

**IMPERIAL**

**Advancing Methods and Tools for  
Probabilistic Resource Adequacy  
Assessment and Capacity Expansion**

**Gord Stephen**

**Department of Electrical and Electronic Engineering  
Imperial College London**

# Agenda

- 01** Personal Introduction
- 02** Advancing Adequacy Assessment Tools
- 03** Adequacy-Aware Capacity Expansion
- 04** Visualization & Interactive Interfaces

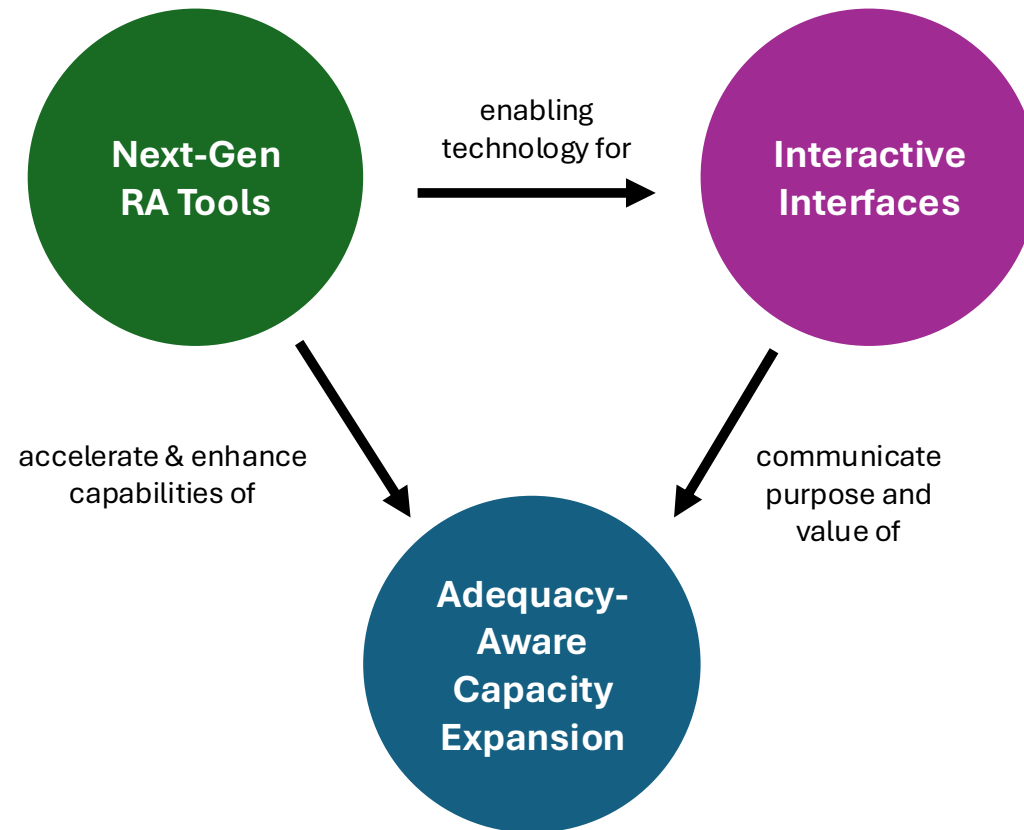
## Personal Introduction

### Professional Background

- Energy system modelling methods researcher in Electric Power Innovation for a Carbon-Free Society (EPICS-UK) group at Imperial College London
- Previously spent 8+ years at US National Renewable Energy Laboratory (now National Laboratory of the Rockies)
  - Lead developer of lab's Probabilistic Resource Adequacy Suite (PRAS) tool
  - Co-lead of Global Power System Transformation Consortium (GPST) Pillar 5 on Open Data and Tools
  - Most recently focused on demonstrating novel methods for adequacy-aware capacity expansion with vertically-integrated utility partners
- Before that, worked at NRCan on renewable electricity policy & program development

# Personal Introduction

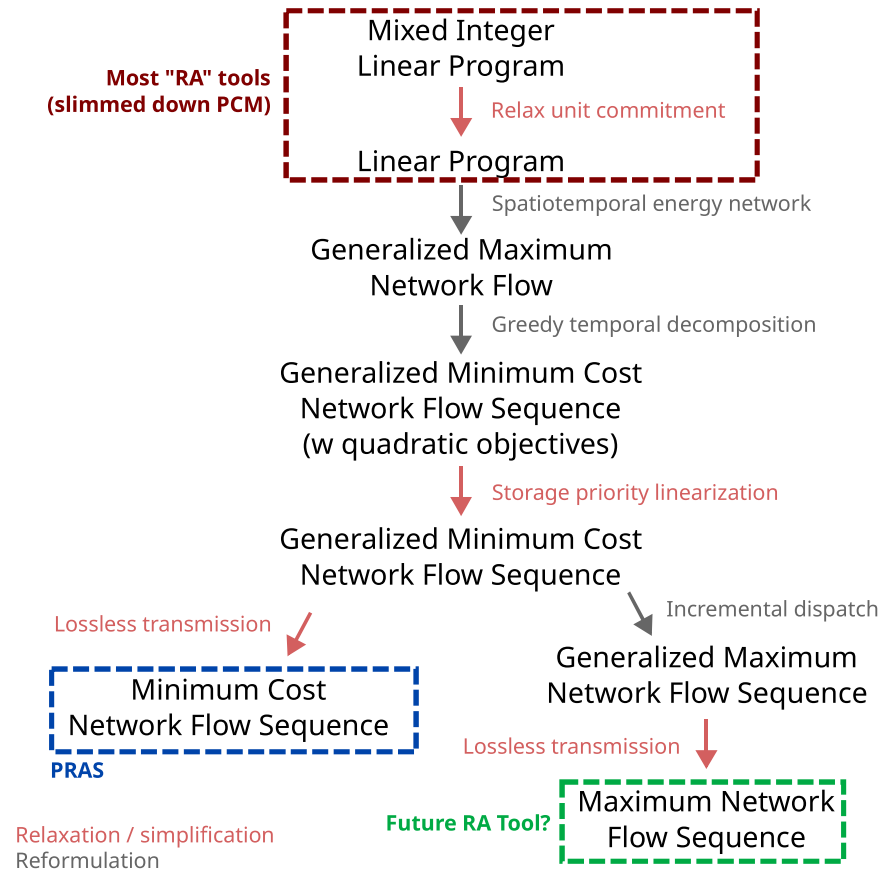
## Research Focus Areas



# Advancing Adequacy Assessment Tools

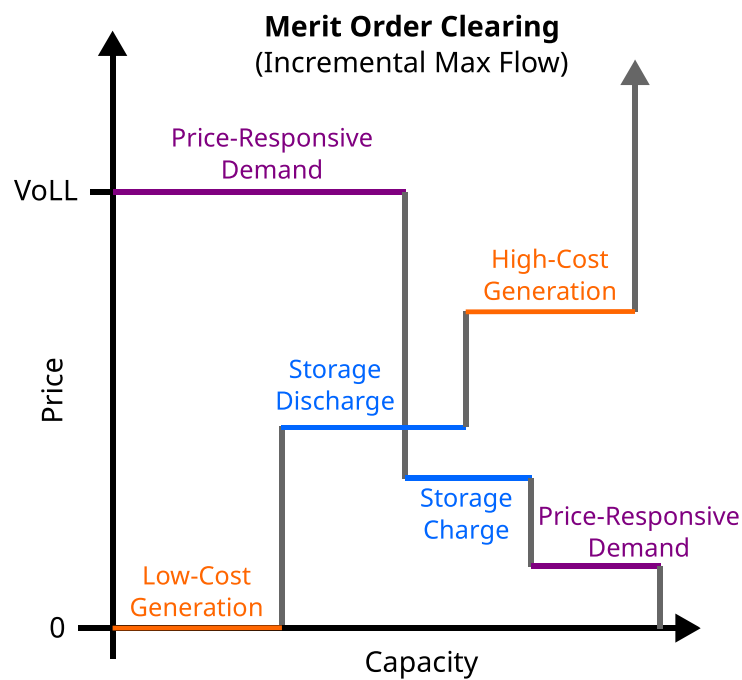
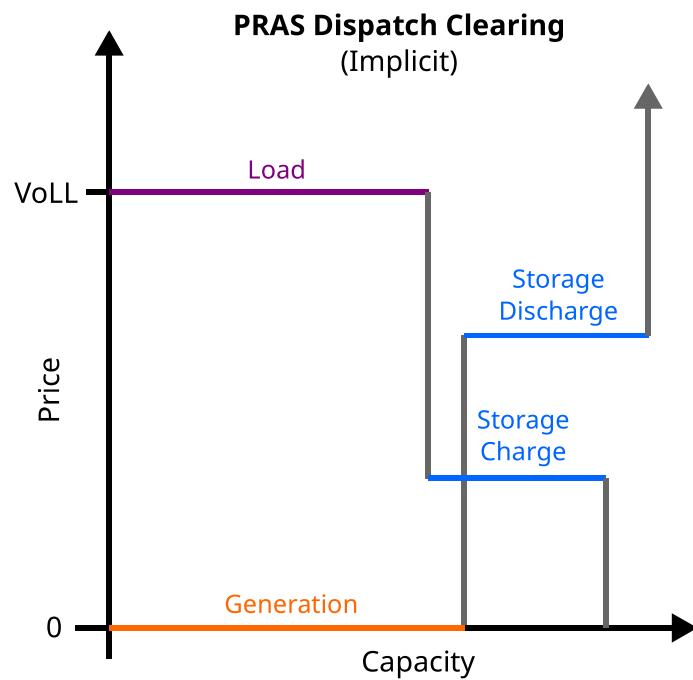
## Efficient Formulations for the Shortfall Minimization Problem with Transmission and Storage

- How can we narrow realism vs speed tradeoffs between fast dispatch strategies that only verify dispatch feasibility, and slow dispatch strategies that produce economically viable solutions?
- Can algorithms and data structures in software implementations be adapted to take greater advantage of computing hardware capabilities?
- How can we efficiently verify whether future system designs provide sufficient operational flexibility under a wide range of potential operating conditions?



# Advancing Adequacy Assessment Tools

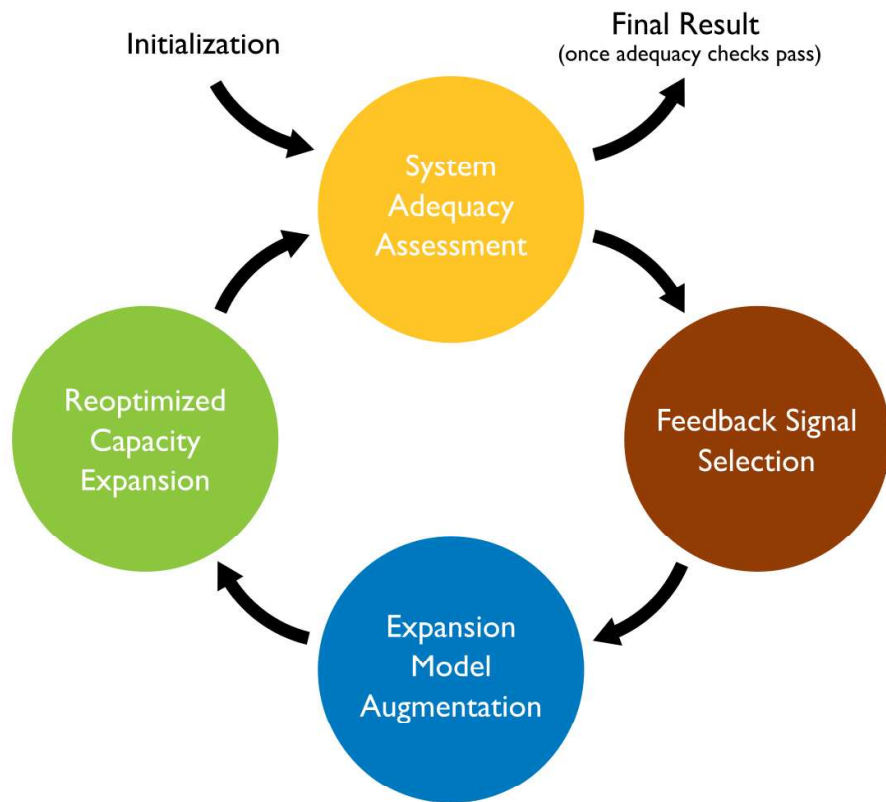
## From Shortfall Minimization to Efficient Merit-Order Dispatch



- Operating cost estimates
- Price-responsive demand
- Controlled adequacy suboptimality (myopic storage scheduling, interregional coordination friction)
- Extra details obtained “for free” by exploiting network flow solver internals

# Adequacy-Aware Capacity Expansion

## Combining Complementary Approaches



### **Adaptive Stress Period Planning**

Identify emergent system risks and explicitly plan against those conditions in the expansion step

### **EUE Cutting Planes**

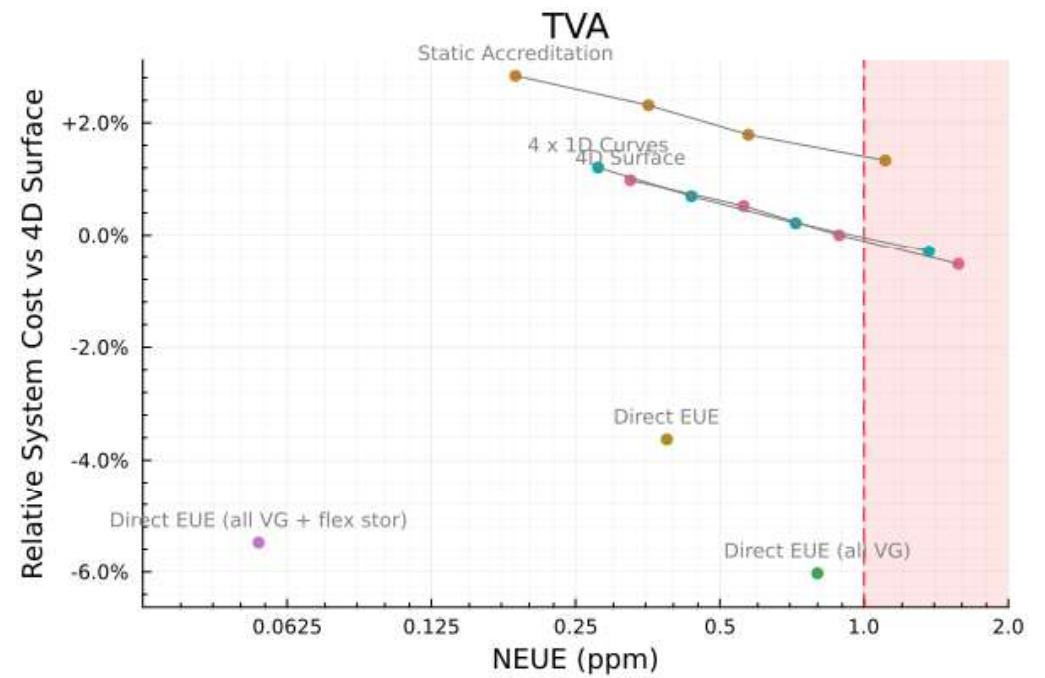
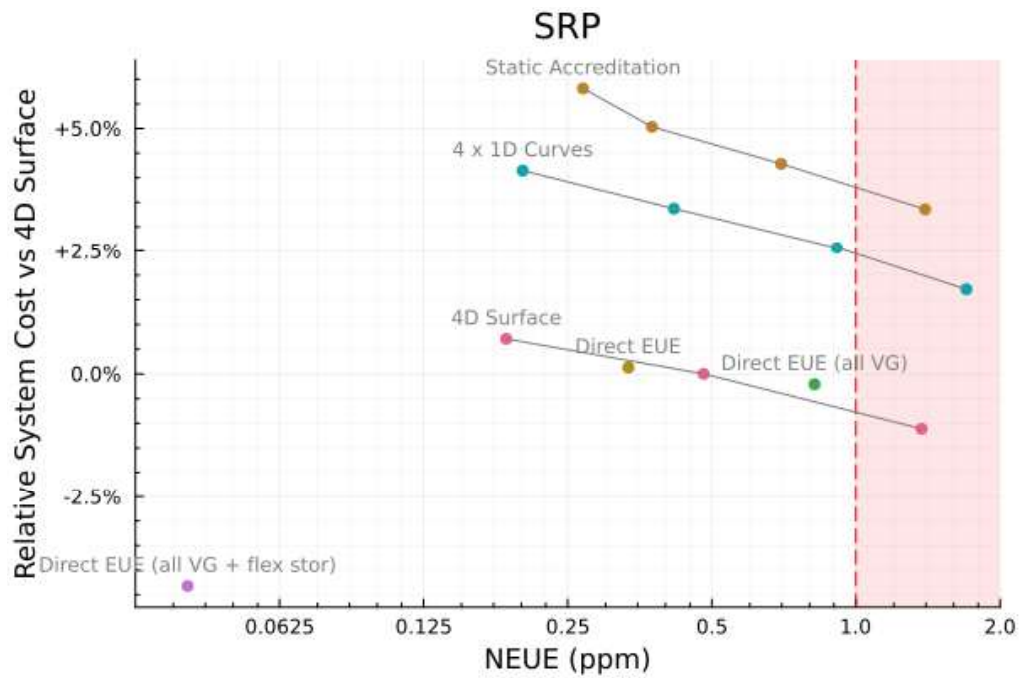
Incrementally refine an internal estimator for resource adequacy as a function of portfolio choices

### **Sparse Chronology**

Efficiently capture long-term energy shifting dynamics from long-duration storage devices, without explicitly modeling all intermediate timesteps

# Adequacy-Aware Capacity Expansion

## Utility Case Studies: Cost vs Reliability Comparison



# Visualization & Interactive Interfaces

- How can high resolution displays augment aggregate statistics reporting and help visualize underlying risk distributions across space, time, and probabilistic scenarios?
- Can we rapidly simulate grid operations and report key outcomes (generation mix, system costs, emissions, etc) for interactively-specified future grid designs?
- How can we visualize high-dimensional, near-least-cost design spaces to understand alternative generation/transmission portfolios that may better satisfy unquantified and/or conflicting stakeholder preferences?



Data Observatory, Imperial Data Sciences Institute

**IMPERIAL**

**Keep in Touch!**

**[g.stephen@imperial.ac.uk](mailto:g.stephen@imperial.ac.uk)**