# Climate Resilience and Related Costs on Electricity Infrastructure in Europe

#### PROPOSING CLIMATE HAZARDS DATASET

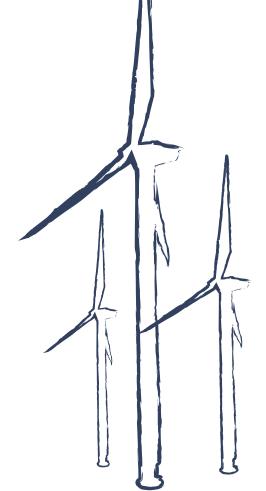
Ira Shefer, RGI





Photos: Swiss RE (2017)





### Climate Hazards Dataset: Rationale

A reference point for the development of the new climate adaptation and resilience measures



Mapping and structuring climate hazards and their impacts on electricity grid infrastructure across Europe



Providing potential corresponding adaptation and resilience measures



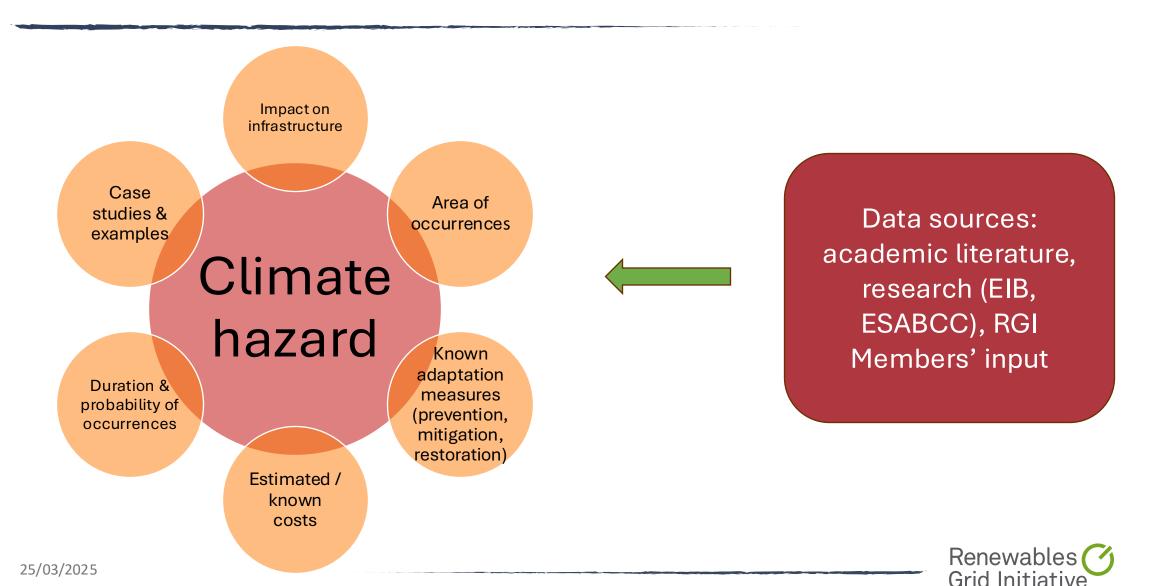
Assessing costs of impacts and solutions



Providing case studies and additional knowledge-base



## Climate hazards dataset: Key elements



#### **CLIMATE HAZARDS DATASET**

Climate Impacts and Related Costs on Electricity Infrastructure in Europe













Type of hazard		Definition	Impact on the infrastructure	Probability of occurences	Geographical area / countries	Duration of hazard	Estimated down time (hours/days/weeks)	Estimated repair time (hours/days/weeks)	Adaptation measures Integration of Sefror During Affer (SDA) approach (9) and Terral's Preventine Mispation Restoration Monitoring (PMSNI) approach (8)			Estimated costs of damages / transmission loss	Estimated investment needed per X: e.g., e.g. €/kW, €/m2 (determining investment as CAPEX or OPEX depends on phase?)	Mitigation measures (CAPEX)	Estimated costs of inaction (TBC) (13)	Examples / cases (hazards and / or costs)
DIRECT HAZARDS									Preventive measures	Mitigation measures	Restoration measures					
Floods	Plantal Rooding	Ground cannot absorb rain (heavy rain in short time)	eavy rain in short time)  Substation flooding / collapse (?)  Substation flooding / collapse  Substation flooding (collapse floorer)  Fast aging of pylone (3)  Potential influence on sensitive monitoring equipment  Pylone collapse (?)  Substation flooding  Caused by extreme  Fast aging of pylone (3)	10% increase of heavey rainfall by 2050 (c)	No geographical distinction	Hours/days			("Before") Building substations on higher grounds. Position substations in natural wetlands Stronger & water proof- foundations Monitoring equipment Stronger & water-proof- foundations	("During")  Monitoring equipment. (cameras?)	("After") Underground new infrastructure (3)	0.07 EANWN (5.p.15)	40 €/kW (5, p.15)			
	Fluvial flooding	Overflow of river and stream banks		10% increase of heavey rainfall by 2050 (a)	No geographical distinction	Hours/days					was as not make 1.5		S.S. AAASII CARRII BIOA			
	Coastal Rooding	Caused by extreme storm surges or tides		10:30 cm increase of avarage sea level by 2050 (6)	No geographical distinction	Hours/days					Avoiding building additional / new substations close to the shore (if possible) (?)					
	Heat	Very high temperatures		50% chance of hotter sum- mers each year by 2050 (6)	Mainly southern Europe	Hours / days			Heat resistant coating		Heat resistant osating					
Extreme temperatures	Snow and ice accumulation	Very cold temperatures (can occur from around 600 meters elevation)	Extreme temperatures may damage pylons materials, cables etc.  Potential influence on sensitive monitoring equipment	Likely decreased chances of scow and see patterns change by 2050 (c)	Mainly northern and central Surope	Hours / days			More insulated coating Anti-tersion devices (8) Hydrophobic paint (9) Interphase spacer devices (see cables away from each of their (8) Satelleito or Wireless senseor network (8)	Emergency measures (vehicles, communication tools) (8)	Exapanded use of helicopters, satellite phones (8) Satellite or Wireless senseor network (8)	0.14 €/MWN, 0.2% extra franzmission losses per 1 ≪ (5, p.15)	40-EAW (5, p.15)  2.6ME to rebuild 21 towers after ice-damaged pylons (7)			Freezing rain 2018 (7)
Heatwaves		Extended period of extreme that) days with no/very little precipitation	High temperatures may damage pylons materials, caloles etc. Brosion of the soil / dry soil may undermine infrastructure basis (e.g. pylons) (?)	50% chance of horter summors each year by 2050 (6)	Mainly southern Europe	Days/weeks						0.07 €/MWh (5, p 15)	40 €/KW (5, p 15)			
Wildfires		Fires in areas of pylons routes	High temperatures damage pylons materials (steel etc.) Potential influence on sensitive monitoring equipment		Mainly southern Europe	Hours/days			Heat resistant coating Integrated Vigetation management (VM) infrastructure monitoring (IX and regular comera to deleted smoke, wind speed measurement (7)	Information sharing (e.g., Forest Fire Alert System of REN) (7) Infractructure monitoring (IR and regular careeras to delect smoke, wind speed measurement). Decision support system (e.g., probability of time and place the hazar of will have an impact on the infrastructure) (7)	Undergrounding new infrastructure Installing new / renewed monitoring measures		200M€ (direct costs; need to clarify, what are grids repairment costs)	Vegetation Management can reduce 25% costs (of maintainance) per hectare (7)	á	2003 tree flachover in gids connectivity and Switzerland (4, p.42) Total of EUR 1.2 billion economic cor- resulting from outages in Italy, Switz- land, Austria and Slovental (4, p.42) Pedregão-Grande The Portugal 2017 Existing viegetation management measures (7)
Sea level rise		Sea level rise causes ground erosion and salination of ground water	Undermoning infrastructural basis and equipment in coastal areas (pylone, substations, underground cables) Salt water affect infrastricture (e.g., fast aging of pylons (3)) (2)	10-30 cm increase of avarage sea level by 2050 (a)	Europé's coastal regions	Years/decades										
Storms / strong wind		Extremely strong gusts of wind	Broken parts & external falling parts (e.g. branches)	"Highly uncertain by 2050" ([6] CCC estimation)— uncertain changes of strom events by 2050?	No geographical distinction	Hours			Vegetation management (e.g. modeling potential faling plants out of Right of Wayl (7.8) Reinforcement of infrastructure (*)		Undergrounding new infrastructure (?)	0.07 €/MWh (5, p.15)	50 €/kW (5, p.15) 2M€ to rebuild 13 towers after extreme storm in a coastal area - wind gusts of 176km/h (7)			2005 Storm Gudrun (4, p. 42) Strom Letile 2018 (7)
NOIRECT HAZARD	S	Dny/salinated soil that can	i.	Total Control	de mi region de											
Droughts		lead to wildfires & pluvial flooding (?)	Undermining the infrstructure (?)	10% drier summers on avarage by 2050 (a)	Southern and central Europe (e.g. Germany)	Days/weeks										
Temperature increase		Steady increase of warm days compared to past decades (may lead to extreme temperatures and heatwaves)	Influence on electricity demand (fluctuation & pick loads, e.g. for cooling)> physical deterioration		No geographical distinction	Years / decades							= = ==			
Heatwaves		Extended period of extreme (hot) days with no/very little precipitation	of the grid		Mainly central and southern Europe	Days/weeks										
Changing water temperature (?)			Changing pH levels (accidity) affecting e.g. subsea cables (*)			Years / decades										
Dust stor	ms (?)															



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## Climate hazards dataset: Data gaps

Probability of occurrences

Partial data available

Down time & repair time

No data available

Adaptation measures

Partial data available

Data sources (e.g., Digital Twins)

Partial data available



## Climate hazards dataset: Data gaps



Damage / transmission loss



**Estimated investments before / after (e.g., €/kW)** 



Little to partial data available



Mitigation measures (as CAPEX?)



Inaction (refraining from addressing hazards / specific hazards)



#### Indirect costs (OPEX?):

- · Labour hours & equipment wearing
- Expected shortage of materials / raw materials

