Dr. Matthew Hannon

Wind and marine CDT| 7th March 2019

Source: Dave Morris

Why research into energy innovation?

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- A 2DS future requires innovation as current suite of technologies insufficient to deliver transformative low-carbon change.
- **How can we learn?** Retrospective studies of (un)successful innovation policy.
- Can inform both:
  - Case for growing level of investment
  - Strategies to channel investment
- We look at case of wave power in the UK to add to the evidence base.

Wave energy – an introduction

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- Wave energy carries both kinetic and gravitational potential energy.
- Ocean waves are generated when the wind blows over the ocean's surface; a function of temperature and pressure differentials.
- Potential for UK to capture 70 TWh/yr (AMEC and Carbon Trust 2012), equivalent to **~21% of UK electricity generation** (2016).

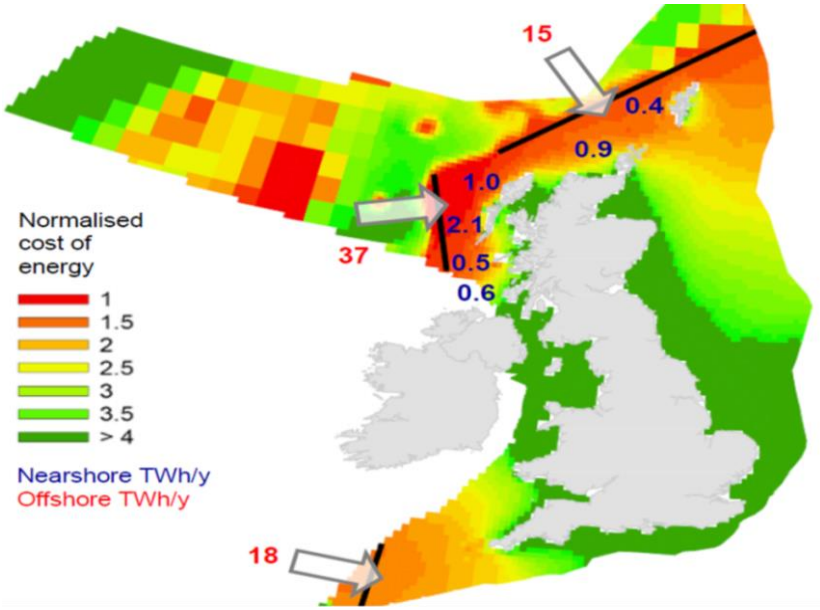

Figure: Practical UK wave energy resource (Source: AMEC and Carbon Trust 2012)

Multitude of wave energy devices

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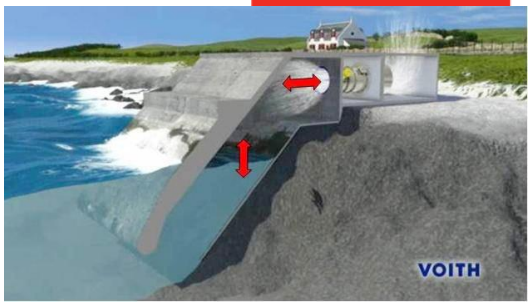
Onshore

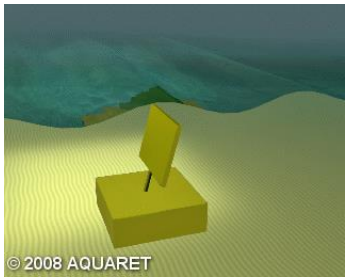
OSCILLATING WATER COLUMN

OVERTOPPING/TERMINATOR DEVICE



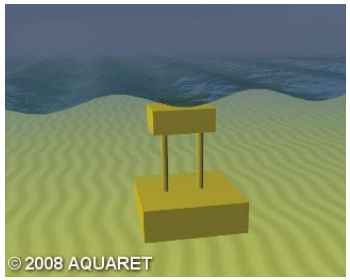
Wavegen Limpet Islay

Nearshore



OSCILLATING WAVE SURGE CONVERTER

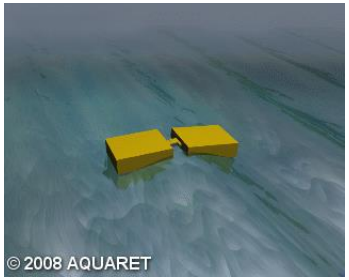
POINT ABSORBER



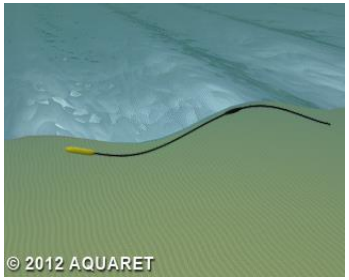
SUBMERGED PRESSURE DIFFERENTIAL

Aquamarine Oyster

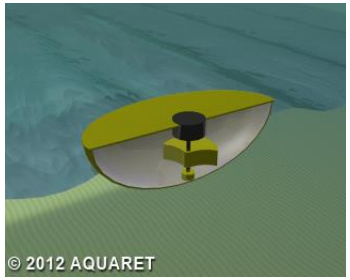
Offshore



ATTENUATOR



BULGE WAVE



ROTATING MASS

Pelamis

Despite investment the UK has yet to deliver a commercial wave energy technology

Methodology

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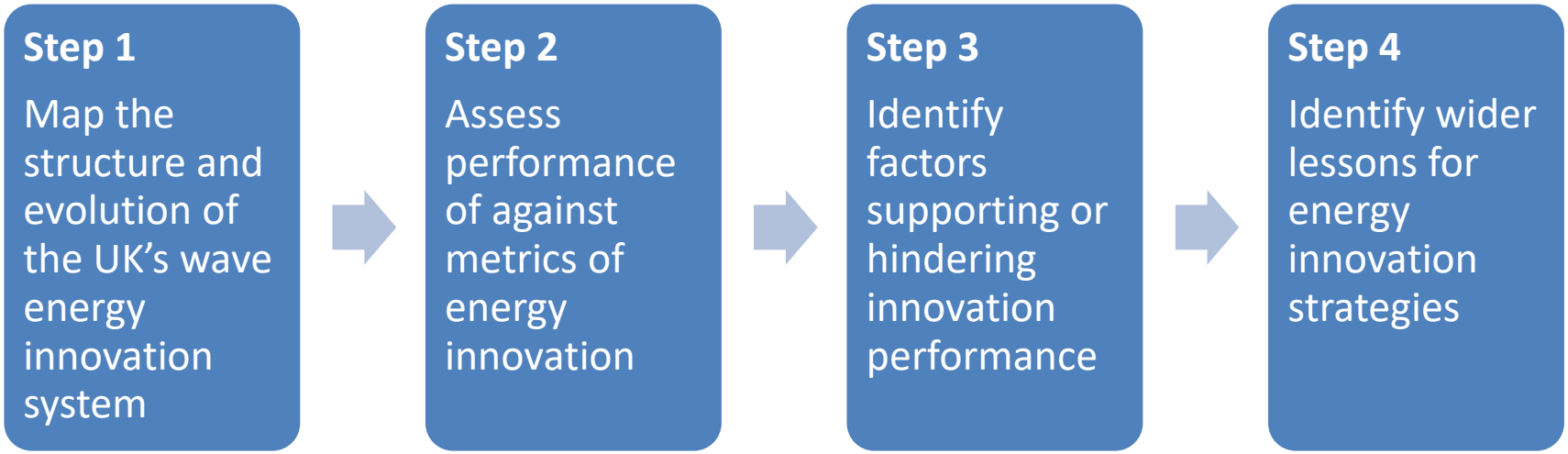
Rationale

- Q – **To what extent can this slow progress be attributed to weaknesses in the UK policy and industrial strategy between 2000 and 2017?**



- Employ a Technology Innovation Systems (TIS) framework.
- **Qualitative** – 33 interviews with experts and analysis of government/industry reports.
- **Quantitative** – Absolute and relative indicators drawing on numerous data sources e.g. ~450 RD&D public grants; scientific publications; patents; installed capacity etc.

UK INNOVATION PERFORMANCE

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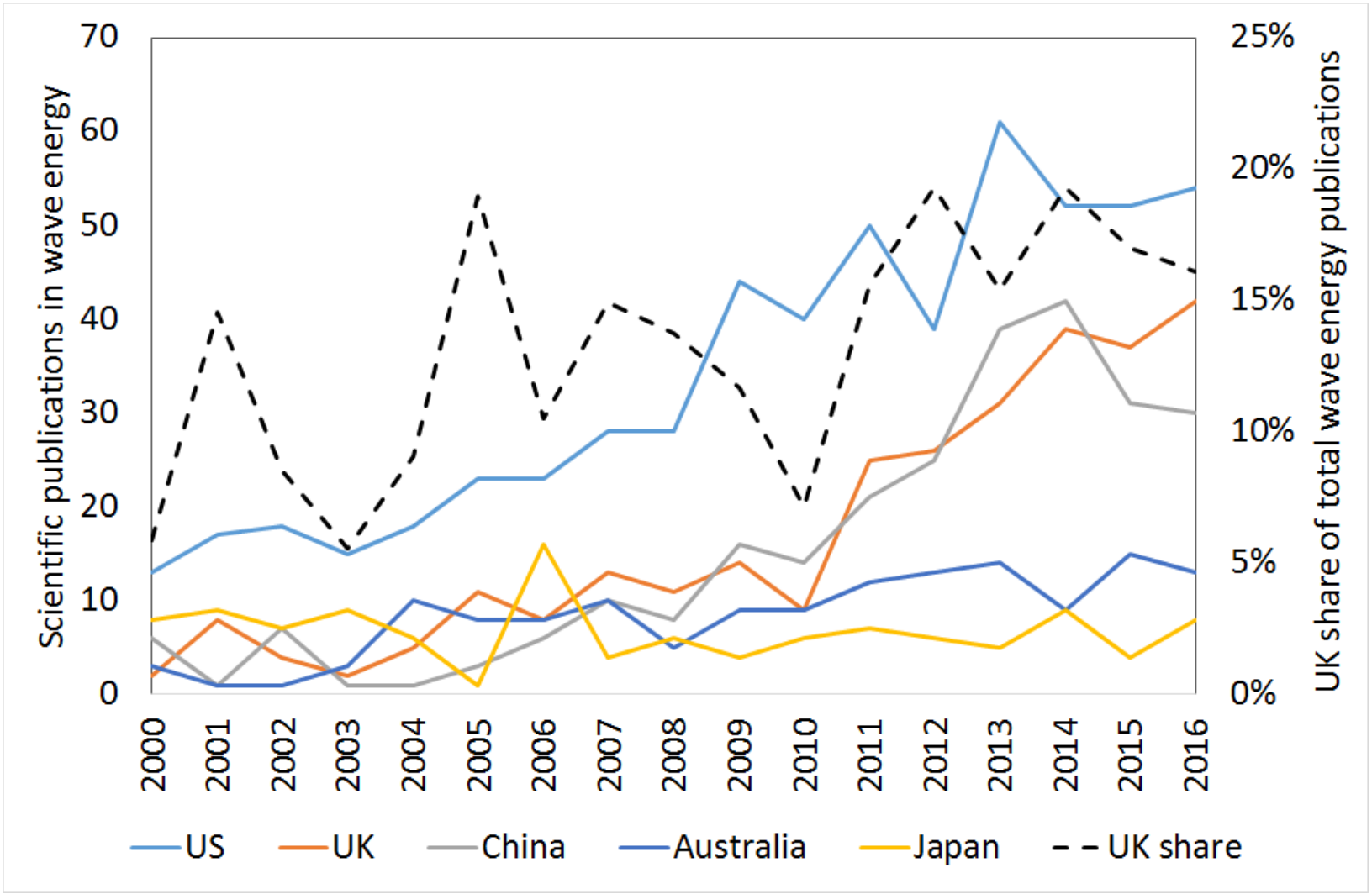
- **Strengthening** performance against:
  1. Scientific publications
  2. Cross-sector fertilisation
  3. Science-industry collaboration

- **Weakening** performance against:
  1. Technological convergence
  2. Scaling up of unit capacity
  3. Levels of installed capacity
  4. Wave energy patents

1. STRENGTHENING PERFORMANCE
Scientific publications



2. STRENGTHENING PERFORMANCE
Cross-sector fertilisation

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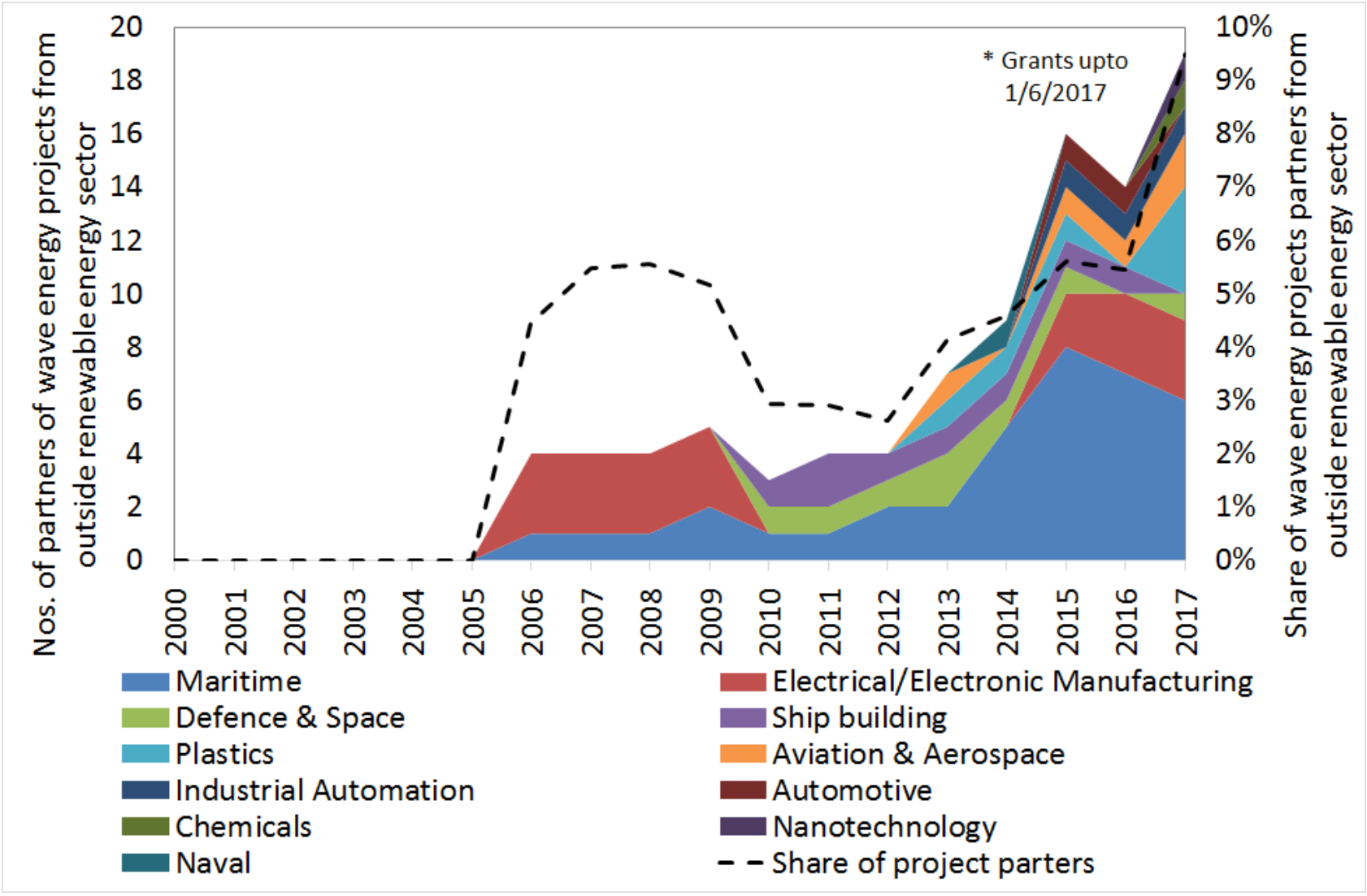

3. STRENGTHENING PERFORMANCE
Science-industry collaboration

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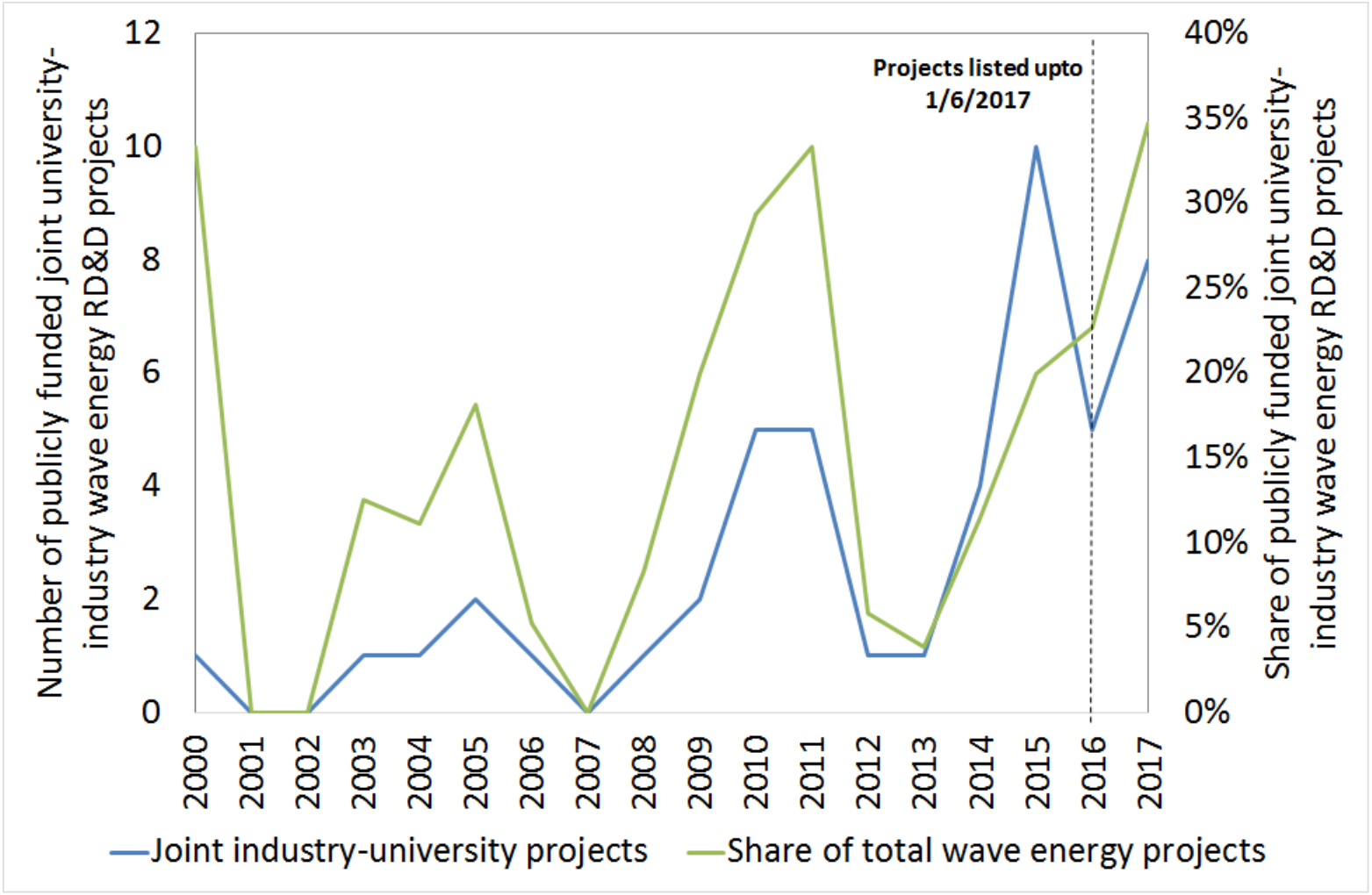

1. WEAKENING PERFORMANCE
Patents

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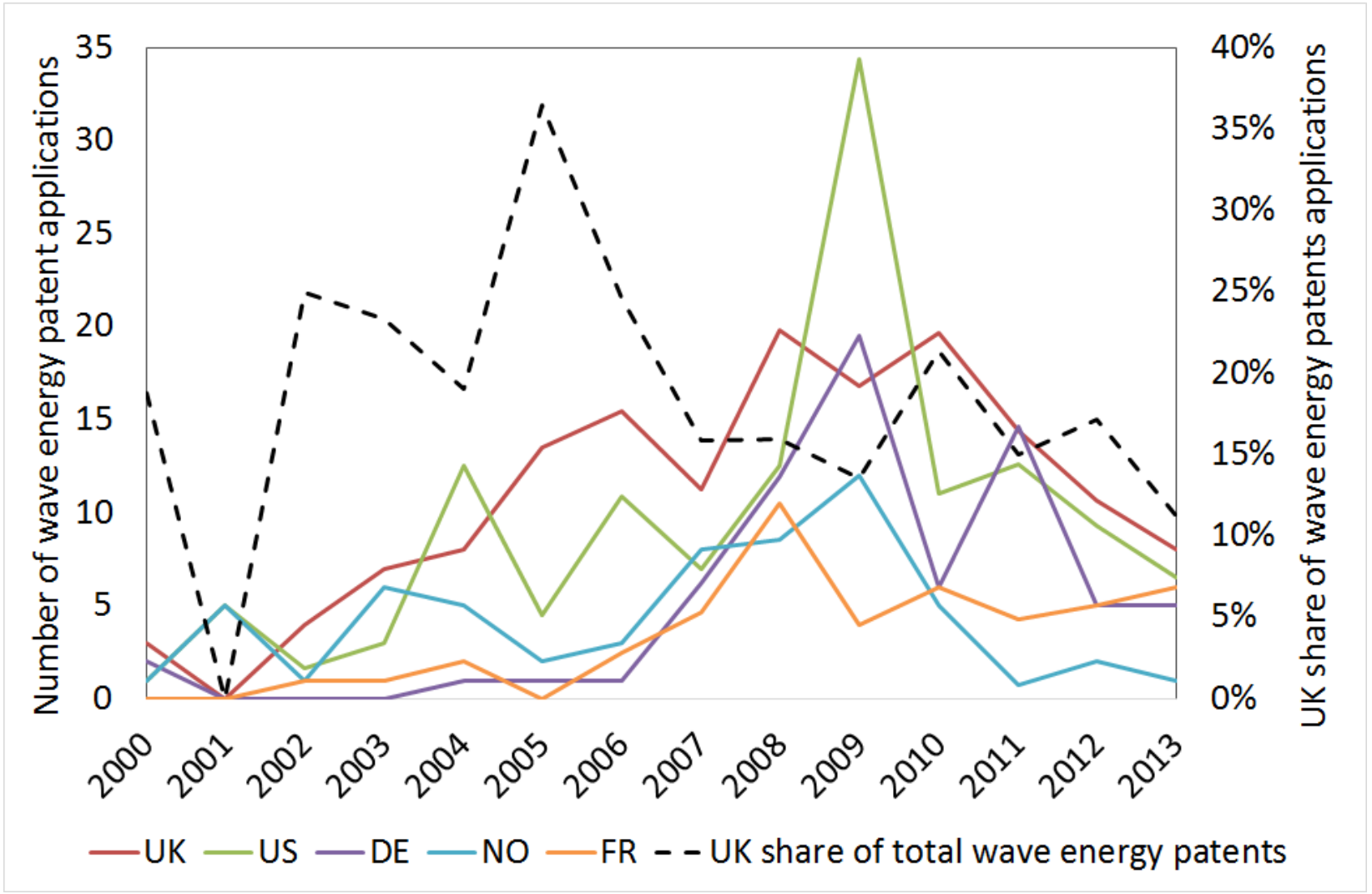

2. WEAKENING PERFORMANCE
Technology convergence

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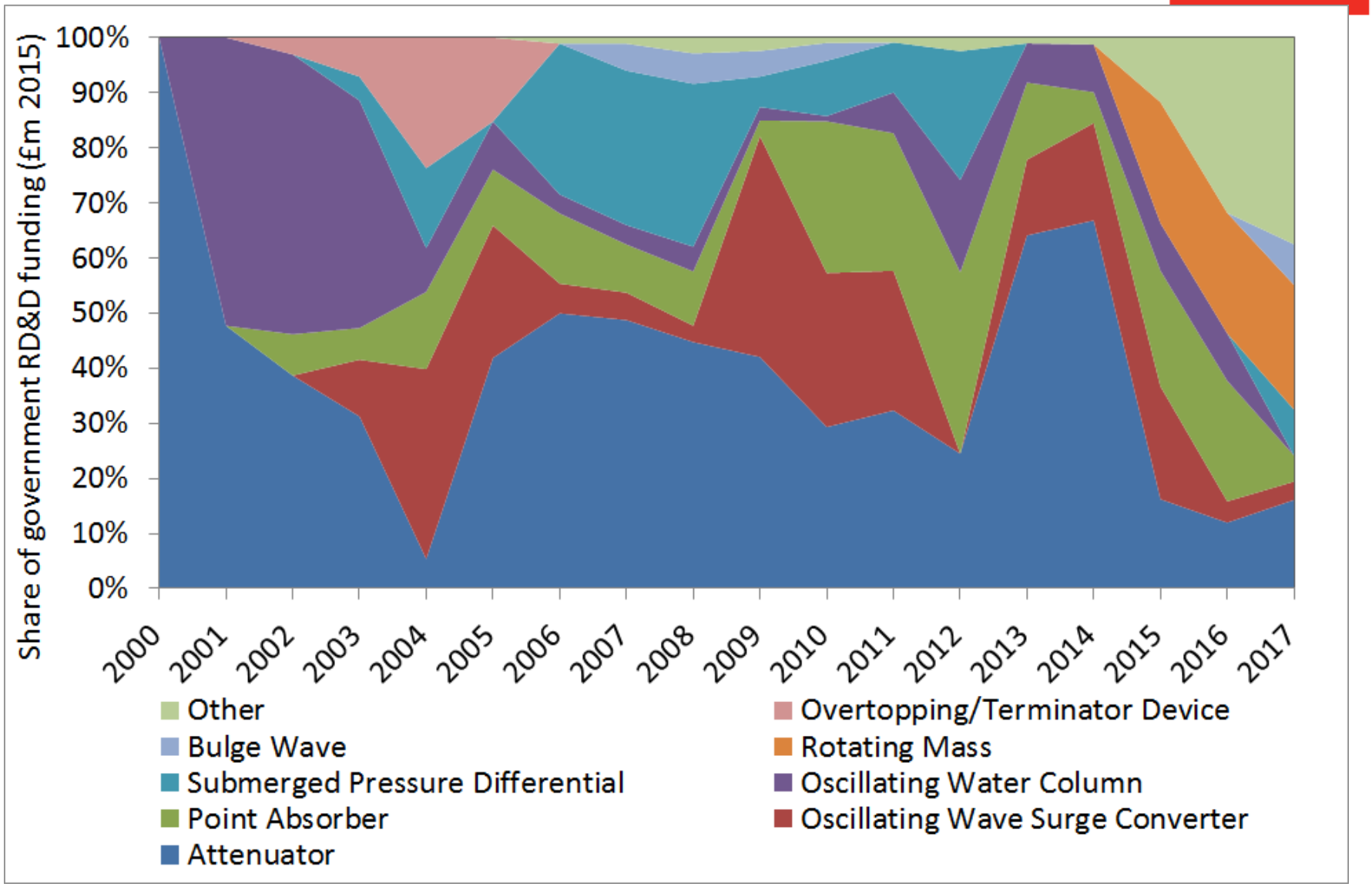
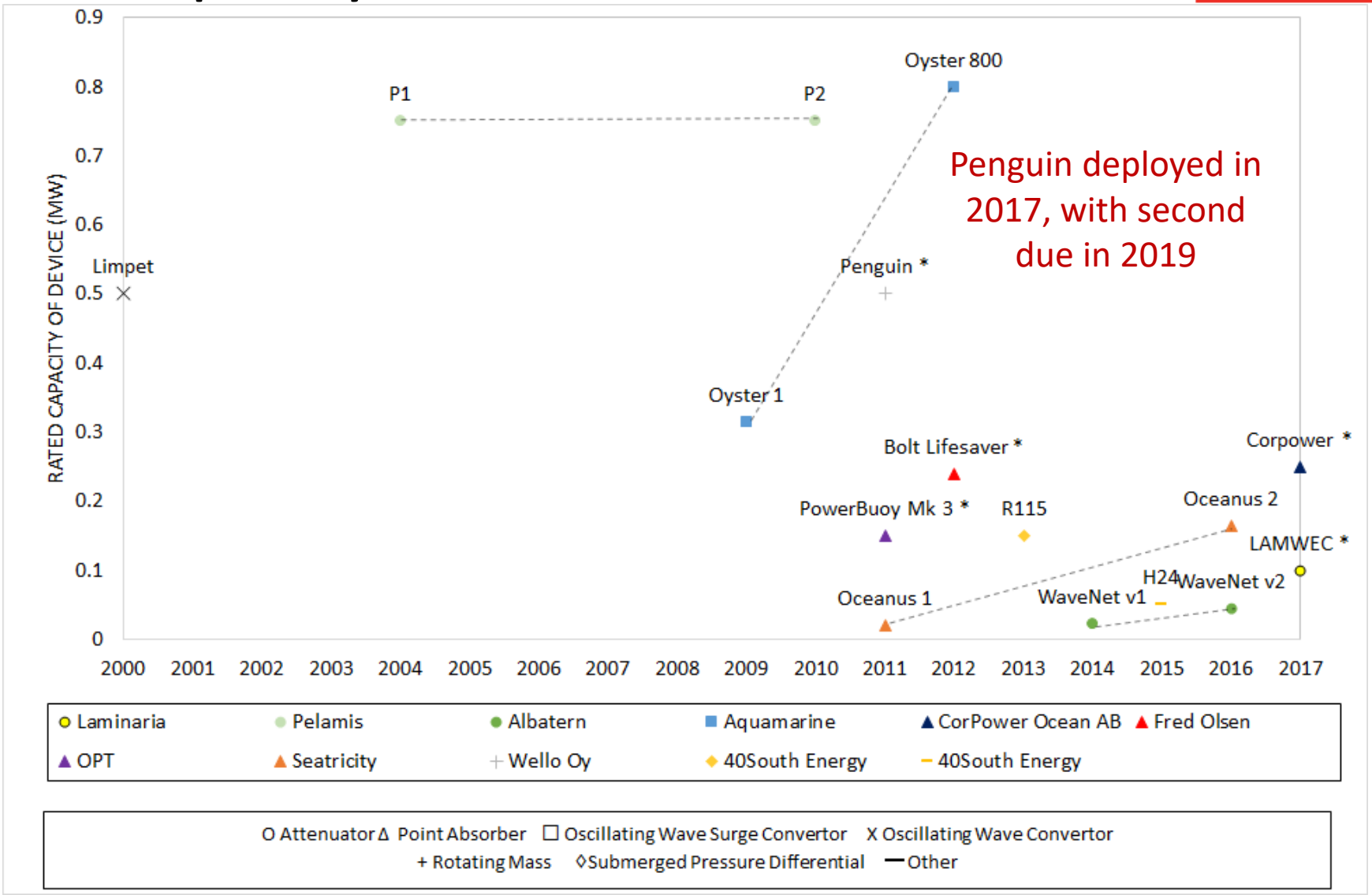


3. WEAKENING PERFORMANCE
Unit capacity



4. WEAKENING PERFORMANCE
Installed capacity

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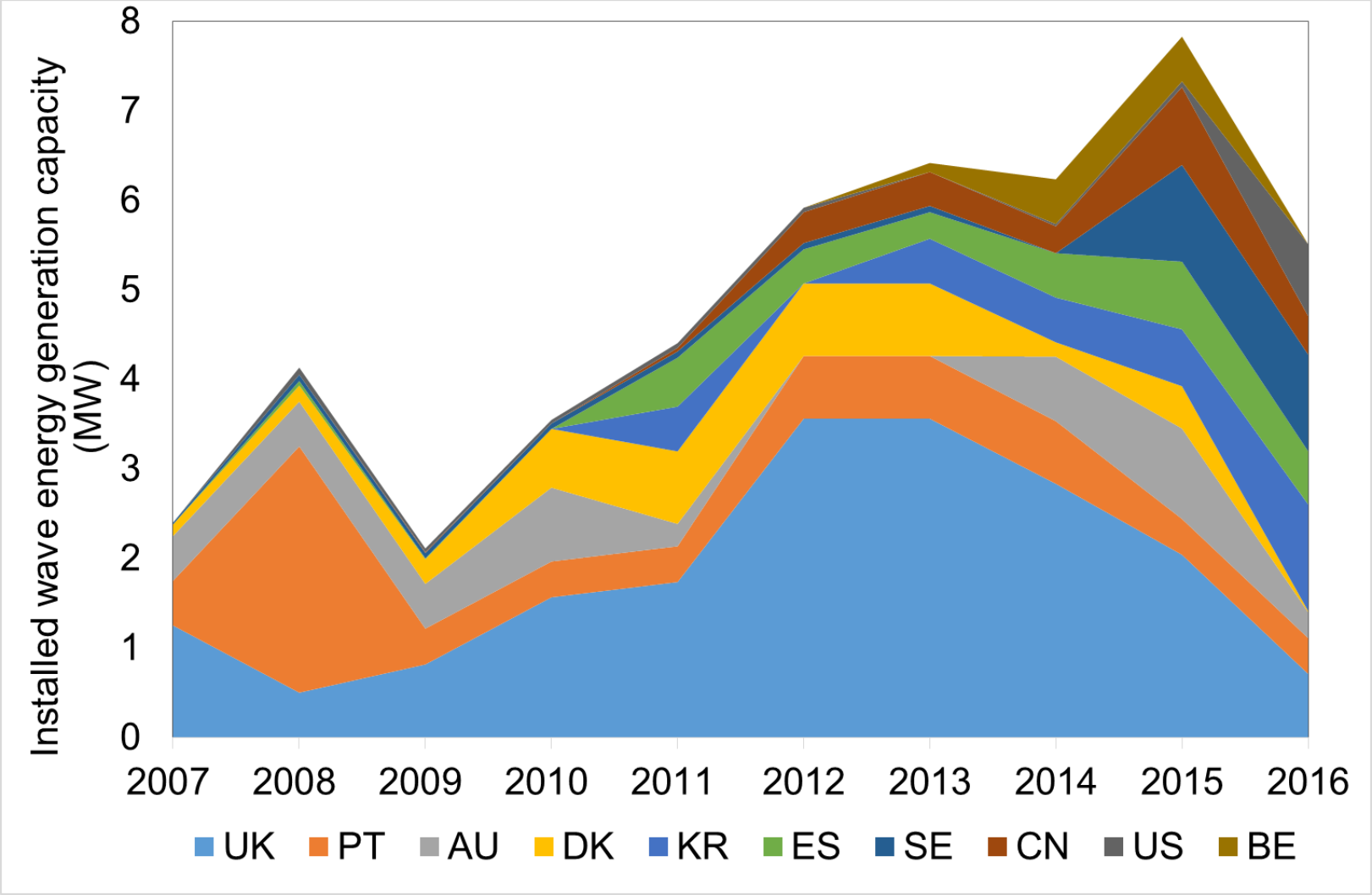
Figure: Top 10 countries for installed capacity of wave energy 2007-2016 (Source: OES)



Wave energy RD&D faces distinct challenges

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- A **fundamentally new engineering challenge** with few opportunities to learn lessons from other technologies, unlike tidal stream that has learnt from wind.

"They're able to learn from what's already been done in the wind industry, so there's a much more rapid sense of convergence. They're standing on the shoulders of giants…in the wave industry it's very hard to find a parallel" - Consultant

Atlantis tidal stream device

- Testing in a very hostile environment (i.e. severe storms, corrosion) and devices very large in order to capture energy, making testing very costly. **This breeds conservatism.**

"We just didn't let [our machines] see anything bigger than 10m waves … We made a risk-based decision not to do it because it was too likely they would all would get smashed up" – Developer

Weakness 1 – Premature emphasis on commercialization

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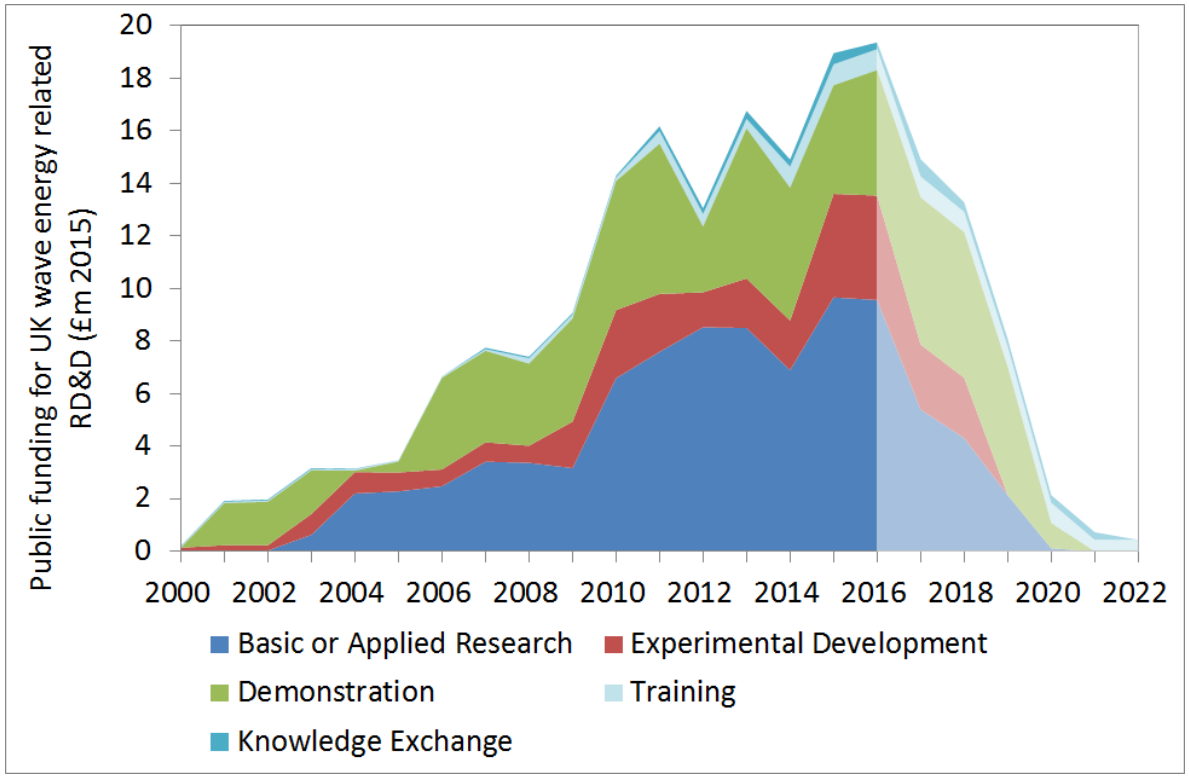
- Incomplete understanding of technical challenge led to unrealistic expectations wave energy could reach maturity very quickly.
- Public and private funding made available for full-scale and array demonstration.
- Developers overpromised but under-delivered, eroding trust and leading to reduced funds.

"'Developers have chased the money that's been available…the funding was designed to go too big, too soon" - Senior researcher



'If we hadn't said we could get a 5-year turnaround…we wouldn't get the [private] money and wouldn't have been able to take it to the next stage' - Developer

Weakness 2 – Poorly coordinated, fast changing & complex policy landscape

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Why?

- Lack of top-down coordination across both government departments and different levels of government.
- Multiple levels of government (e.g. Scotland > UK > EU) sees numerous bodies supporting wave energy for different reasons and in different ways.
- Short-term government spending review periods (~4 years).
- Strong culture of policy change with new governments.

'It's all been a bit fragmented and we've seen different schemes popping up more or less trying to do the same…not particularly joined up' - Public servant

'The money pops up for a [five] year window but it's not actually secured and allocated until halfway through that' - Innovation NDPB manager

Weakness 3 – Lack of collaboration between technology developers

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- As technology is pre-commercial, developers' main currency is the intellectual property (IP) of their technology, which breeds secrecy.
- Public funding programmes do not require developers to share IP and private sector 'match-funding' increases pressure to operate secretively.
- Funding to develop wave energy devices not sub-systems - Little incentive to co-develop common solutions to shared problems.

'Developers have worked too much in their own box. They've been so frightened about somebody stealing their IP that they've lost out on the benefits of collaboration' - Test facility manager

"The same mistakes have been repeatedly made because there hasn't been the exchange of information" - Senior researcher

Weakness 4 – Wave competing with more mature technologies

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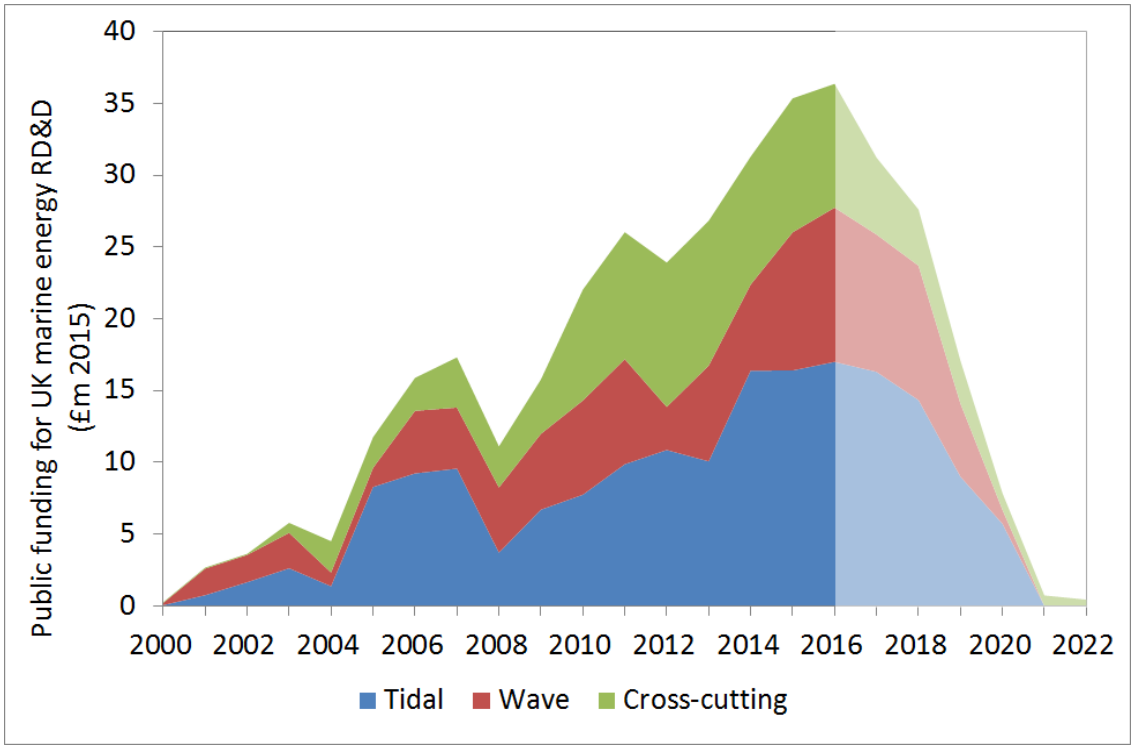
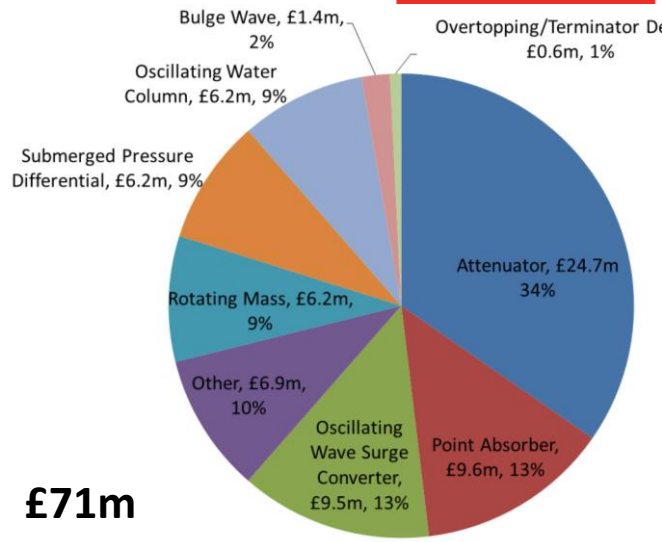
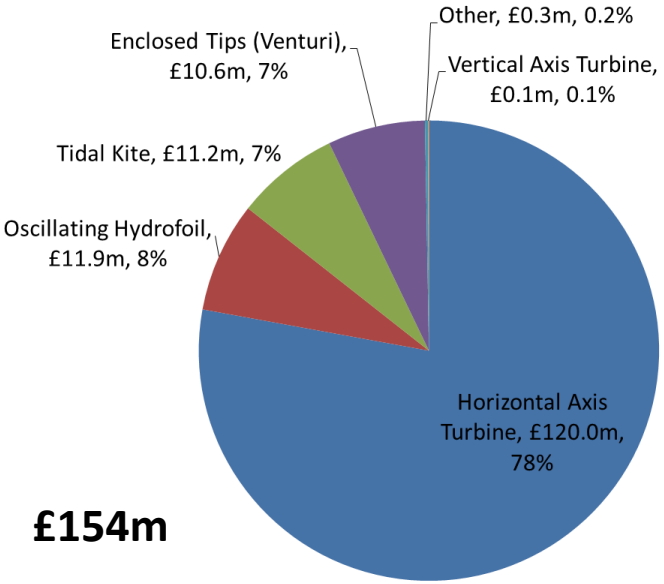
Funding for wave energy bundled with more mature energy technologies (e.g. marine energy programmes, CfDs) = less funding.

Also little funding split across lots of designs.





£71m



£154m

Policy reboot addressed many problems [1]

There has been a major recalibration of UK wave energy policy led primarily by Scottish Government's Wave Energy Scotland:

- **Premature emphasis on commercialisation** - 100% funding avoids need for private sector match funding and re-focused on sub-systems not whole devices (also Saltire Tidal Fund)
- **Poorly coordinated, complex landscape** – Single source of funding that offers stage-gated route to market
- **Crowding out by other technologies** – Decoupled from tidal
- **Inter-actor collaboration** – (1) Multi-partner requirement, (2) emphasis on common sub-component solutions, (3) requirement to licence IP, (4) encouragement of universities to apply and (5) open to EU via procurement
- **Knowledge depreciation** – Long-term funding stream that has also funded capturing of knowledge from second phase

Policy reboot addressed many problems [2]

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TEST FACILITIES

- Critical gap in test infrastructure for mid-stage experimentation filled with 1:10 scale test tanks (e.g. FloWave TT) and 1:4 scale nursery sites (e.g. Scapa Flow)
- Transnational subsidised access to facilities (e.g. MARINET)

POLICY COORDINATION

- Inter-departmental and governmental bodies have been established to promote coordination (e.g. UK Energy Innovation Board)

SKILLS TRAINING

- Centres for doctoral training established (e.g. IDCORE)

Idcore
Industrial Doctoral Centre for Offshore Renewable Energy

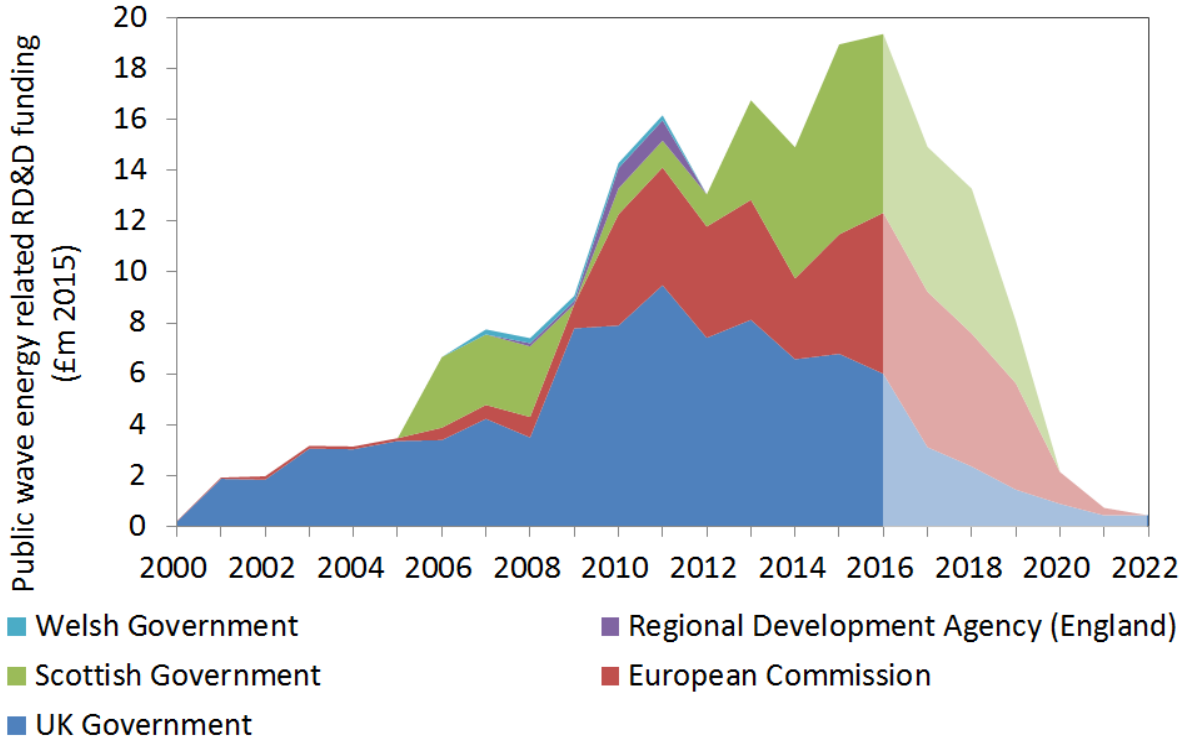
INDUSTRY-SCIENCE COLLABORATION

- Catapult centre for offshore renewables encourages industry-science collaboration through short-term projects

CATAPULT
Offshore Renewable Energy

New threats on horizon

- **UK Clean Growth Strategy** - incremental innovation of more mature low-carbon techs. UK accounted for 47% of funding 2000-2017
- **Brexit –** EU = 27% of all wave funding awarded 2000-2017



€17m CEFOW project, funded by H2020

Wello Penguin WEC2 being lifted into the sea in Tallinn, Estonia. Due to be towed to EMEC, where it will be deployed alongside Wello's original Penguin WEC. (Courtesy of Wello)

Renewable Obligation

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- Potential gap in EU demonstration funds made worse by removal of Renewable Obligation.
- Why? Created a long-term revenue stream for high-risk but potentially high-return demonstration projects.
- See tidal stream examples.
- Post-Wave Energy Scotland earlier stage RD&D grants, **insurmountable gap before being able to access CfDs**

Wave energy policy recommendations

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1. **Demo £** - Retain access to EU demonstration funding post-Brexit (H2020, ERDF) and/or UK-based demo grant or revenue payments (e.g. Renewable Obligation)
2. **Competition** - Avoid competition for subsidies with more established technologies, such as offshore wind and tidal stream
3. **Coordination** - Improve co-ordination of policy support across multiple layers of government.
4. **Learning** – Demand transfer of learning from public projects
5. **Patience** - Time for new UK wave energy policies to take effect and selective need for private sector match funding
6. **Strategy** – Clear, realistic plan for next steps beyond WES
7. **Market formation** - Support formation of niche market for wave energy deployment
8. **Facilities** - Easy access to test facilities in UK and beyond

Conclusions

- Almost £200m of public funds awarded to UK based wave energy related RD&D since 2000 but a commercial technology has yet to materialize.
- Slow progress can in part be attributed to policy and industrial strategy weaknesses such as:
  1) Premature pressure to commercialise full-scale devices;
  2) Poorly coordinated, fast-changing and complex landscape;
  3) Lack of incentive for collaboration between technology developers; and
  4) Competition for funding with more mature technologies.
- **BUT** effective learning about successful innovation policy, especially from Scottish Government, has triggered a re-configuration of the wave energy innovation policy that has addressed most weaknesses.
- Now much better placed to deliver commercial device BUT major threats from Brexit and UK's new Clean Growth Strategy.
- Need for a clear strategy to outline route to market post-WES.

Thank you

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