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

A: Beachley Barrage
B: Shoots Barrage
C: Welsh Grounds Lagoon
D: Cardiff-Weston Barrage
E: Bridgewater Bay Lagoon
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)
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
Addition of the Barrage

400kV AC Cables across 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

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PENAI40 400 kV

PENAI 50 DC 500 kV

WESM 50 DC 500 kV

P = 2250.000 MW

WESM 40 400 kV
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 – With Barrage

![Graph showing current and overload frequency for transmission line.]

- Current (A)
- Overload Frequency
- Transmission Line
- Max Overload
- Average Overload
- Line Rating
- Frequency
National Grid Study Zones
Wind Scenario – Zones 13 & 17

No Barrage

With Barrage
Wind Scenario – Zones 13 & 17

Hinkley Point: No Barrage

Ironbridge – Mid West Wales: No Barrage

Hinkley Point: With Barrage

Hinkley Point – Weston: With Barrage
All Scenario Results – Box Plot
All Scenario Results – Box Plot
Tidal Range and Electricity Demand

January 2011

Tide Height (m)

Electricity Demand (MW)
Normal Ebb Operation – 14th 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: ~3.18 Gwh
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