Evaluation and Enhancement of Potential Severn Barrage Schemes

IET Power Academy Seminar
Cardiff 2012

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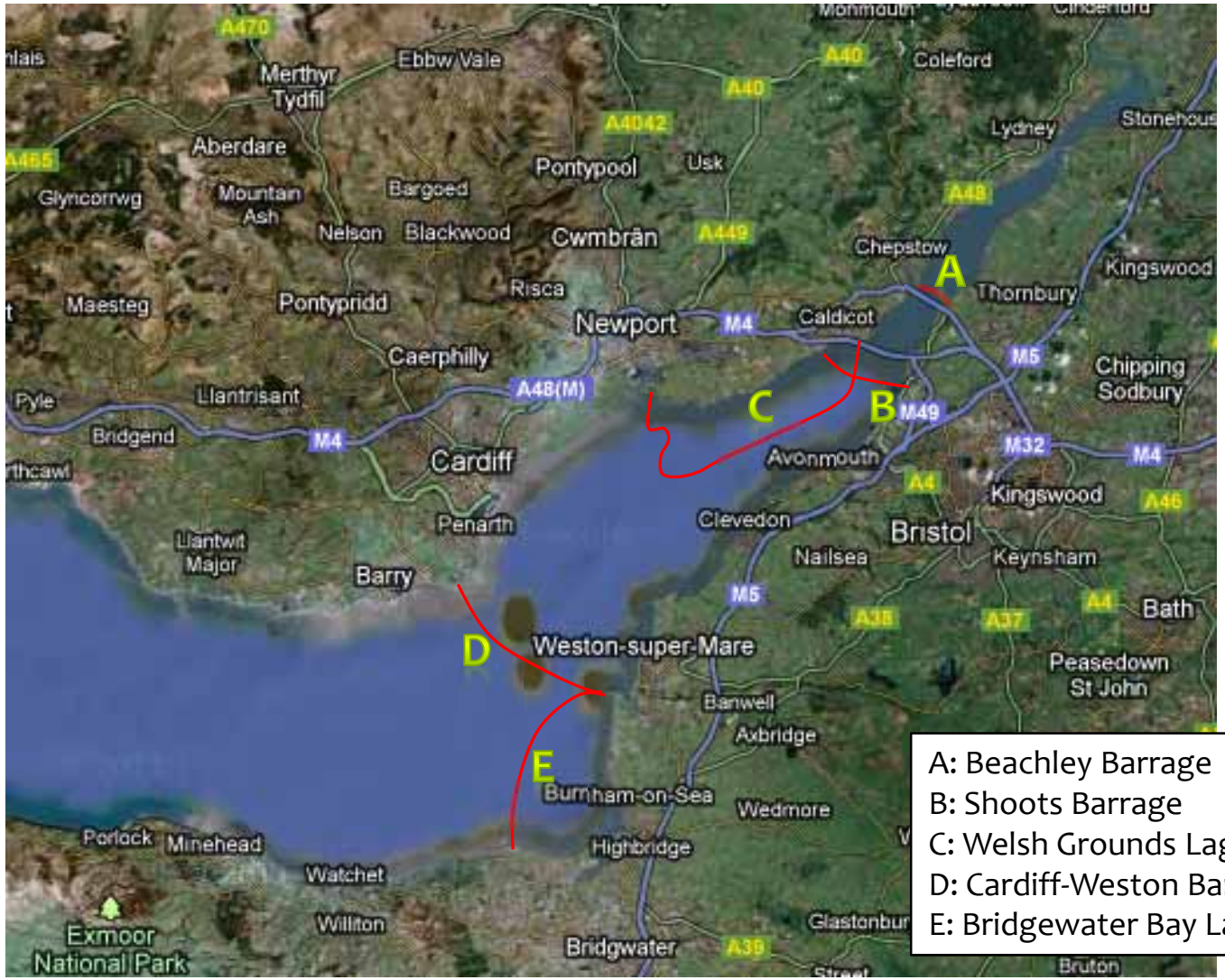
Background

* Most recent review in 2010 for DECC
* Renewed interest in Severn tidal generation from private investors
* New estimated connection date of 2030

Project Aims

* Review previous proposals
* Develop 2018 model
* Investigate 2030 model
  * Uncertain energy future scenario
* Add Severn Barrage to model
* Investigate the effect of the Severn Barrage
* Investigate required network reinforcement
* Determine economic feasibility

Schemes Selected for DECC Study



Project Cost

- Based on a previous model (Parson's Brinkerhoff)
- Project cost split into following areas:
  - PRE-CONSTRUCTION = 1%
  - CONSTRUCTION & GENERAL CIVILS =12.5 %
  - CAISSONS = 25.5%
  - M&E = 36%
  - ADDITIONAL ITEMS = 5.5%
  - COMPENSATORY HABITATS = 19%
  - PROMOTIONAL COST = 0.5%
- Inflation Rate

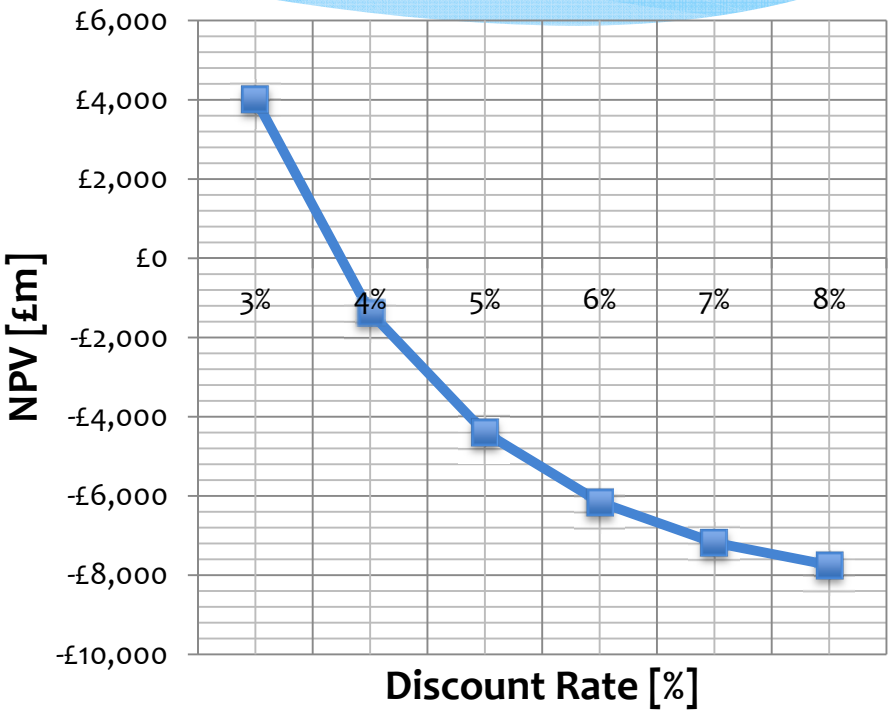
Benefits

* Renewable Obligation Certificates
* Severn Obligation Certificates
* Feed-in-Tariff
  * 7.8p/kWh
* Annual income £1.3bn

NPV Study

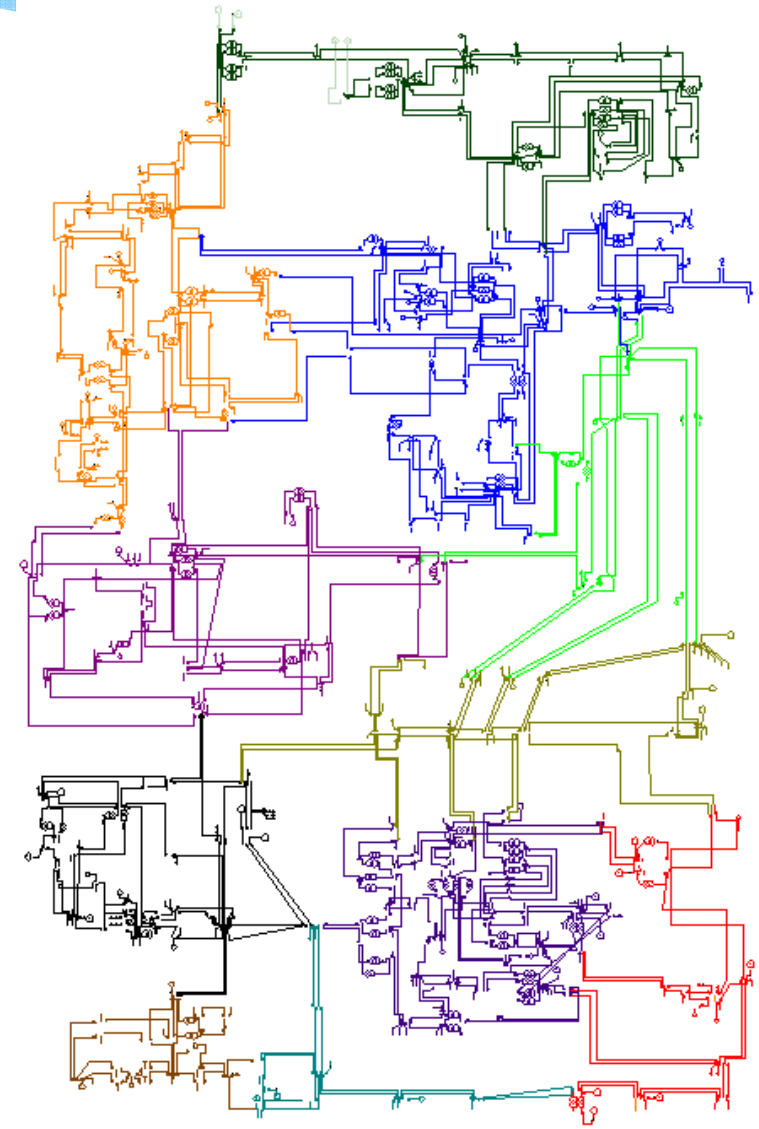
* Base Year = 2012
* Length of study 120 years
* Discount rate of 8%
* NPV = -£7.747bn

* Promote interest through more incentives



Simulated UK Transmission Network

* Power System Analysis CAD
* Quasi-geographical one line diagram
* National Grid Transmission Assets (275/400kV)

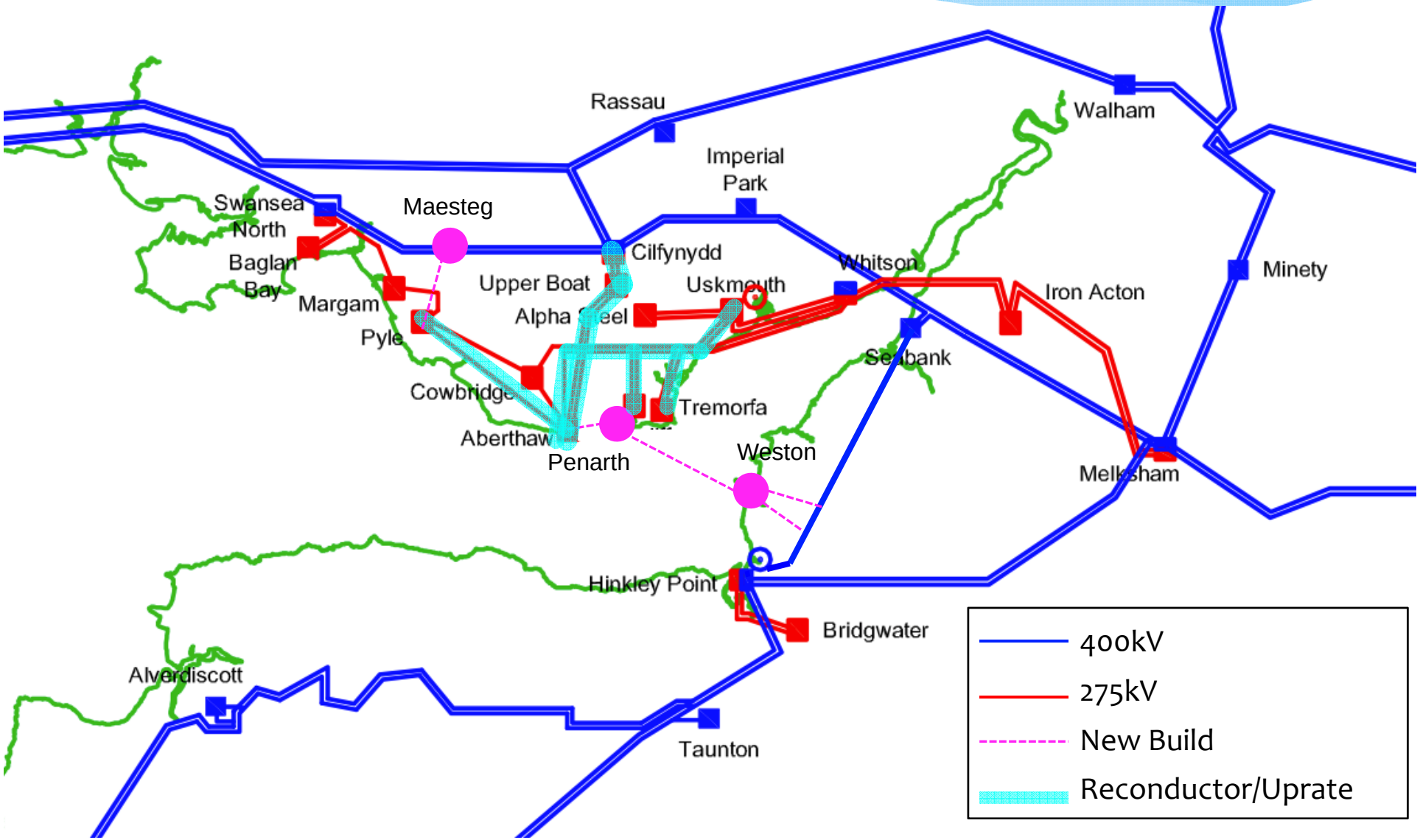


NEPLAN
By BCP Switzerland

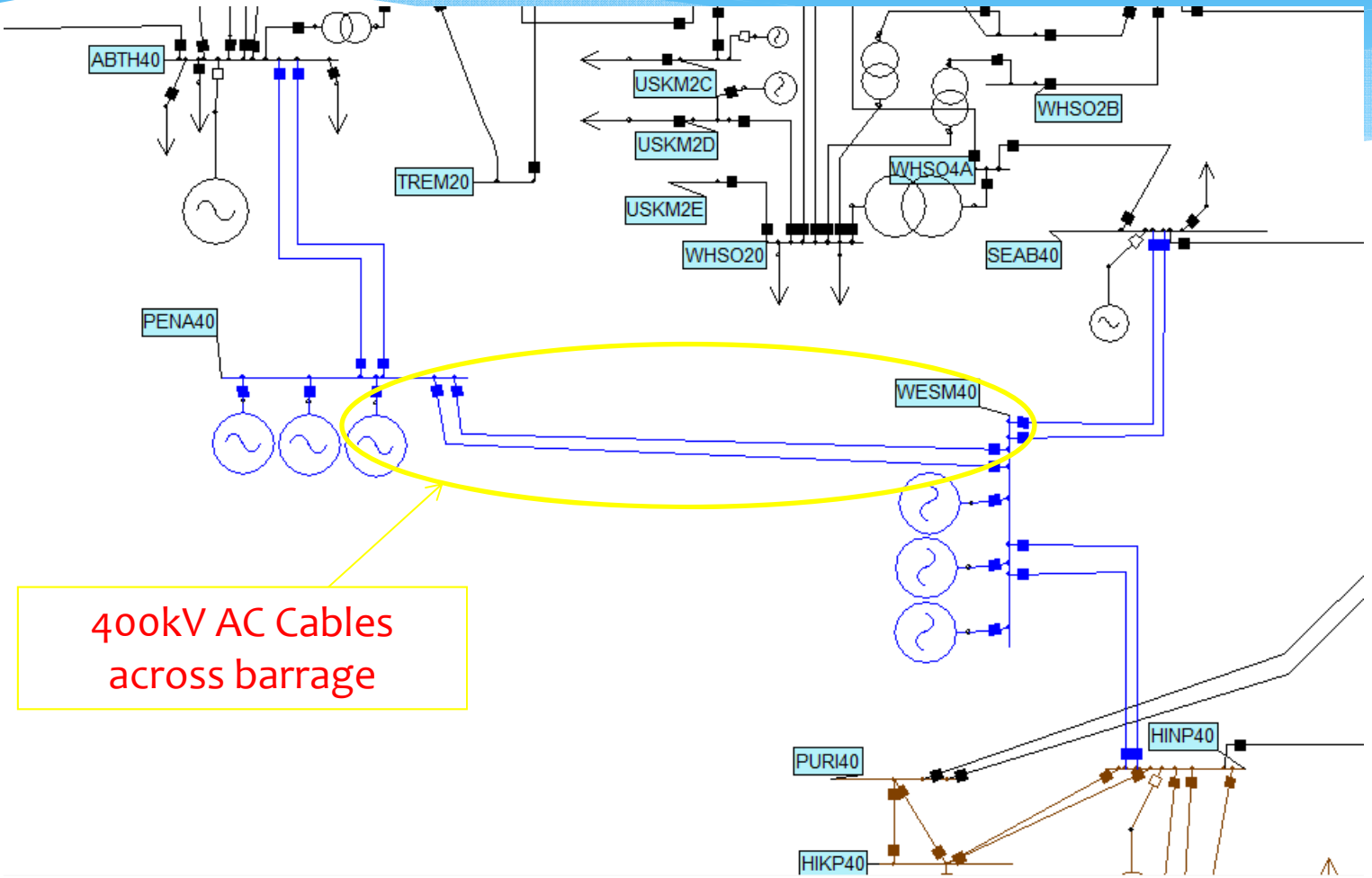
Transmission System Modelling to 2018

* Automated update process using Excel macros
* National Grid data was converted to a Neplan compatible format
* Unique Neplan compatible names were generated for new additions
* Process is easily repeatable for different scenarios and future users

Cardiff-Weston Barrage Connection with Circuits Across Barrage



Addition of the Barrage

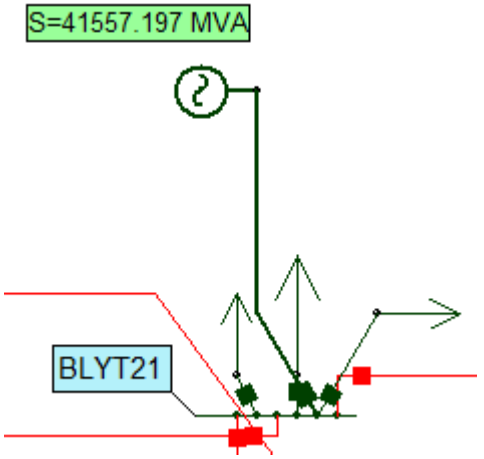


2030 scenario implementation

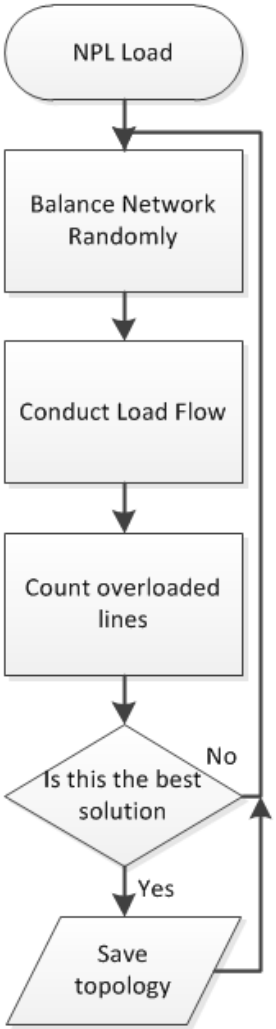
* 10% load increase (Electrify all sectors)
* 15% of electricity from DG (Low energy demand)
* Large amount of wind (Renewable generation)
* Centralised generation (Nuclear generation)

Power System Analysis

* DC Load Flow
  * Balancing
  * Capacity Requirements
* Extended Newton Raphson Load Flow
  * Power Flows
  * Voltage levels

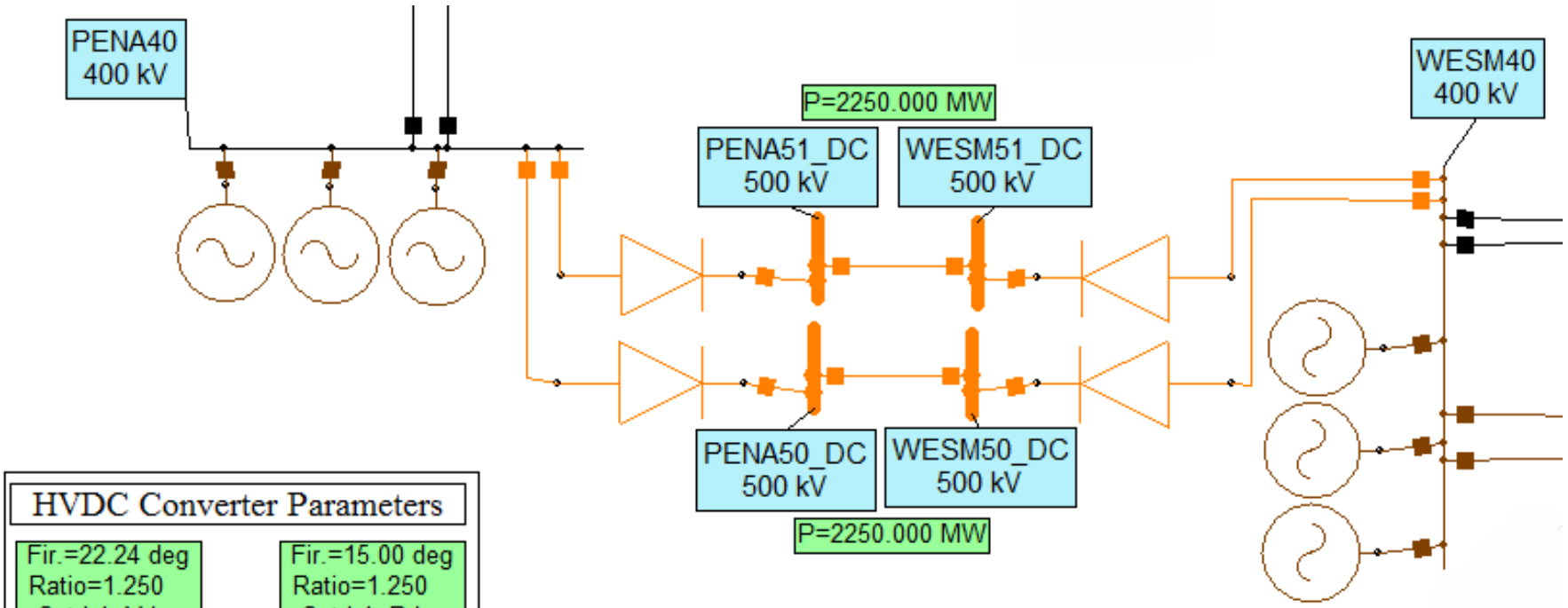


Implementation: NPL



* C++ based interface
* Automated network modification and testing
* Programs written
  * Balance network
  * Find ideal network configuration
  * Line up-rating
  * Load flow contingency testing

HVDC Barrage



HVDC Converter Parameters	
Fir.=22.24 deg Ratio=1.250 Cntrl 1=Vd Cntrl 2=NONE	Fir.=15.00 deg Ratio=1.250 Cntrl 1=Pd Cntrl 2=NONE
Fir.=22.24 deg Ratio=1.250 Cntrl 1=Vd Cntrl 2=NONE	Fir.=15.00 deg Ratio=1.250 Cntrl 1=Pd Cntrl 2=NONE

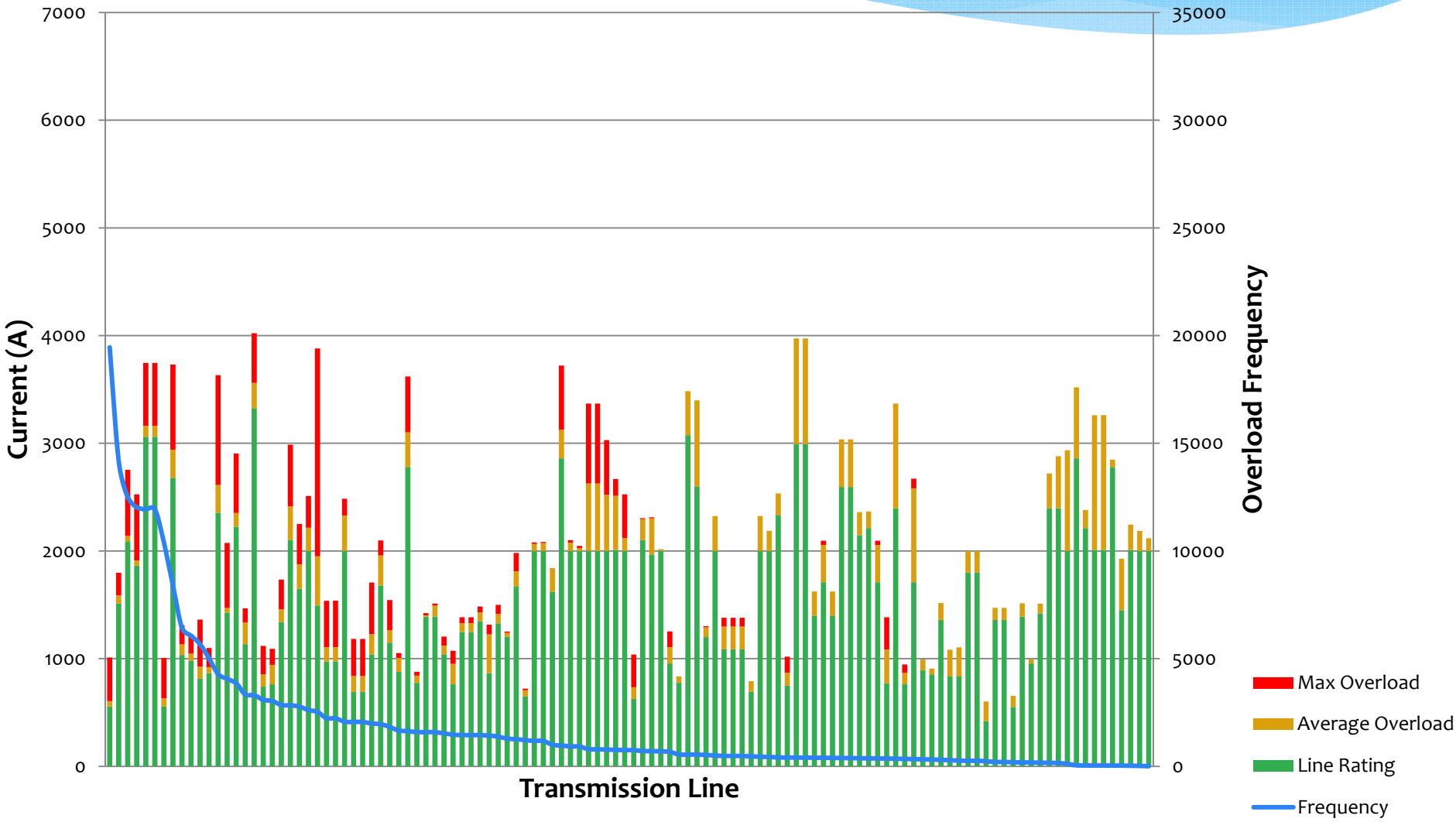
Modelling Method

* Balance network
  * Load & Generation according to scenario
* Reinforce network to required capacity
  * Line up-rating to required capacity
* Simulate outage conditions
  * Reinforce in order to meet outage requirements

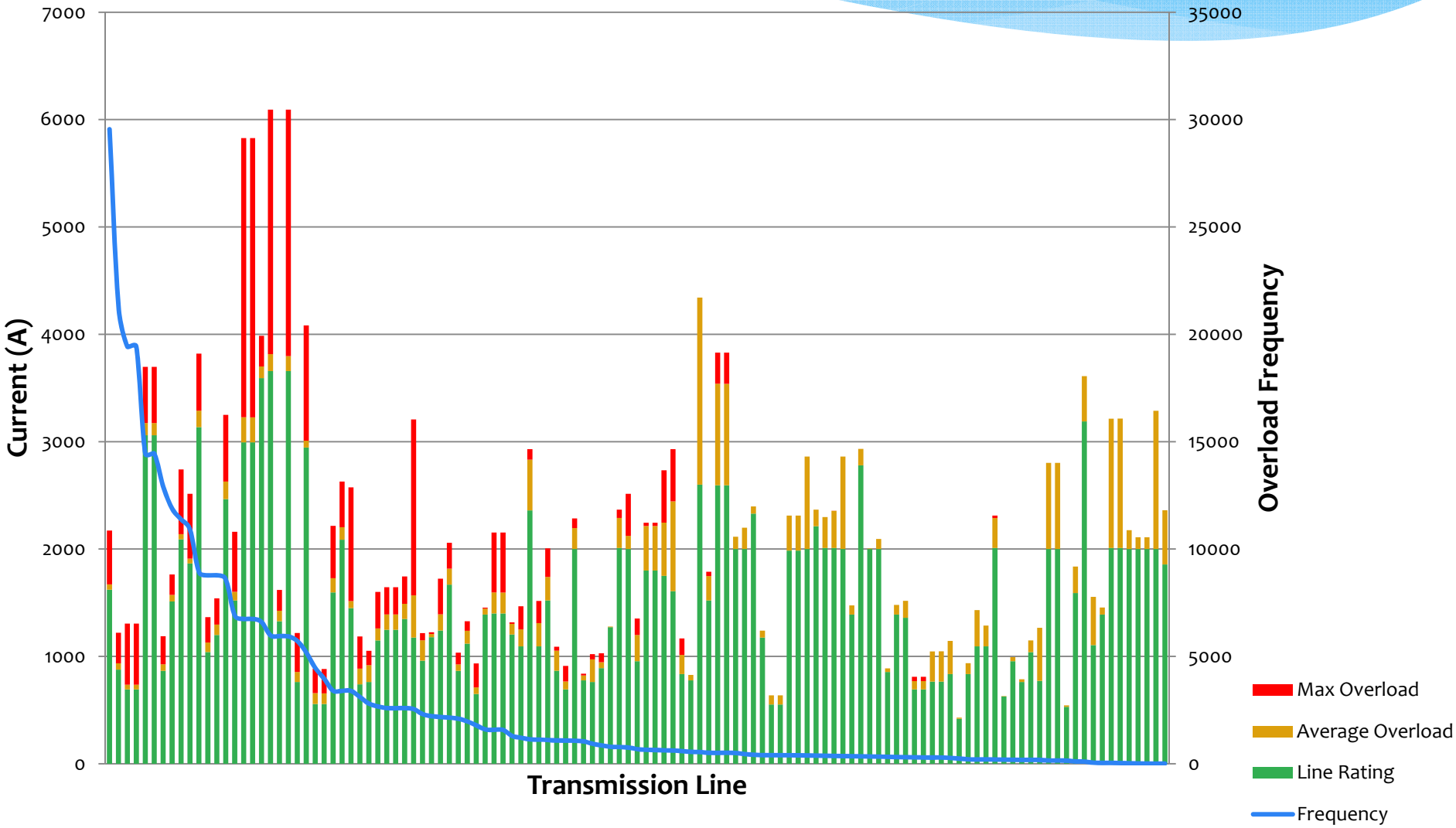
Contingency testing

* Entire network:
  * 571 transmission lines
  * ‘n – 1’ = 571 combinations
  * ‘n – 2’ ≈ 200,000 combinations
    * 4 scenarios, with and without barrage
      * 1.6 million simulations
  * Reinforcement
    * Security & Quality of Supply Standards

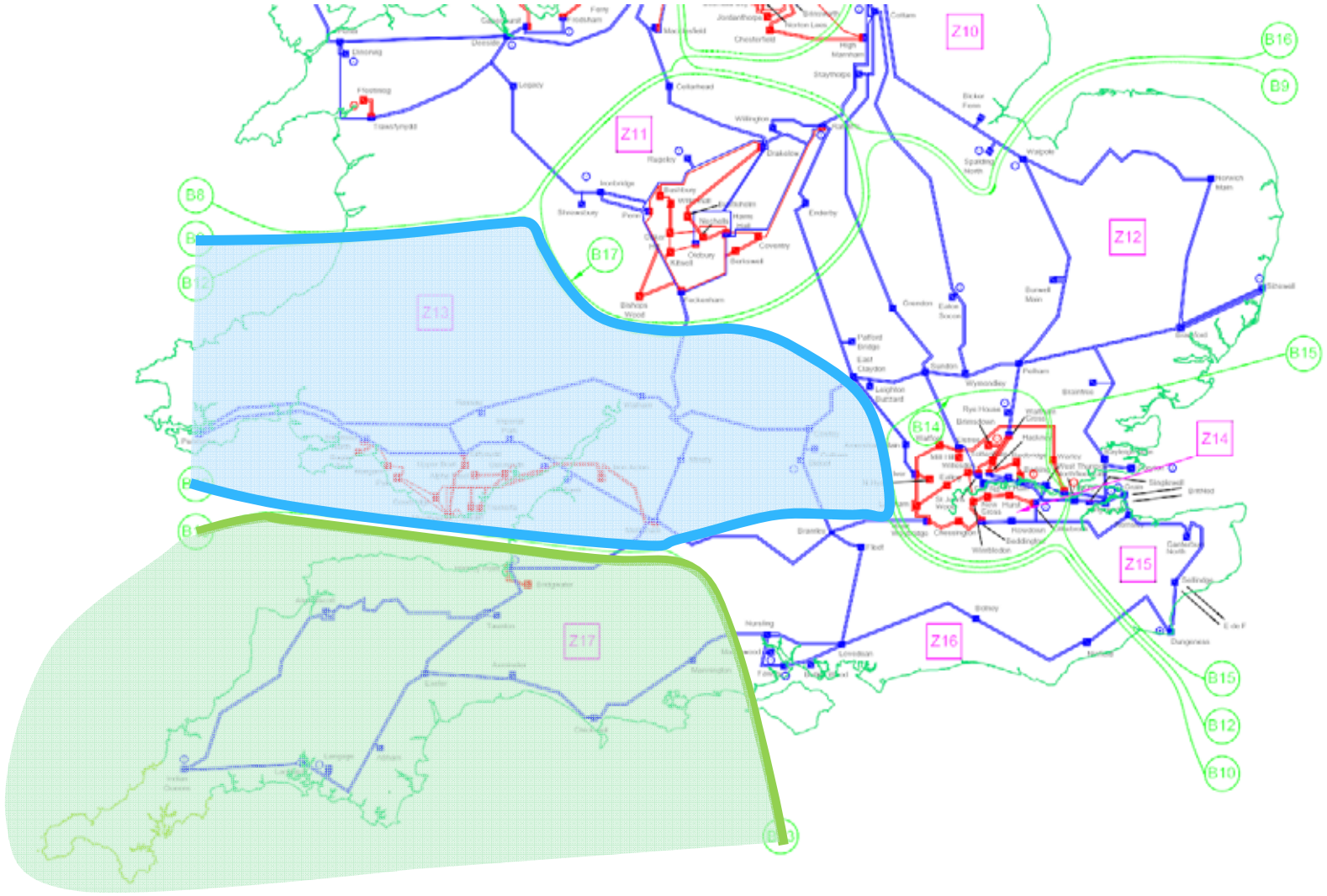
Wind Scenario – No Barrage



Wind Scenario – With Barrage

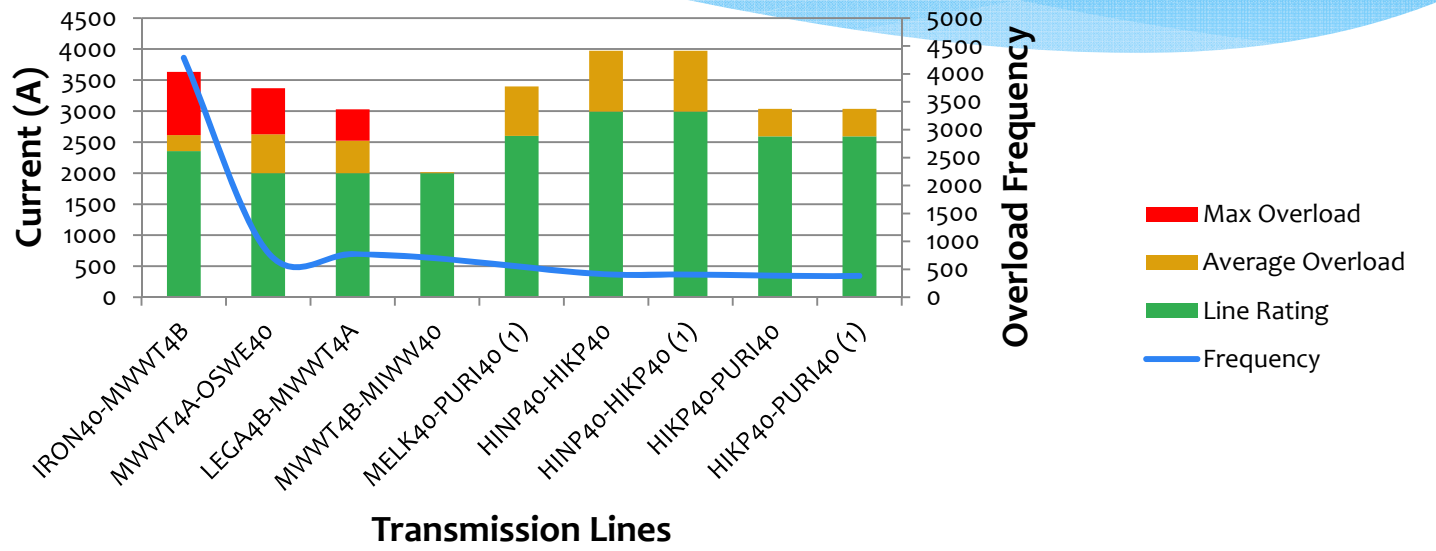


National Grid Study Zones

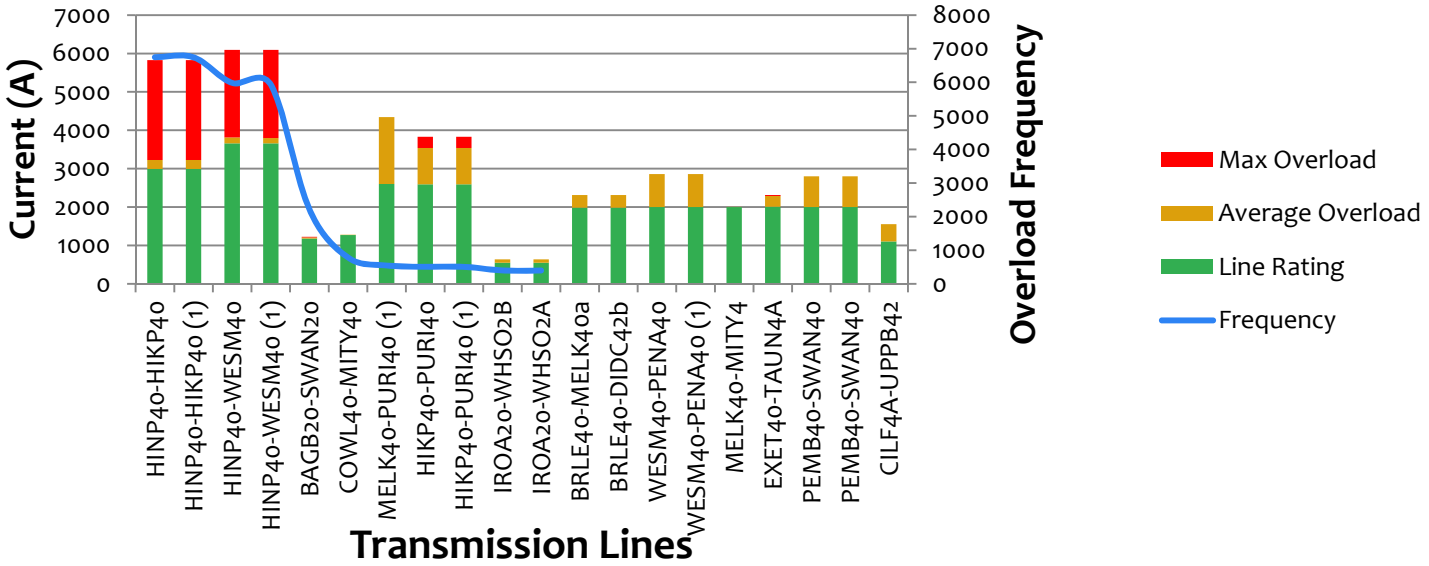


Wind Scenario – Zones 13 & 17

No Barrage

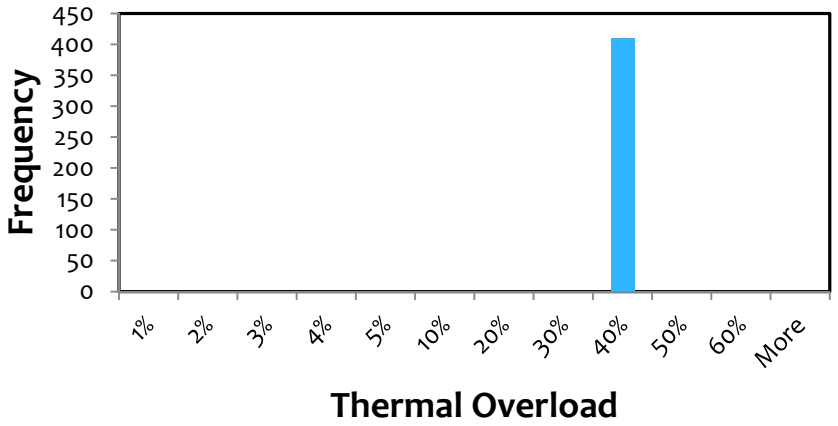


With Barrage

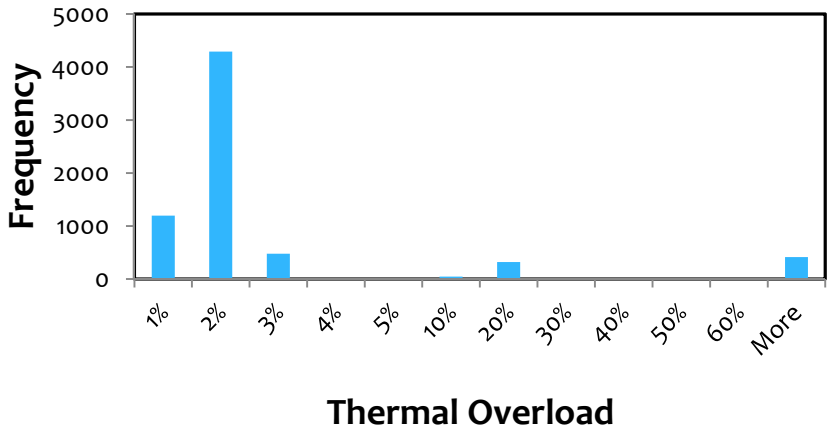


Wind Scenario – Zones 13 & 17

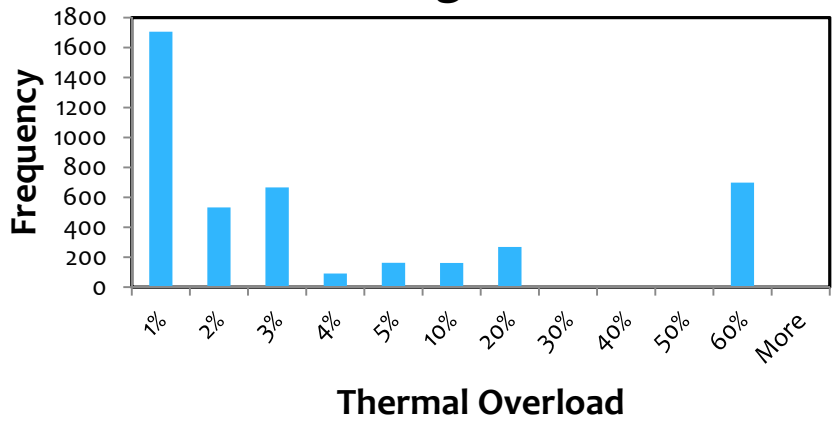
Hinkley Point: No Barrage



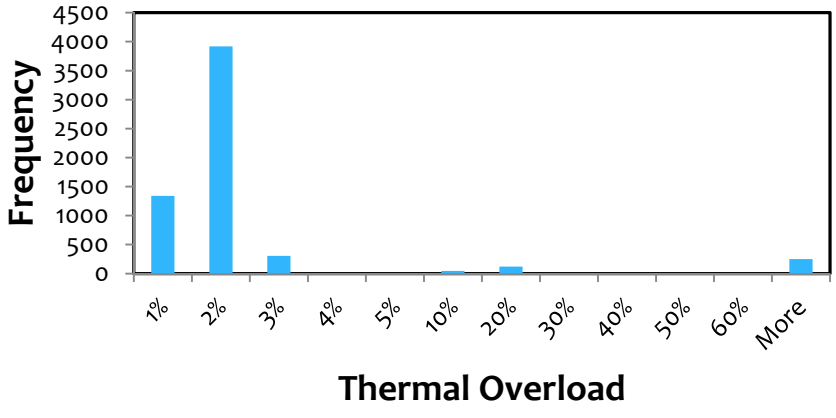
Hinkley Point: With Barrage



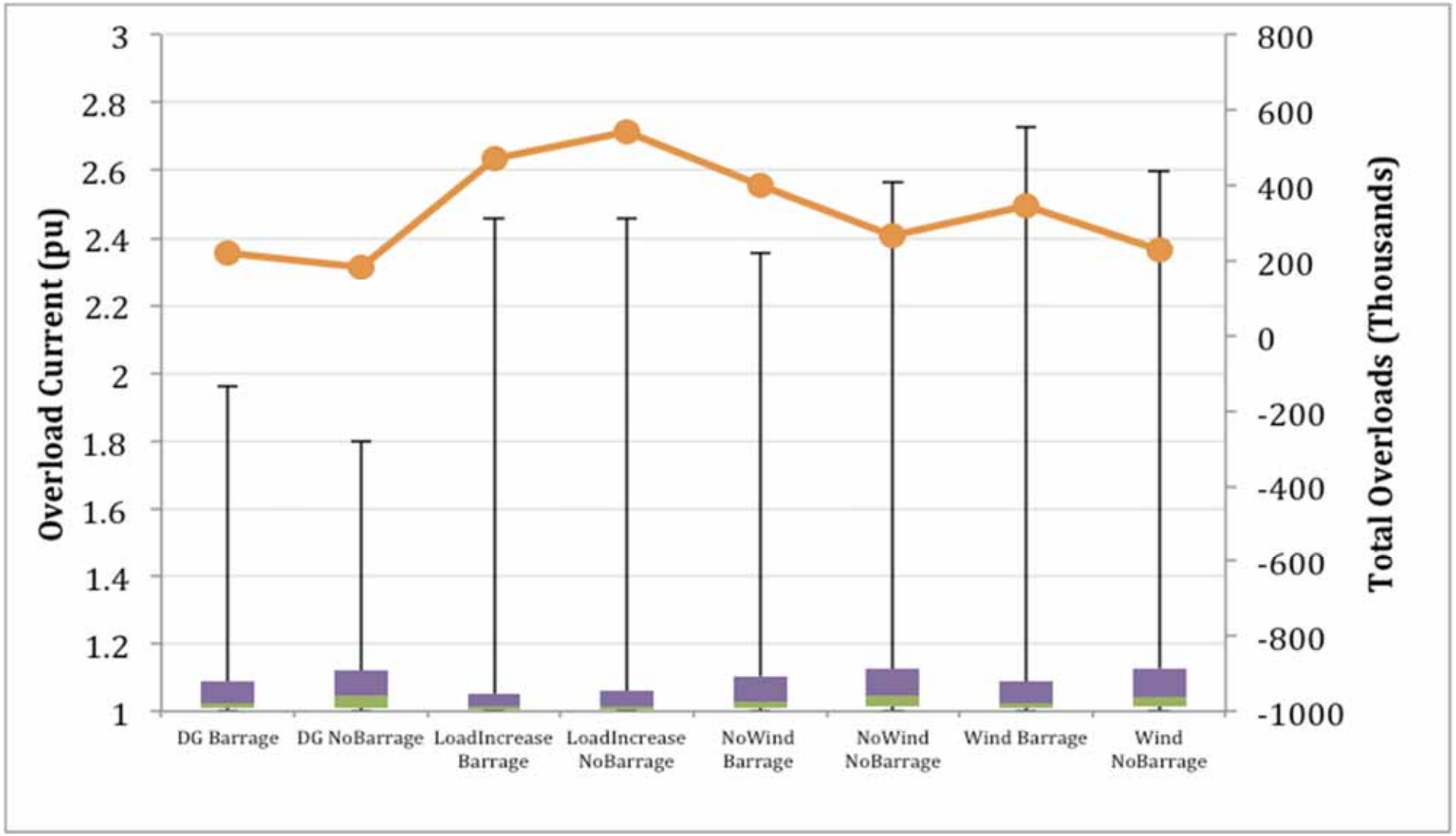
Ironbridge – Mid West Wales: No Barrage



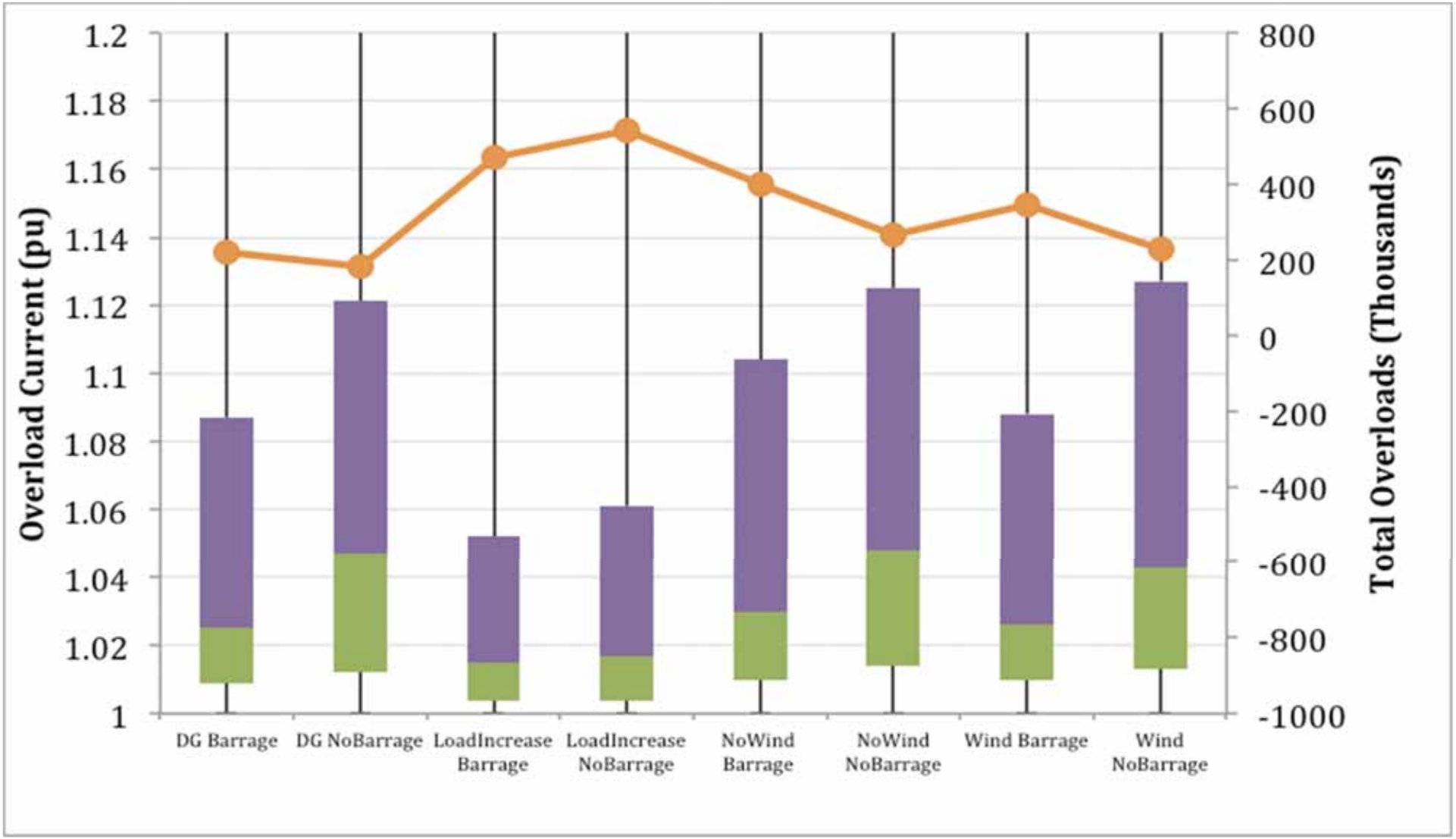
Hinkley Point – Weston: With Barrage



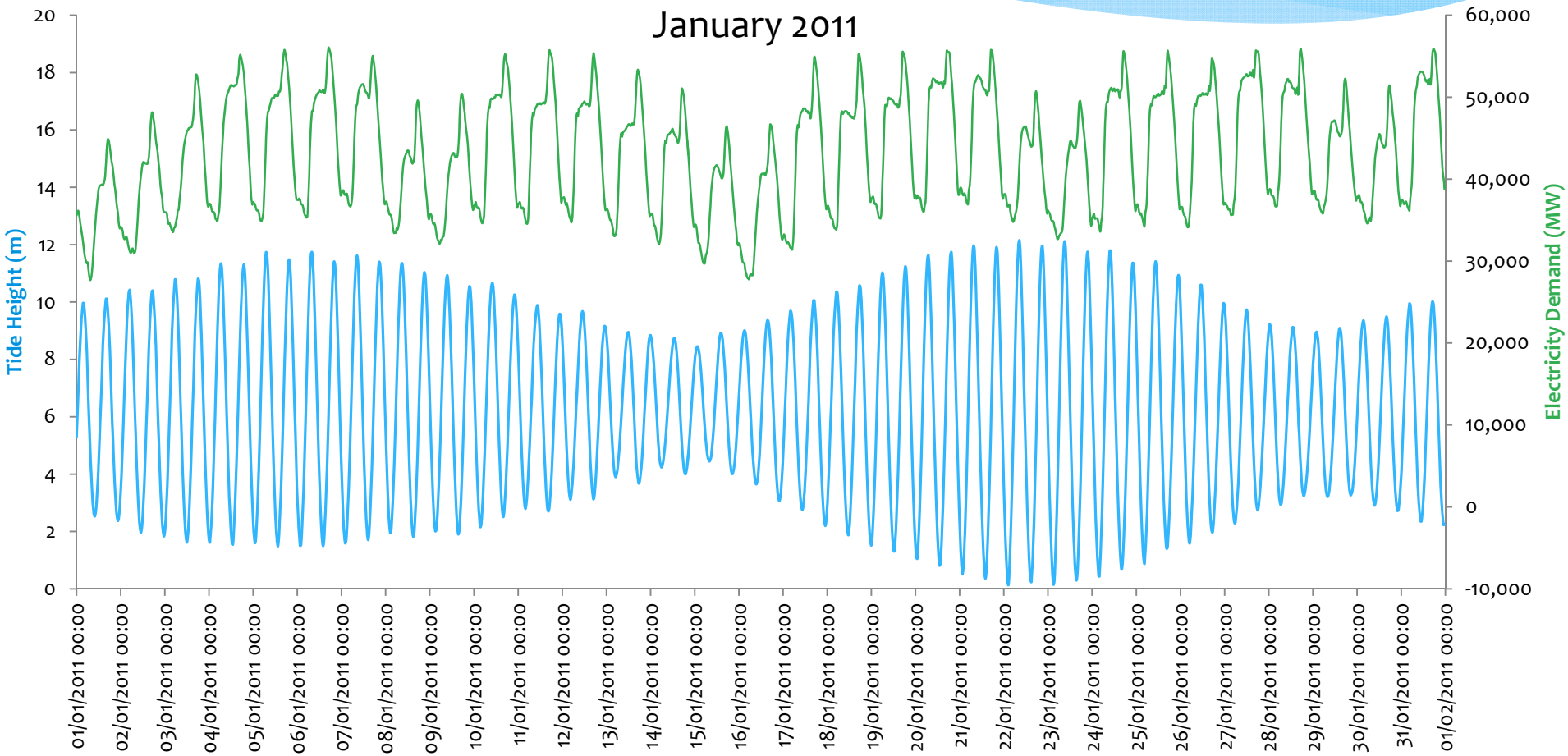
All Scenario Results – Box Plot



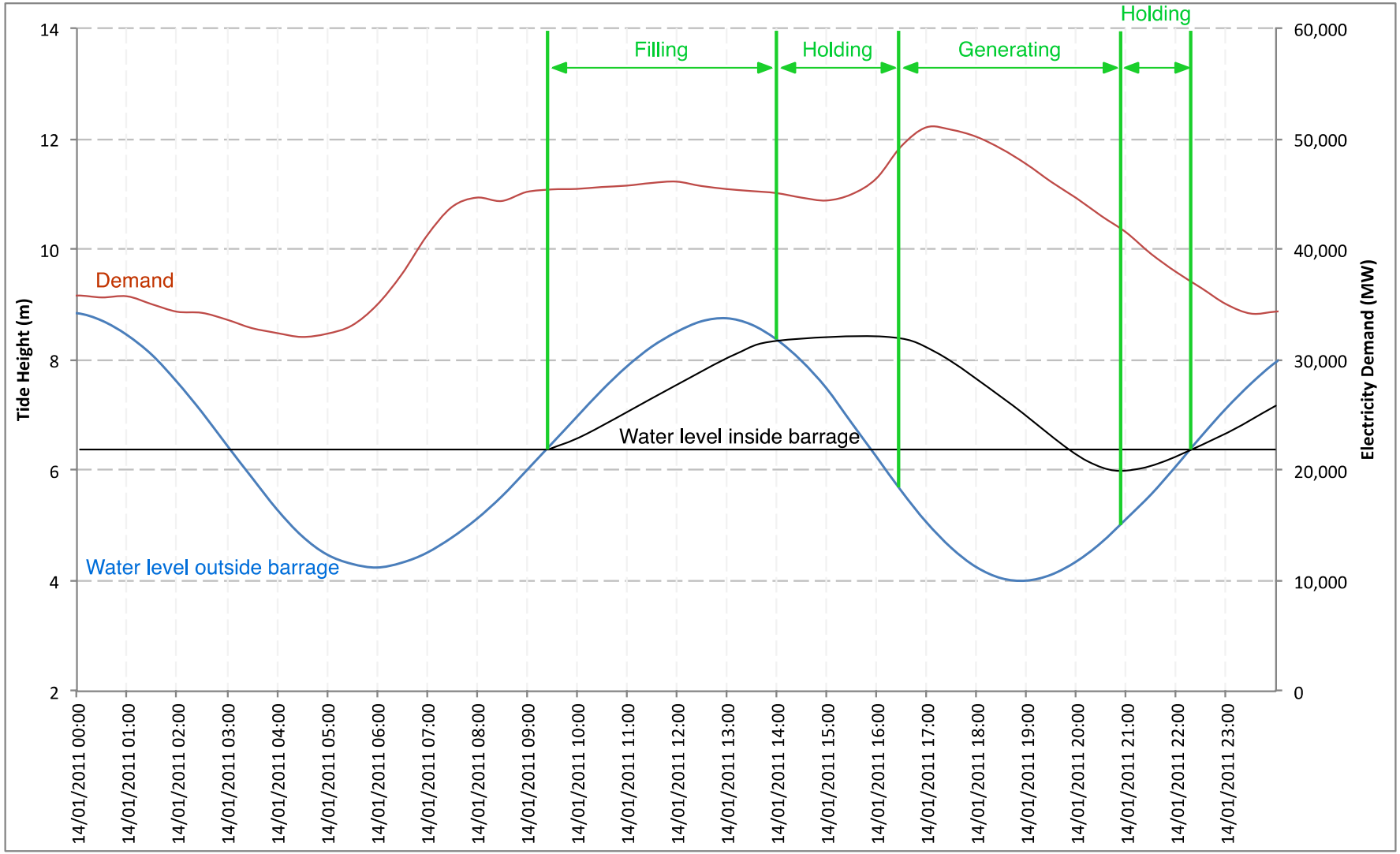
All Scenario Results – Box Plot



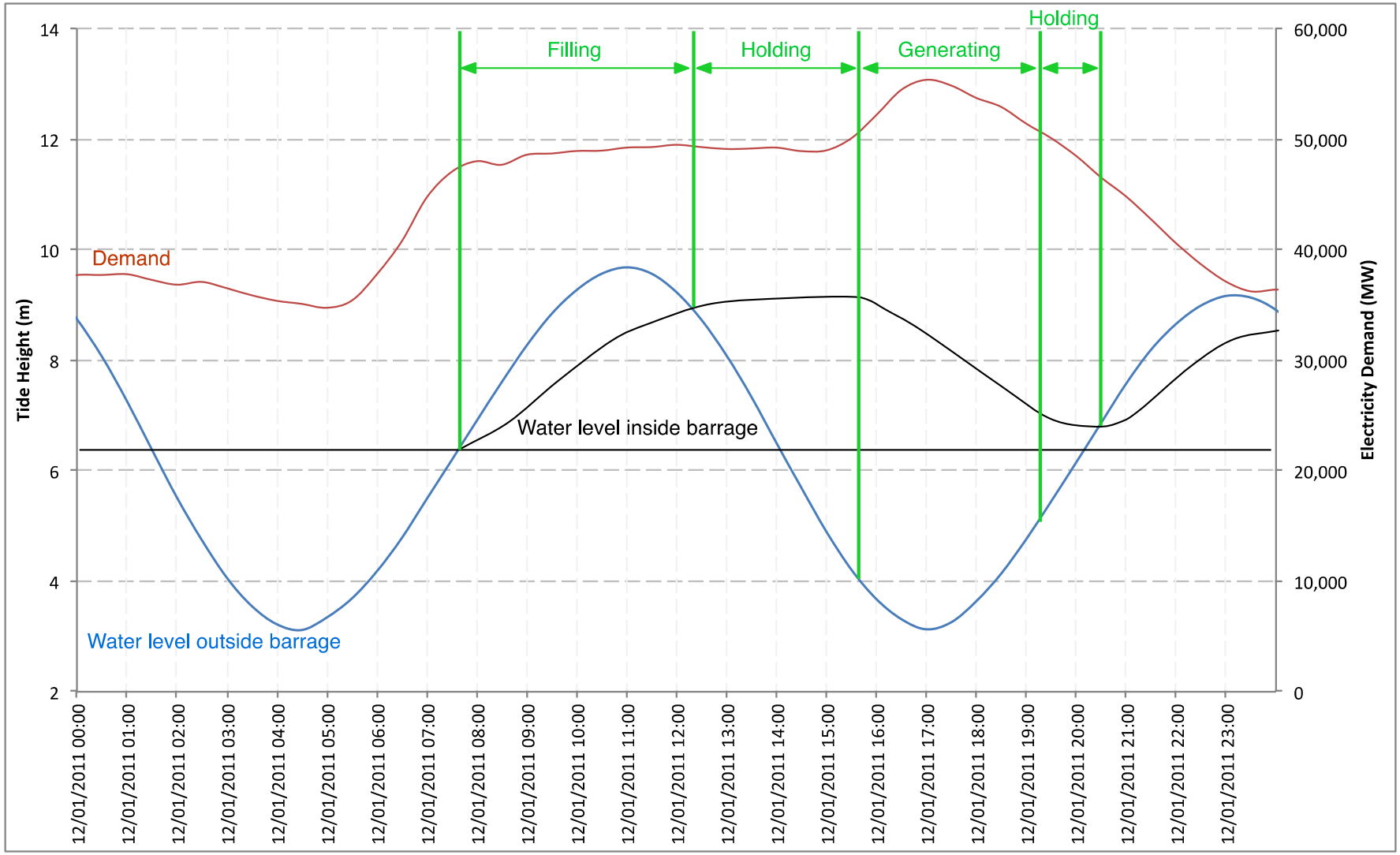
Tidal Range and Electricity Demand



Normal Ebb Operation – 14th Jan 2011



Delayed Ebb Operation – 12th Jan 2011



Delayed Operation

* Offset carbon intensive generation
* Fast demand response
* High price of electricity
* Lower energy output
* Carbon saving?
* Limited opportunities

12th & 14th January

* Normal operation: ~4.03 GWh
* Delayed operation: ~3.18Gwh

Conclusions

* Financial feasibility relies on government support
  * Key asset for 2050 targets
* Proposed new mode of operation
  * Potential carbon savings
* Software framework for future use
  * Statistical analysis of power systems possible
* Modern conductor technologies allow ‘n-2’ contingency with barrage connected