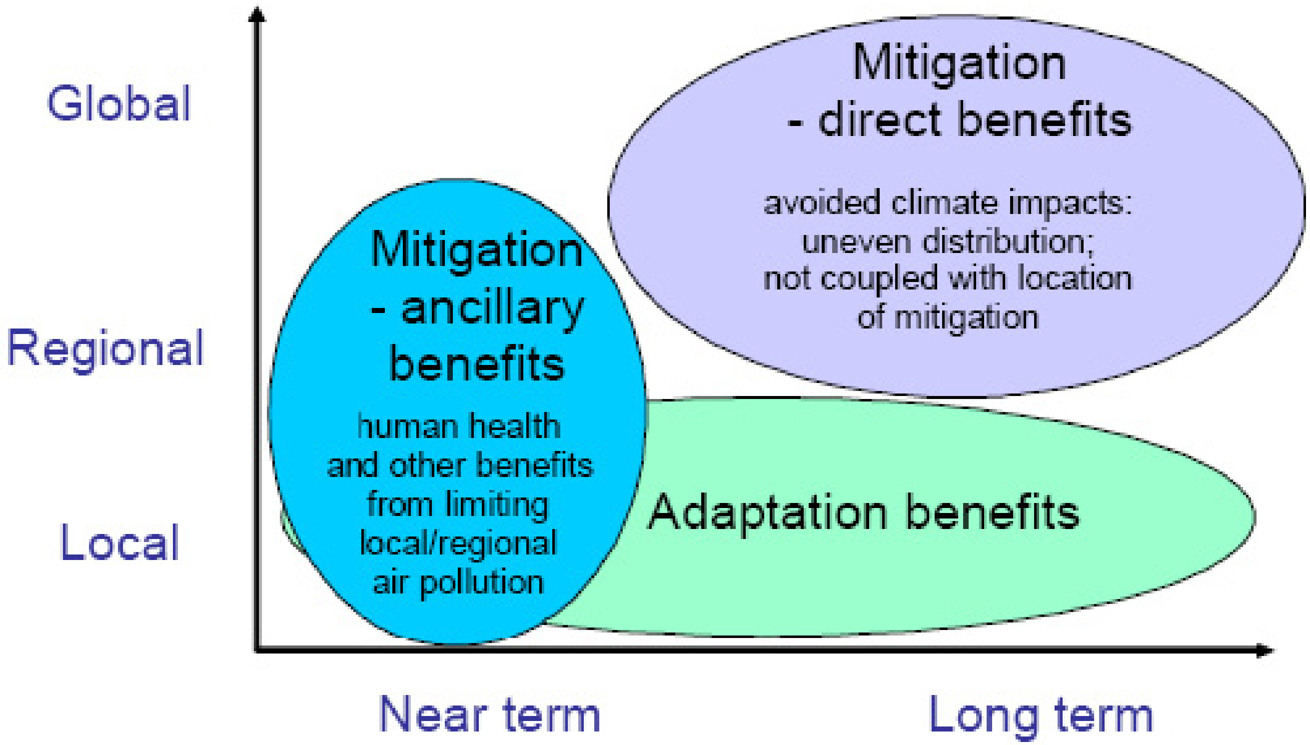


Rahmstorf, Cazenave, Church, Hansen, Keeling, Parker and Somerville (Science 2007)

Mitigation and adaptation: costs and benefits across time and space

In need of both mitigation and adaptation

Incentives differ



(Source: Morlot and Agrawala, 2004)

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How do climate change affect energy systems?

IMPACTS, VULNERABILITY and ADAPTATION

MITIGATION

How do climate change effects companies?

- Regulatory risk – How can the company compete in a carbon-restricted world?
- Supply chain risk – How do regulations affect suppliers?
- Litigation risk – How to avoid the risk of lawsuits (similar to the tobacco industry)?
- Reputational risk – How to show that a company is a „good citizen“?
- PHYSICAL RISKS

On the basis of: Lash and Wellington 2007

Please note:

Climate is what you expect,
weather is what you get!

What could be potential impacts of climate change on the energy system?

Overview

Weather and climate impacts on the sources, use, and transport of energy (DUTTON 2010, p.5):

Activity	Weather, climate & environmental variable
Energy sources	
Fossil sunlight (coal, oil, gas)	Severe weather impacts on drilling and production platforms and facilities, heavy precipitation and floods on mines
Solar power	Insolation as affected by latitude and clouds
Wind power	Wind speed (V^3), icing
Hydropower	Precipitation, evaporation, surface slope
Biomass power	Temperature, precipitation, insolation
Wave and tidal power	Wind
Nuclear power	Earthquakes, severe weather
Energy uses	
Heating	Temperature (HDD), wind speed, insolation, clouds
Cooling	Temperature (CDD), wind speed, insolation, clouds
Illumination	Insolation, clouds
Transportation	Weather related delays and cancellations
Industrial processes	Severe weather, industry dependent effects
Energy transport	
Electrical transmission wires	Wind, icing, lightning, local ground movements, precipitation
Trucks and trains	Severe weather, icing
Ships and barges	Wind and waves, severe weather

Overview

Direct and indirect impacts of changes in meteorological variables (MICHAELOWA et al. 2010, p. 73):

Direct change	Direct impact	Indirect impact	Cross effects
Temperature increase	Heat-wave	Increased electricity demand	
	Glacier melting	Short term increase of water flow, long term reduction	Droughts/floods
		Formation of moraine lakes with outbursts	Floods
		Sea-level rise	Floods
	Increased evaporation[a]	Reduction of stream flow	Droughts
	Stronger cyclones/storms		Floods
Increase in precipitation	Floods		
Decrease in precipitation	Droughts		
Decrease in cloud cover	Increased evaporation	Reduction of stream flow	Droughts
Increase in cloud cover	Decreased evaporation	Increase of stream flow	Floods

[a] Also influenced by changes in wind speed and overall humidity

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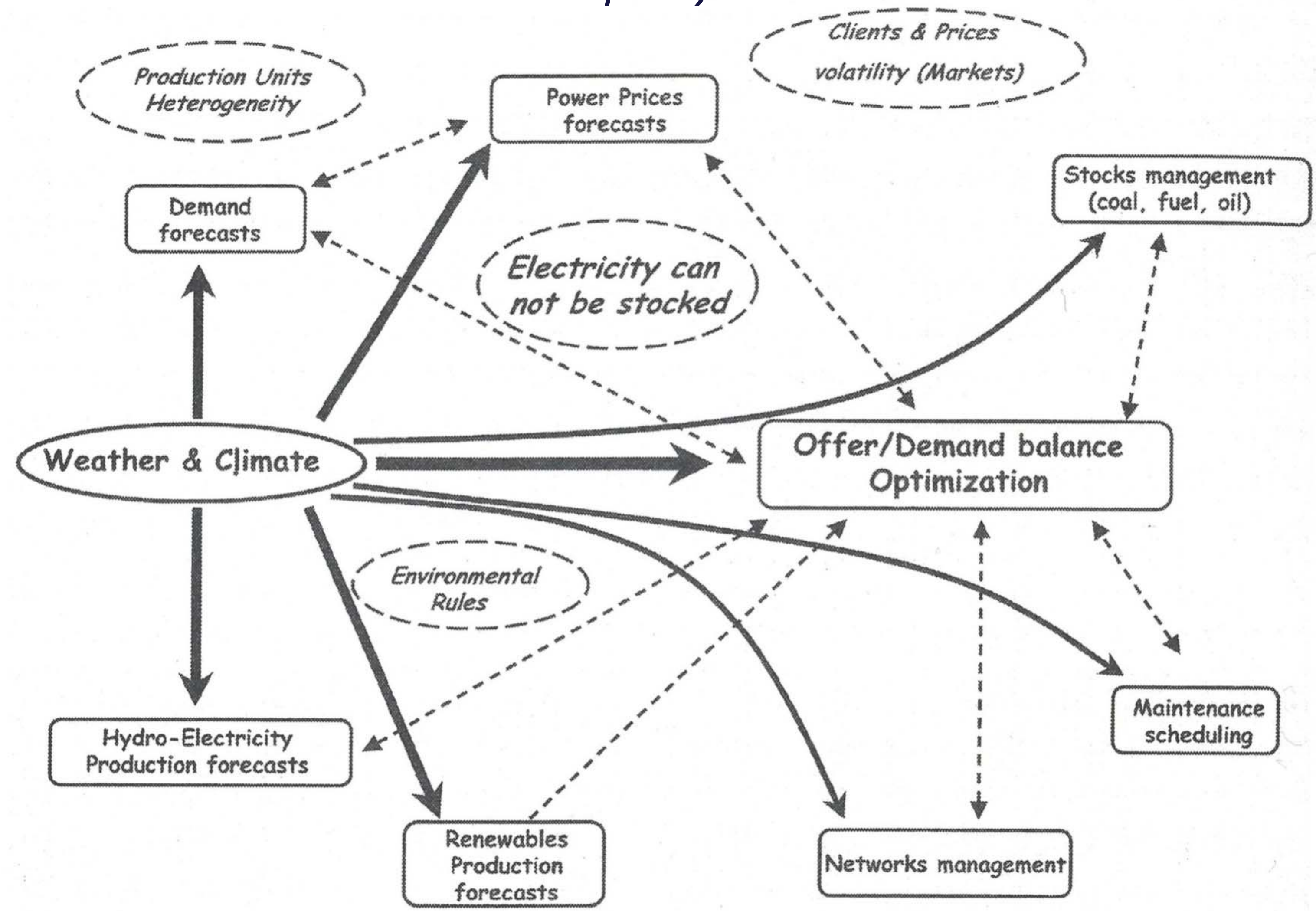
Overview

Direct and indirect impacts of climate on electricity systems (MICHAELOWA et al. 2010, p. 74):

Change in meteorological variable	Impact on electricity transmission	Change of electricity use due to change in meteorological variable
Temperature increase	Some	Increase due to higher cooling needs Decrease if sea-level rise displaces population and industrial production
Decrease in cloud cover	None	Decrease due to reduced lighting needs
Increase in cloud cover	None	Increase due to increased lighting needs
Increased frequency and/or strength of storms/cyclones	Failure of transmission lines	Reduced electricity demand due to damage to houses and factories
Floods	Failure of transmission equipment from flooded power plants	Sharply reduced electricity demand due to interruption of production in flooded factories/cessation of electricity consumption in flooded houses
Droughts	Risk of destruction of transmission lines due to forest fires.	Slightly reduced electricity demand due to interruption of production in factories whose supply of raw materials has been depleted/cessation of electricity consumption in houses of people abandoning the drought area

Overview

Schematic view of the offer/demand balance process and its links with weather and climate (DUBUS 2010, p. 178):



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Climate and Hydro power plants

- Flooding: Impacts on Hydro power plants
- Flooding: Hydro power for adaptation
- Increasing risk of land slides
- Changes in siltation
- Changes in seasonal run-off patterns

Source: ProClim 2003

Melting Glaciers in Austria

1938 **Pasterze**, longest glacier in the Eastern Alps **2003**

Source: www.gletscherarchiv.de

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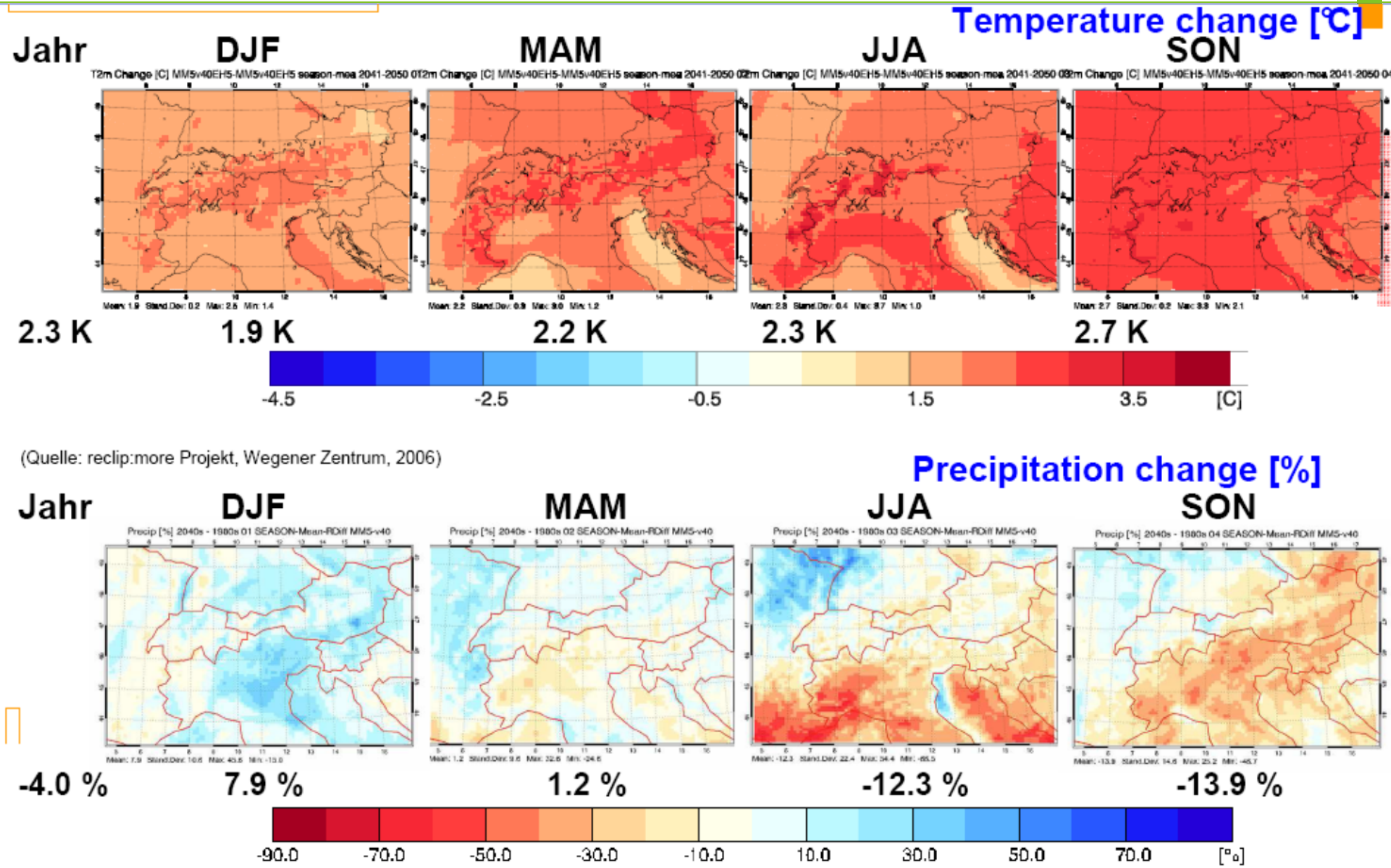
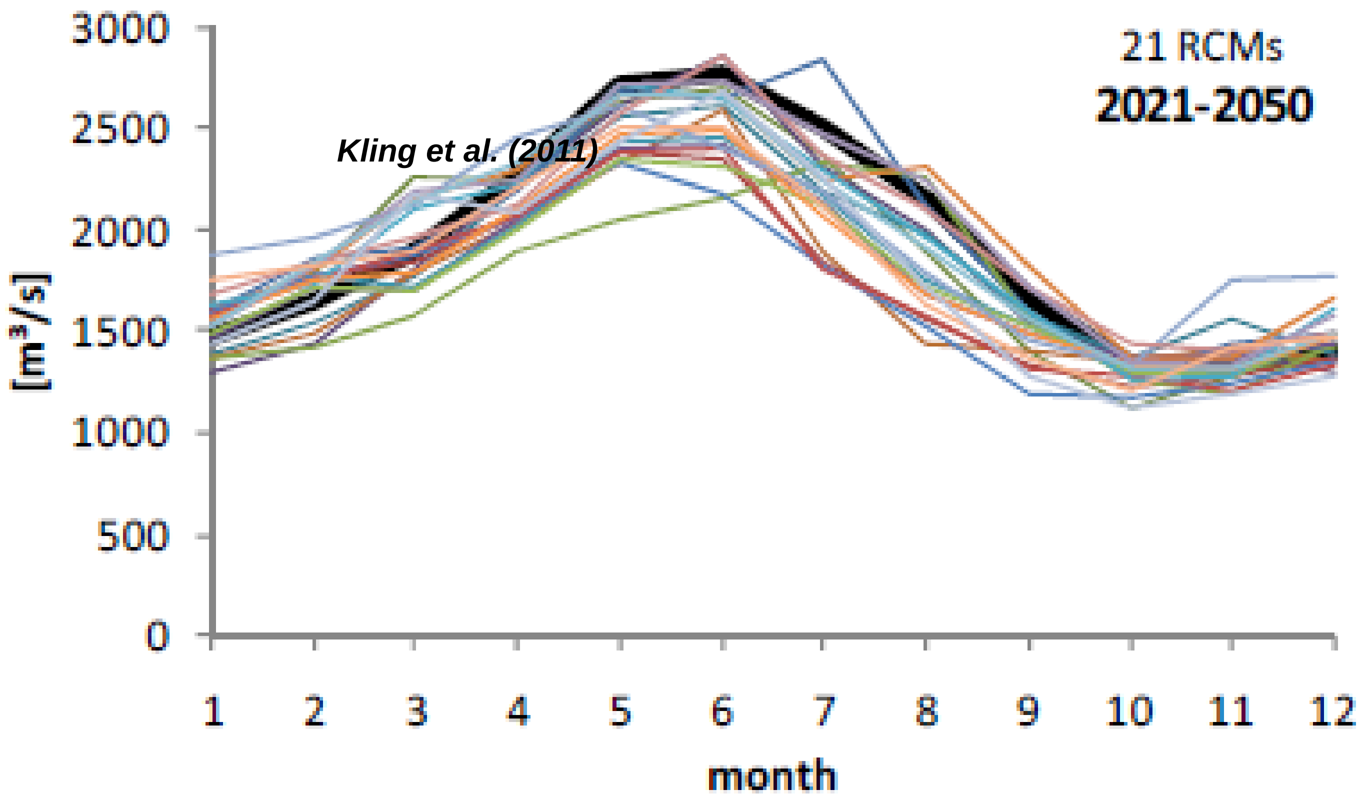
Temperature and precipitation change 1980s to 2040s: (10 km x 10 km resolution)

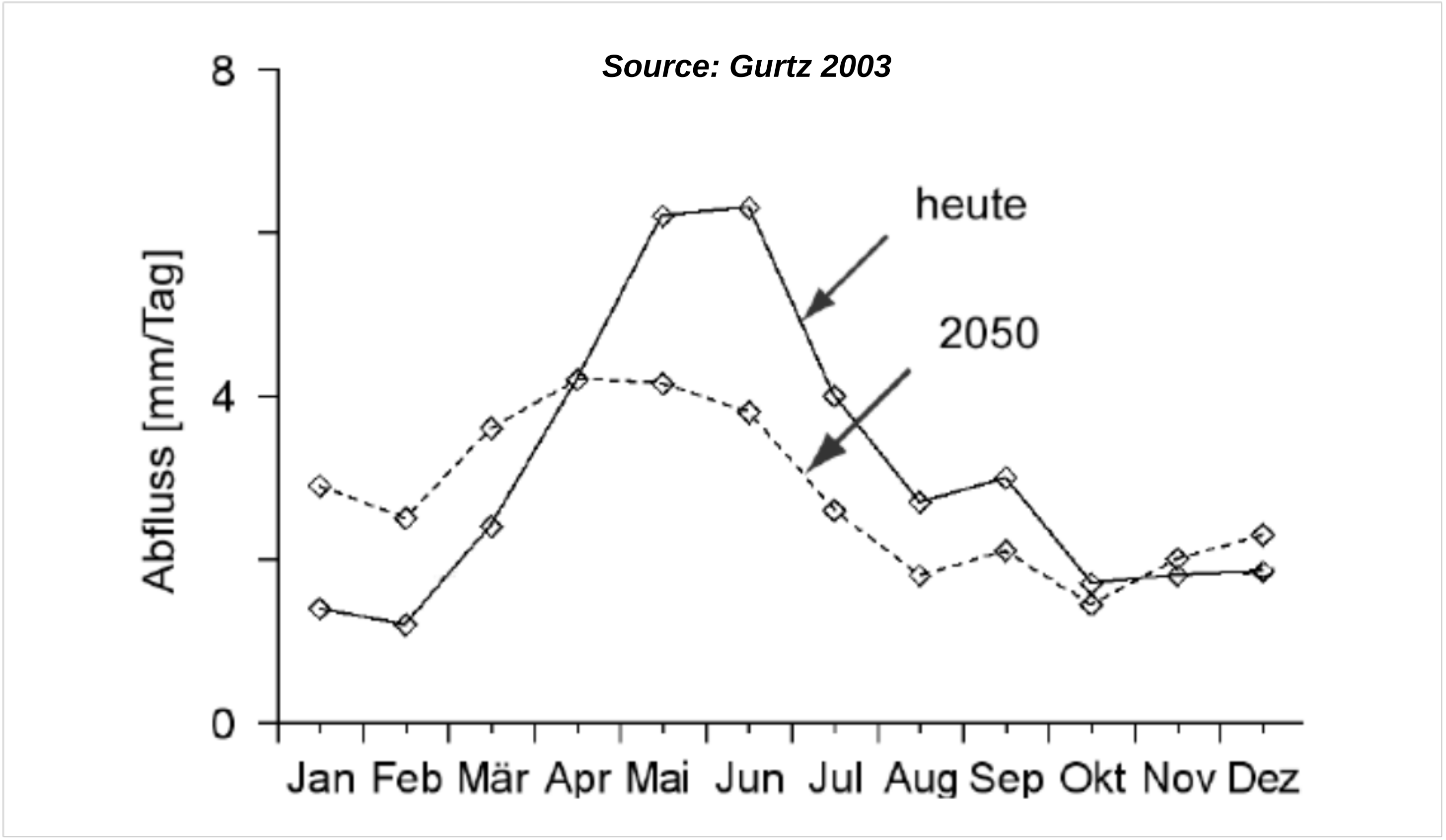


(Quelle: reclip:more Projekt, Wegener Zentrum, 2006)

Example Danube (Kienstock)



Example Stein/Thur (CH)



Mean monthly run off – NEED TO CONSIDER ALSO EXTREME EVENTS!

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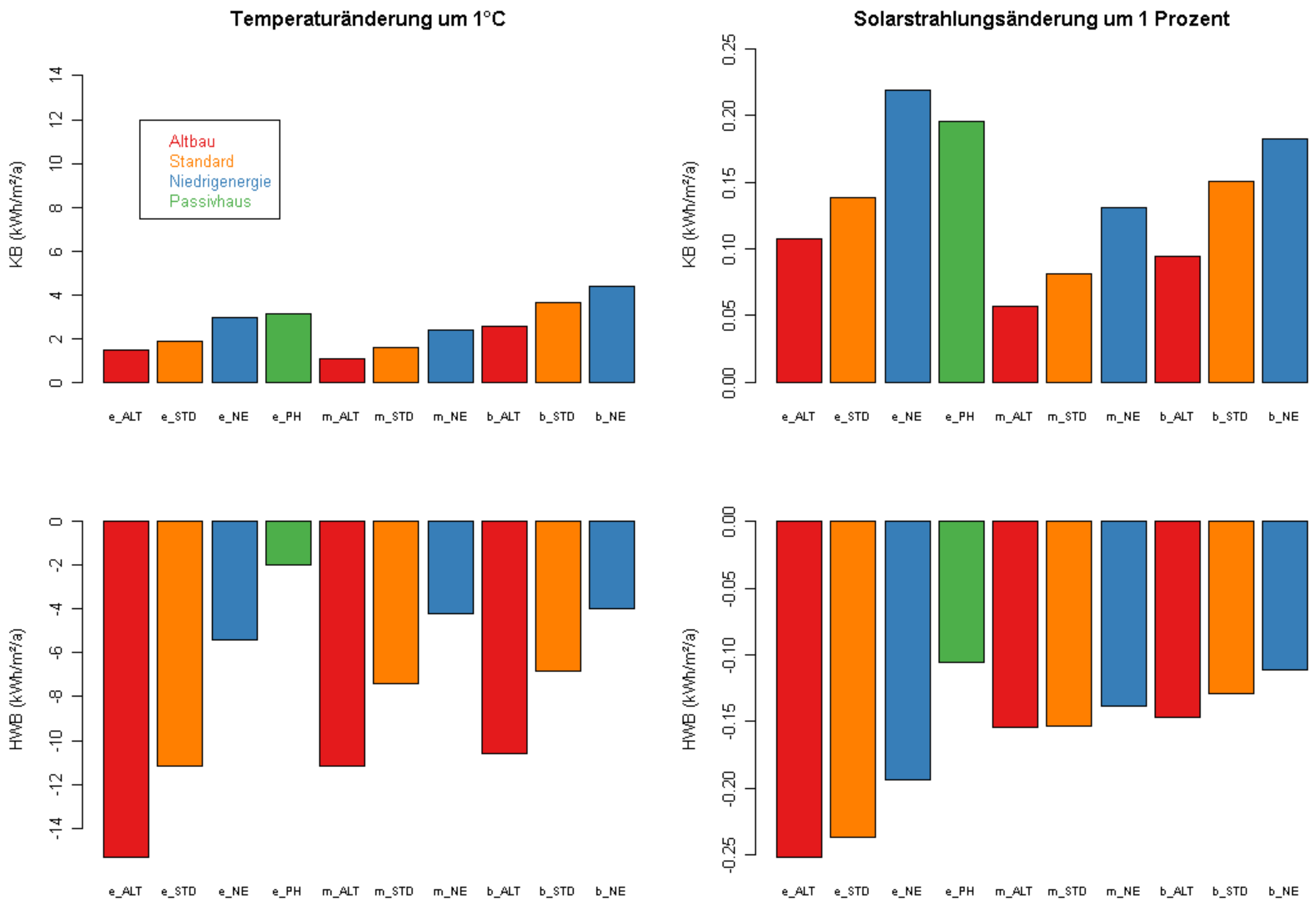
How would you model Climate Change Impacts on Energy/Electricity Demand?

Switch to EL.ADAPT PRESENTATION

How sensitive are buildings?



Source: Toeglhofer et al. (2009)

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Cooling: Residential and commercial AC markets

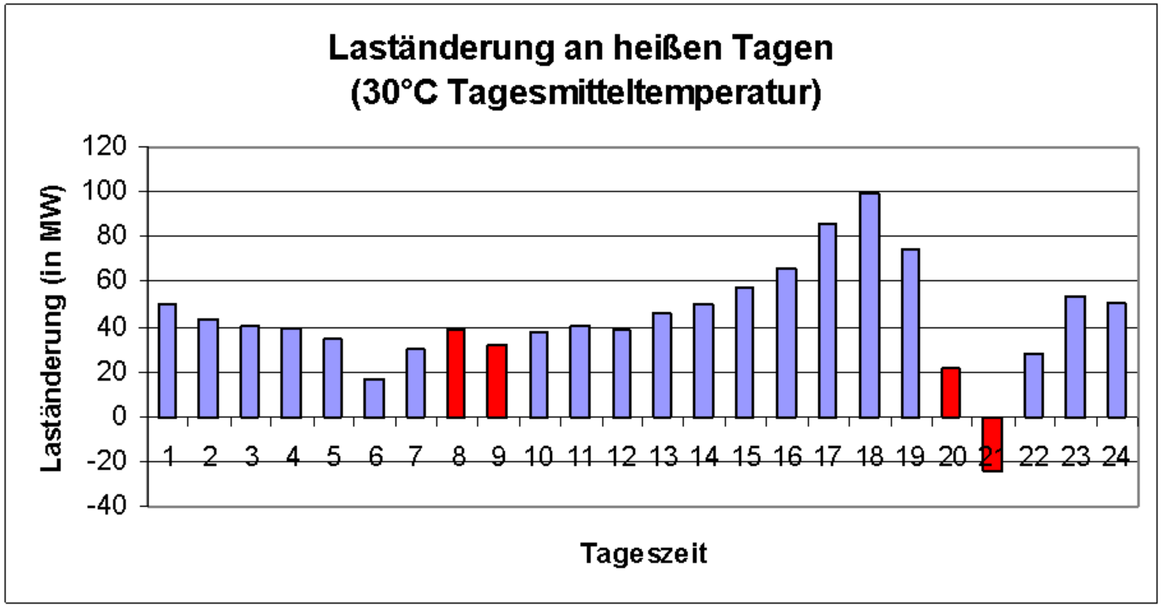
- ***Percentage of Households with Air Conditioning***
- **□□USA 65%**
- **□□Japan 85%**
- **□□Europe 5%**

- ***Percentage of Commercial Buildings with Air Conditioning***
- **□□USA 80%**
- **□□Japan 100%**
- **□□Europe 27%**

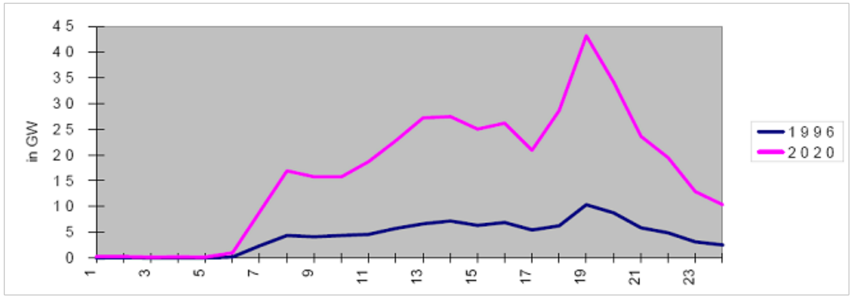
Source*: Centre for Energy Studies 2003 (in: *Paul Waide, IEA 2004)

Cooling: Is it already an issue in Austria?

Source: Klimastudien Land Niederösterreich – Toeglhofer et al. (2008)



Source: Adnot et al. (2003)



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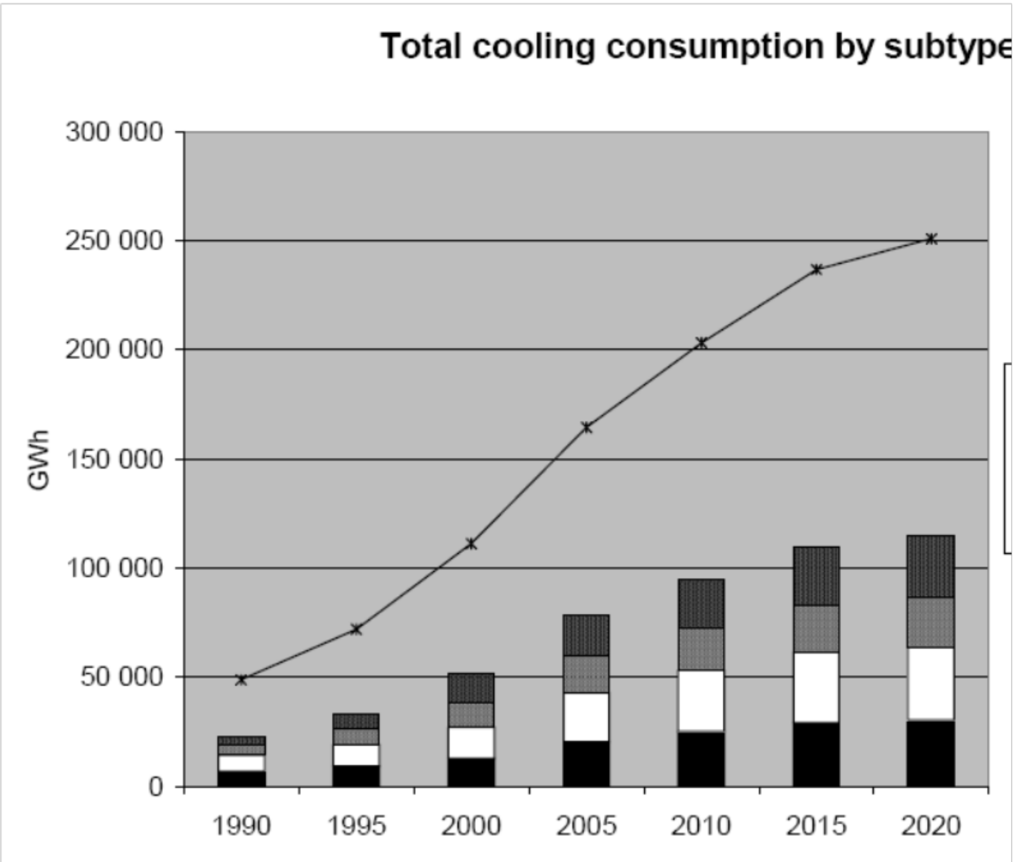
Cooling energy consumption in the EU-15: BAU projection



COMPARE:

Total Austrian electricity demand 2005: 65,747

Austrian emissions 2005: 93 000
Kyoto target: 68 700

CO_2 emissions (in thousand tons)

Total	18 073	27 336	33 154	38 371	40 103

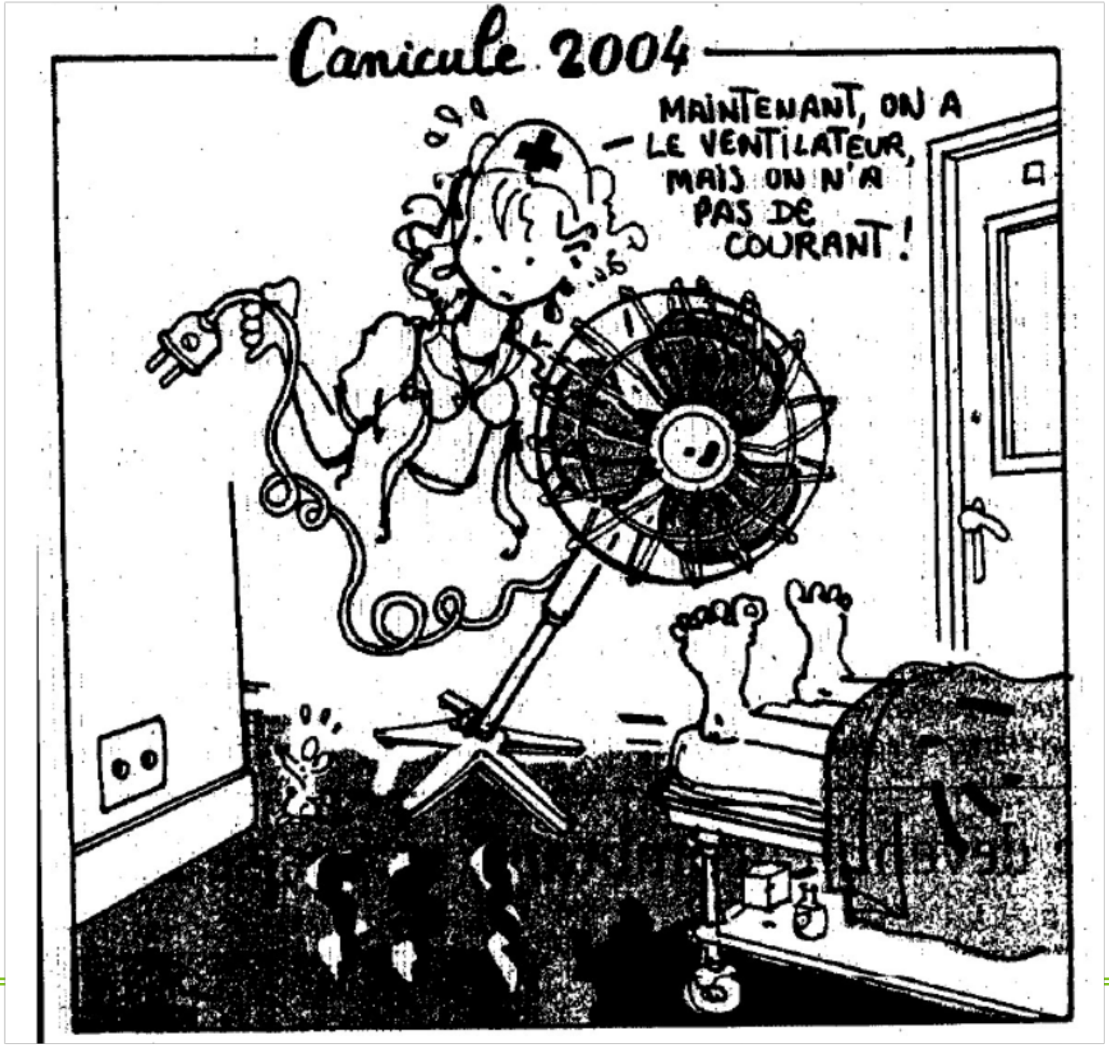
Source: Adnot et al. 2003

Increase in Cooling Degree days, what else matters?

- Increasing affordability of cooling devices
- □□ Shifts in comfort culture, behavioural patterns and consumer expectation
- □□ Increasing internal loads
- □□ Increase in urban heat island phenomenon
- □□ Movement toward universal building designs which are poorly adapted to the local climatic conditions

Source: Paul Waide, IEA 2004

Where are we going?



Source: Le Monde 2003

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Questions? Comments?

THANK YOU!