Climate Change Impacts and Nuclear Energy Supply:

Evidence, Uncertainty and Research Needs

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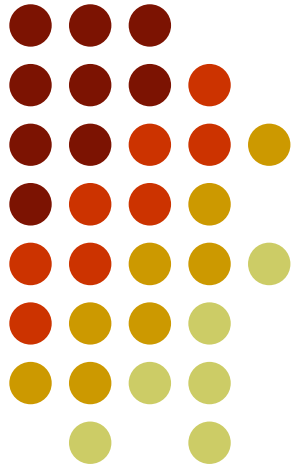

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Direct impacts

Mechanisms of Climate Impacts on Various Energy Supplies in the U.S.

Energy Impact Supplies		*Climate Impact Mechanisms*
Fossil Fuels (86%)	Coal (22%)	Cooling water quantity and quality (T), cooling efficiency (T, W, H), erosion in surface mining
	Natural Gas (23%)	Cooling water quantity and quality (T), cooling efficiency (T, W, H), disruptions of off-shore extraction (E)
	Petroleum (40%)	Cooling water quantity and quality, cooling efficiency (T, W, H), disruptions of off-shore extraction and transport (E)
	Liquified Natural Gas (1%)	Disruptions of import operations (E)
Nuclear (8%)		Cooling water quantity and quality (T), cooling efficiency (T, W, H)
	Hydropower	Water availability and quality, temperature-related stresses, operational modification from extreme weather (floods/droughts), (T, E)

Direct impacts 2

Mechanisms of Climate Impacts on Various Energy Supplies in the U.S.

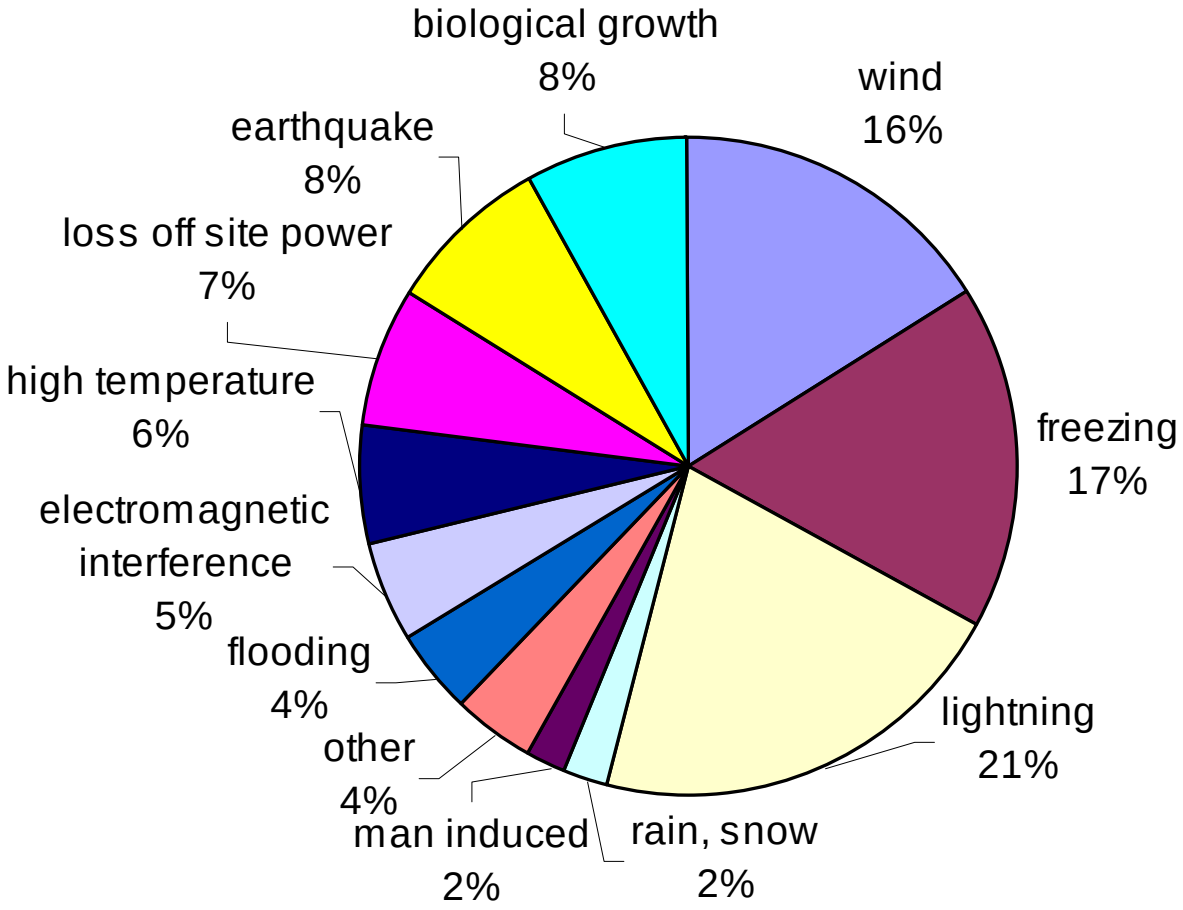
Renewables (6%)	Biomass	
	• Wood and forest products	Possible short-term impacts from timber kills or long-term impacts from timber kills and changes in tree growth rates (T, P, H, E, carbon dioxide levels)
	• Waste (municipal solid waste, landfill gas, etc.)	n/a
	• Agricultural resources (including derived biofuels)	Changes in food crop residue and dedicated energy crop growth rates (T, P, E, H, carbon dioxide levels)
	Wind	Wind resource changes (intensity and duration), damage from extreme weather
	Solar	Insolation changes (clouds), damage from extreme weather
	Geothermal	Cooling efficiency for air-cooled geothermal (T)

Source: CCSP, 2007

Impacts on nuclear energy

- Water availability and cooling
  - 1 kWh – 95 l water
  - 5.5 ° C ↑ – 3-4% ↓ in power output of a gas turbine
- Floods from rivers, precipitation
- Leakage from groundwater
- Other – ice intake, biological fooling, salt
- Low temperatures
- High temperatures
- Storms – energy infrastructure

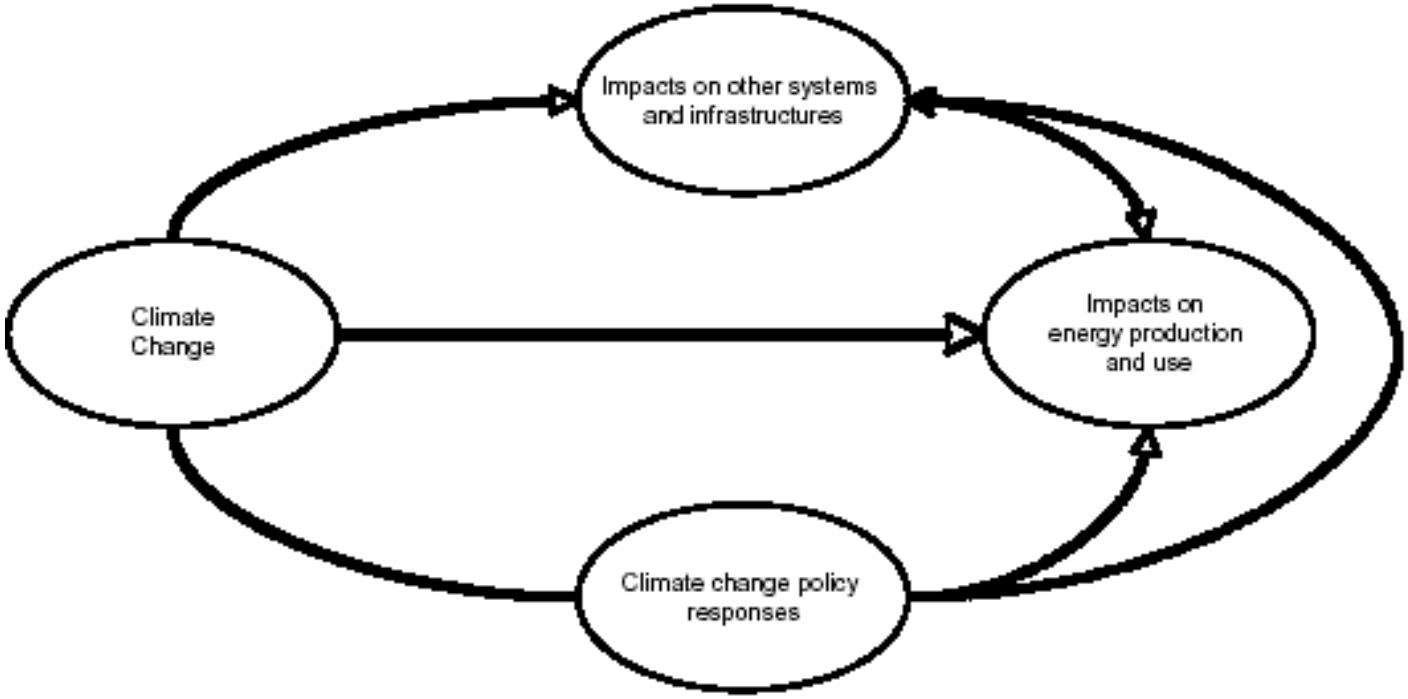
IAEA database



Research projects

- Technical Research Centre of Finland, Finnish Meteorological Institute 2007-2009
  - frequency (return periods and probabilities) of extreme weather conditions, combinations of dangerous weather events in Finland, occurrence in the future
- CLAVIER project, 6th FP, 2007-2009
  - economic impacts of climate change on nuclear energy production in Bulgaria based on climate projections with very high detail

Indirect impacts



Source: CCSP, 2007, p. 82

Overview of knowledge in the U.S.

Indirect Effect On Energy Systems	From Climate Change	From Climate Change Policy
On energy planning and investment	Very limited	Considerable literature
On technology R&D and preferences	Very limited	Considerable literature
On energy supply institutions	Very limited	Limited
On energy aspects of regional economies	Very limited	Some literature

Overview of knowledge in the U.S.

Indirect Effect on Energy Systems	From Climate Change	From Climate Change Policy
On energy prices	Almost none	Considerable literature
On energy security	Almost none	Very limited
On environmental emissions from energy production/use	Very limited	Considerable literature
On energy technology/ service exports	Almost none	Very limited

Research needs

- Hazards related to extreme events for reactors and nuclear waste sites
- Combined effects of several extreme events occurring simultaneously
- Indirect impacts
- Economic impacts – methods:
  - valuation of non-market goods, discounting
  - general equilibrium models and input-output models
- Adaptation strategies

Thank you!

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