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IMPACTS OF CLIMATE CHANGE ON ENERGY INFRASTRUCTURE AND OPERATIONS – INSIGHTS FROM RESEARCH AND PRACTICE

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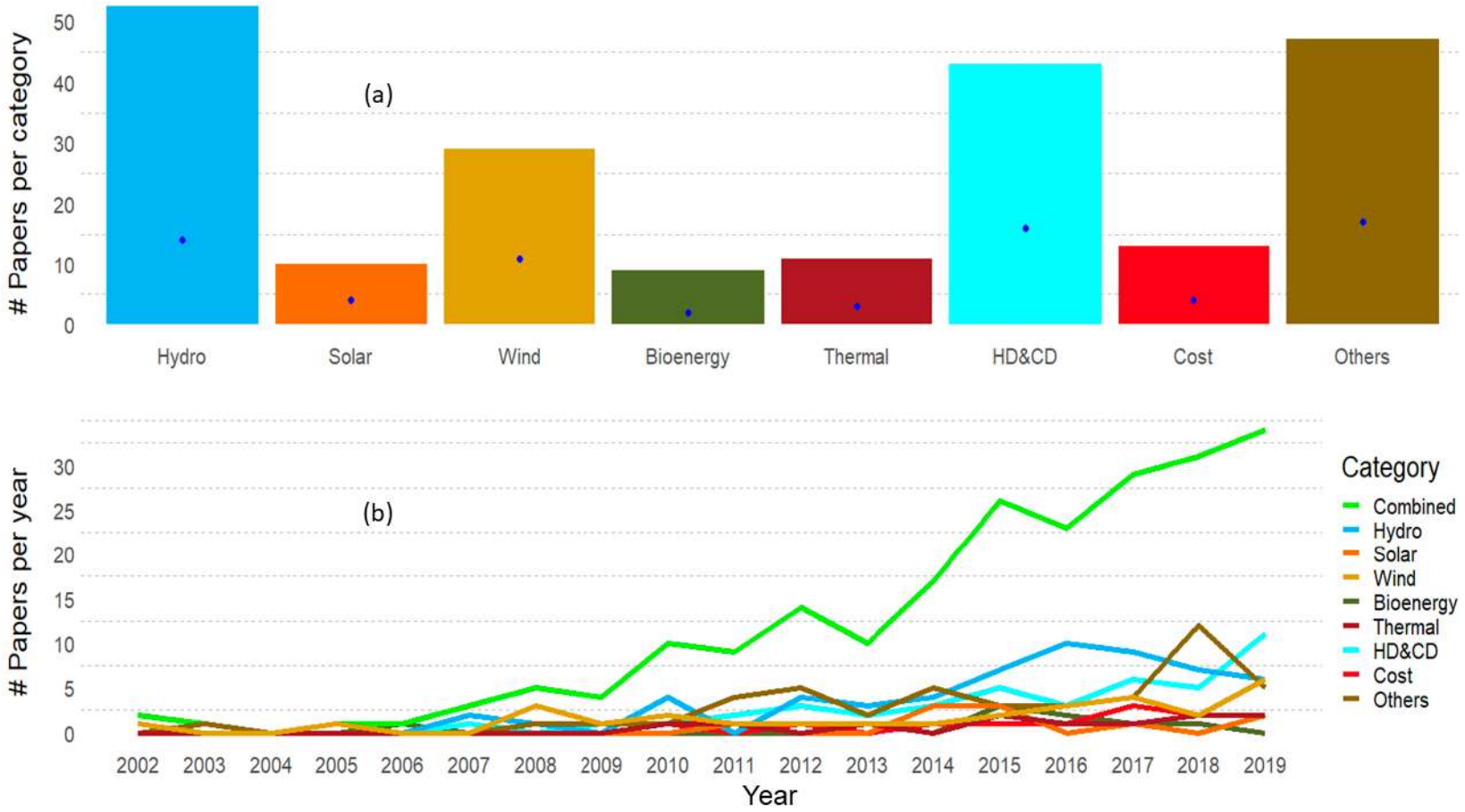
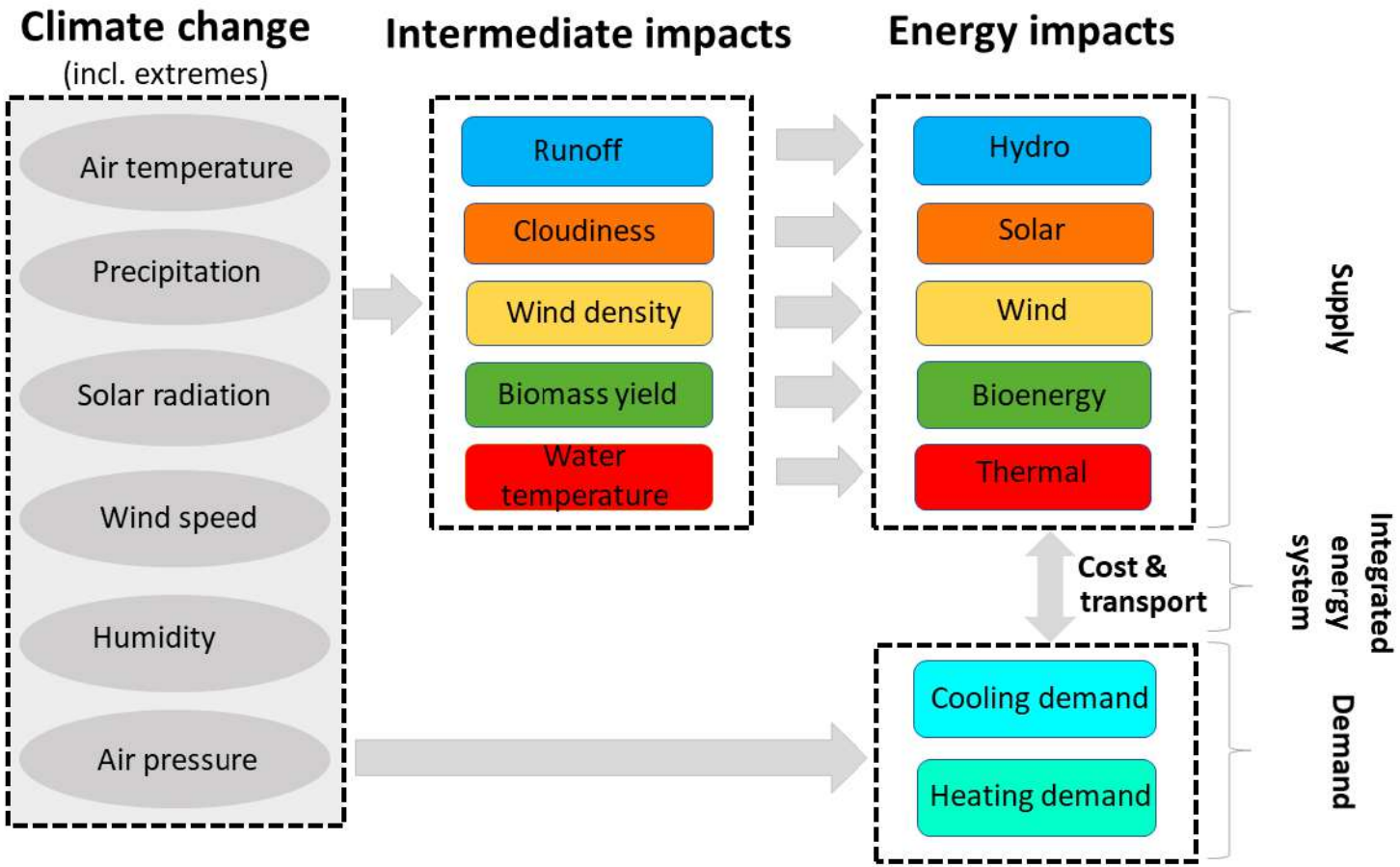
14 March 2022

Research activity has increased, evidence base is much stronger.



Yalew et.al., 2020, Nature Energy

The complex web of climate impacts



Yalew et.al., 2020, Nature Energy

Severity by stakeholder over the short term (2 years)

Source: Global Risk Report 2023

Climate risks are already material to Europe's energy security

France

France became a net energy importer in 2022 for the first time in 42 years. Prolonged drought conditions led to severe water shortages used in the cooling of nuclear plants. France's nuclear outputs plunged by 23% in 2022.

Spain

In 2022, the cumulative impact of heatwaves, record summer temperatures and dry weather led to a 48% drop in Spain's hydropower capacity.

Germany

The 2021 European floods damaged a considerable number of German power utilities. Over 200,000 people were impacted by power outages. RWE, a major producer, reported damages in the double-digit million Euro range.

Italy

Northern Italy was hit by hurricane-force snow winds for 3 days in 2018. The storm damaged electric transmission and distribution systems, causing over 90 blackouts, and a 5000MW gap in power supplies.

Climate risks will escalate

In 2020, 87% of global power generated from thermal, nuclear and hydroelectric systems directedly depended on water availability

Climate impact	Effects on generation	Effects on transmission and distribution	Effects on demand
Rising global temperatures	• Cooling efficiency • Generation potential • Need for additional generation	• Efficiency	• Cooling and heating
Changing precipitation patterns	• Output and potential • Peak and variability • Technology application	• Physical risks	• Cooling • Water supply
Sea-level rise	• Output • Physical risks • New asset development	• Physical risks • New asset development	• Water supply
Extreme weather events	• Physical risks • Efficiency	• Physical risks • Efficiency	• Cooling

Source: International Energy Agency, Climate Resilience Electricity Security 2021

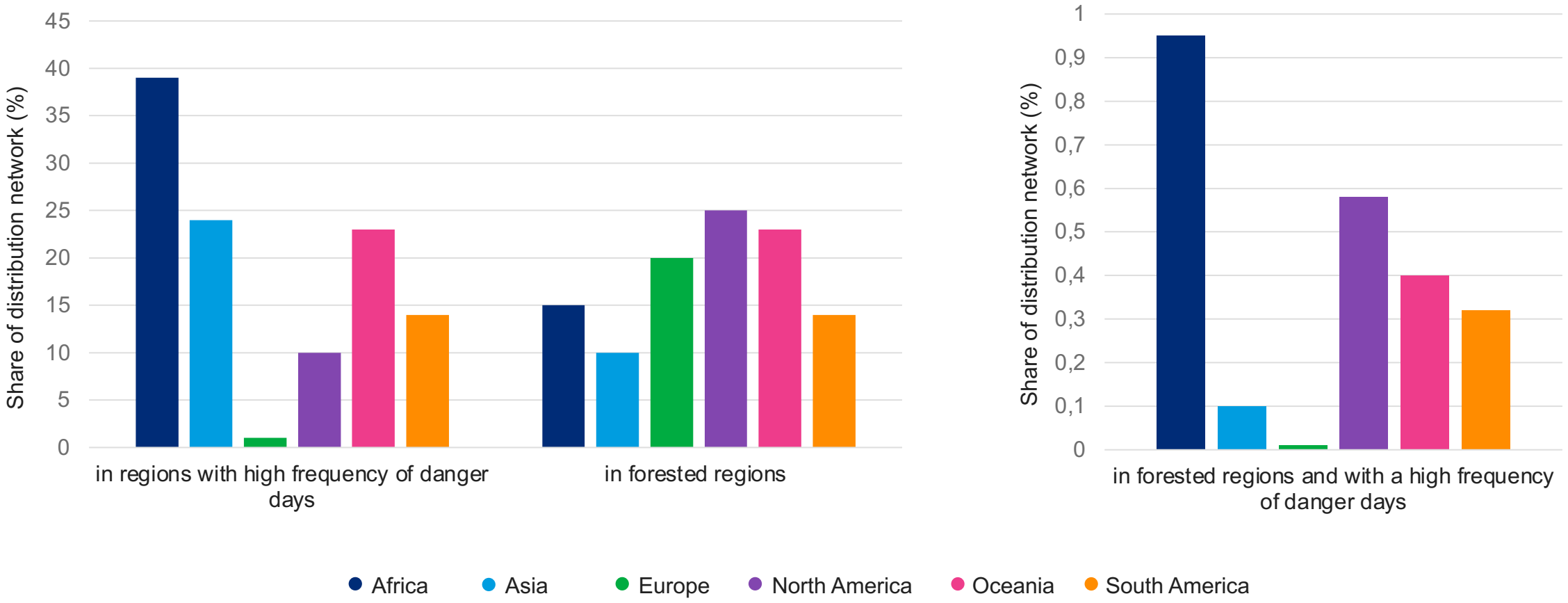
According to Marsh McLennan's Flood Risk Index, over a quarter of Europe's power generation capacity may be affected by floods under 2.0 and 3.5℃ conditions

	Present Conditions	2 °C	3.5 °C
Global	23%	41%	48%
EU	**7%**	**28%**	**29%**
United States	23%	36%	41%
United Kingdom	5%	16%	18%

Source: Marsh McLennan, Flood Risk Index

European energy systems are at relatively low risk of fires

Regional share of distribution networks at fire risk due to both weather and fuel availability



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Source: International Energy Agency, Climate Resilience Electricity Security 2021

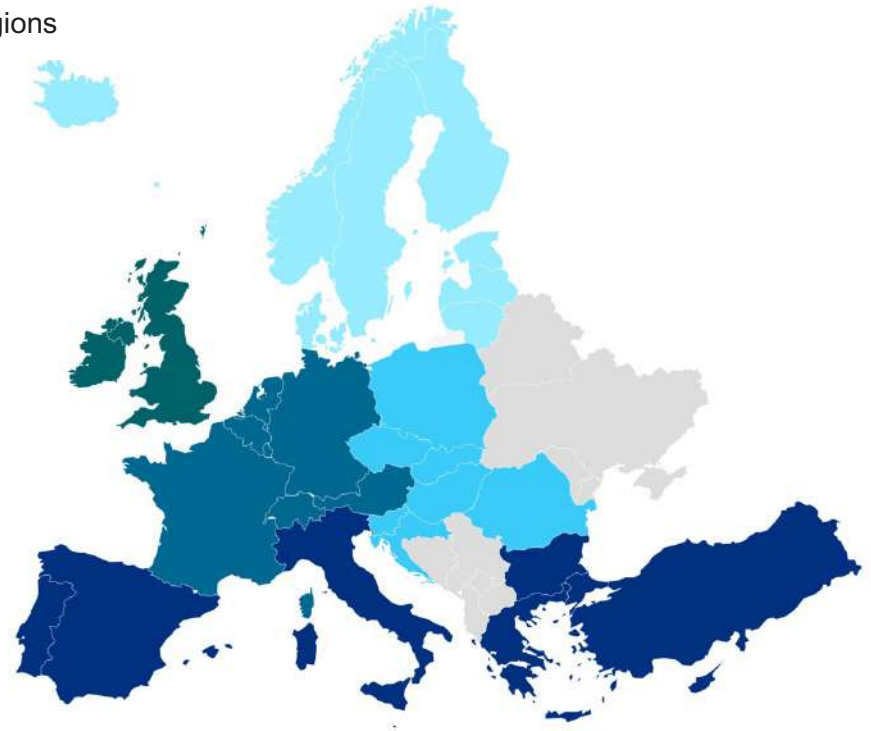
Impacts of climate on European energy systems

Across Europe

- ⊕ Heating and cooling demands for regions except the South
- ⊖ Transmission and distribution grids across all regions

Legend

- ⊖ Predominantly adverse impacts
- ⊕ Predominantly beneficial impacts



British Isles

- ⊖ Offshore energy production, coastal energy infrastructure, electrical substations

Central Western Europe

- ⊖ Offshore energy production, thermal power plants, electrical substations

Northern Europe

- ⊕ Hydropower, offshore wind power, biomass energy
- ⊖ Offshore energy production, coastal energy infrastructure, oil and gas transport

Central Eastern Europe

- ⊖ Thermal power plants, electrical substations

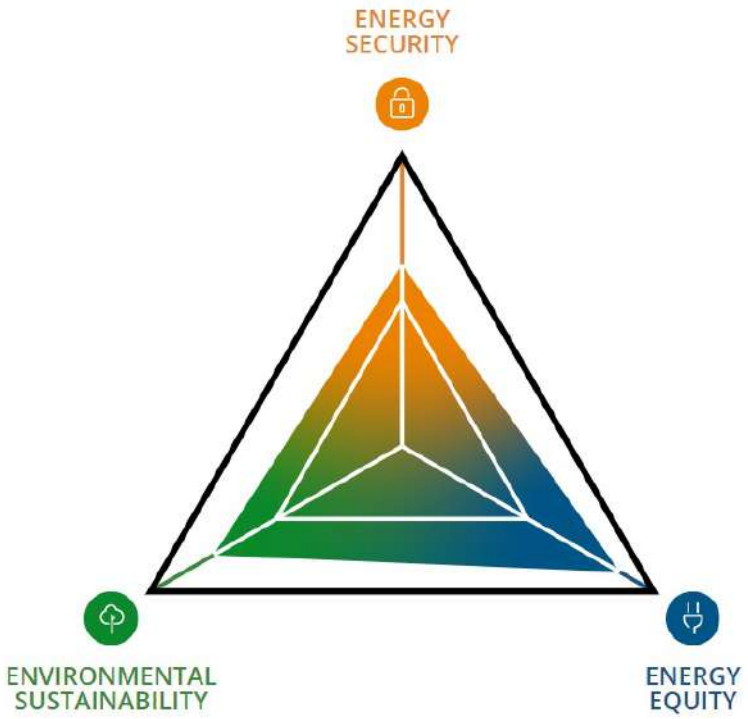
Southern Europe

- ⊖ Hydropower, solar power, biomass energy
- ⊖ Thermal power plants, pumped hydro storage, peak electricity demand, energy demand for desalination

Source: European Environment Agency, 2019

Risk hotspots for Europe’s energy transition

Understanding energy resilience through the lens of the energy trilemma



	Definition	Risk hotspots
Security	Capacity to meet current and future demand reliability, and rebound swiftly from disruptions	Impacts from climate change are increasingly disruptive to energy systems, including renewables
Equity	Ability to provide universal access to affordable and abundant energy	Decreased energy outputs and high oil and gas costs from the Russia-Ukraine conflict leading to decreased energy affordability and availability
Sustainability	Transition of an energy system to mitigate and avoid environmental harm and climate change impacts	According to the latest Global Risks Report, the unfettered rollout of renewable energy sources can lead to unintended costs to nature, which compound climate effects

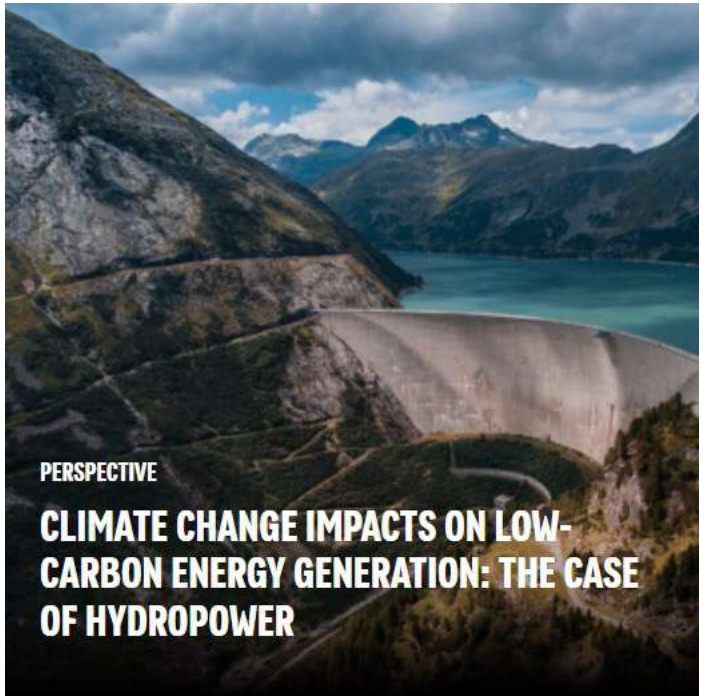
Impact of climate change on hydropower

61% of hydropower dams worldwide will be in river basins with high to extreme risk of water scarcity, floods or both by 2050

Global hydropower exposed	Floods	Water Scarcity
2050	57%	32%

Source: WWF, Water Risk Filter

- Hydropower is the EU's second largest renewable energy source, accounting for 33% of renewable energy and 17% of all EU energy
- Dams in Spain and Bulgaria stand at some of the highest risks of water scarcity globally, while flood risks remain high for dams in Ireland
- In 2022, extreme heat and droughts reduced hydroelectricity output in France and Spain by 30% and >50% respectively
- **Way forward**: assessing the EU's hydropower exposure to climate risks, bolstering resilience efforts, and strategically diversifying renewable sources

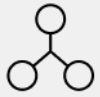


Building climate-resilient energy systems

Energy security is still a low priority for adaptation; as of 2020, only 40% of global NDCs prioritize adaptation in the energy sector

Enhance preparedness

Mitigate the impacts of climate risks through early action, strategic reinforcements, and stakeholder engagement



Incentivize data sharing across stakeholders to improve existing climate models, identify and prioritize high-risk areas

Invest in green and grey climate adaptation infrastructure (including nature-based solutions)

Reinvigorate aging grids with smart grid technology (e.g., smart meters, microgrids, energy throttling systems)

Respond with agility

Swiftly recover assets and operations by coordinating action, mobilizing stakeholders, and evaluating resilience targets

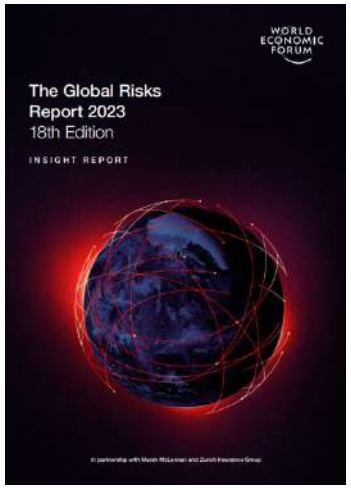
Grant emergency powers to local stakeholders (e.g., emergency services) and afford flexibility to adapt plans and priorities

Mobilize community-based action to reduce losses (e.g., community resilience hubs)

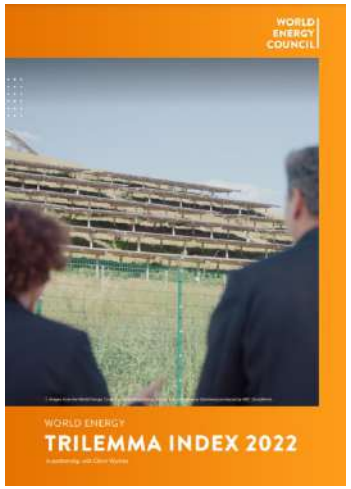
Work closely with re/insurers and financiers to build financial resilience

Develop response protocols to reduce inefficiencies in recovery

Marsh McLennan Energy and Climate Research



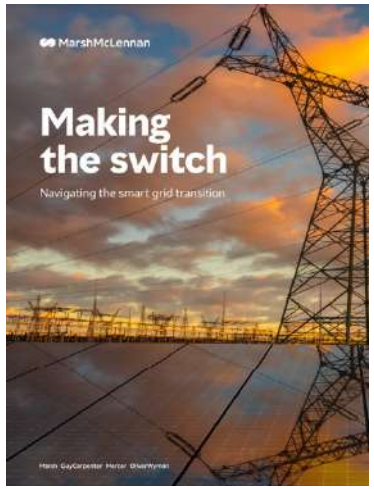
Global Risks Report 2023
In partnership with the World Economic Forum



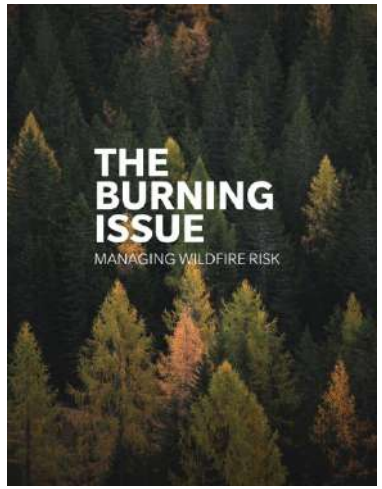
World Energy Trilemma 2022
In partnership with the World Energy Council

Global Risks for Infrastructure: The Climate Challenge
In partnership with the Global Infrastructure Investors Association

Time to Recharge: Accelerating the rollout of EV charging infrastructure



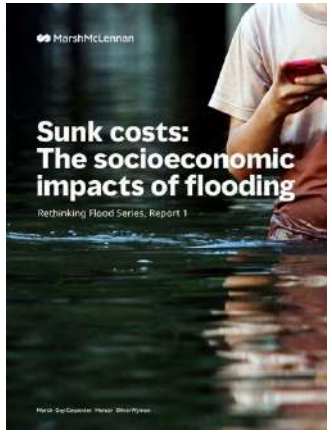
Making the Switch: Navigating the smart grid transition



The Burning Issue: Managing Wildfire Risk

Marsh McLennan Energy and Climate Research

Example: The Rethinking Flood series



June 2021

- Implications for national-level stakeholders and policymakers
- Rising flood risk and costs
- Flooding as a driver of inequality
- Existing flood insurance programs and challenges

December 2021

- Brief explores flood implications for corporates and presents strategies to effectively build flood resilience in enterprise risk management practices

July 2022

- Online interactive presents flood risk at the national level according to hazard, exposure and vulnerability under multiple climate change scenarios
- Users can visualize data made available by multiple research institutions to view urban & rural exposure to flooding

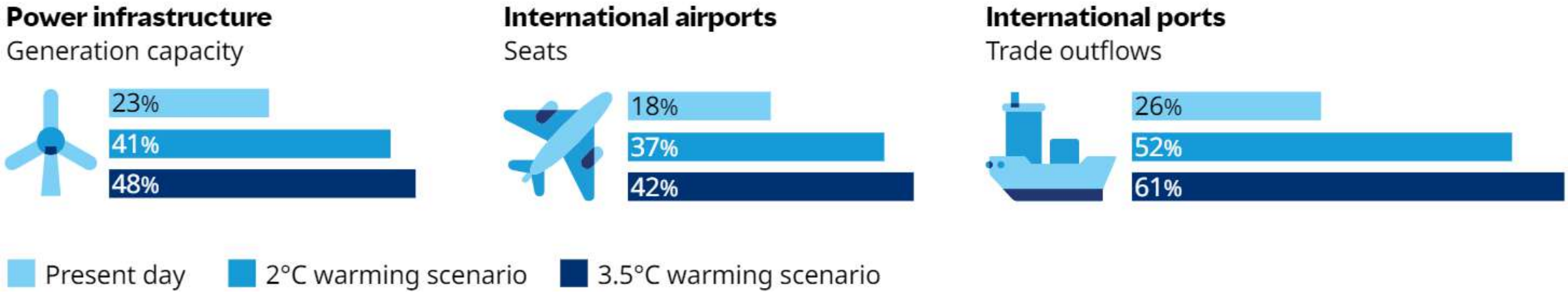
February 2023

- Key impacts of rising flood risk and points of failure of current flood risk strategies
- Tools and principles guide a transformation in risk management
- Innovative solutions and strategies to build resilience and enablers to mobilize action

Rising flood risk increasingly places key infrastructure under threat

- Findings from the Marsh McLennan Flood Risk Index reveal key vulnerabilities in global power infrastructure, international airports and international ports. Even under a 2°C global warming scenario, the percentages of these three infrastructure classes at risk are set to approximately double.
- Failure of critical infrastructure prolongs and exacerbates flood impacts, such as business interruptions, disruptions to supply chains, and recovery costs.

Infrastructure at risk under present and under 2°C and 3.5 °C warming scenarios



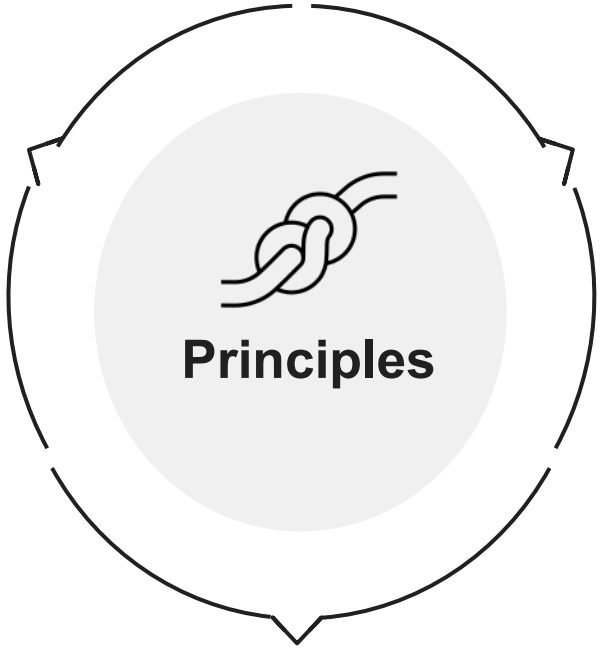
Source: [Marsh McLennan Flood Risk Index]

Three principles to guide adaptation strategies

1

Embrace current and forward-looking trends

Strategies need to incorporate information on climate change projections and evolving risk drivers to minimize the risk of maladaptation, blind spots, and lock-ins.



2

Coordinate the implementation of tools through new modes of collaboration

New models of participation can coordinate action and align incentives among a wide range of stakeholders, such as corporates, households, communities and governments.

3

Harness co-benefits by taking a systems-level approach to resilience

Leveraging the broad range of social, economic and environmental co-benefits can strengthen the business case for resilience and unlock investments.

Bold action and strong leadership are required to scale and fund these transformative changes.

There is a narrowing window of opportunity to drive transformative changes. To break the climate risk cycle, critical enablers across governance and risk culture, land use and infrastructure planning, and finance and insurance are required.

1

Build a risk culture that balances fairness and individual responsibility

- Replace protection goals with resilience objectives
- Integrate resilience and forward-looking considerations into existing risk models
- Inform about risk trends and the effectiveness of risk management

2

Transform land use and infrastructure planning

- Switch to innovative governance mechanisms
- Ensure the enforcement of building standards
- Establish statutory requirements for the combination of gray and green infrastructure
- Offer financial incentives for rural land management

3

Mobilize financial capital for climate resilience

- Standardize co-benefits assessments and integrate them into ESG frameworks
- Strengthen the role of resilience ratings in awarding contracts

4

Shift to a resilience-focused insurance system

- Remove regulatory barriers and transform regulatory frameworks
- Create innovative insurance models

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We are leaders in risk, strategy and people. One company, with four global businesses, united by a shared purpose to make a difference in the moments that matter.

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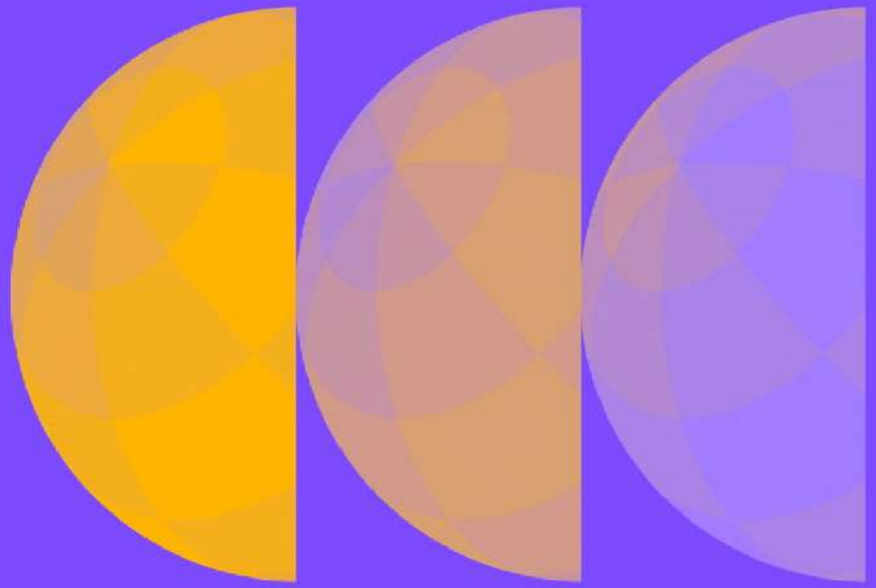

Climate Change Committee

Delivering a reliable decarbonised power system

Our approach

New and detailed modelling, illustrating a realistic mix of solutions to achieve the Government's Energy Security Strategy, while operating a decarbonised GB electricity system based mainly on variable renewables.

- Uses historical weather data, including 2010's 'low-wind year' (a 1-in-50 year event) and an extreme 30-day period of wind drought.
- Considers wider enabling factors required, including network and system planning and changes to the design of electricity markets.
- Delivers new insights into hydrogen use and production and the infrastructure required to support it.
- Shows how to manage climate-related risks to the energy system, given the increasing dependence of the future economy on clean electricity.

Delivering a reliable decarbonised power system
Key findings – planning for climate resilience

The climate risks to the electricity system are currently underplayed. Climate-related impacts will multiply as we rely increasingly on electricity for heat and transport needs.

The cascading impacts of electricity failure are already significant. The risks will grow as the economy becomes increasingly electrified and as extreme weather events become more common and severe due to climate change.

Given the level of investment needed, we must not miss the opportunity to build in system-and asset-level resilience from the start. Reformed processes must ensure infrastructure is built to be resilient to the changes in UK weather (including flood risks and heat extremes) that will occur over its lifetime.

Government ambitions entail greater weather-dependence, but analysis shows that the 2035 decarbonised power system, with a higher degree of weather-dependent generation, can be reliable and resilient.

Potential impacts on the energy system due to climate trends & extreme weather events in the UK

Climate hazard	Expected change by 2050
Heatwaves	~50% chance of 2018 summer each year (around 10-25% currently)
Flooding (river, surface and coastal)	~5% wetter winters on average (compared to 1981-2000) ~10% increased intensity of heavy rainfall 10 – 30 cm increase in average sea levels (above 1981-2000 levels)
Drought	~10% drier summers on average (than over 1981 – 2000)
Wind strength and wind regimes	Highly uncertain
Storminess and occurrence of storm events	Highly uncertain
Snow and ice	Decreasing but still possible

Source
UKCP18 Projections; summarised in CCC (2021) Independent Assessment of UK Climate Risk