



Resilient Investment and Operation in Power Systems

Dr. Rodrigo Moreno
University of Chile

CIGRE Workshop, March 27th 2017
Gestión de Riesgos en la Planificación y Operación del Sistema Eléctrico

Conicyt-RCUK Project: Disaster Management and Resilience in Electric Power Systems

The University
of Manchester

MANCHESTER
1824

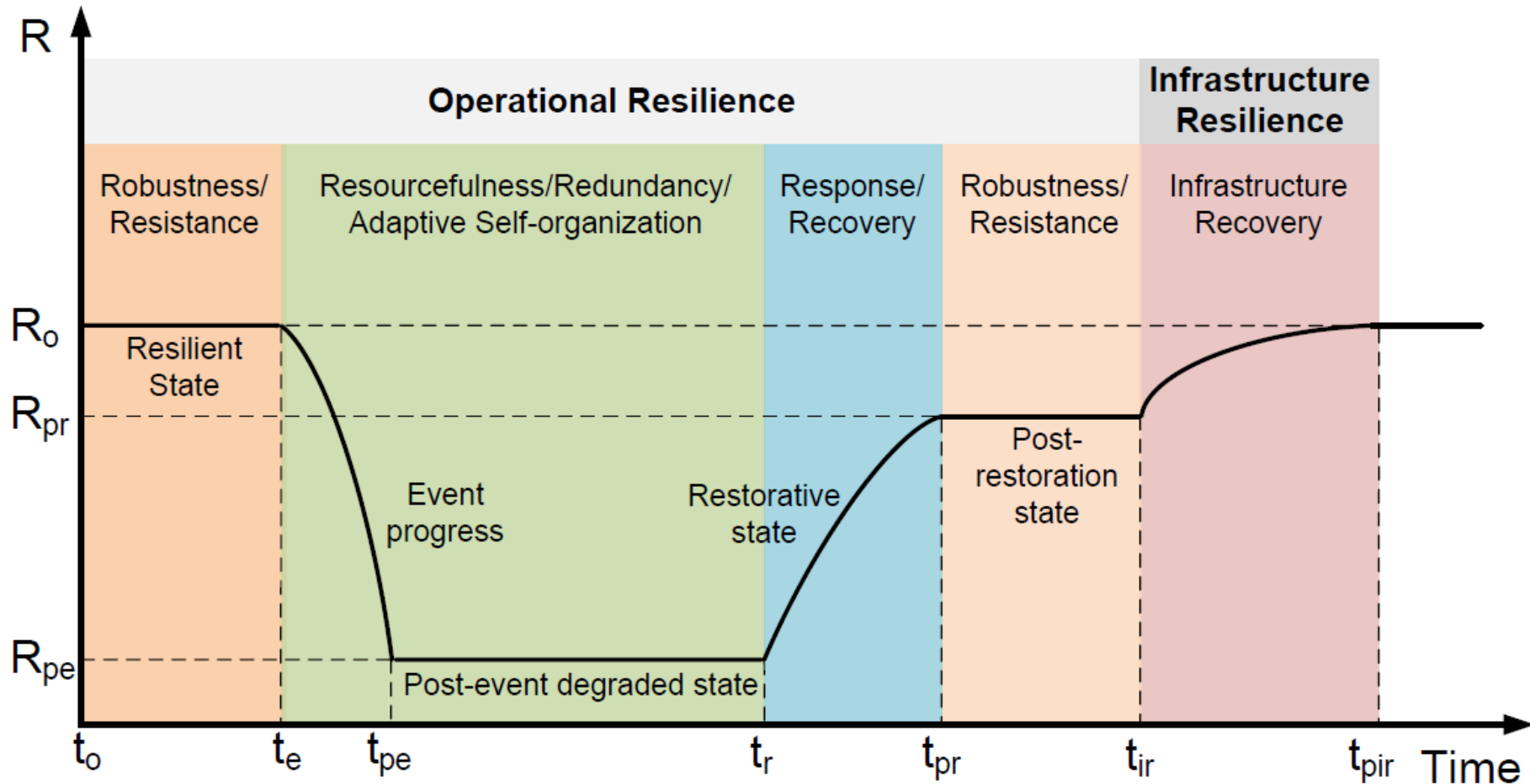


**Project workshop: Tue March 28th, 8.30am-11:00am,
Beauchef 851, DII (sala 314)**

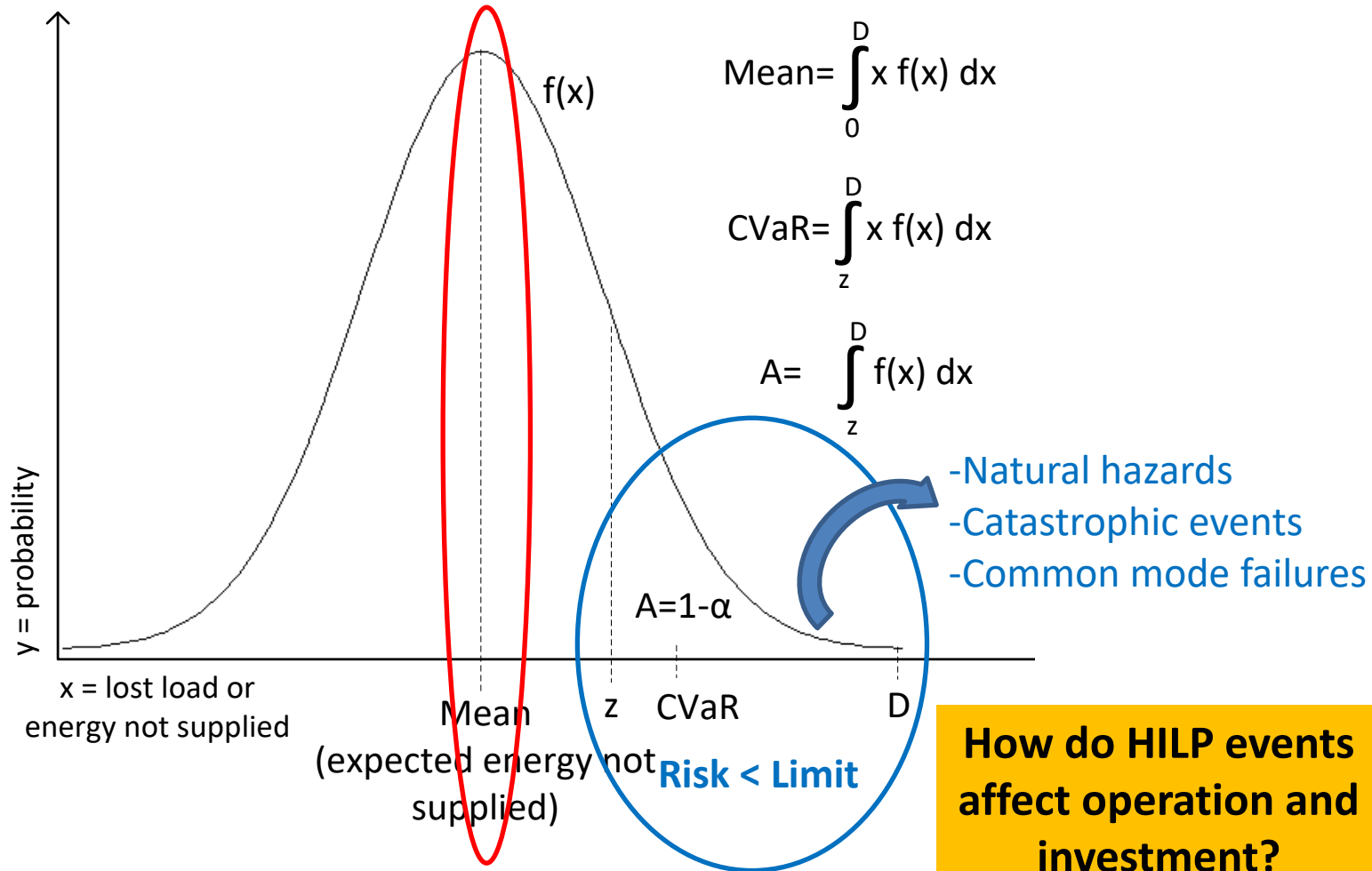
Table of contents

- Definitions
- Methodology
- Illustrative example
- Large-system examples
- Conclusions

Resiliency is dynamic

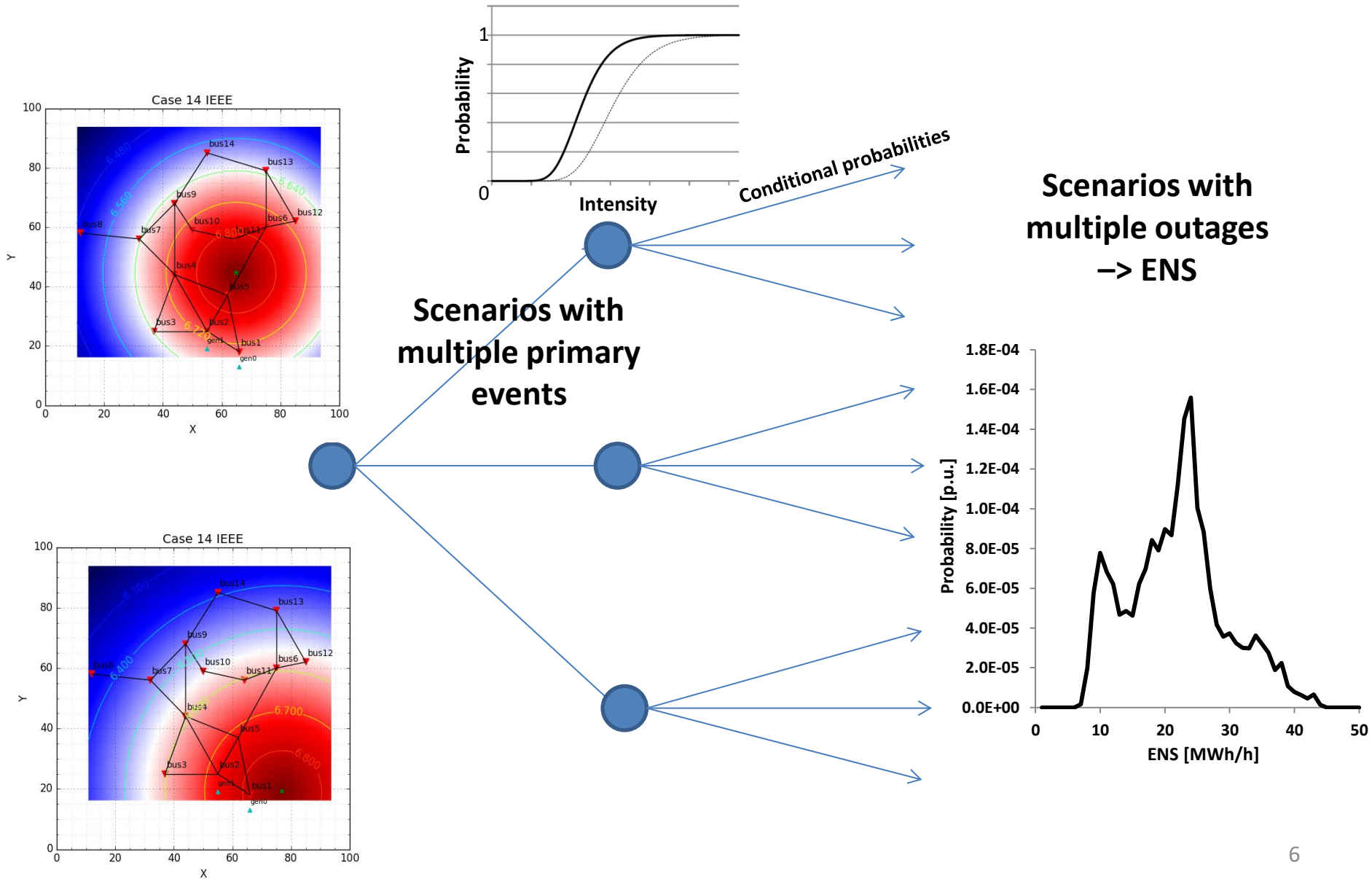


Resiliency focuses on catastrophic, HILP events

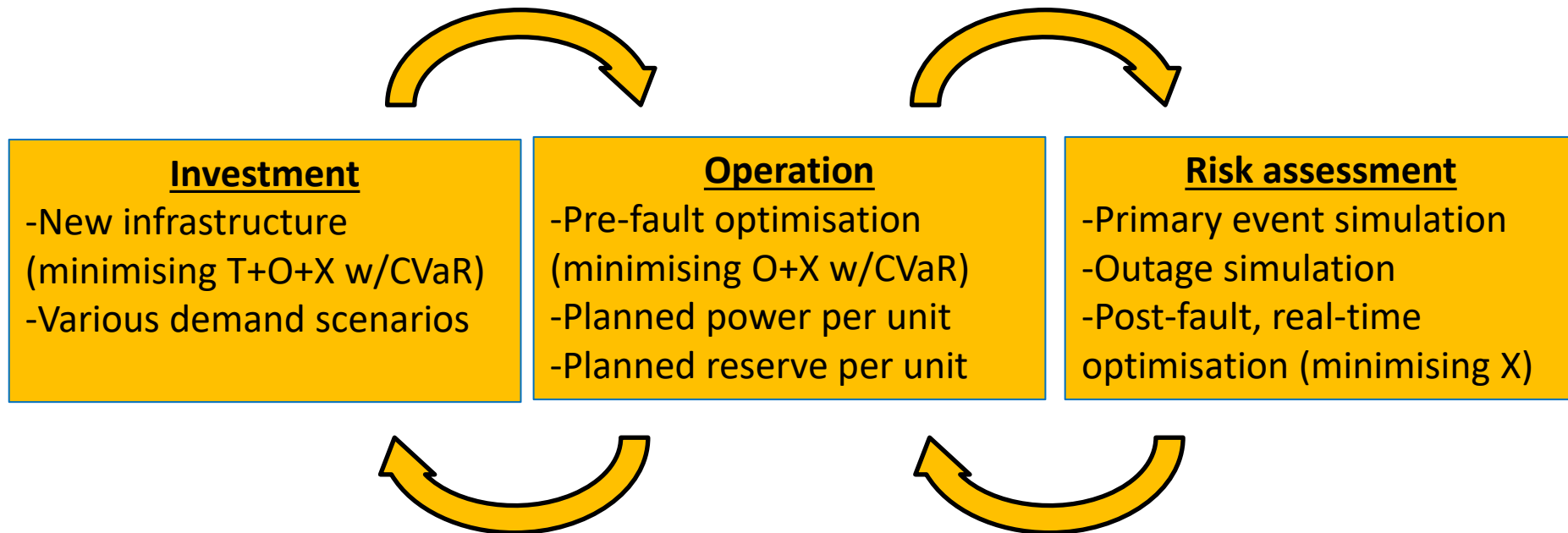


Investment + Operation + EENS x VoLL

Risk assessment methodology

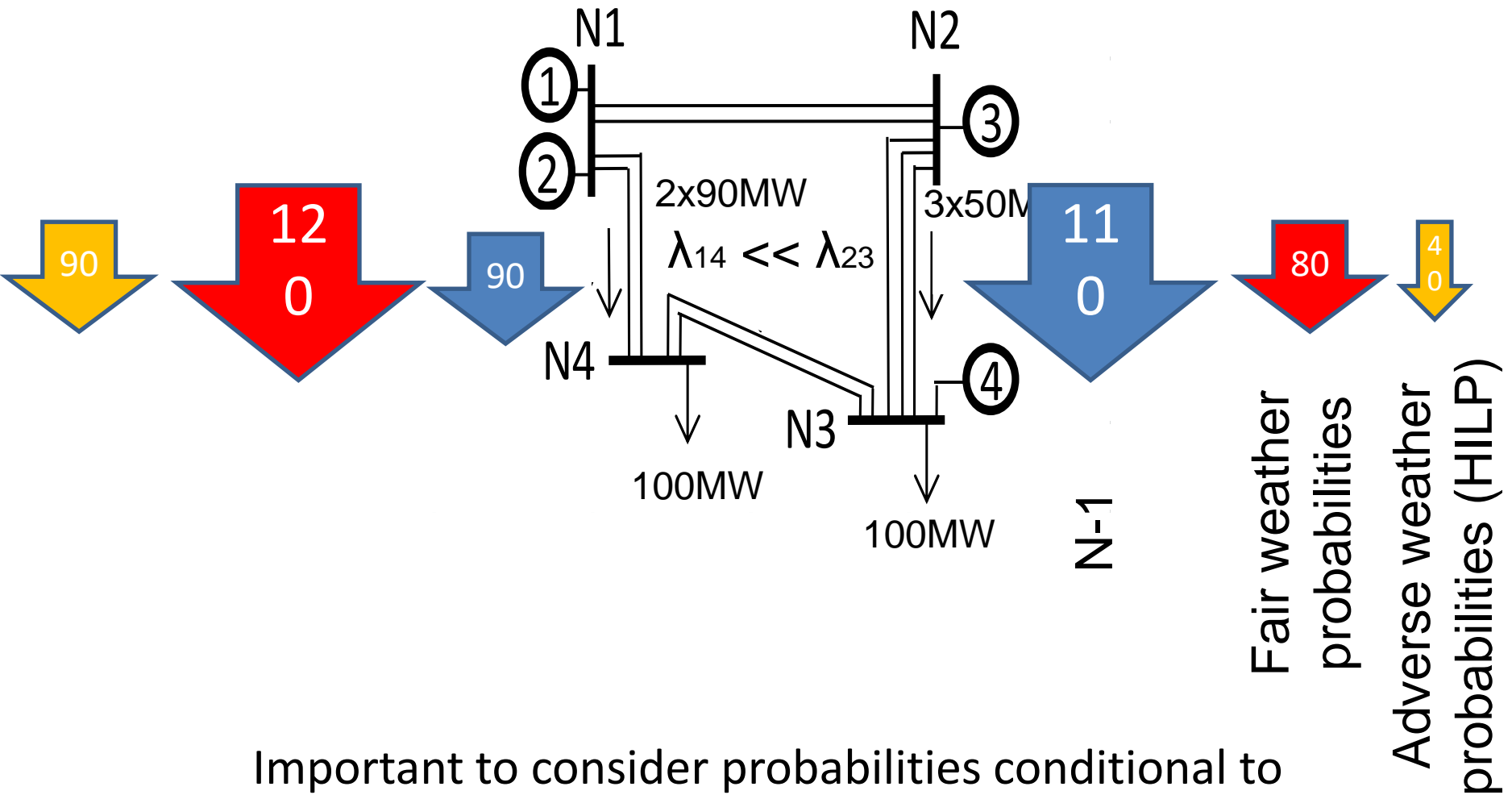


Optimising resiliency in operation and planning



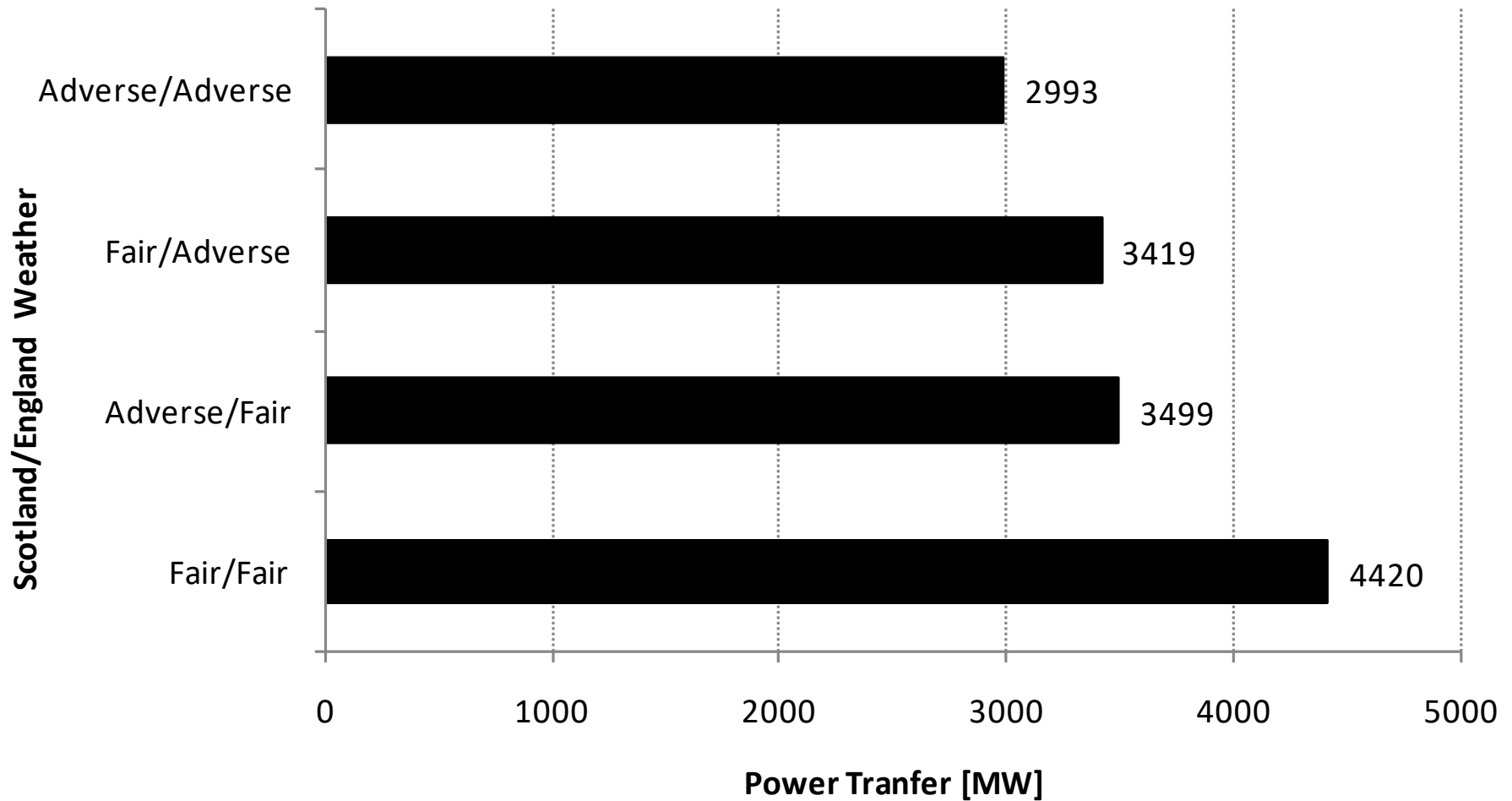
There are multiple optimisation techniques to coordinate the iterations and ensure delivery of “very good” and even optimal decisions (e.g., genetic algorithms, Benders cuts)

HILP ability to affect operation

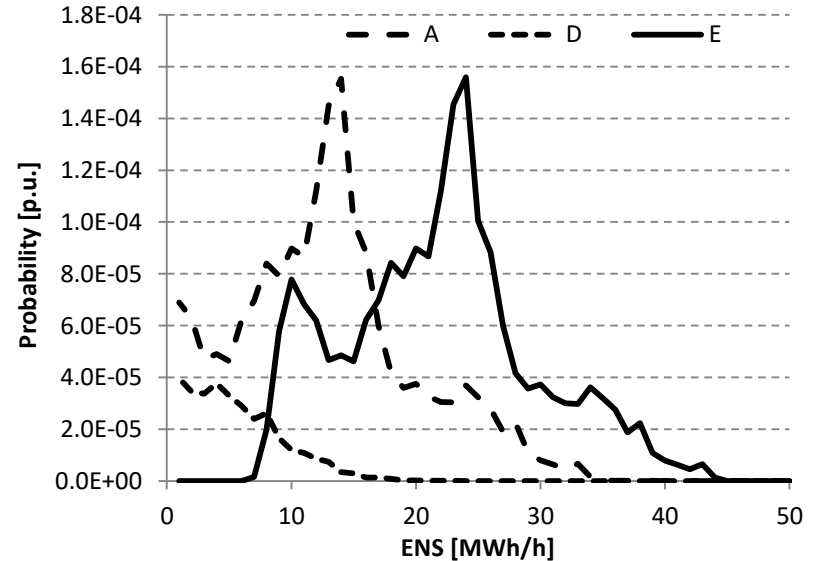
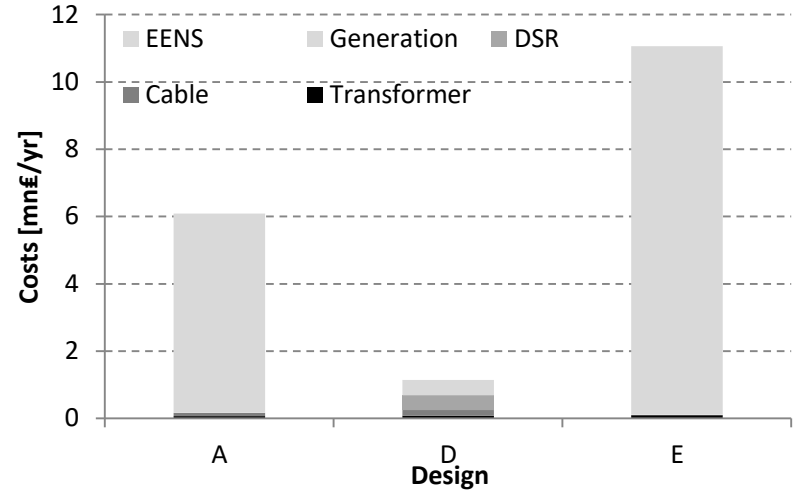
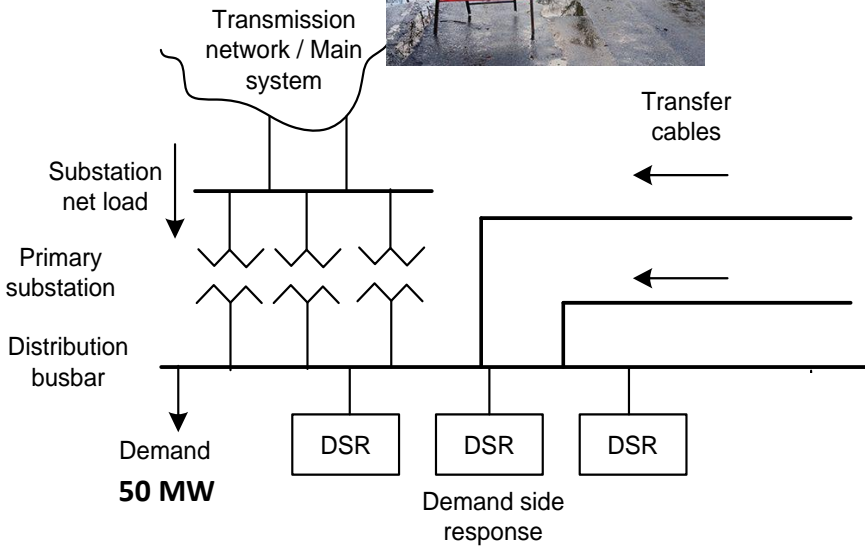


Important to consider probabilities conditional to primary common cause (e.g., weather conditions)

Resilient network operation



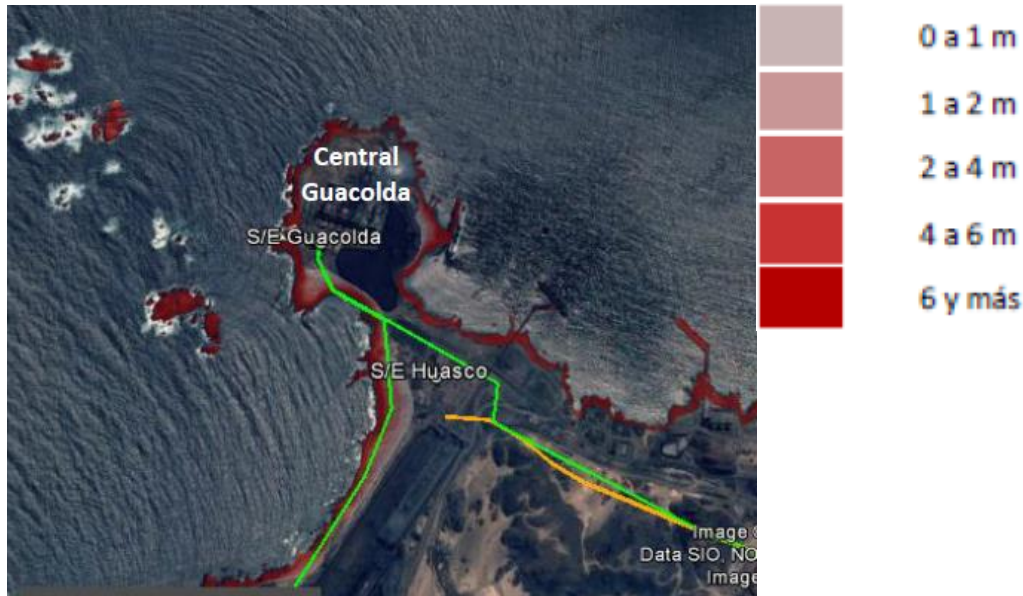
Resilient investment against flooding



Optimal when ignoring CMF Optimal when assuming CMF Traditional N-1

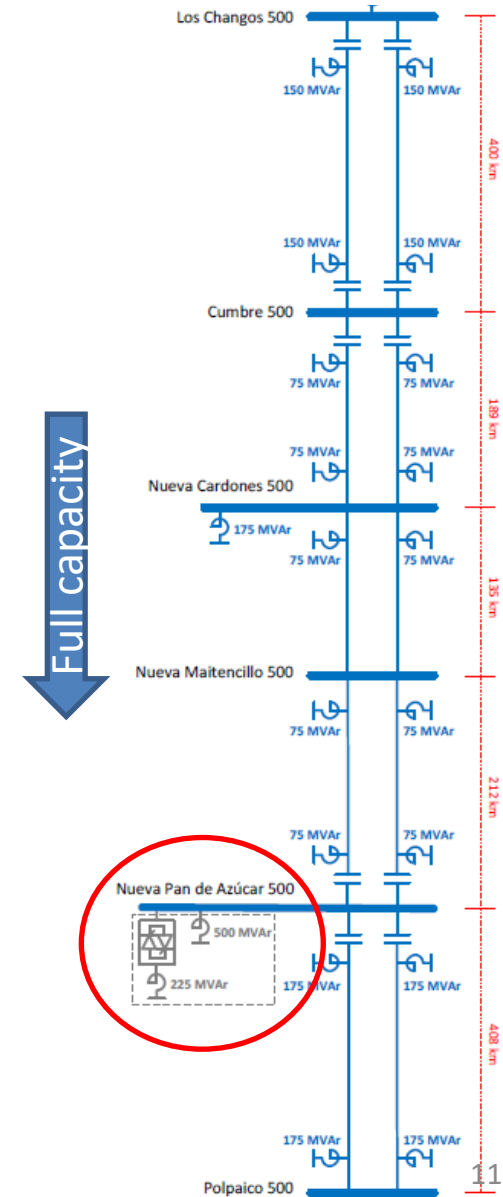
Infrastructure	A (MW)	D (MW)	E (MW)
Transformer	2x34	2x35	2x50
Cable	1x10	2x10	0
DSR	0	3x3.33	0

Resilient reactive power investment

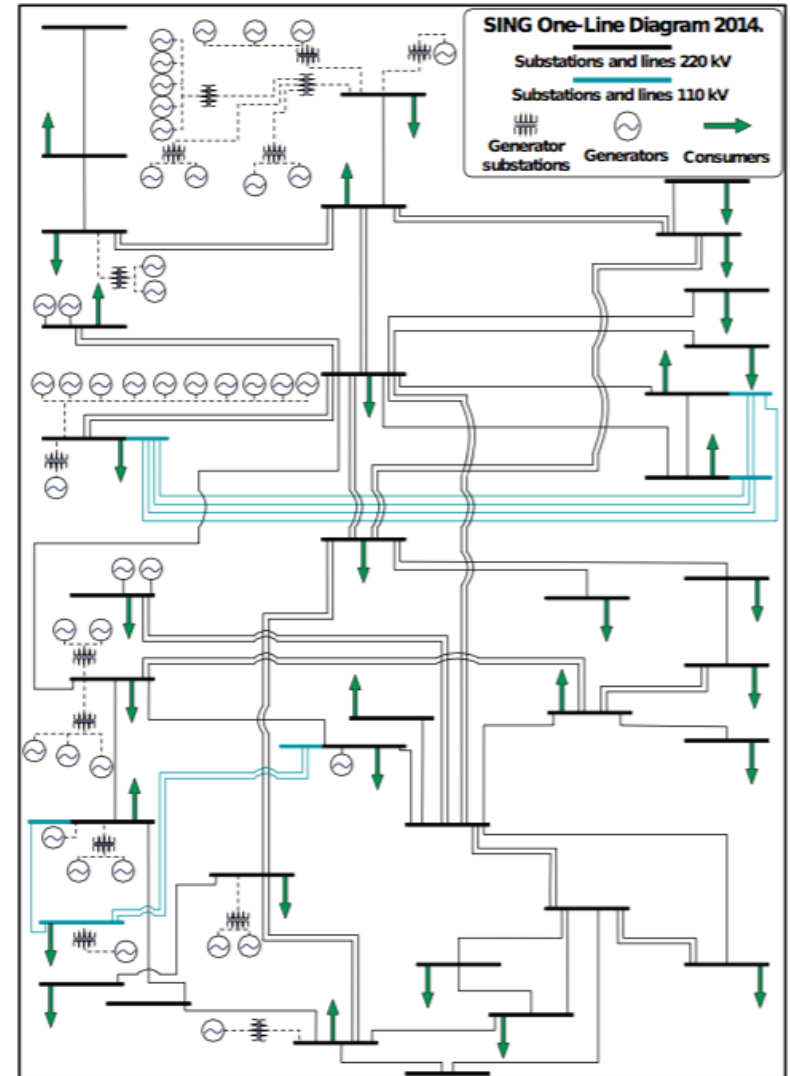
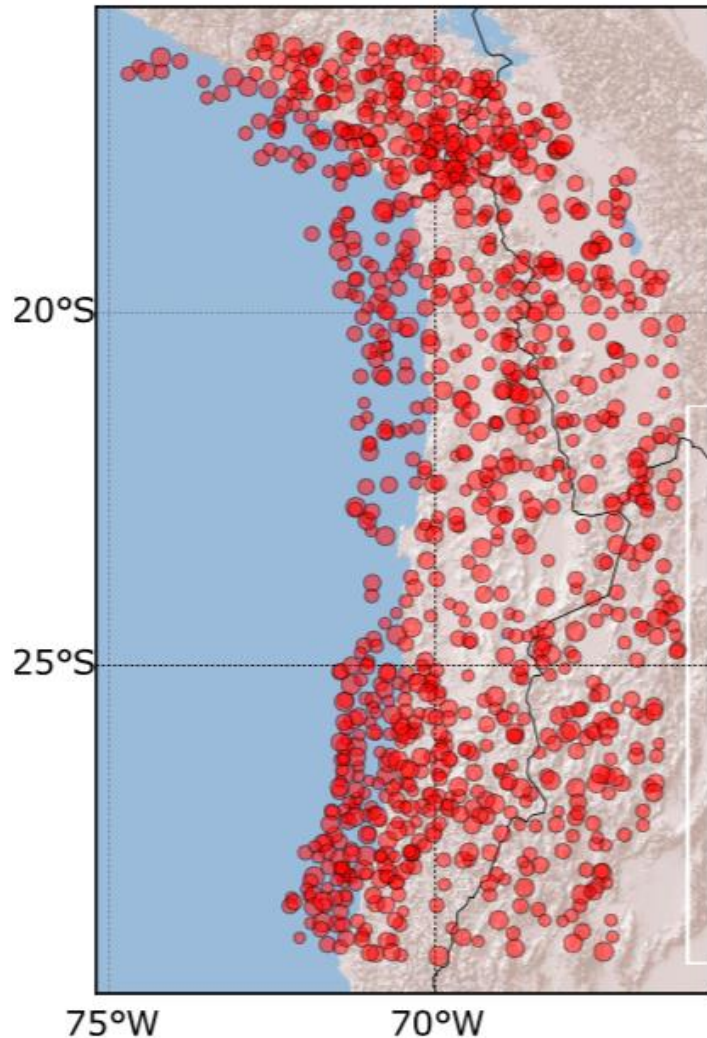


Escenario 1			
Barra	Con Guacolda control PV	Sin Guacolda	Guacolda control PQ subexcitada
Nueva Cardones 500	1,044	1,051	1,035
Nueva Maitencillo 500	1,055	1,064	1,045
Nueva Pan de Azúcar 500	1,066	1,075	1,058
Polpaico 500	1,025	1,025	1,025

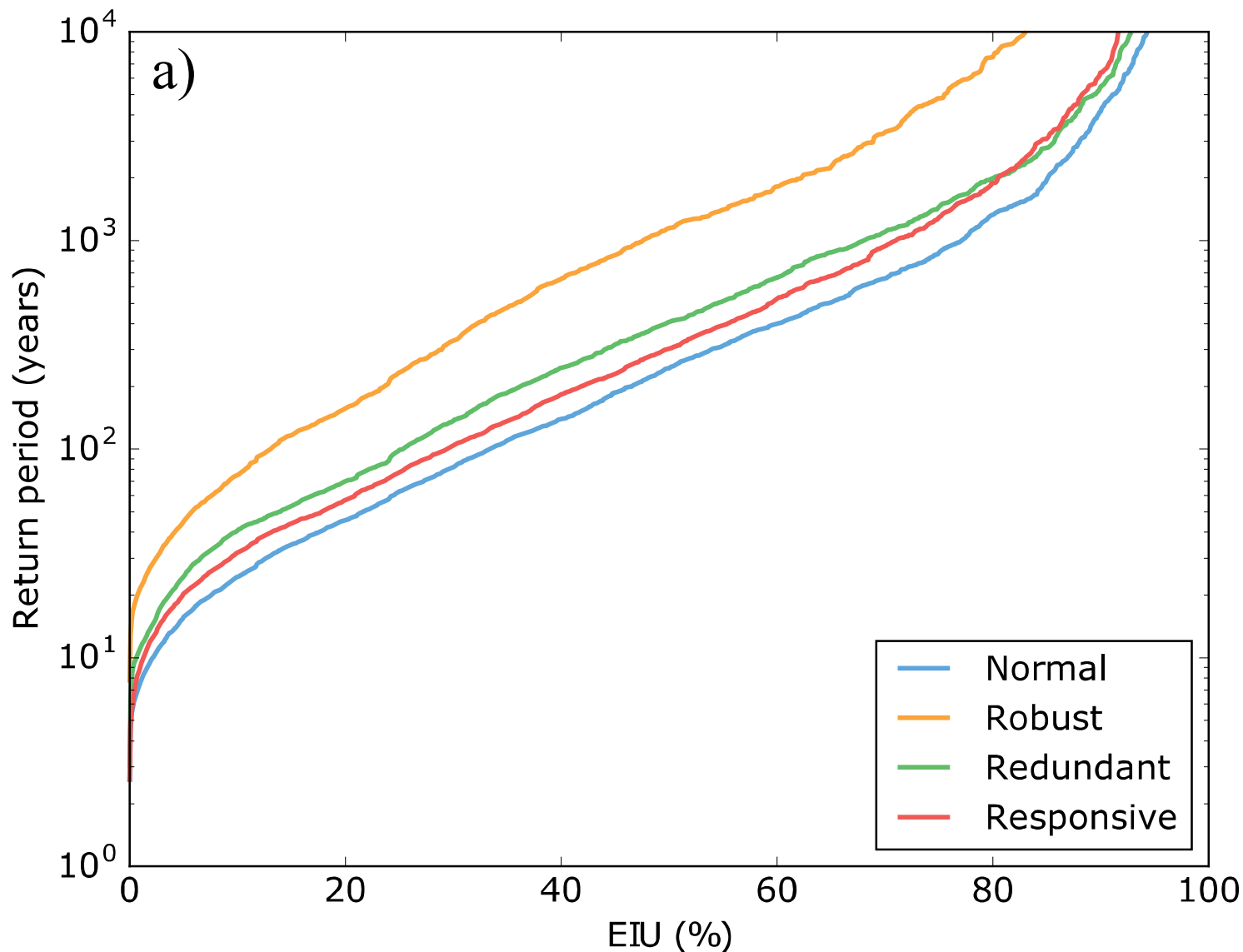
Escenario 1 + SVC 725 MVAR en Nueva Pan de Azúcar 500 kV (500 MVAR fijos + 225 MVAR tiristorizados)			
Barra	Con Guacolda control PV	Sin Guacolda	Guacolda control PQ subexcitada
Nueva Cardones 500	1,023	1,026	1,017
Nueva Maitencillo 500	1,027	1,030	1,020
Nueva Pan de Azúcar 500	1,025	1,029	1,025
Polpaico 500	1,025	1,025	1,025



Different mitigation/adaptation strategies in SING (1)



Different mitigation/adaptation strategies in SING (2)



Conclusions

- Resilience is a dynamic concept
- Resilience goes beyond N-1 and consider conditional outages given a common event
- Multiple outages happen simultaneously
- We developed a mathematical programming methodology for decision making
- We demonstrated that HILP impacts significantly on operation and design

Questions?

Further reading:

- Strbac, G., Kirschen, D., and Moreno, R., “Reliability Standards for the Operation and Planning of Future Electricity Networks”, Foundations and Trends® in Electric Energy Systems”, Vol 1, Issue 3, pp 143–219, 2016.
- Espinoza, S., Sacaan, R., Rudnick, H., Poulos, A., De la Llera, JC., Panteli, M., Mancarella, P., Navarro, a., Moreno, R., “Seismic resilience assessment and adaptation of the Northern Chilean Power System”, IEEE PES 2017 General Meeting, Chicago, USA, Jul 2017
- Moreno, R., Pudjianto, D., and Strbac, G., “Transmission Network Investment with Probabilistic Security and Corrective Control”, IEEE Transactions on Power Systems, Vol 28, No 4, pp 3935-3944, Nov 2013
- Moreno, R., Pudjianto, D., and Strbac, G., “Integrated Reliability and Cost-Benefit-Based Standards for Transmission Network Operation”, Journal of Risk and Reliability, Vol 226, No 1, pp 75-87, Feb 2012
- Moreno, R., and Strbac, G., "Integrating High Impact Low Probability Events in Smart Distribution Network Security Standards Through CVaR Optimisation", IET International Conference on Resilience of Transmission and Distribution Networks (RTDN), Birmingham, UK, Sep 2015.
- Moreno, R., Chen, Y., and Strbac, G., "Evaluation of Benefits of Coordinated DC & AC Flexible Transmission Systems with Probabilistic Security and Corrective Control", IET International Conference on Resilience of Transmission and Distribution Networks (RTDN), Birmingham, UK, Sep 2015.
- Strbac, G., Moreno, R., Pudjianto, D., and Castro, M., “Towards a Risk-Based Network Operation and Design Standards”, IEEE PES 2011 General Meeting, Detroit, USA, Jul 2011
- Moreno, R., Pudjianto, D., and Strbac, G., “Future Transmission Network Operation and Design Standards to Support a Low Carbon Electricity System”, IEEE PES 2010 General Meeting, Minnesota, USA, Jul 2010