

· System Services for a 100% Renewable Power System

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Wind in the Electricity Market in Ireland

Mark O'Malley,
Electricity Research Centre, University College Dublin

Paul Smith, EirGrid

23 Oct 2006

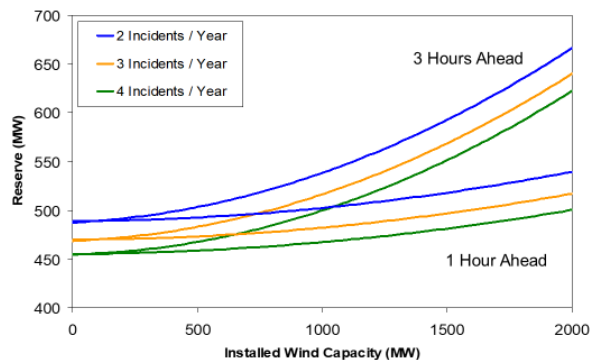
UWIG, Oklahoma City, USA

Impact of wind on generation reserve requirements in Ireland

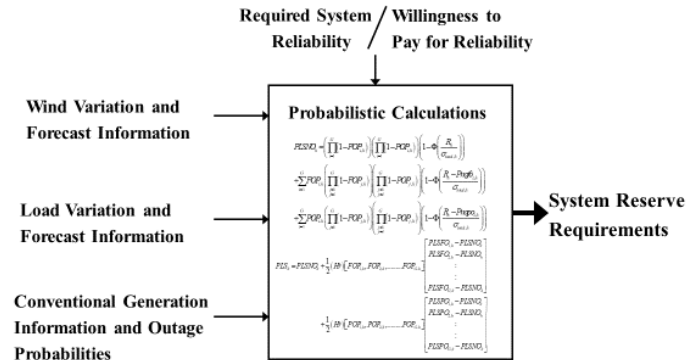
Mark O'Malley, Electricity Research Centre, University
College Dublin

25th October 2006
UWIG, Oklahoma City, USA

Operating reserve required



Outline of Methodology



Where we were then

Local

Specific

Piecemeal

Opaque

Expensive & unreliable ?

Where we wanted to go

Global

General

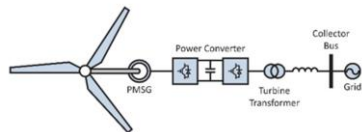
Holistic

Transparent

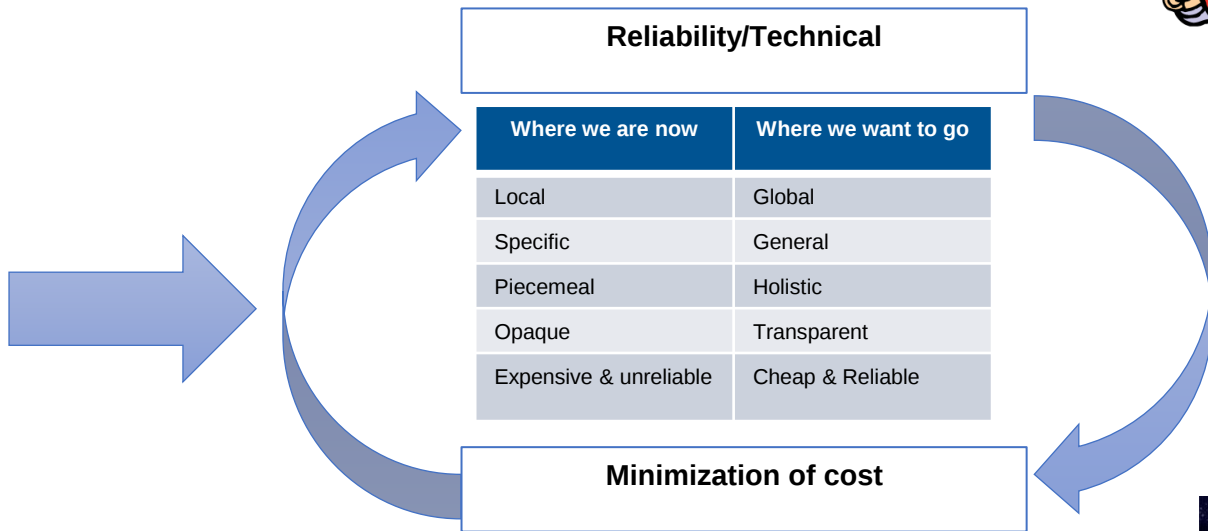
Cheap & Reliable ?

Research Program	Description	Number of Questions
<i>Inverter Design</i>	Development of capabilities, services , design methodologies and standards for IBRs.	10
<i>Tools and Methods</i>	New tools and methods required to ensure reliability, security, and stability in power systems.	9
<i>Control Room of the Future</i>	Development of new technologies and approaches for enhanced real-time visibility and analysis in power system operator control rooms.	17
<i>Planning</i>	New planning metrics, methods, and tools to capture the characteristics and influence of a changing resource mix.	15
<i>Black Start</i>	Creating new procedures for black starting and restoring a power system with high or 100% IBR penetrations.	1
Services	Quantifying the technical service requirements required of future power system to maintain the supply-demand balance reliably and at least cost.	7

Cost reliability trade off



Type IV



IBRs replacing Synchronous Machines



System Needs and Services for Systems with High IBR Penetration

Janusz Bialek
University of Newcastle, UK

Thomas Bowen
NREL, USA

Tim Green
Imperial College London, UK

Debbie Lew
ESIG, USA

Yitong Li
Imperial College London, UK

Jason MacDowell
GE, USA

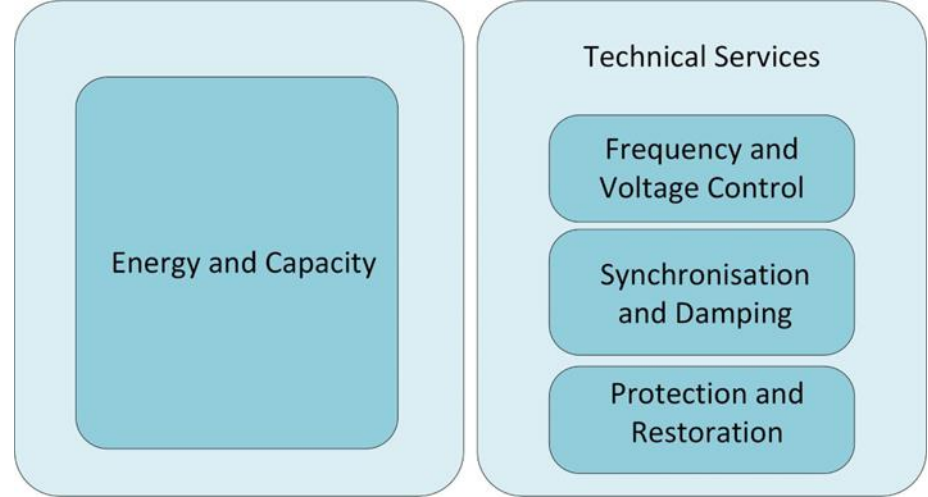
Julia Matevosyan
ERCOT, USA

Nicholas Miller
HickoryLedge, USA

Mark O'Malley
ESIG, Ireland

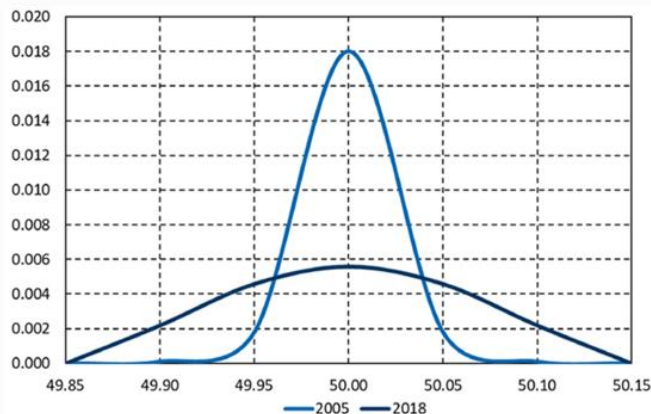
Deepak Ramasubramanian
EPRI, USA

October 8th, 2021



Major programs

Figure 1: Frequency distribution within the normal frequency operating band in the NEM (2005 Snapshot vs. 2018 Snapshot)



Source: AEMO, Removal of disincentives to the provision of primary frequency response during normal operating conditions – Electricity rule change proposal, 1 July 2019, p.14.

Fast Frequency Response

Very Fast FCAS Market Commencement

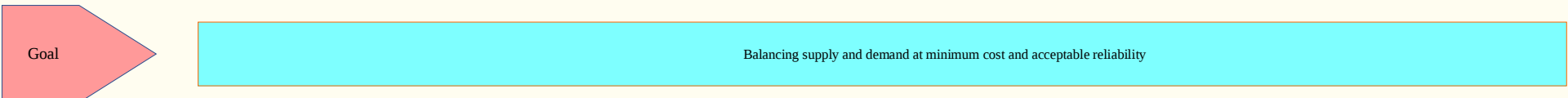
On the 15 July 2021, the AEMC made a [final rule](#) to introduce two new market ancillary services in the NEM under the existing Frequency Control Ancillary Services (FCAS) arrangements, the very fast raise and very fast lower FCAS markets.

Following consultation with stakeholders and work undertaken by AEMO, the very fast raise and very fast lower FCAS markets opened on **Monday 9 October 2023 at 1.00pm (Market Time)**.

Very Fast FCAS Market Commencement – Go for Monday 9 October 2023



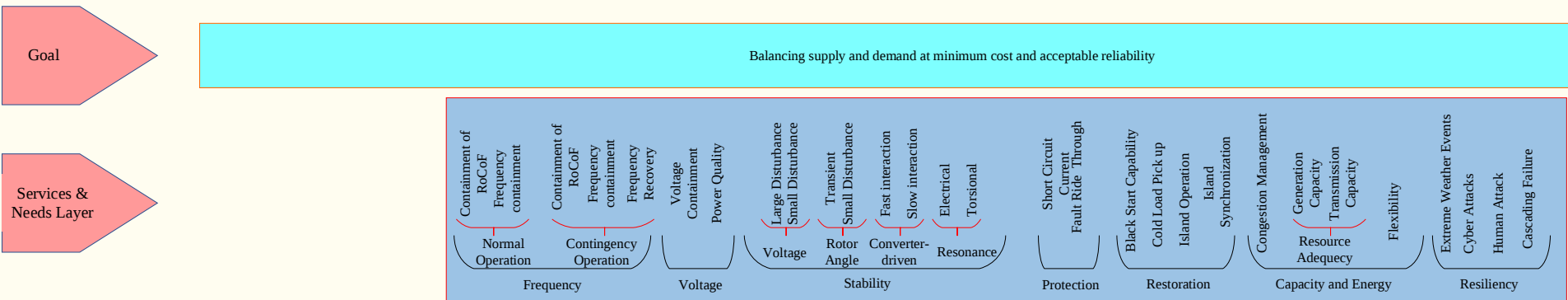
Framework: Primary layer



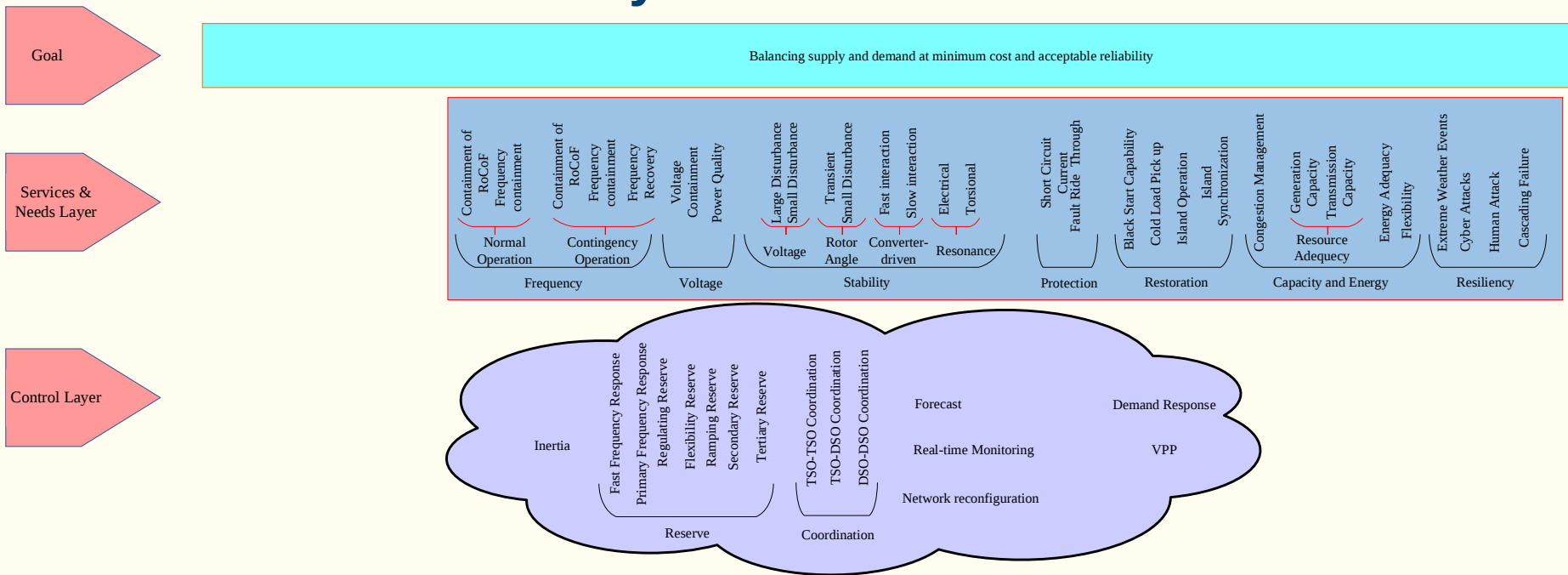
Goal

Balancing supply and demand at minimum cost and acceptable reliability

Framework: Services and needs layer



Framework: Control layer



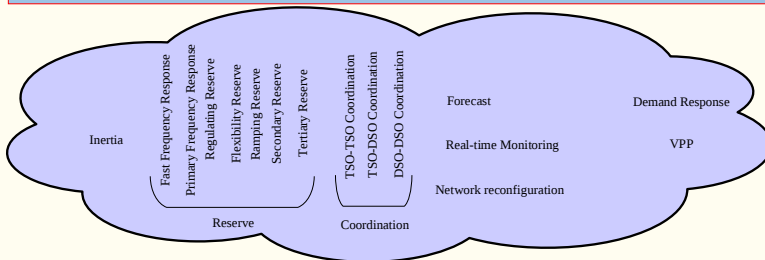
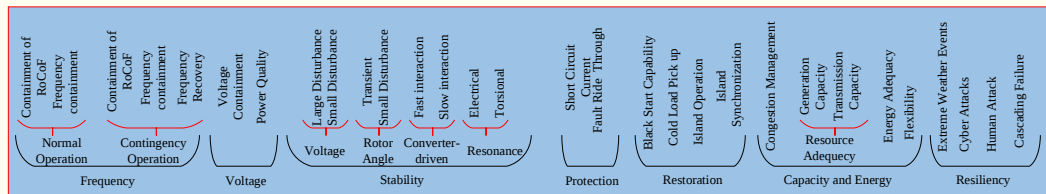
Goal

Services &
Needs Layer

Control Layer

Technology
Layer

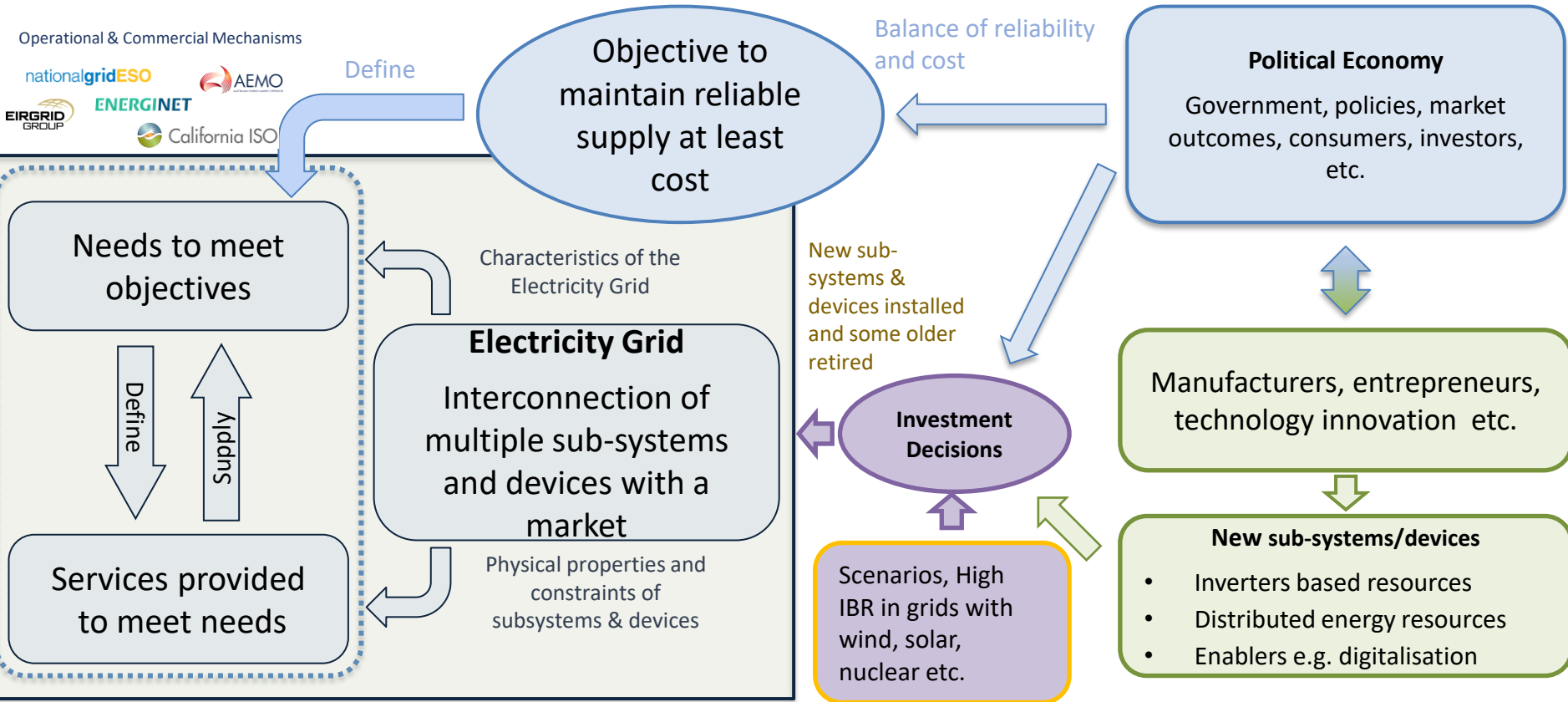
Balancing supply and demand at minimum cost and acceptable reliability



Generation System		Bulk Power System Technology	Distribution and Demand Side Technology	Communication System	Storage			
Primary Resources	Generation Technology	Transmission Lines Transmission Interconnection FACTS Synchronous Condenser HVDC Lines Relays Circuit Breakers Power System Stabilizer PMU Transmission Substation	Distributed Energy Resources Electrical Cars Smart Buildings Smart Meters Relays and Fuses Micro-PMU Distribution Substation	Communication Infrastructure Internet .	Long Term Pumped Hydroelectric Storage	Medium Term Compressed Air Energy Storage	Short term Battery Energy Storage Flow Battery Energy Storage	Very Short term Capacitor and supercapacitor Superconducting Magnetic Energy Storage Flywheel
Nuclear Geothermal Wind Solar Biomass Hybrid . . .	Synchronous Machines Grid Forming Inverters Grid Following Inverters . . .			Gas Network Control System SCADA ADMS EMS AMI . . .	Thermal Energy Storage Hydrogen storage and fuel cell			



Bring it all together Institutionally for Transformation of the Global Power System



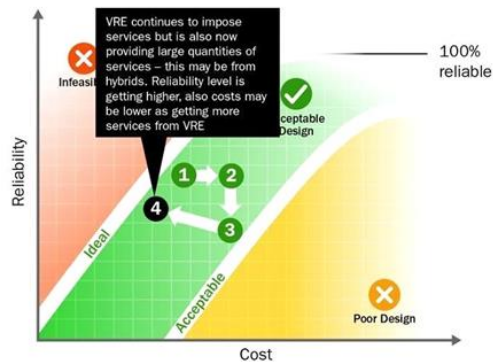
Framework needs much more work



A



B



D



C



O'Malley et al., "Grand challenges of Wind Energy Science – Meeting the needs and services of the power system", Wind Energy Science, in review.

Conclusion

- Significant detailed system level work needed to gain generalisable insights (ongoing)
- Managing needs and services due to IBRs replacing SMs we to have a rigorous process/methodology
- Need a framework to do this ?
- Have made a start – more to be done

Acknowledgements & Further Reading

- Leverhulme Trust International Professorship

Further Reading

- <https://globalpst.org/>
- <https://www.esig.energy/>