Foreword to the special issue: climate change, extremes, and energy systems

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Due to the immense inertia of the Earth's biogeophysical system, a considerable degree of climate change is unavoidable even if very ambitious efforts are made to curb greenhouse gas emissions over the next few decades (IPCC 2007). Climate change is already shifting the patterns of some types of extreme events in many world regions, and further changes are projected in the nature, magnitude, and frequency of different extreme weather events as climate change unfolds (IPCC 2012). Shifting patterns of extreme weather events have the potential to exacerbate existing risks and spawn new threats for energy installations and infrastructure. This Special Issue addresses key scientific and policy issues related to climate change, weather extremes, and energy systems by examining the exposure and vulnerability of different components of the energy system and options to reduce vulnerability and adapt to those impacts.

While the impacts of non-weather-related natural hazards on energy systems are reasonably well-understood, and some initial assessments of climate change impacts have been made as referenced in this Special Issue, there are still many open issues that need to be explored in order to consider and apply the emerging knowledge in national climate change adaptation and energy planning. The scientific importance and timeliness of these issues is demonstrated by the fact that the IPCC Special Report on “Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation” confirmed that over the 21st century the frequency and magnitude of warm daily temperature extremes will increase at the global scale, the frequency of heavy precipitation or its share in total precipitation will increase in many areas, and the average tropical cyclone maximum wind speed is likely to increase, although increases may not occur in all ocean basins (IPCC 2012). There is less certainty about the patterns and degrees of changes in other extreme events, but the threats for the energy sector may well increase.

The policy relevance of exploring these issues is apparent from the fact that, according to the 2012 World Energy Outlook of the International Energy Agency, globally USD 37 trillion (in 2011 dollars) will need to be invested in energy systems between 2012 and 2035 (IEA 2012). Many of the new installations and infrastructures will be subject to significantly

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changing weather patterns over their multi-decade lifetime. Over 60 % of this investment will be required in non-OECD countries, mostly in new facilities to satisfy fast increasing energy demand. It will be particularly important to implement these investments in a climate-resilient manner by considering possible threats from gradual climate change and changing patterns of extreme weather events in infrastructure siting, design parameters, technical choices, and protection provisions.

This Special Issue draws on the work of scientists and experts from climate science, energy systems, and risk assessment to provide an overview of the state-of-the-art in the relevant fields and a platform for exploring linkages and for synthesizing knowledge across the above domains.

This Special Issue addresses the following general topics:

- state of the scientific knowledge and current uncertainties about the changes in the nature, magnitude, and frequency of extreme events triggered by anthropogenic climate change, as well as their formulation for use in impact and risk assessments for energy systems;
- impacts of climate change and extreme weather events on energy installations and energy supply infrastructures;
- technological options and policy strategies to reduce exposure and vulnerability and to increase the resilience of energy systems to weather-related and non-weather-related hazards.

The impacts of climate change and extreme weather events (including temperature, precipitation, wind; tropical cyclones, floods, droughts, coastal storm surges (also considering sea-level rise); wildfires, landslides) are evaluated for key components of the energy system:

- coal fuel cycle, on both front end (mining, storage and transport) and back end (waste management and carbon dioxide capture and storage);
- oil and gas sector (extraction, transport, processing, delivery);
- thermal power plants (fuelled by coal, oil, gas);
- hydropower (dams, water supply, power plant operation);
- solar energy (solar heating, photovoltaic technologies, concentrating solar power);
- wind power (offshore, onshore); and
- electric grid (transmission, distribution, transformation).

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