Energy and **Telecom** infrastructure safety in the context of climate change

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Aplicaciones en Informática Avanzada S.L., Spain.

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Outline

- **Climate change**
  - Extreme Weather Events
  - Impact and challenges in the E&TC sector
- **Work within RAIN project**
  - Electrical contingency analysis ⇔ meteorological threats
  - Impact evaluation
- **Summary**

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Climate change

Extreme Weather Events (EWE)

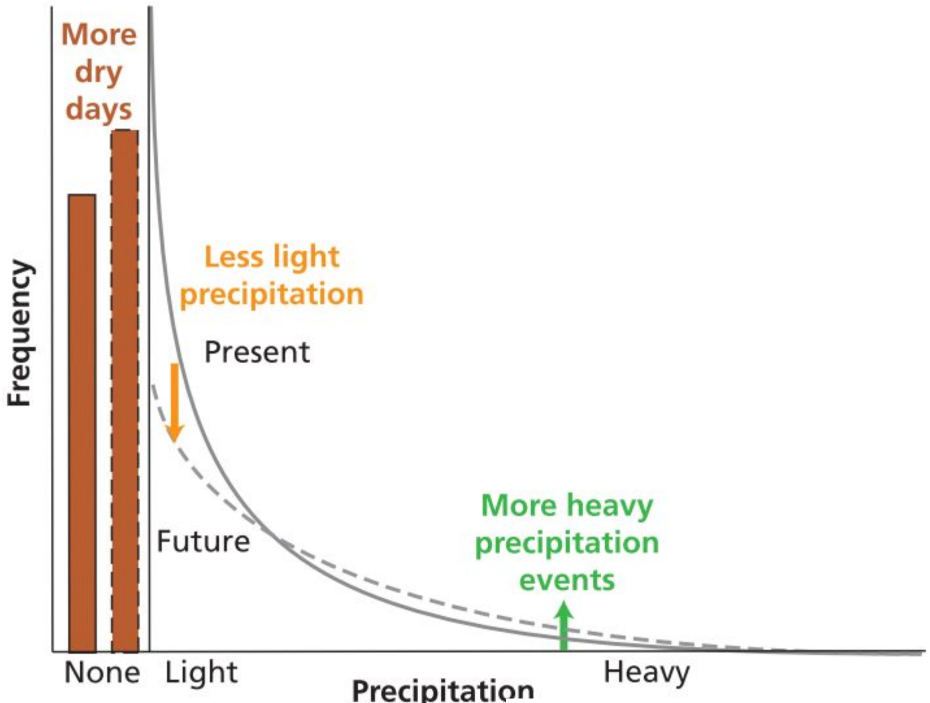
- more frequent
- more severe

Precipitation

- More draughts
- More rainstorms

May affect:

- generation (hydro)
- state of the assets

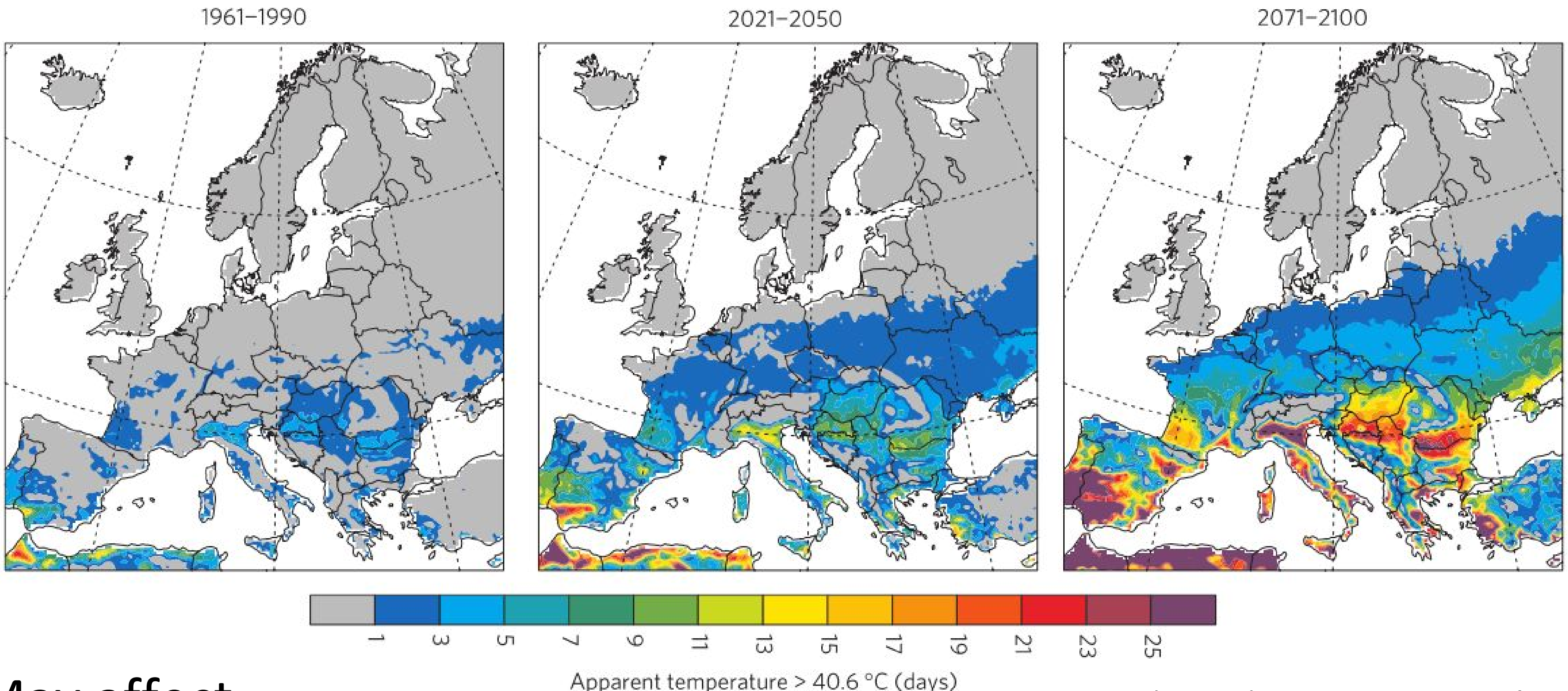


Swiss Climate Change Scenarios CH2011

Climate change

Heat waves

- More frequent
- Longer
- More spread out



*Fischer & Schär, Nat. Geoscience **3** (2010)*

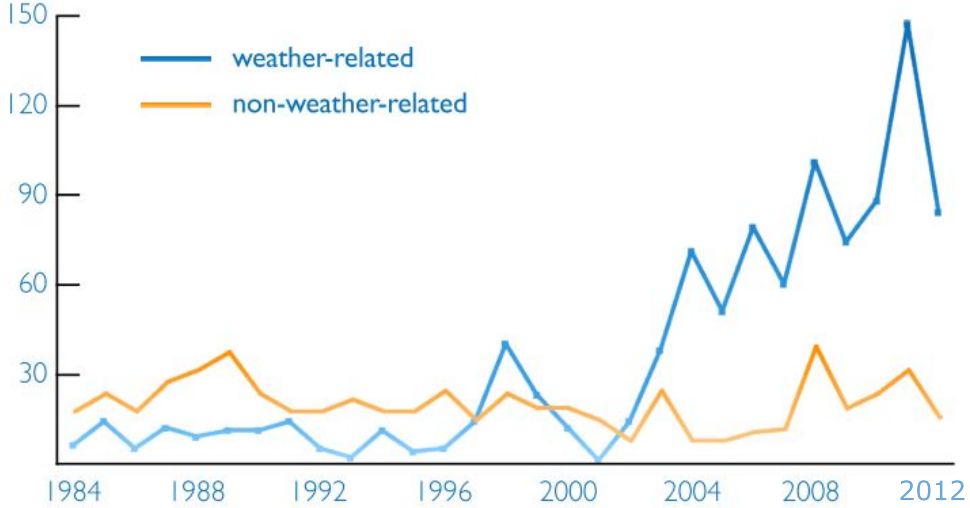
May affect:

- consumption patterns (i.e. more AC)
- facilities maintenance and performance

Climate change

Impact on Electrical infrastructures

Number of **power outages per year** in the U.S.



Kenward & Raja, Climate Central report (2014)

Effects of **tropical storm Delta**
Canary Islands (Spain), 2005

Foro contra la incineración de Tenerife (2005)

Climate change

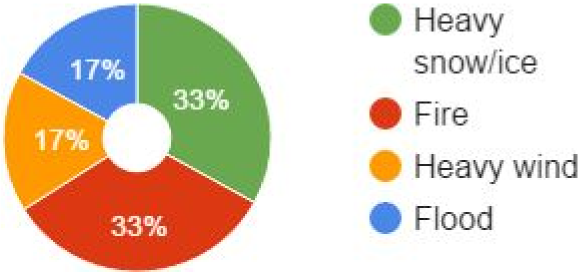
Impact on Electrical infrastructures

- **European examples:**
  - **Heavy snow/wind storms** in Poland (Nov. 2004):
    600k customers, fresh water supply, 25 tramway traction lines
  - **Windstorm** Gudrun/Erwin (Sweden, Feb. 2005):
    663k customers affected (82k up to 7 days after), telco
  - **Tropical Storm** Delta (Canary Islands, Spain, Nov. 2005):
    300k customers (20k 4 days after), water supply affected
  - **Freezing rain** (Slovenia, Jan. – Feb. 2014):
    250k customers for days, rail transportation, roads, telco, water supply

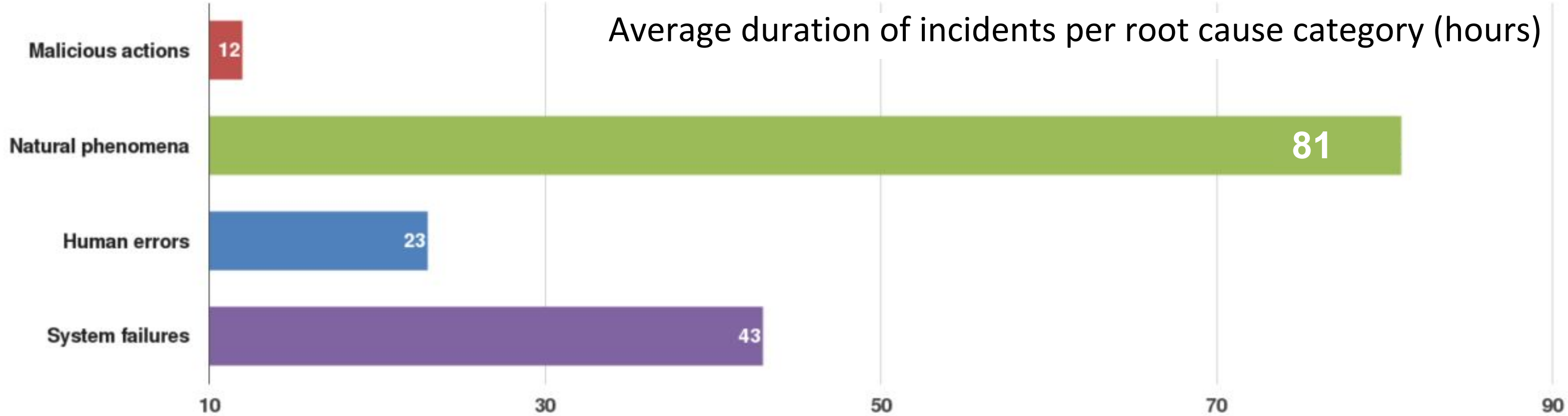
Climate change

Impact on Telco infrastructures in Europe

- **6%** of large incidents **directly** caused by **natural phenomena** during 2014 (14% in 2013)
- indirect effect through **power cuts**: **13%** during 2014 (26% in 2013)



Long recovery times



ENISA Annual Incident Reports 2014

Climate change

Challenges in the E&TC sectors

- **Direct damage**:
  - Wind storms: galloping, fluttering, falling of towers and lines, right-of-way effects…; braking systems in wind generators
  - Ice/snow storms: overweight, right-of-way; icing on the blades
  - Heat waves: power transmission performance, line sagging...
- Changes in **Generation** and **Consumption patterns**:
  - Droughts: affect hydroelectric power plants
  - Heat waves: increase in use of AC systems
  - Wind: affects wind power plant generation
- Therefore, consequences in:

Planning, Operation, Maintenance

RAIN contribution

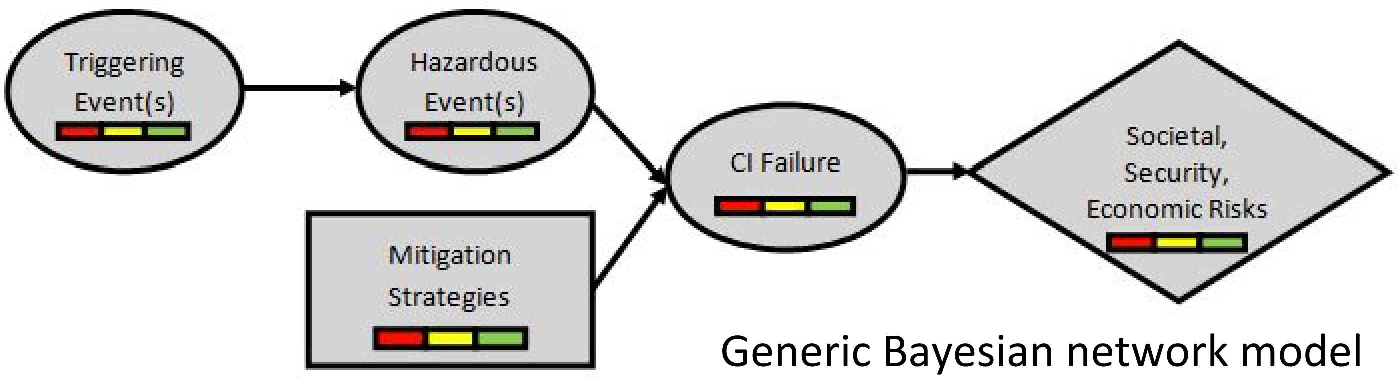
Goals

electrical contingency analysis ⇔ specific meteorological threats

+

holistic impact evaluation (not only €)

Example of the implementation of the **RAIN risk assessment framework***:



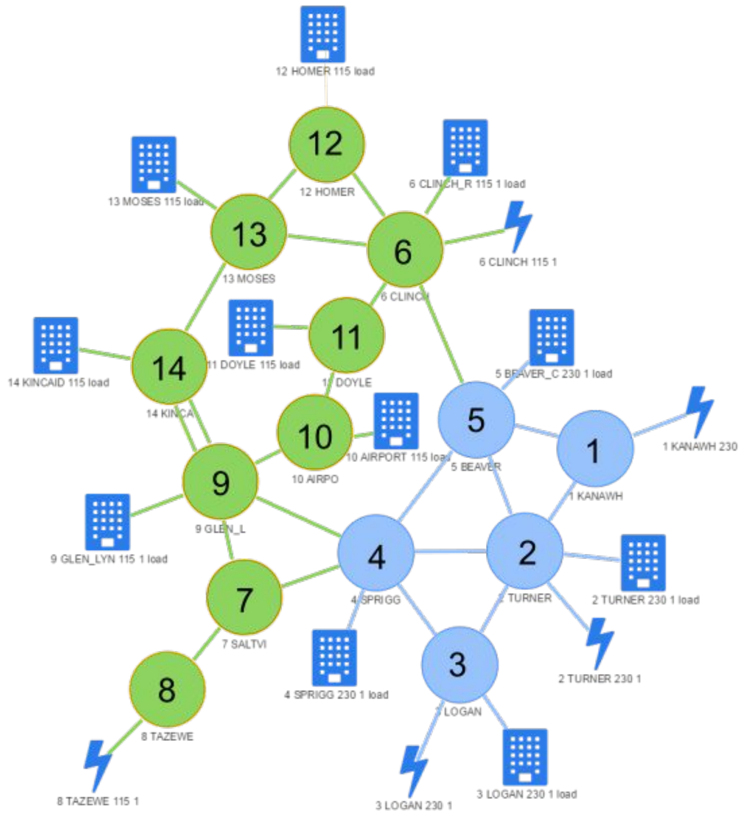
Generic Bayesian network model

**see next talk*

RAIN contribution

Implementation: electrical system

Example: standard well-studied **IEEE 14-bus model** + geographical **context**

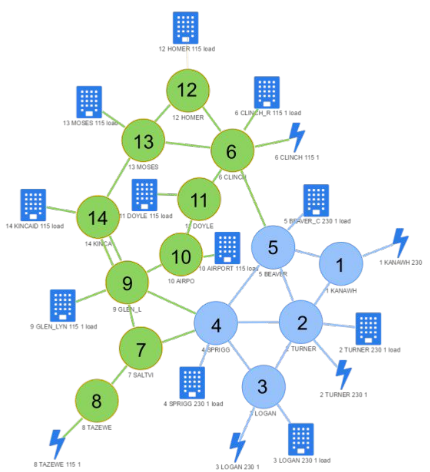


Standard IEEE 14-bus model

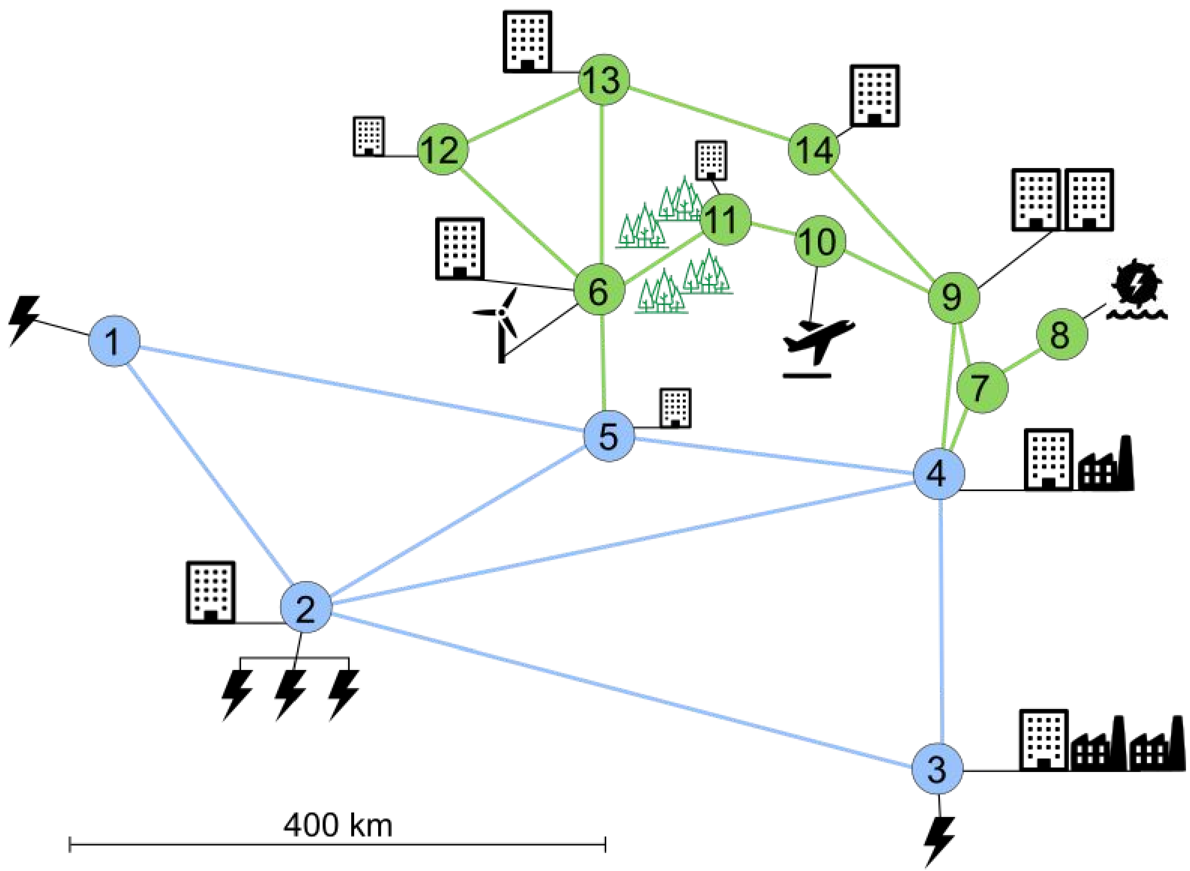
RAIN contribution

Implementation: electrical system

Example: standard well-studied **IEEE 14-bus model** + geographical **context**



Electrical model



Pseudo-geographical representation inspired by Belmudes et al., (2009)

RAIN contribution

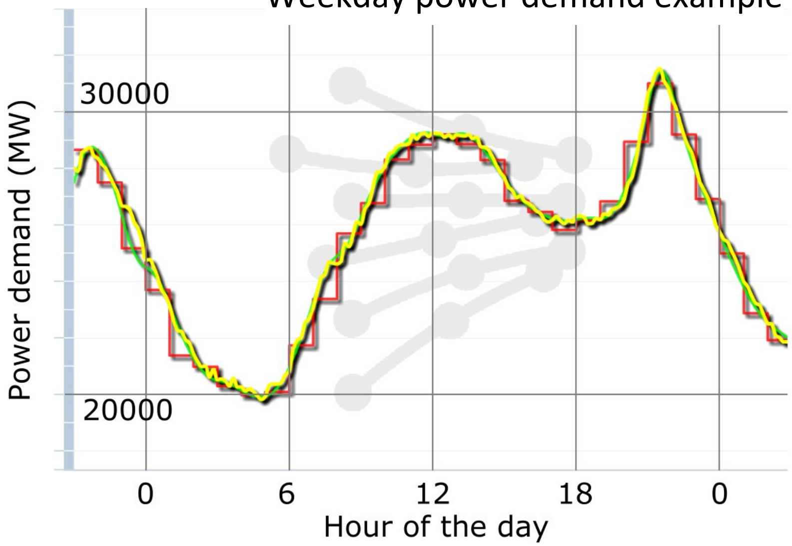
Implementation: failure probabilities

Failure probabilities for each **element** of the network are defined per **EWE**:

- **Context**:
  - geographical situation:
    location of the elements (urban, forest, valley, etc.),
    proximity to EWE
  - state of the network:
    physical properties, maintenance state
  - load distribution:
    consumption at the time of the
    EWE, type of load, telco location...

- **Contingency** analysis:
  - weather threat considered:
    effects on each network element
  - possible prevention/mitigation measures

Weekday power demand example



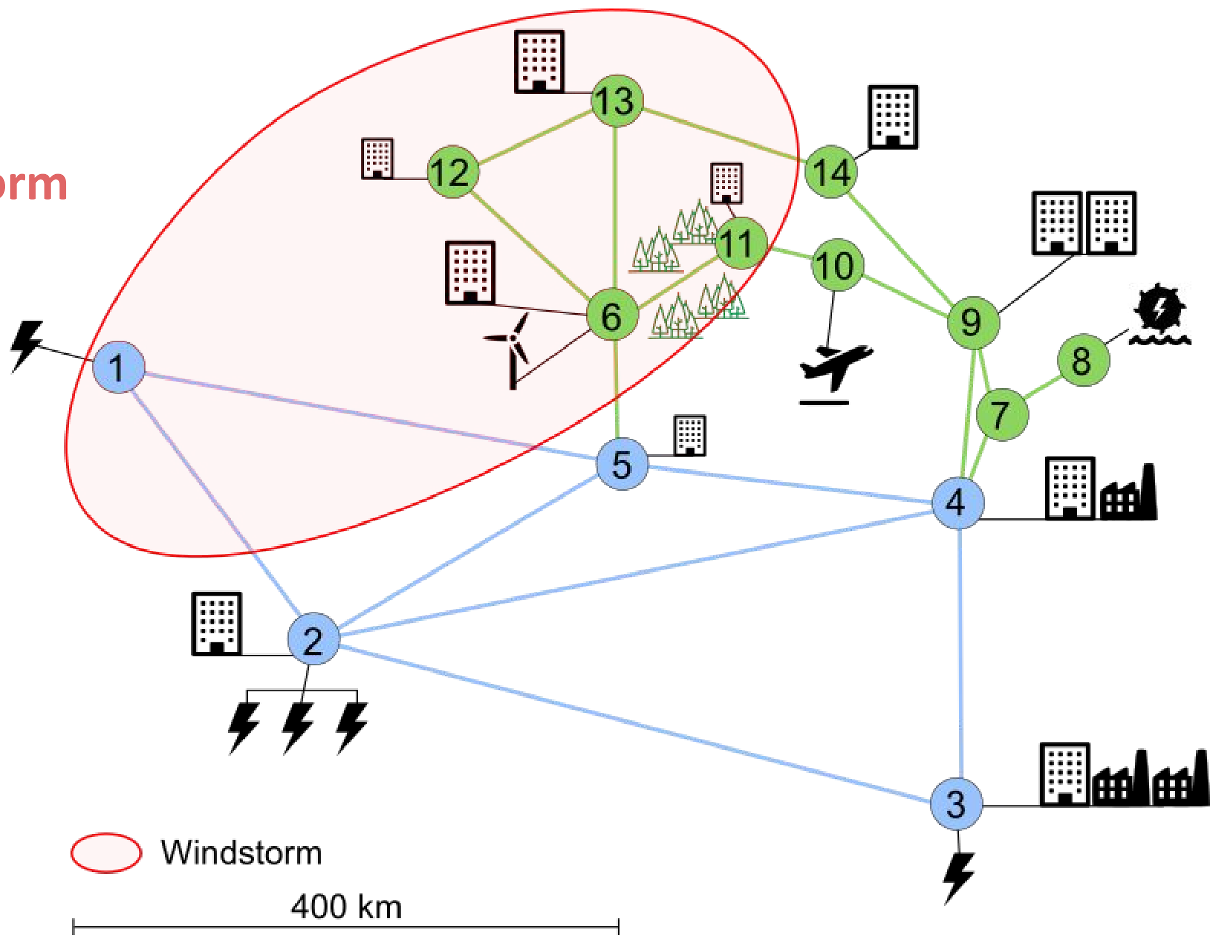
Adapted from REE.es

RAIN contribution

Implementation: failure probabilities

Failure probabilities are calculated given an Extreme Weather Event.

Example:
Heavy windstorm



RAIN contribution

Implementation: failure probabilities

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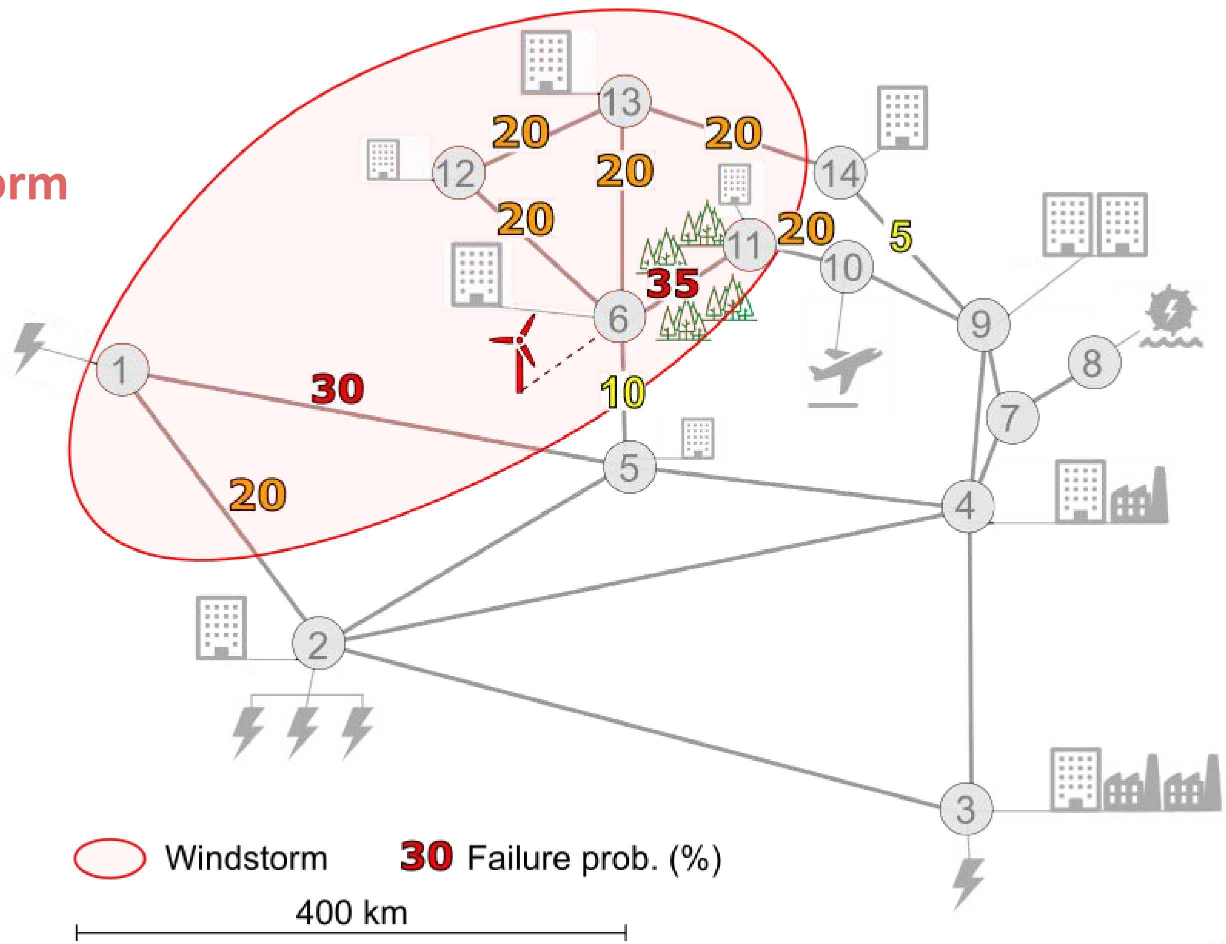


RAIN contribution

Implementation: scenarios

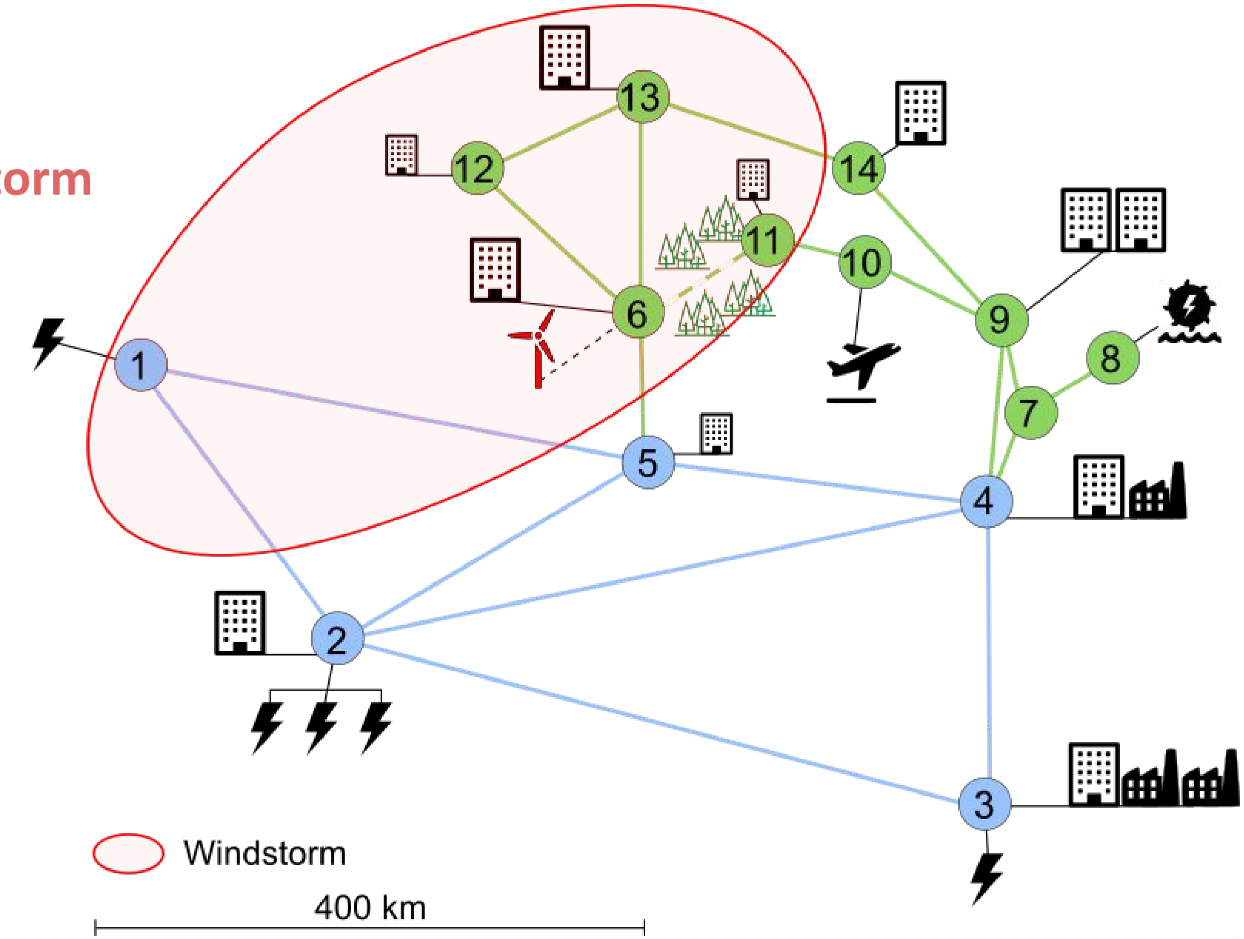
Based on the **failure probabilities**, different **scenarios** are considered, simulated, and analysed.

Example:

Heavy windstorm

Scenario A

7 %



RAIN contribution

Implementation: scenarios

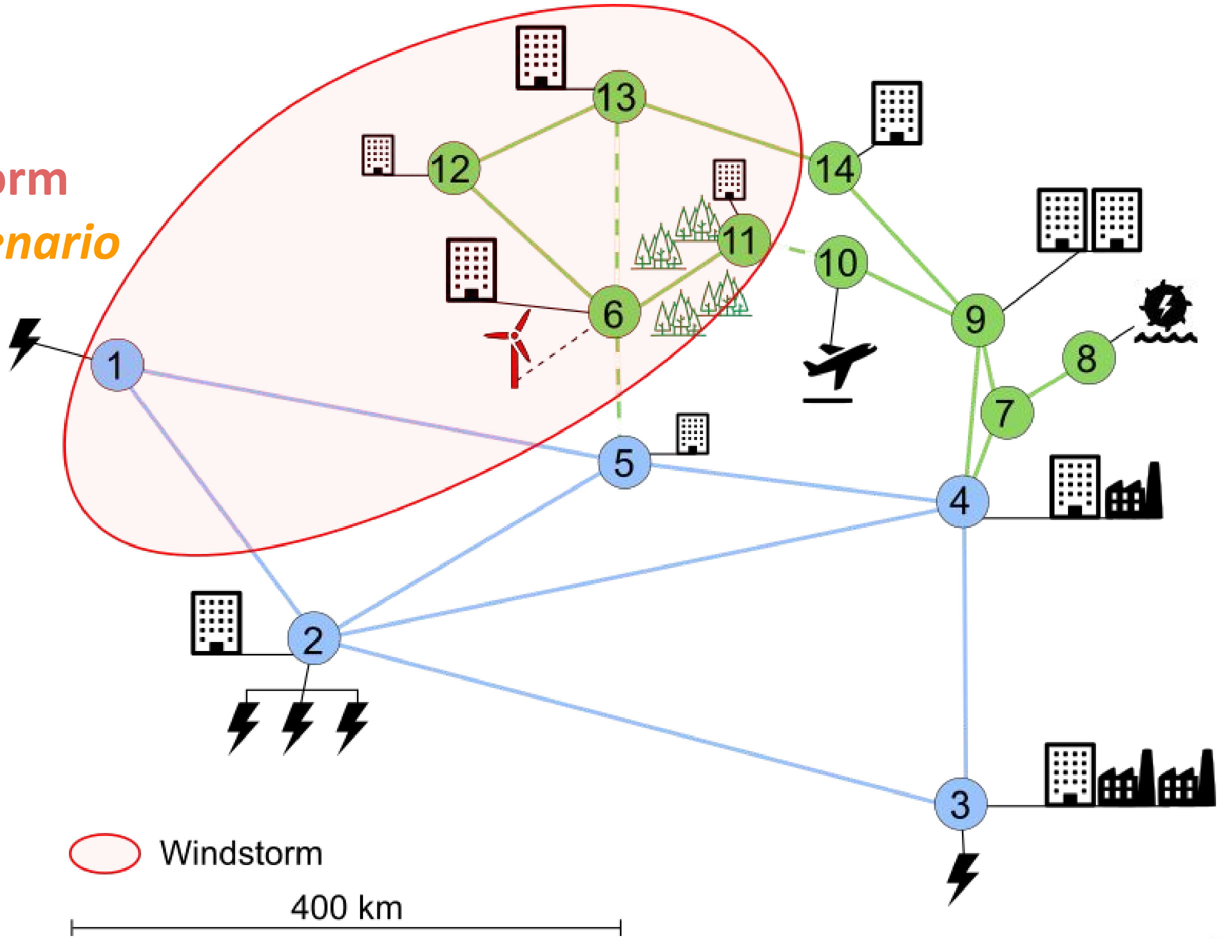
Based on the **failure probabilities**, different **scenarios** are considered, simulated, and analysed.

Example:

Heavy windstorm

Worst case scenario

0.5 %



RAIN contribution

Implementation: simulation results

Results are compiled in a HTML report, and prepared for integration within the *RAIN risk assessment framework*.

RAIN Analysis Report

Aplicaciones en Informática Avanzada

Milenko Halat, Xavier Clotet

31/03/2016

Load Flow simulation results

Context 10

Description: IEEE 14b under the effect of a strong windstorm

Properties

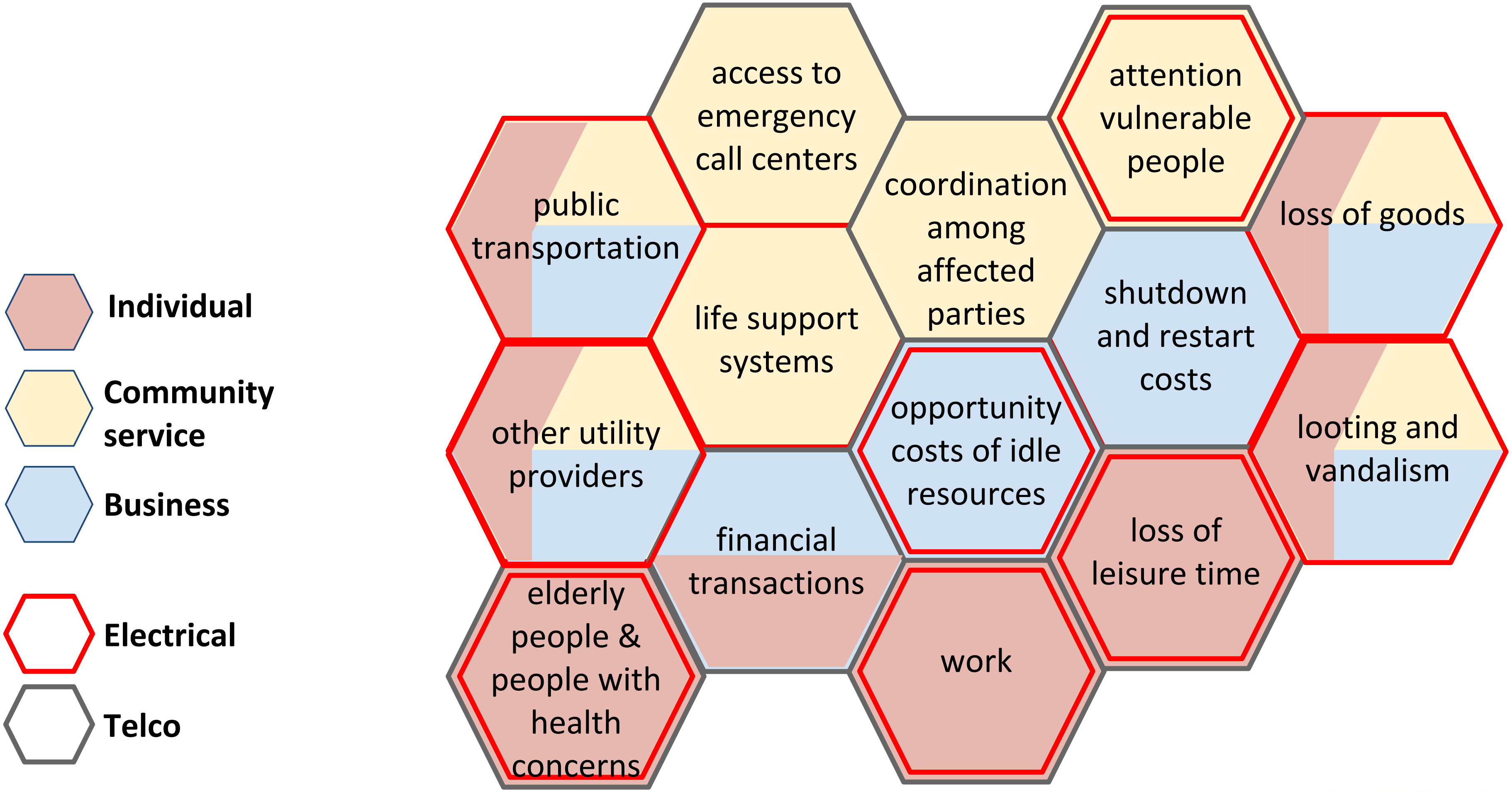
Number of simulations: 200

Possible Scenarios:

RAIN contribution

Implementation: impact evaluation

Results will be analysed in terms of **economic** and **societal impacts**



RAIN contribution

Implementation: impact measurements

Value of lost load

- Economic measurement (e.g. GDP) over a measurement of electricity consumption (e.g. kWh).
- Widely used.

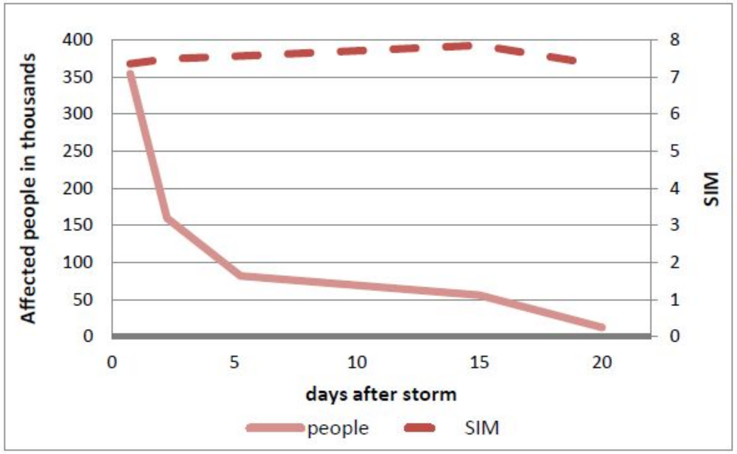
Social Impact Magnitude (SIM)

- A_{people}: number of affected people (macro scale)
- A_{length}: duration of the outage (micro scale)

$$\mathrm{SMI} \equiv \log_{10}(A_{people} \cdot A_{length})$$

0 ≤ SMI < 3	None or small problems
3≤ SMI < 5	Problematic
5≤ SMI < 7	Severe problems
7≤ SMI	Critical problems

Adapted from Hämmerli, Svendsen, & Lopez, (2012)



Windstorm Gudrun/Erwin (Sweden, Feb. 2005)

Summary

RAIN PROJECT

Given an **Extreme Weather Event** and a **system**:

Study → **What-if** → **Best option**

Study

- What does it happen?
- Failure probabilities of the elements.
- Impact assessment.

What-if

- Consider possible preventive measures.
- Consider possible mitigation measures.
- Consider day/night differences, stronger storm, etc.

Best option

- Provide insight in the different options.
- In which elements is better to invest given a limited budget?
- Is it more efficient mitigation or prevention?

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Summary

We are working towards creating a **reproducible workflow** which integrates **weather threats** and **physical context** to estimate the **social impact** described by specific markers, that can be useful for **decision support** (in planning and operation).

Thank you

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RAIN Project

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GRUPO AIA

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