SUPERGEN MARINE

Research to reduce the risk & uncertainty in marine energy development

Equitable Performance Appraisal

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The Question

- How can the economic viability of marine technologies be compared in an unbiased way?
  - Provide guidance on the types of devices which are likely to be economic at large scales of installation.
  - How do engineering design choices affect the economic efficiency of marine energy?
  - Which generation system offers best prospects for commercialisation? (carbontrust, 2004)

Objectives

- Identify parameters affecting economics of large scale marine energy generation.
- Develop an unbiased method for comparing marine energy schemes.
- Investigate the influence of engineering design choices on large scale economic viability.

- Provide inputs to macro-economic models
  - Time variation of investment per industry sector
  - Regional job creation figures

Economic Model Approaches

- Engineering costing (per component)

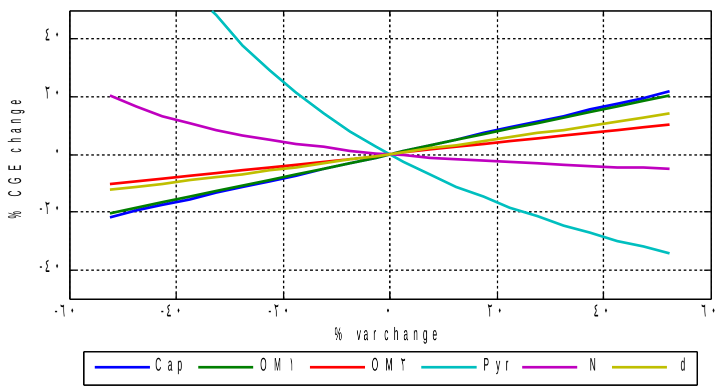
  Consider cash flows and present value COE

  + Inclusion of risk by Capital Asset Pricing Model

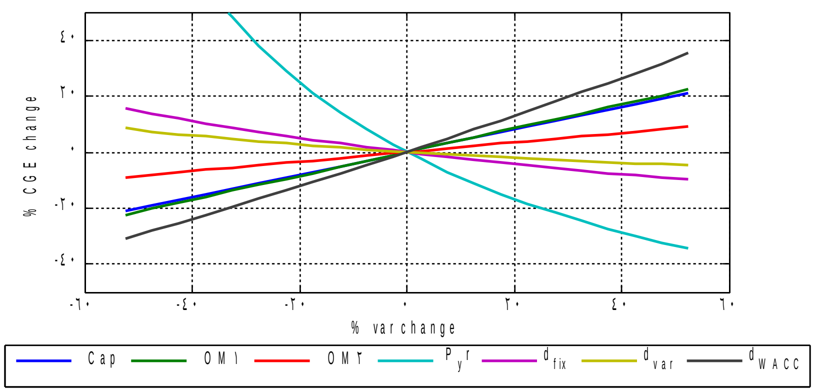
  – Dependent on detailed design

  – Lack of reliable component cost data

  Thorpe (1999), the carbon trust (2006), Bedard *et al.* (2004-6)



R. Boud (2005)



Discount rates from Awerbuch (2003)

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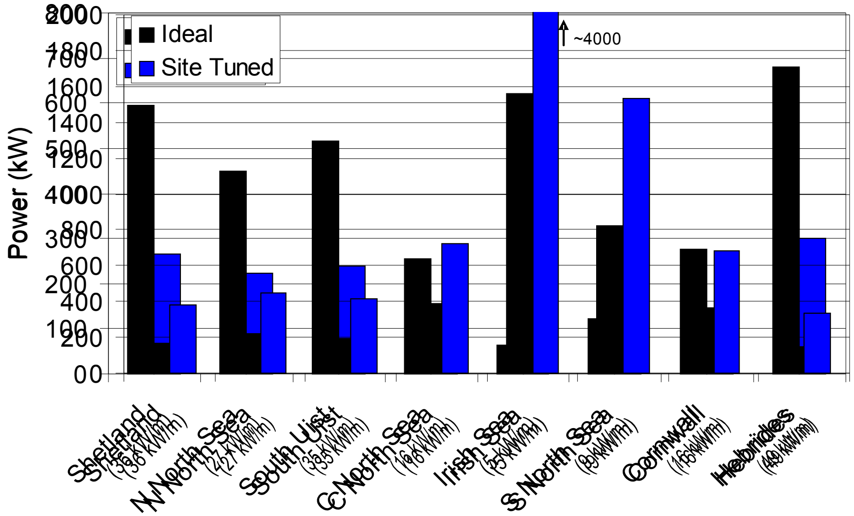
- Comparative approach

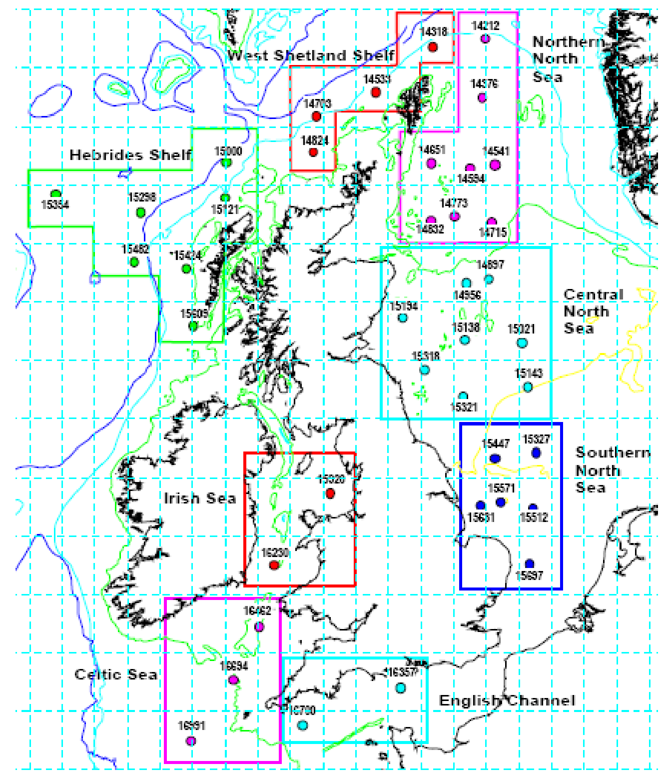
  Consider efficiency of alternative options

  + Independent of ‘expert’ or future cost estimates

Device Comparison

- 100MW scheme comparison

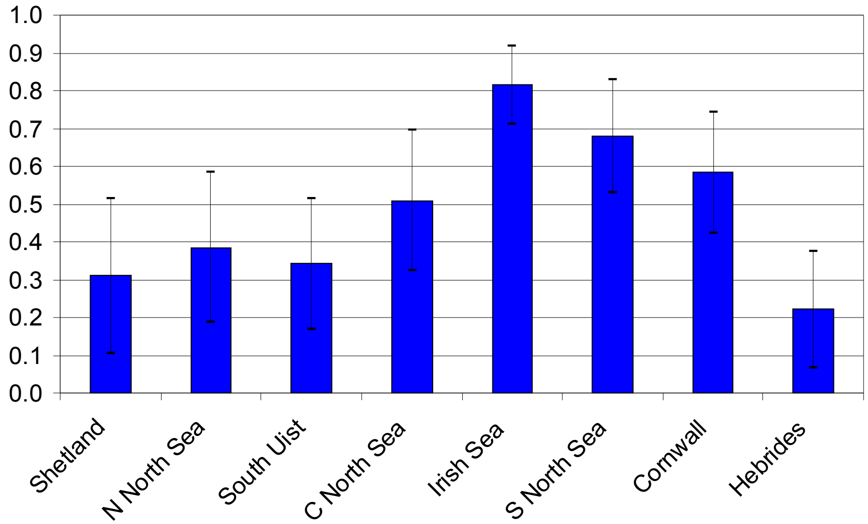




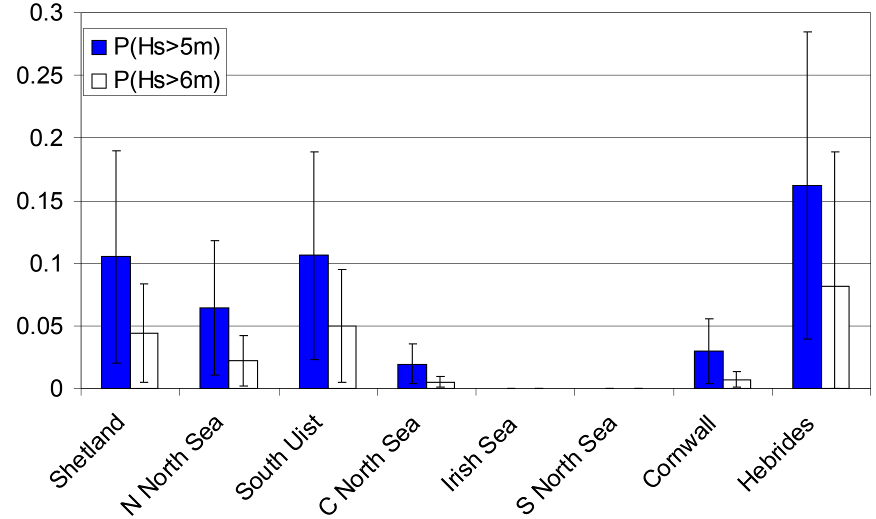
HSE, Fugro (2001)

Site Characteristics

Accessible sea-states (H_s<2m)



Extremely severe sea-states



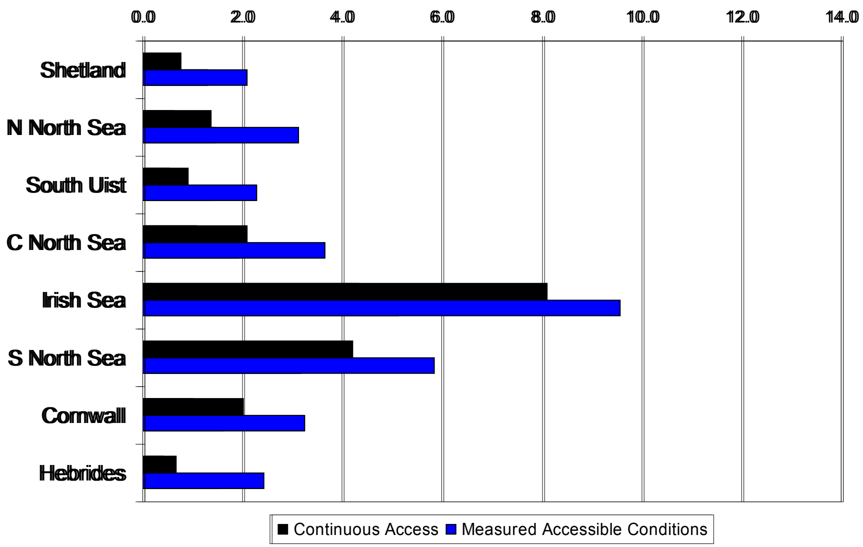
- Significant variation of summer / winter accessibility at energetic sites
- Approx 20% occurrence of Hs>6m at energetic sites

- Severe loading influences failure rate
- Access time influences maintenance schedule

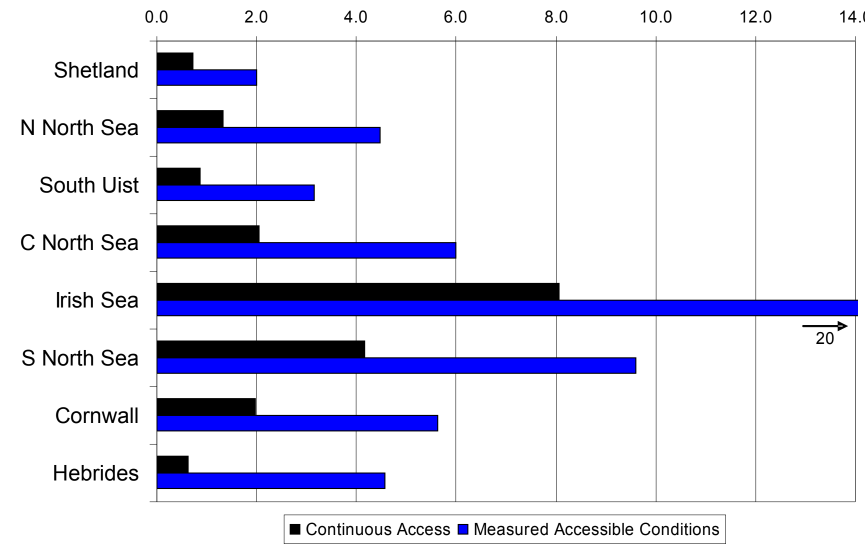
Scheme Maintenance Rate

Daily rate of installation, or access, required for 100MW scheme

Occurrence $Q(H_s<2m)$



Persistence, $R(H_s<2m, T_{ac}>24\text{ hr})$



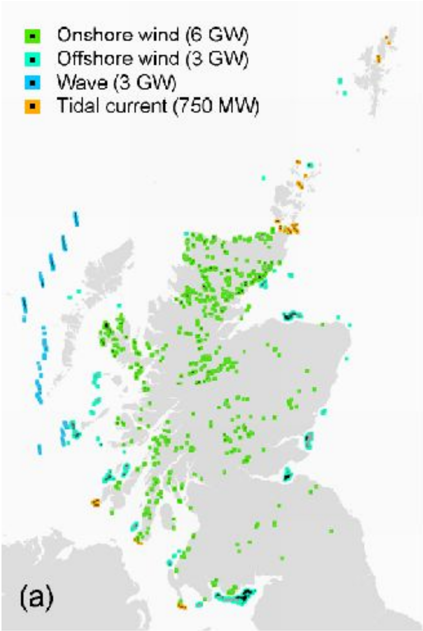
- Ideal Point Absorber ($P = \lambda_w/2\pi$)
- Site Tuned Absorber ($T_N \sim T_{Site}$)
  - Irish sea – higher reliability required
  - Implications for vessel requirements

Site & Technology Efficiency

- Data Envelopment Analysis
  - Identify producer that minimises inputs to attain output(s)
  - Technology selection
    - Kouja (1995), Shang & Seuyoshi (1995)
  - Power generation & environmental impact
    - Ramanathan (2000), Criswell & Thompson (1996)
- Rank technology & site options by ‘efficiency’
  - Single output: 100MW
  - Efficiency of producer m: $\gamma_m = \min \sum_{i=1}^{I} u_{im} x_{im}$
  - Environmental impact and macro-economic indicators

Continuing Work

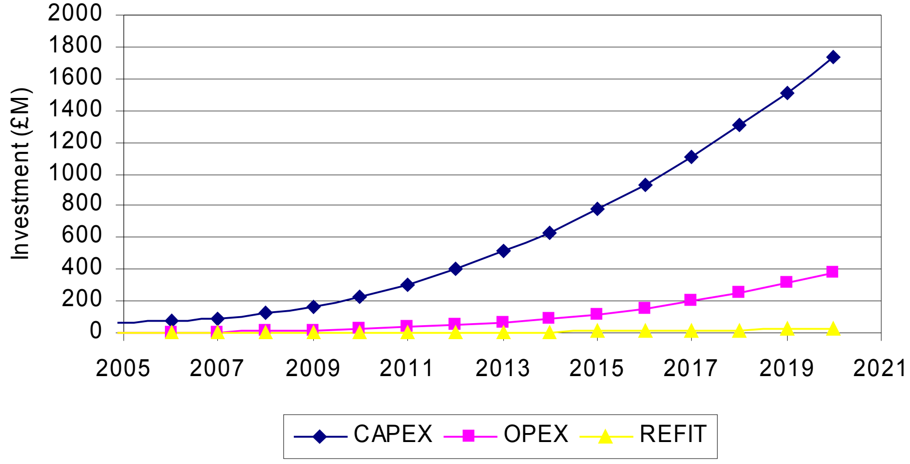
- Selection of economically efficient technology for a site
  - Identify technologies for further R&D
- Scenarios for macro-economic model
  - Transient investment based on installation at economic sites
  - Alternative technology costs
- Sensitivity of design ranking to macro-economic criteria
  - job creation, GDP, generating portfolio variance

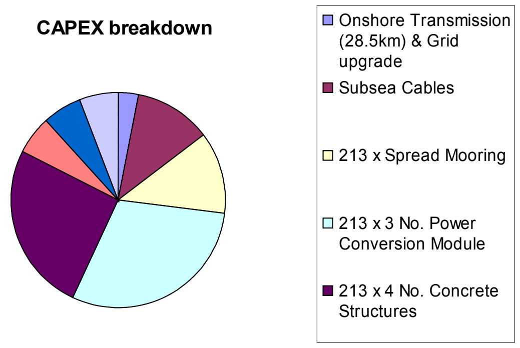


Boehme *et al* (2006)

Input to Macro-Economic Model

- Forecast installation rate to 2020





- 3GW of wave power installed by 2020
  - Supply up to 20% of Scottish Demand (Boehme *et al.*, 06)
  - Cost breakdown based on published data for OPD Pelamis at generic site (Previsic *et al.*, 2005)

Future Knowledge

- Unbiased method for selecting technologies which economically exploit the available resource.
  - inc. Location, Technology and Macro-economics

- Cost-benefit of implementing alternative control techniques for oscillating devices.
  - Based on validated time-domain models