Wave energy innovation needs for deployment by 2050 in Ireland

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Wave energy context: RESOURCE & TECHNOLOGY

WORLD RESOURCE - 3.7 TW
IRISH RESOURCE POTENTIAL - 21 TWh/yr

Type of WEC worldwide

- Attenuator
- Point absorber
- Oscillating water column (OWC)
- Oscillating water surge converter
- Overtopping/terminator
- Submerged pressure differential
- Rotating mass
- Other

Data: IRENA sources (2017), Monk (2010), Mustafa (2018)
Methodology

- Irish TIMES Energy Systems Modelling
- Historical Energy Technology Innovation
- Learning Curve Theory
- Wave Energy Innovation Needs
  - Technology Cost Reductions
  - Energy System Features

INSIGHTS
Irish TIMES integrated energy system model

CO2-80 SCENARIO: no wave energy in results
Policy scenario of 80% reduction in CO2 emissions by 2050
Technology costs based on JRC assumptions (report ETRI 2014)

OTHER SCENARIOS
1. Only domestic bioenergy resources: 
   \textit{DB scenario}
2. Non-synchronous electricity penetration increased to 70%: 
   \textit{ASY}_70 scenario
3. Combination of case 1 and case 2: 
   \textit{DB}_{ASY}_70 scenario

SENSITIVITY ANALYSIS
1. Wave energy fixed costs: -20% to -50% 
   JRC-20% and JRC-50%
Costs’ drop enhances wave energy deployment but alone it is not enough

Reduction costs from 2015 to 2050 (JRC-50%): 85% Tidal 77% wave
Wave energy deployment 2050
Technology cost insights

The role of other energy resources in the energy system

Natural Gas CCS dispatchable support
Onshore wind dominant
Offshore wind is a direct competitor with wave energy
Wave Energy deployment 2050
Energy system insights

Total Final Consumptions – 20%JRC scenario

Energy system electrification is increased

Base year 2010 – 19%

Year 2050
25% CO2-80/ ASY70
45% DB-ASY70
50% DB

Total Final Energy (without Electricity)
Total Final Energy (Electricity)
Limited availability of primary energy resources is influencing wave energy diffusion

DB-ASY70
24% Electricity generation from Wave (6.1 GW)

DB
20% Electricity generation from Wave (5.1 GW)
Historical precedent for similar energy technology innovation?

Technology cost reductions in a period of 30 years

LCOE [€2016/MWh]

PV    Wind onshore    Wave
Historical analysis: learning curve theory

Learning drivers

- Industrial learning (LBD)
- Research Learning (LBR)
- Inputs cost reduction (IMC)
- Scale effects (SE)
- Societal, Political Factors (SF-PS)
- Spillovers effect (LBI)
- Market effect (ME)
<table>
<thead>
<tr>
<th><strong>Innovation</strong></th>
<th><strong>Demonstration</strong></th>
<th><strong>Growth</strong></th>
<th><strong>Saturation</strong></th>
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<tr>
<td><strong>Research</strong></td>
<td>1952-1988: ENEA and CESI research centre (module and cells research, and electric system, test and certification). <strong>LBR</strong></td>
<td>1990 -2000: Demonstration plants ENEA/ENEL PLUG (100 Wp each) SERRE demonstration plant (3.3) <strong>LBR</strong></td>
<td>2000-2001: Focus of other fields as HV-grid, and architectural integration, On-grid centralised project. <strong>LBR</strong> 2001: Research collaboration between CNR, University and Industries and ENEA and CESI. <strong>LBI</strong></td>
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<td><strong>Market</strong></td>
<td>1950 - 1970: Niche market: space industry. <strong>ME</strong> Mid-70s: switch to terrestrial applications. <strong>ME</strong></td>
<td>1989: Reduction of silicon price to 50 $/kg. <strong>IM</strong> 1991: start of the electricity market liberalization. <strong>ME</strong> 1992: Main niche market: off-grid applications <strong>ME</strong></td>
<td>2004: Silicon price reaches the minimum cost of 25 $/kg. <strong>IM</strong> 2005:50% of the market is now on-grid rooftop applications. <strong>ME</strong></td>
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Learning for Solar – PV (Italy)

Innovation stage

Drivers
- Landscape factors - SF
- LBR
- LBI – international research
- IMC
- LBI – industry/research collaboration

Stakeholder sectors
- R&D (university and research centres)
- Industry (utility involvement)
- Niche Market (From space to off-grid applications)
Learning for Solar – PV (Italy)

Demonstration stage

Drivers
- LBR – Demonstration plants different market applications
- PS - Tech. pull & Market pull policy
- LBD – Utilities, First manufactures
- IMC – Decrease of Si price
- ME – Few competitors safe Italian market for local manufactures
- LBI – Utilities/Policy/Research

Stakeholders sectors
- Demonstration &Pilot
- Industry - Few enterprises
- Market - Safe Market formation
- Policy - Technology push policies & regulation
Learning for Solar – PV (Italy)

Drivers
- **PS** – Market pull incentives to customer and producers
- **SF** – public acceptance
- **LBR** – Architecture and HV grid
- **LBI** – international research/policy
- **ME** – Competition in the national market/boom of demand
- **LBD/LBI** – International companies JV
- **LBD** – improvements and market adoption

Stakeholder sectors
- **R&D** – correlated fields
- **Industry** – Cluster and more partner in the industry/opening to international business
- **Market** – high demand but high competitive Market
- **Policy** - Market pull policy and plans/international plans
Learning for Solar – PV (Italy)

Saturation stage

Drivers
- Negative LBR – grid issues
- LBI – international research
- LBD – Delocalization abroad
- Negative PS – SF – ME
- Economic crisis/stop to policies
- ME – interest in new markets (ongrid-centralised, new PV tech.)

Stakeholder sector
- R&D – stacking on big grid issues/blocked by policies
- Industry - international competitors/delocalization
- Market – New markets option/first saturation stop
- Policy – stop of market pull policies
Innovation needs for wave energy deployment in Ireland

Wave Energy Innovation Needs

1. Definition of **STANDARD DESIGNS** Vs **NICHE MARKET** - the best technology for the niche
2. **TECHNOLOGY SCALING-UP** in a phase of growth/saturation
3. **TECHNOLOGY COMPETITION** – Land use/electrification

Energy System Features

1. **INTERACTION** – the role of utilities/incumbent industry during demonstration, to avoid delays
2. **FINANCIAL SUPPORT** to de-risk - technology push/market pull, industry/clusters support, permits/regulation
3. The role of national **INDUSTRY & MARKET & INTERNATIONAL COMPETITION** (Ireland small country)
4. **NATIONAL ENERGY PLAN POLICIES** – tech. roadmap/role of electricity/ CCS
Thanks

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