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Resilient, Low-Carbon Energy Systems

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Lecturer in Power Systems

30th April 2018

Disaster management and resilience in electric power systems

Participants:

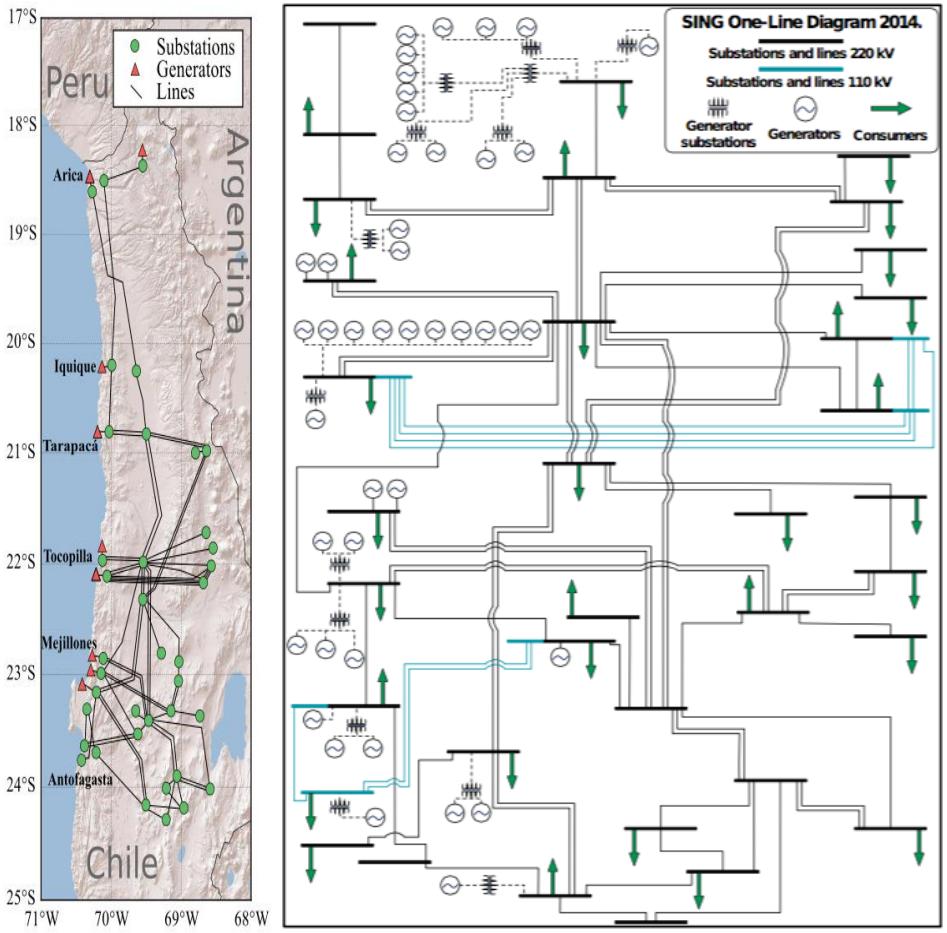
Funders:

Multi-disciplinary research: Electrical engineering, civil engineering, operations research, social science and economics

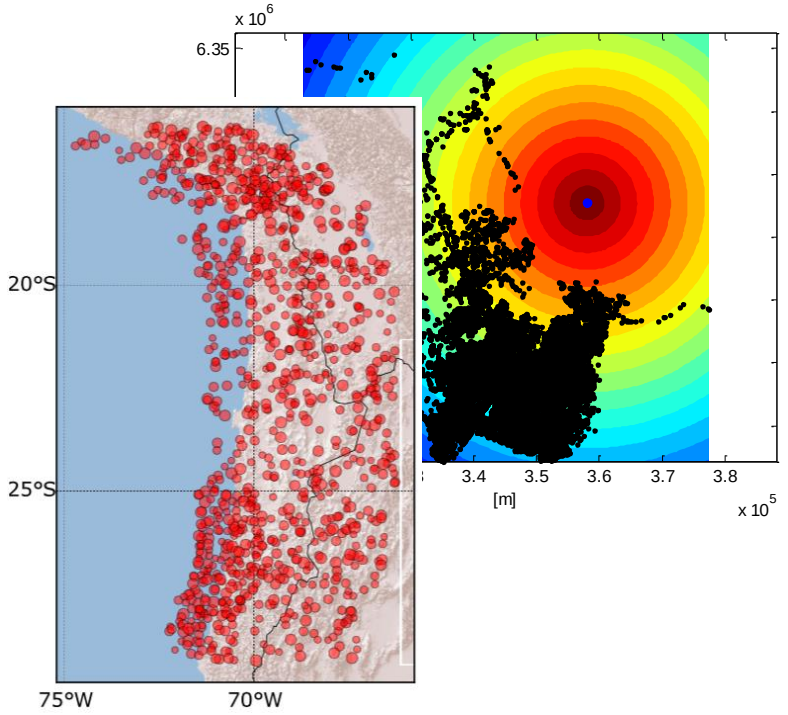
Key research objectives

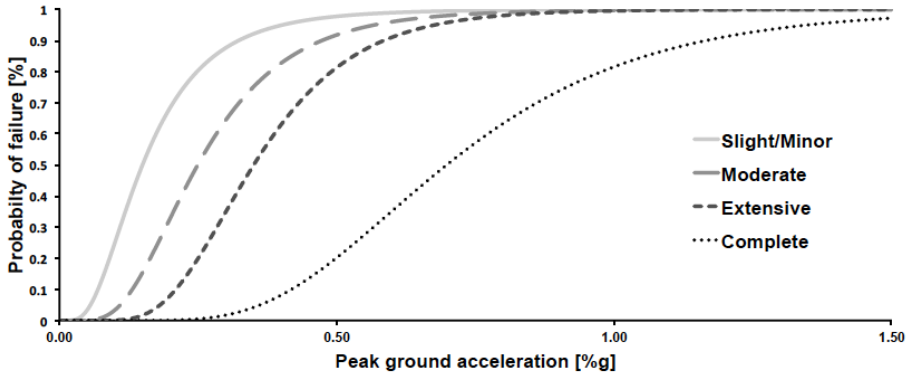
1. Develop **techno-economic models** for **risk quantification** and for assessment of **optimal portfolios of measures** to increase power system resilience to natural hazards
2. Develop **social models for community** preparedness and response to natural disaster
3. Develop a general **socio-technical framework**, bringing infrastructure and community measures together, to manage and therefore lessen the effects of power outages due to natural disasters
4. Develop a **quantitative understanding of strengths and weaknesses of the current good practices** on technical and social options

Case Study Application: Chile



Northern Chilean System (geographic and network diagram)





Mix of Mitigation Decisions

1. New lines (all voltage levels) to create alternative, redundant “routes” to transfer electricity from production to consumption centres
2. Hardening substations (anchoring) and lines to make them more “robust” against earthquakes
3. Distributed (low-carbon) generation and shorter response times by enhanced stocks, more crews and smart, online monitoring and control

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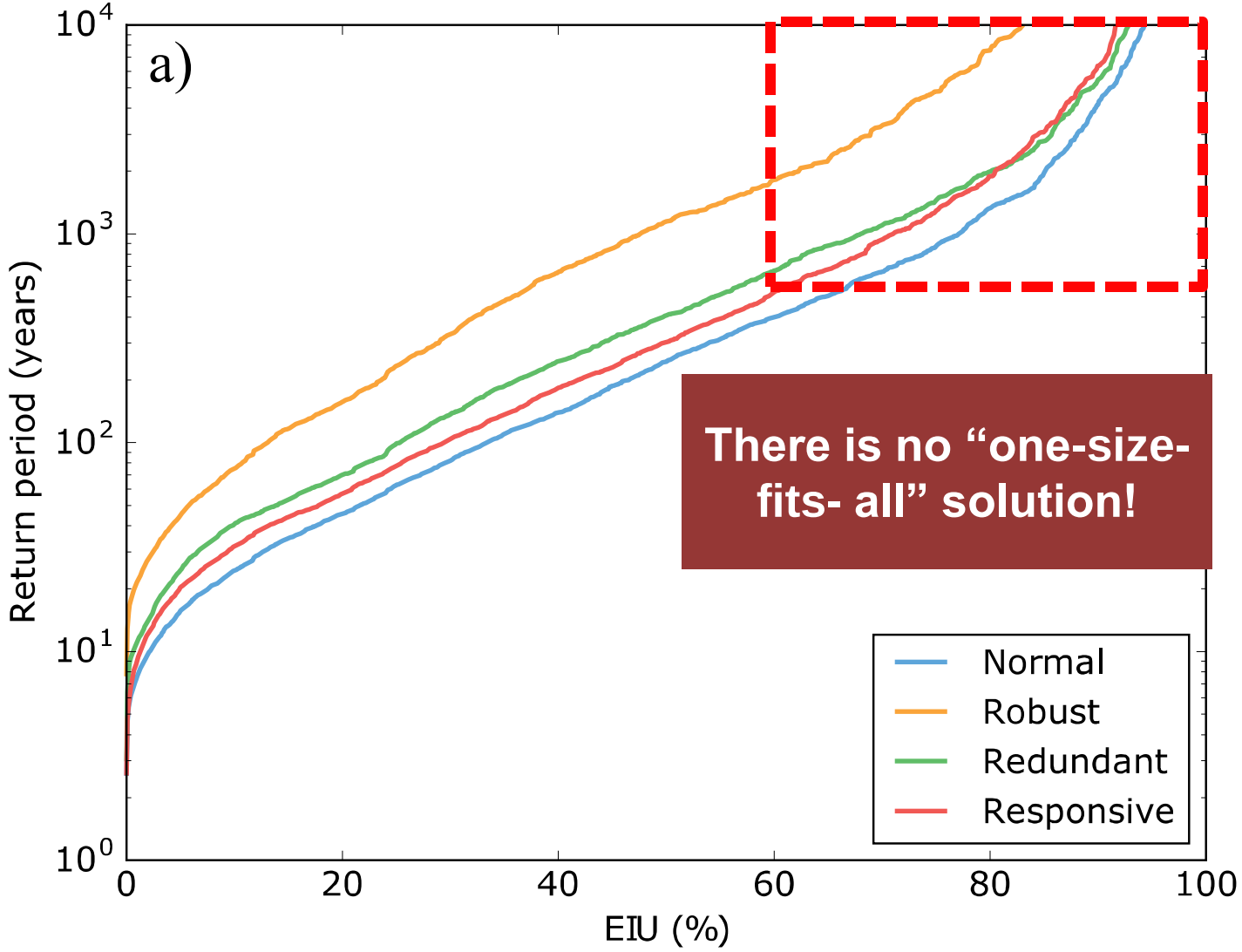
Impact of mitigating decisions



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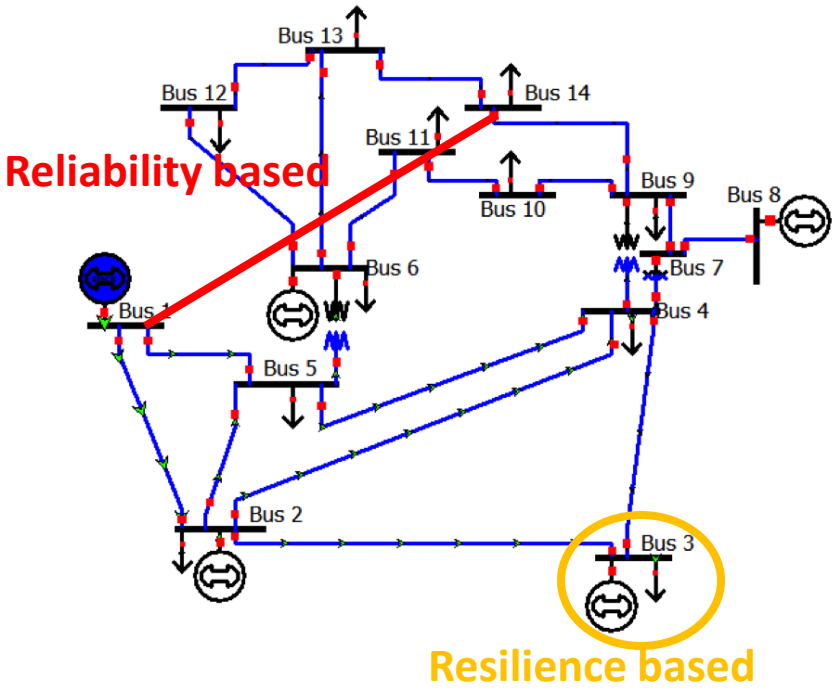
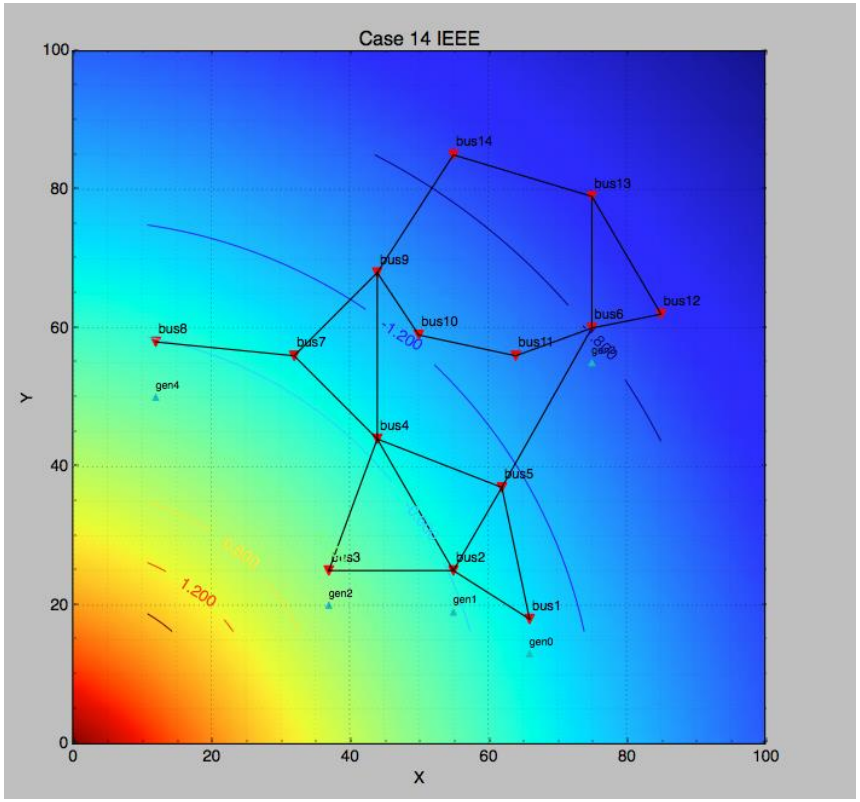
Reliability Vs Resilience Planning

- **Resilience planning**: going beyond the traditional reliability planning for known/credible conditions and contingencies
- **Resilience-driven** investments can be different than **reliability-driven** investments

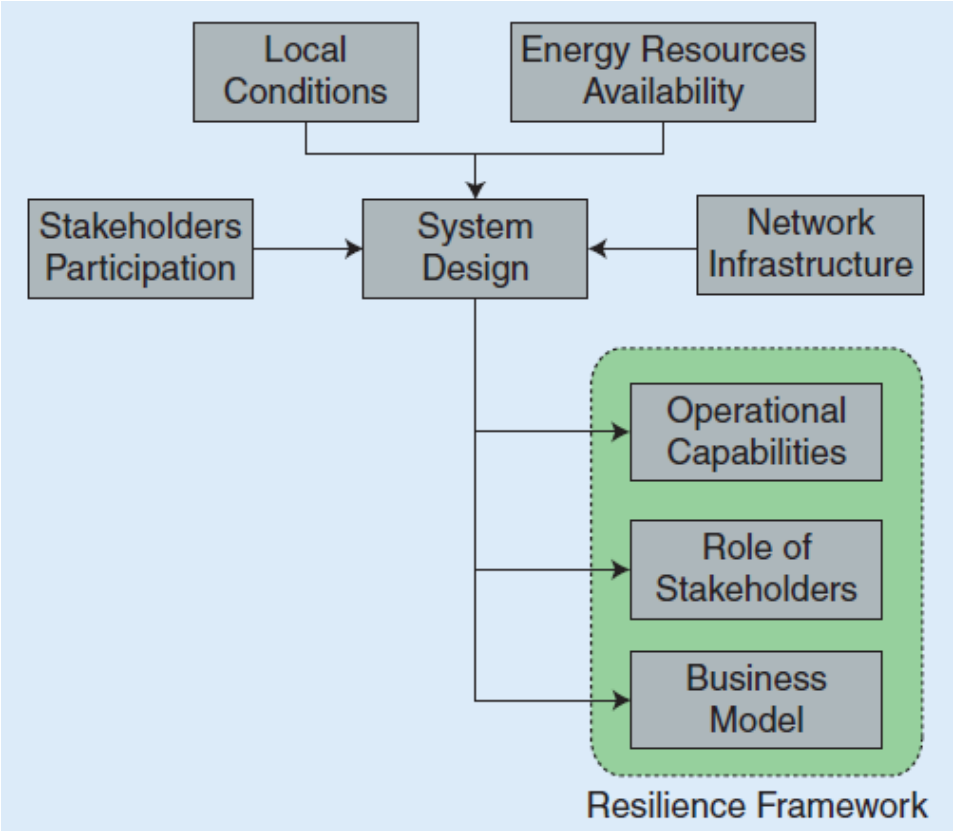


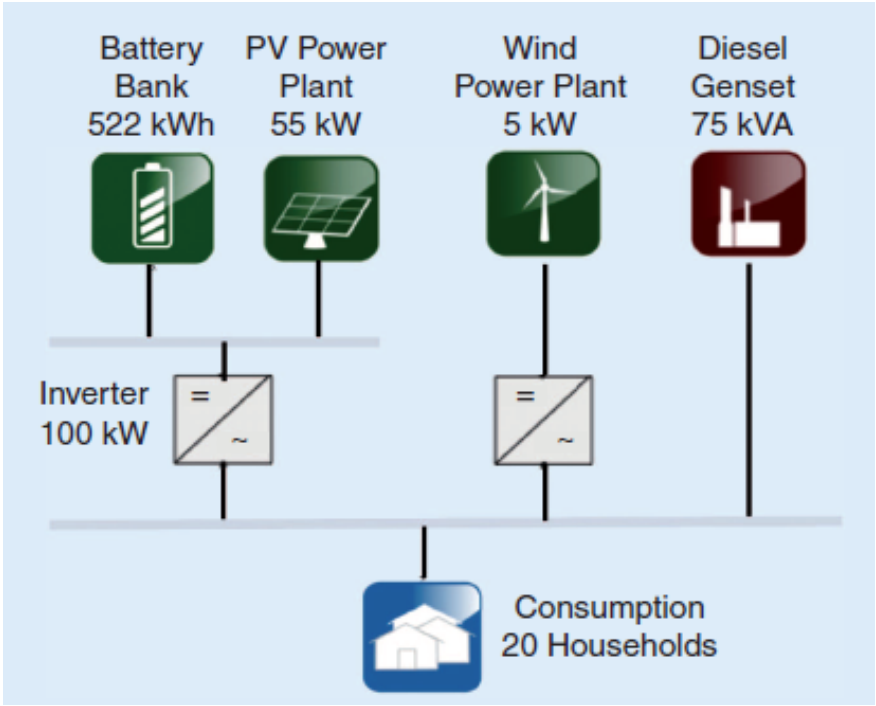


Achieving Resilience through Isolated Community Microgrids

Experiences with microgrids from three isolated communities in Chile:

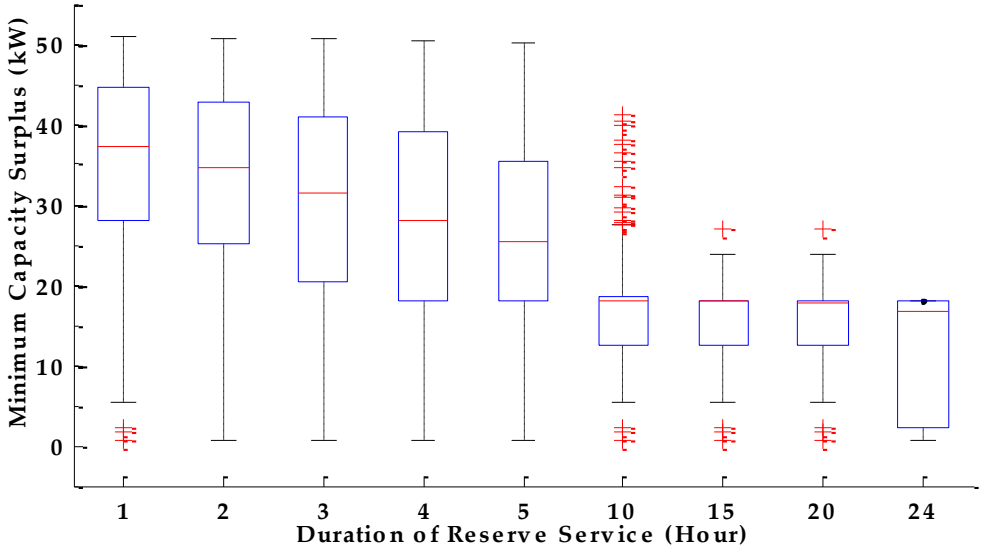
Hualacondo, Ollagile and Puertecitos



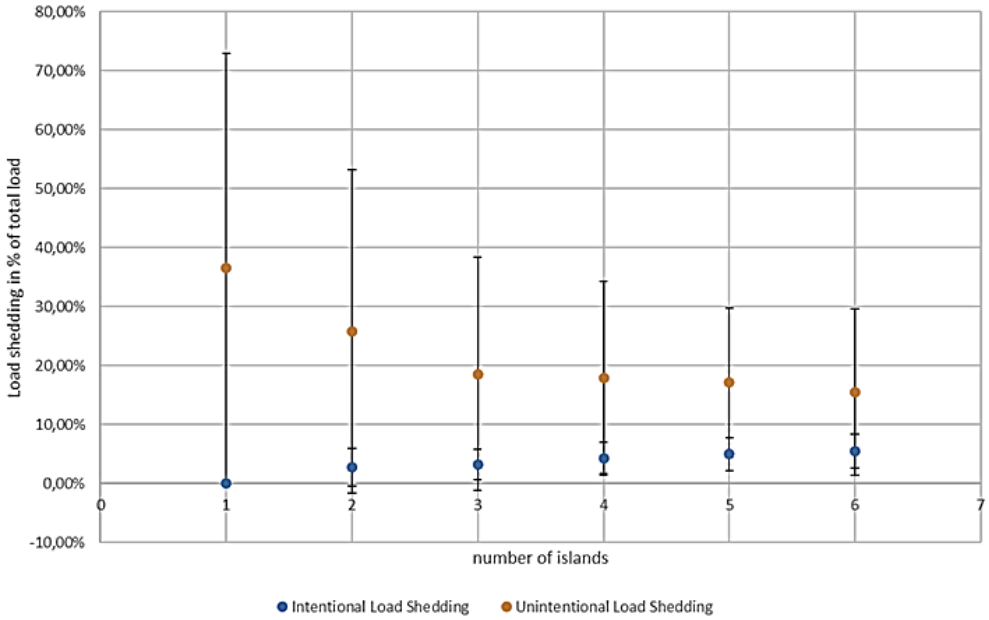


How can microgrids contribute to system-level resilience?

System reserve services to “reliability” events (i.e., normal expected outages) and “resilience” events (i.e., rare, extreme events)



Preventive, dynamic formation of islands (microgrids) in the face of an upcoming disaster (e.g., windstorm)



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Recently Awarded (Ongoing)

Research Projects

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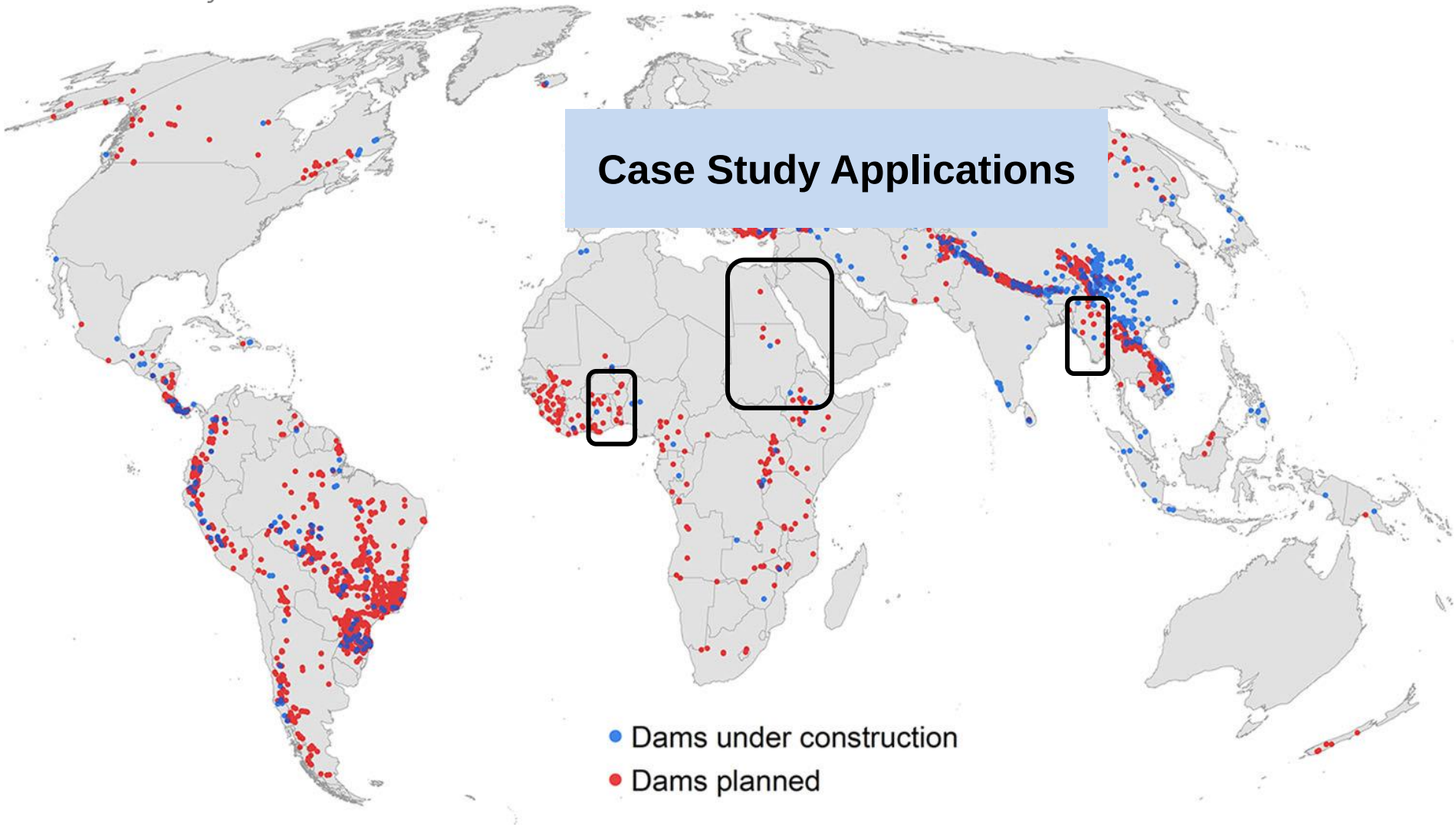
FutureDAMS: Design and Assessment of resilient and sustainable interventions in water-energy-food-environment Mega-Systems

- Recently RCUK awarded project (£8m), led by The University of Manchester (EEE Academics: Dr M. Panteli, Prof. J. Mutale, Prof P. Mancarella)
- Multi-disciplinary consortium of a large number of leading universities in UK and organizations worldwide
- **Mission:** provide transformative research and knowledge on how new dams and systems of new and existing dams are assessed, selected, designed and operated to provide water, food, and energy security for all

A Global Boom in Hydropower Dam Construction



Aquat Sci (2015) 77:161–170
DOI 10.1007/s00027-014-0377-0
Aquatic Sciences
RESEARCH ARTICLE

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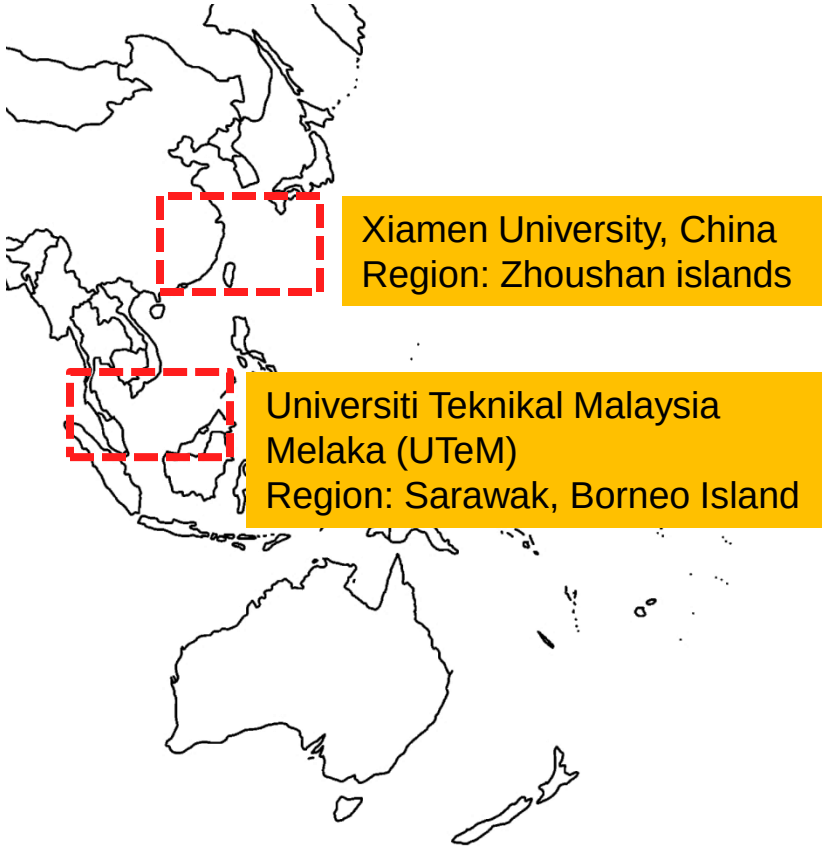
Integrated water-energy simulator

- **Integration of renewable energies:**
  - Determine the optimum use of water and energy resources for the integration of intermittent energies
- **Uncertainty modelling:**
  - The models should be able to consider different scenarios (e.g., climate change) and sources of uncertainty (e.g., wind and solar)
- **Techno-economic analysis of large-scale energy storage (investment and operation)**
  - What are the benefits compared to hydro pumped-storage?
- **On-grid vs off-grid electrification (long-term planning):**
  - Different types of infrastructure (e.g., storage, off-grid systems), interconnected/isolated systems, etc.
- **Adaptive prioritization of water users:**
  - The water and energy models must be able to interact and influence each other

Techno-Economic framework for Resilience and Sustainable Electrification (TERSE)

- Recently EPSRC awarded project (£1.2m), led by The University of Manchester (EEE Academics: Dr M. Panteli, Prof P. Mancarella)
- **Aim:** development of integrated techno-economic framework for supporting decision-making and planning of sustainable, cost-effective *and* resilient energy infrastructure
- **Work packages on**: hazard modelling, modelling emerging/low-carbon technologies, on-grid/off-grid techno-economic evaluation, resilience planning, user-engagement, etc.



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CROSS BOrder management of variable renewable energies and storage units enabling a transnational Wholesale market (CROSSBOW)

- Recently multi-partner, multi-million EU awarded project
- A TSO driven project, with the ambition to provide TSOs increased grid flexibility and robustness through:
  1) A better control of cross-border balancing energy at interconnection points;
  2) New storage solutions – distributed and centralized-, offering ancillary services to operate Virtual Storage Plants (VSP);
  3) Better ICT and Communications -e.g. better network observability, enabling flexible generation and Demand Response schemas
  4) The definition of a transnational wholesale market, proposing fair and sustainable remuneration for clean energies though the definition of new business models supporting the participation of new players –i.e. aggregators- and the reduction of costs

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Prof Jovica Milanovic:

- Improved observability of network by transmission system state estimation (e.g. congestion management, day-ahead/near real time forecasting, etc.)
- Study the impact and potential contributions of demand side management on increased cross border power transfers while ensuring system stability (voltage, angular and frequency stability)

Dr Mathaios Panteli:

- development of advanced optimization algorithms to enable the optimal management of distributed energy storage units under uncertainty for system stability and increased cross-border penetration of renewable energy sources

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Dr Alessandra Parisio:

- development of control-oriented optimization models and control algorithms for the optimal coordination of available energy storage units forming a virtual storage plant (VSP) to provide frequency support, voltage regulation and cross-border power transfers

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Thank you for your attention!

Questions?

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