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From laggard to leader: Explaining offshore wind developments in the UK

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Abstract
Offshore wind technology has recently undergone rapid deployment in the UK. And yet, up until recently, the UK was considered a laggard in terms of deploying renewable energy. How can this burst of offshore activity be explained? An economic analysis would seek signs for newfound competitiveness for offshore wind in energy markets. A policy analysis would highlight renewable energy policy developments and assess their contribution to economic prospects of offshore wind. However, neither perspective sheds sufficient light on the advocacy of the actors involved in the development and deployment of the technology. Without an account of technology politics it is hard to explain continuing policy support despite rising costs. By analysing the actor networks and narratives underpinning policy support for offshore wind, we explain how a fairly effective protective space was constructed through the enrolling of key political and economic interests.

Keywords
UK renewable energy policy; offshore wind; technology politics

1. Introduction

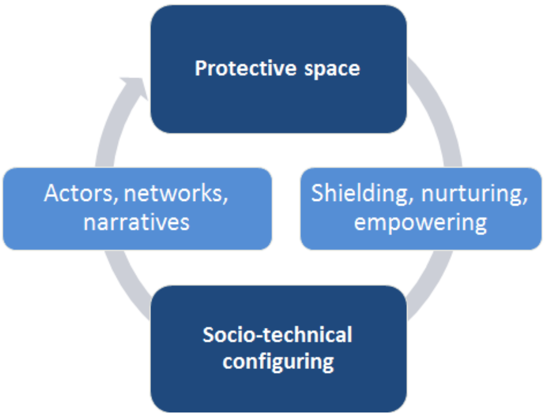
Renewable energy technologies (RET) are key to tackling climate change (IEA 2011; IPCC 2011). One technology prominent in several European countries is offshore wind (OSW). The European Wind Energy Association anticipates 150 GW of capacity by 2030 (EWEA 2011). Globally, the UK leads in deployment: installed capacity reached 2.7GW in 2012 (DECC 2012). The government expects a capacity of 18GW by 2020 and 40 GW by 2030 (DECC 2011: 42). This comes as quite a change as the UK had hitherto been lagging behind in the deployment of RET (Mitchell, Bauknecht et al. 2006; Toke 2011).

One explanation for the rapid deployment might be that learning and competition have driven down costs making the technology competitive (Neij 2008; Junginger, van Sark et al. 2010). This is clearly not the case: OSW remains amongst the most expensive RET (IEA 2012) and costs have increased (Greenacre, Gross et al. 2010; IEA 2012b). A second possible explanation is that policy support makes the technology investible, which is the case in the UK (Toke 2011; IEA 2012b). However, analysis needs to explain why these policies came about and how technology advocates were able to shape a favourable space for deployment. This is a distinct gap in the existing literature (Markard and Petersen 2009; Green and Vasilakos 2011; Toke 2011; Luo, Lacal-Arantegui et al. 2012).

For insights into technology advocacy, we turn to the literature on the importance of niches within wider processes of socio-technical transformation (see Raven 2007; Schot and Geels 2008; Smith, Voß et al. 2010; Markard, Raven et al. 2012). In this literature niches are conceptualised as 'protective spaces' where real world experimentation takes place (Kemp, Schot et al. 1998). Smith and Raven (2012) suggest a particularly relevant framework. They argue that understanding RET deployment requires analysis to trace recursively between the agency creating space for development, and how the characteristics of that space shape the socio-technical configuring[1]: the further development of the technology within a social context (Figure 1).

[1] Configuring refers to the fact that the shape of emerging technologies is often not yet settled in the early stages of development (e.g. there is no dominant design, business model, or developed supply chain yet).

Figure 1: Protective space and socio-technical configuring: a recursive relationship



Taking this framework as the point of departure, we answer two questions:

1. How and by whom has 'protective space' been created for offshore wind in the UK?
2. What impact has the 'protective space' had on offshore wind developments in the UK?

The development of OSW is only one piece of the puzzle of electricity system transformations in the UK (Foxon, Hammond et al. 2010; Foxon 2013). Policy makers are trying to meet the challenging RE and climate change targets by using a variety of support instruments for RETs, nuclear, carbon capture and storage as well as energy efficiency. Controversies abound around the degree of centralisation or decentralisation as well as the relative prominence of these technologies in different decarbonisation pathways. Many of these technologies have received increased policy attention over the last couple of years. Our analysis focusses on OSW as this technology has been most successful in deployment. Support for OSW has complemented rather than replaced support for other technologies. Analysis of the interactions between OSW and other low carbon technologies is an interesting subject but is beyond the scope of this paper.

The framework and methodology are explained in the next section before turning to a history of OSW (section 3). Section 4 analyses the actor networks and narratives constructing ‘protective space’ for OSW, answering the first question. Section 5 analyses how this ‘protective space’ shaped developments in OSW, answering the second question. This is followed by a discussion of results in section 6 and conclusions in section 7.

2. Analytical framework and methodology

2.1 Protective space

The transitions literature analyses the transformation of socio-technical regimes in energy, transport or food systems (Geels 2002; Elzen, Geels et al. 2004; Smith, Stirling et al. 2005; Jacobsson and Lauber 2006; Smith, Voß et al. 2010). A key argument is that sustainable technologies often fit poorly within established regimes (e.g. in terms of price, performance, consumer preferences) (Smith 2007). Therefore emphasis is put on the provision of ‘protective space’, i.e. niches, to improve performance and societal embedding of technologies, and facilitate wider breakthrough into dominant regimes (Kemp, Schot et al. 1998).

2.2 Nurturing, shielding and empowering as processes of socio-technical configuring

Smith and Raven (2012) propose a framework for analysing ‘protective space’ which suggests productive niches require three processes: nurturing, shielding and empowering. They argue that successful nurturing involves learning, the building of positive, robust expectations, and the formation of broad and deep networks. Shielding processes provide temporary relief for niches against adverse selection environments of incumbent regimes. Empowering involves actors network who represent niches positively to the wider social world in order to mobilise resources. Empowering can be achieved through two processes:

either the new socio-technical configuration becomes increasingly competitive under the existing selection environment ('fit and conform') or the selection environment is changed in order to better accommodate the characteristics of the novel socio-technical configuration ('stretch and transform'). The framework not only focusses on niche-level processes (nurturing and shielding), but also explores niche-regime dynamics through the concept of empowering. Technology advocates engage in both inward-oriented work to improve the performance of the core technology as well as outward-oriented socio-political work to influence the status of the technology in the wider social world.

Smith and Raven argue that evidence for these ideal-typical processes requires analysis of the actors, their networks and the narratives used to promote the niche. Narratives can help to create positive expectations about the niche, make claims for reforms and critique existing regimes. Actors and their networks are important in studying the politics of creating 'protective space' as it is actors who negotiate the mobilisation of resources, represent lessons to be drawn, lobby policy makers, and (re-)produce narratives. This framework has already been applied to explaining PV developments in the Netherlands (Verhees, Raven et al. 2013) and the UK (Smith, Kern et al. 2014). Here we apply it to the case of OSW.

2.3 Methodology

A case study methodology is appropriate for our aims, where we study a situation involving a complex and contemporary social phenomenon un-attributable to a clearly identified single cause (Yin 1994). The analysis used a process tracing approach to identify causal mechanisms (George and Bennett 2005: 6). The study is based on a systematic review of the academic literature, policy and stakeholder documents, relevant trade press and media articles (including ENDS, Real Power, BBC and Wind Power Monthly). The resulting history is complemented with data on public R&D funding and deployment. The evidence was used to construct a timeline of developments. Semi-structured interviews with 13 stakeholders involved in OSW were conducted between April and May 2012 (see Appendix A) to explore why processes were happening and how these processes shaped the development of OSW. All interviews were transcribed, coded and analysed using the indicators specified in Figure 2.

Figure 2: Key concepts and indicators used for analysis

Key concepts	*looking for evidence of activities aimed at…*	*Code*
Nurturing	broad and reflexive learning; articulating specific and shared expectations; building broad and deep networks	N
Shielding	mobilising pre-existing support; implementing innovation in favourable (geographic) locations; creating financial support, temporary rule exemptions for innovation; tolerating 'poor' economic/technological performance	S
Empowering	'fit and conform': arguing and promoting that innovation will be competitive under conventional criteria; arguing that no radical change is required; framing shielding as temporary; framing nurturing as targeting performance improvement; 'stretch and transform': arguing for and achieving institutional reforms; framing shielding as manifestations of sustainable values; framing nurturing as learning processes towards sustainability	E
Key actors	actors who are repeatedly mentioned as important for offshore wind developments	KA
Pro narratives	metaphors or other statements portraying offshore wind in a favourable light	PRO
Counter narratives	metaphors or other statements portraying offshore wind in a negative light	CON
Networks	formal or informal interaction, communication or collaboration involving several actors	Net

Source: developed by authors, partly based on (Verhees, Raven et al. 2013)

3. A history of UK offshore wind developments

3.1 1970-1980s: Wind considered as alternative after oil crisis

The oil crisis in the 1970s triggered a search for alternative energy sources in the UK. Using wind turbines to generate electricity was one of the options considered. During the late 1970s and early 1980s exploratory studies on OSW resources and wind farm design were undertaken (Gaudiosi 1996). The British Wind Energy Association (BWEA) was set up in 1978. There was also academic interest in wind technology (interviewee 1). The UK government's interest at the time was in developing offshore turbines. A R&D programme was initiated in the early 1980's in partnership with the developer McAlpine. This led to the manufacturing of a vertical axis turbine in 1986. Also the Central Electricity Generating Board showed interest in developing 'offshore wind power stations' during the 1980s (interviewee 12). However, commercial and government support generally was equivocal and drops in the price of oil led to a loss of interest (Real Power, 2008: 35). Efforts subsequently focused on the development of onshore wind. The first onshore wind farm in the UK was constructed in 1990.

3.2 1991-2000: Taking wind from onshore to offshore

This period was characterised by the emergence of the first offshore wind farms (OSWF) in Denmark (Greenacre, Gross et al. 2010) while UK policy continued to be characterised by the view that OSW was prohibitively expensive. R&D funding concentrated on technologies close to commercialisation while OSW technologies were deemed unlikely to be economic even by 2025 (ENDS 1994). Nevertheless, in 1995 the East of England Development Agency provided £3.65m alongside £500,000 from Renewables East to sponsor a Centre for Offshore

Renewables in Lowestoft to provide office accommodation targeted at SMEs in the offshore renewables sector and giving them access to R&D expertise (Real Power, 2005: 18).

In the late 1990s energy minister John Battle proposed eight OSW demonstration projects as part of plans to meet a 1997 election promise of 10% of electricity to come from renewables by 2010. This initiative followed lobbying from the wind industry for more investment in OSW, referring to rapid increases in OSW capacity by Denmark and Germany (ENDS 1997; interviewee 11). During this time a number of small, engineering-based companies were trying to develop OSWF in the UK and applied for EU and UK funds.

3.3 2001-2007: early offshore wind experiments

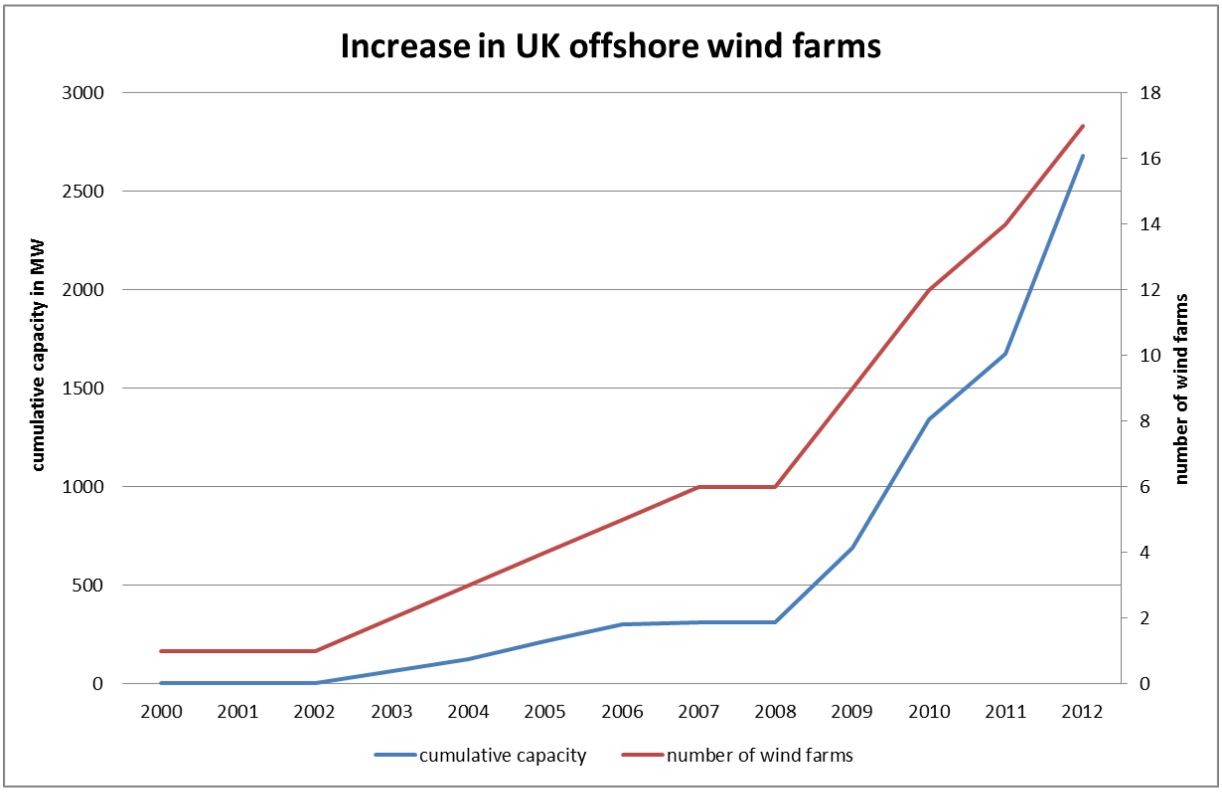
The UK's first OSWF in Blyth started operating in 2001 (Bilgili, Yasar et al. 2011). In the same year the Crown Estate (CE) awarded 13 Round 1 leases for OSWF (Toke 2011). The CE is a company set up by government to manage Crown owned land which includes most of the UK seabed outside the 12mn zone. Its profits go back to the Treasury. Developers need a license to develop an OSWF and have to pay a fee to the CE. The government also announced capital grants for OSWF under which projects received up to £10m (BWEA, 2010). However, developments on the ground were slow (see Figure 3).

In 2003 the CE announced a second round of licenses, focused on larger farms intended to provide 6GW of capacity by 2010 (BWEA, 2003). OSW development was given a further impetus in 2007 when the government signed up to binding EU targets of 15% of energy to come from renewables by 2020 which acted as a powerful driver for RET policy (Toke 2011).

3.4 2008- 2012: accelerated ambition and commitment to offshore wind

The most recent period is characterised by a step change in government involvement in OSWF as well as rapid deployment (Figure 3). During this period, the UK turned from a relative laggard in terms of RE deployment (Mitchell, Bauknecht et al. 2006) to a frontrunner in terms of OSW installed capacity (Toke 2011).

Figure 3: Number and cumulative installed capacity of offshore wind farms in the UK



source: own illustration, data from Greenacre, Gross et al. 2010 and DECC 2012

Given the challenging renewables and climate targets, the Department of Energy and Climate Change (DECC) argued that large scale industrial development of OSW is essential to bring costs down so that the technology could contribute to the targets (DECC 2009). A variety of support schemes for OSW were set up (see details in section 5.1).

One important element was a change of the Renewables Obligation (RO), which had done little to support OSW (Woodman and Mitchell 2011). In 2009, the government introduced technology-based 'banding' for Renewables Obligation Certificates (ROC) to offer greater support to more expensive technologies. The ROC scheme works by providing generators with certificates for every MWh of electricity produced. Under the banded RO OSW received 1.5 certificates/MWh compared to 1 certificate/MWh previously (Woodman and Mitchell 2011: 3919). This was revised to 2 certificates/MWh in 2010 as an 'emergency response' essential to the continued development of OSW (Greenacre, Gross et al. 2010: 94).

Another important element of this acceleration process was Round 3 of the Crown Estates' licensing in which 9 zones with a potential for 25GW were offered. While in Rounds 1 and 2 developers bid for self-proposed sites, the CE now became more strategically involved, identifying zones which had the greatest economic potential. The CE also started to co-invest alongside developers and implemented a new Zone Appraisal and Planning process designed to reduce risks to project delivery and accelerate the programme.

Ongoing changes to electricity market rules are intended to incentivise investment in low carbon technologies including OSW, nuclear power and carbon capture and storage. A package of instruments, including paying electricity providers a fixed premium price above the electricity price (so-called 'contracts for difference'), is currently going through the legislative process (Kern, Kuzemko et al. forthcoming).

Amid these developments OSW capacity reached 2.7GW, making the UK the world leader in deployment (DECC 2012) even though between 2004 and 2009 the capital costs of OSW doubled from £1.5m/MW to over £3.0m/MW, making it the most expensive commercially available RET (Greenacre, Gross et al. 2010). What explains this boom in deployment and increasing policy and industrial commitment?

4. The creation of 'protective space' for offshore wind

4.1 Main actors and their networks

The recent deployment of OSW is led by a number of large utility and energy companies (Table 1). For a more extensive overview of actors involved in OSW, please see Appendix B.

Table 1: UK offshore wind farms

Year	Name	Generating capacity	Turbine model	Operator
2001	Blyth	4MW	Vestas V66	Blyth Offshore Windfarm Ltd, SKM
2003	North Hoyle	60MW	Vestas V80	RWE Npower Renewables
2004	Scroby Sands	60MW	Vestas V80	E.ON Renewables
2005	Kentish Flats	90MW	Vestas V90	Vattenfall
2006	Barrow	90MW	Vestas V90	Dong Energy, Centrica, Barrow Offshore
2007	Beatrice	10MW	REpower 5M	Scottish and Southern Energy (SSE)
2009	Lynn and Inner Dowsing	194.4MW	Siemens SWT-3.6	Centrica
2009	Burbo Bank	90MW	Siemens SWT-3.6	Dong Energy
2009	Rhyl Flats	90MW	Siemens SWT-3.6	RWE Npower Renewables
2010	Gunfleet Sands 1 & 2	108MW (1), 64.8MW (2)	Siemens SWT-3.6	Dong Energy
2010	Robin Rigg	180MW	Vestas V90	E.ON Renewables
2010	Thanet	300MW	Vestas V90	Vattenfall
2011	Walney 1	183.6MW	Siemens SWT-3.6 107	Dong Energy, SSE, PGG M & Dutch Ampere
2011	Ormonde	150MW	REpower 5M	Vattenfall
2012	Greater Gabbard	503MW	Siemens SWT-3.6	SSE and RWE npower renewables
2012	Sheringham Shoal	317MW	Siemens SWT-3.6 107	Statoil and Statkraft
2012	Walney 2	183.6MW	Siemens SWT-3.6 107	Dong Energy, SSE, PGG M & Dutch Ampere

Specialised project developers like Renewable Energy Systems or Mainstream Renewable Power are becoming important players (interviewee 6). Also civil engineering contractors like Balfour Beatty are increasingly involved in developing transmission infrastructure (interviewee 12). Turbine manufacturers, i.e. Vestas and Siemens, have featured heavily (Breton and Moe 2009). Other companies like the German small turbine manufacturer Daywind struggled to gain a foothold (interviewee 12). The UK does not currently have any domestically located turbine manufacturers but several firms have announced plans (see section 5.2).

Initially government had little interest in OSW. However, in the most recent phase a number of departments have been very active. DECC is the policy lead on OSW and in charge of key policies such as the RO and the Electricity Market Reform. The Department of Business, Innovation and Skills (BIS) is interested in stimulating a UK supply chain in offshore renewable energy (interviewee 3). The Treasury is important in funding decisions and controlling public spending (interviewee 4). Ofgem, the regulator of gas and electricity markets, plays an important role being responsible for the rules on grid connections etc.

There is also a variety of at least partly publicly funded organisations which are increasingly involved in OSW, including the Engineering and Physical Sciences Research Council (EPSRC), Carbon Trust, Energy Technologies Institute (ETI), Crown Estate (CE), National Renewable Energy Centre (NAREC) and the Technology Strategy Board (TSB). The CE has taken a very proactive role. Aside from managing the leasing rounds described earlier, it also started to co-invest in developing projects and proactively supports OSW in a number of other ways (e.g. organising supply chain events). This forward-looking engagement of the CE has been praised as a "visionary, bold step which has moved the whole industry on" (interviewee 5; also interviewee 8).

Importantly, OSW also has enthusiastic support from environmental NGOs including Greenpeace, the Royal Society for the Protection of Birds, Friends of the Earth and WWF (Toke 2011: 528).

In terms of networks, one of the central organisations is RenewableUK (formerly known as BWEA), the trade body around which the offshore wind industry has galvanised. Since 2002 BWEA/RenewableUK has organised yearly OSW conferences which have grown to 5,000 visitors in 2012 (RenewableUK 2012). Initiatives like the TSB offshore renewable energy 'catapult' are aimed at facilitating knowledge sharing from existing offshore engineering expertise to accelerate the commercialisation of offshore renewables (TSB 2011).

In addition there has been an increasing formalisation of public-private networks. The Offshore Wind Developers Forum (OSWDF) is a network of developers aimed at discussing common problems facing the industry. It was set up by the Crown Estate in 2010 and is jointly chaired by the Minister for Energy and Climate Change and the CEO of ScottishPower. A manager from a utility company sees the network as very helpful in terms of 'having a united position as an industry' (interviewee 6). In 2011, DECC set up the Offshore Wind Cost Reduction Taskforce to bring together government with important industry players such as Crown Estate, Alstom, Gamesa, Siemens, Mainstream Renewable Power, Vestas, DONG, Centrica, Lloyds Banking, E.ON UK, EDF, RWE Innogy, ScottishPower, Statoil, Vattenfall and SSE Renewables. It is chaired by Andrew Jamieson, Chair of RenewableUK. Both of these networks have high-level access to government ministers.

In summary, a highly networked coalition of powerful and resourceful actors emerged which helped boost the credibility of and channelled resources into OSW. Formal networks centre around key public organisations as well as incumbent energy regime actors. Small independent companies which were very active in the beginning have fallen away or play a minor role. Environmental groups also helped create space for offshore wind by supporting the technology.

4.2 Narratives

Analysis of the narratives actor networks used to enrol support for OSW, identified a range of frequently used claims. These portray offshore wind as:

- helping to meet renewable energy and carbon reduction targets;
- contributing to energy security;
- creating jobs;
- utilising a currently unexploited resource ; and
- escaping from onshore wind planning issues.

The most obvious narrative is that the technology is key to meeting renewable energy and carbon targets as well as tackling energy security. After agreeing to the EU targets several government publications argued that OSW "will play an important part in meeting Britain's renewable energy and carbon emission reduction targets as well as improving energy security by 2020 and beyond" (BIS and DECC 2009: 20; DECC 2009). Energy security issues were also listed as one reason for supporting OSWF development in the 2007 Energy White Paper. Also the Committee on Climate Change (CCC) concluded: "there is an important role for offshore wind as part of the least cost path for decarbonising the power sector" (CCC 2010). Wind industry proponents even argued that "At a time when climate change climbs to the top of the political agenda, wind energy continues to be the only advanced technology ready and able to deliver renewable power on a large scale" (Real Power, 2006b: 2).

Already in 1998 Border Wind claimed that a UK wind energy industry could create 36,000 jobs by 2010 (ENDS 1998). However, it is in the most recent period, during a time of economic recession, when rhetoric about re-balancing the economy away from financial services towards manufacturing became salient, that this narrative has gained traction within government. OSW is portrayed as a key sector in which the UK can create economic value. Advocates were asking for serious state backing to kick-start private investment by referring to promises of an additional 70,000 jobs and a £60 billion economic boost by 2020 (Real Power, 2010). A senior civil servant in DECC argued: “it is my judgement given that this [deployment support] is funded from consumer bills, it is not credible for me not to take an interest in the jobs argument” (interviewee 13).

Another narrative was the availability of an unexploited resource and offshore engineering skills (Real Power, 2006: 6; interviewee 1; 3). Civil servants indicated that a key starting point for the Low Carbon Industrial Strategy was to identify where the UK has a natural opportunity: in offshore wind “we have better resources than anyone else proportionally” (interviewee 13). Such claims were repeatedly made by actors including BWEA (Real Power, 2007: 3), the Carbon Trust (2003: 29) and the government’s Technology Innovation Needs Assessment (LCICG 2012: 1). Interview evidence indicates that this narrative was very effective with politicians (interviewee 8).

Another strategy was to position OSW as an escape from the onshore wind planning and public acceptability issues (interviewees 4; 5; 8; 9; 10; 11; 12). The CEO of DONG is reported to have said: “We’re going offshore, offshore is invisible…we don’t bother any of the inhabitants, we don’t change the landscape onshore” (interviewee 9); also see (Trident Energy, 2011). This is also purported to have been a strong motive for policy makers to support the move offshore (interviewee 10); also see (Jones and Eiser 2010).

However, OSW has also been contested. For example three projects in Scotland were shelved in March 2011 due to local opposition, e.g. Wigtown Bay (interviewee 3). Also, wind subsidies have been argued to increase electricity prices (e.g. see public letter written by 100 mainly Conservative MPs to the PM in Feb 2012). Also the CCC voiced concerns about the cost of OSW and argued that the government should limit the amount of OSW contributing to the 2020 target and focus on the most cost-effective options (2011). Toke argues that the extent of the British OSW programme "is likely to depend heavily on consumer reactions to price increases" (2011: 526). A Reuters analyst also raised the question why Britain is placing so much faith in offshore wind although it "is the most expensive green power technology" (Wynn 2013). In response to such pressures, the Prime Minister insisted that while renewables are low carbon, they also need to become low cost (Endsreport, 26 April 2012).

The analysis shows that advocates of OSW were drawing on a range of supportive narratives that align with wider political and social goals (such as climate change mitigation, energy security, creation of jobs). Key networks succeeded in presenting a credible and appealing image of OSW to funders, policy makers and the general public, helped by the re-emergence of industrial policy considerations on the political agenda. While similar narratives are also used to advocate other RET such as PV (Smith, Kern et al. 2014), we argue that the interest shown by large energy firms in combination with support from key public bodies gives them particular weight. OSW satisfies the economic and political interests of key actors: Politicians are committed to meeting renewables and carbon targets, creating new jobs, and want to avoid public backlash against more onshore wind; the Crown Estate is interested in creating revenue from offshore leases, as is the Treasury; and for the utilities and investors this is a new business opportunity. In this sense OSW can be seen as a mutually beneficial state-capital alliance in what Newell and Paterson have described as climate capitalism (2010). This does not mean that OSW was not contested as shown above. However, challenges from residents, analysts and advisors have (so far) not been influential enough to undermine OSW advocacy.

4.3 The creation of protective space: summary

In summary, the argument is that over time the multitude of narratives supporting OSW and the increasingly influential actor networks involved in voicing them have contributed to a rather beneficial situation for OSW in the UK. The situation was very different in the initial phases described in sections 3.1-3.3 where a number of small independent companies, environmental groups and academics tried to create a protective space for OSW and wanted to transform incumbent electricity systems. While the 1970's oil crisis put some pressure on incumbent firms and governments to explore alternative forms of energy and stimulated early interest in OSW, advocates struggled to mobilise sufficient resources and obtain political buy-in at the time. For example an interviewee remembers: "In the early days the UK was very strong in the wind sector, you know, when it was an initial R&D idea. It was very much an academic space and then it lost it and it all went to Denmark [because of a lack of funding in the UK]" (interviewee 1) (see section 5.1). Being in such a difficult economic environment several smaller contractors involved in early project went bankrupt because of cost overruns (interviewee 8) (see section 5.2). Other small players were taken over (e.g. Wind Energy Group was taken over by Vestas and Borderwind was taken over by AMEC, a consultancy, engineering and project management firm mainly working for the oil and gas industry). The management of Borderwind early on was aware of the fact that to play an important role in offshore wind a larger company was required so they sold Borderwind to AMEC (interviewee 5). However, this also meant that important and resourceful actors entered the offshore wind niche.

Only later on the emergence of climate change on the political agenda provided a window of opportunity for OSW advocates to obtain protective space to enable further development and deployment. In this later phase the Crown Estate became a very proactive and a trusted actor with close links to government and other public bodies while also being credible with business actors. The CE therefore can be seen as a 'system builder' in Hughes' sense (1979) who related 'everything to a single central vision', reached out beyond their special competences and played an entrepreneurial, system building role. These developments are argued to constitute the kind of 'protective space' the literature refers to.

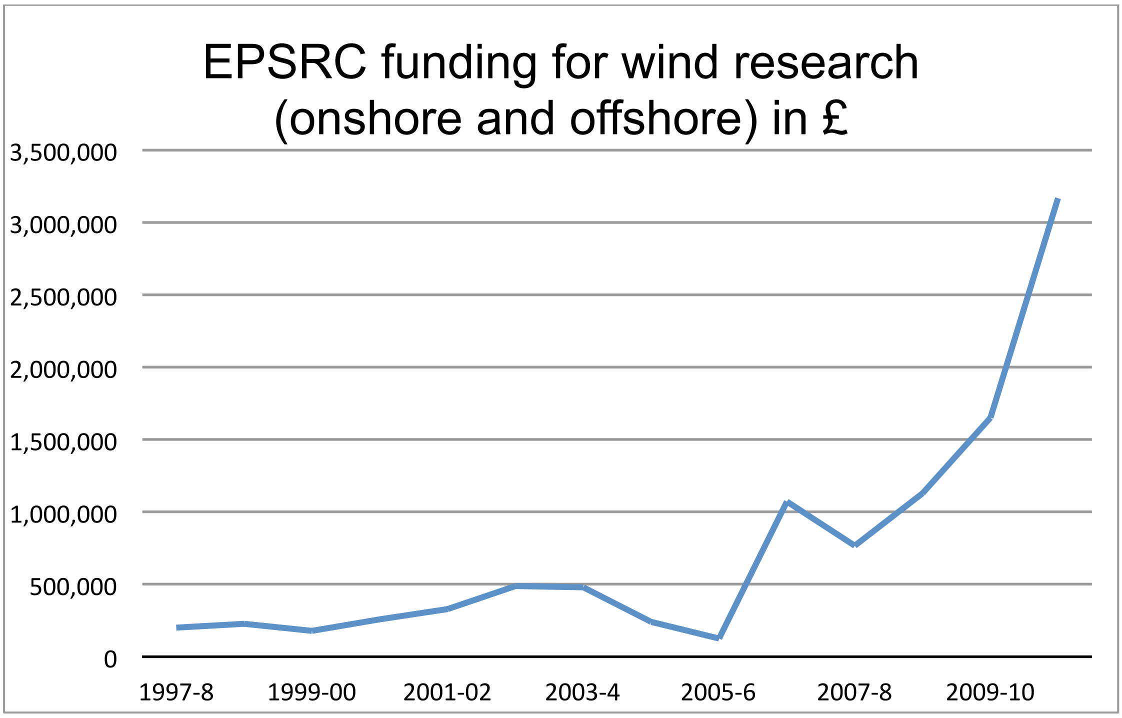
5. What impact did the 'protective space' have on offshore wind developments?

5.1 Shielding of offshore wind developments

With OSW unable to compete with incumbent technologies, the analysis identified a number of specific processes shielding the niche from regime selection pressures that enabled its continued development.

During the early period of our analysis, very few resources were spent on public R&D. What little R&D into renewables emerged in the 1970s ended in the 1980s. A member of a judging panel for the Science and Engineering Council in 1987-88 recalled: "We had a significant number of wind projects...We used to say the pump has been primed. We don't need to fund any more research" (interviewee 12; also interviewees 10; 11). Public funding remained low until the mid-2000s (Figure 5). Since then energy R&D funding has been rising "prompted by the drive for efficiency improvements and overall cost reduction" (Halliday and Ruddell 2010: 2).

Figure 5: Engineering and Physical Sciences Research Council (EPSRC) funding of wind research in £



Source: own illustration, based on data obtained from the EPSRC

Ironically, some initial shielding for OSW deployment was provided by a policy mechanism introduced in 1990 to support nuclear power (the Non-Fossil Fuel Obligation – NFFO) (Mitchell and Connor 2004). EU State Aid rules meant government also had to include renewable energy. NFFO contracts provided a small market niche for wind (219MW of installed capacity, mainly onshore) (Wood and Dow 2011). The follow-up instrument (RO) was introduced in 2002 and was designed to be technology-neutral. Only after the banding of the RO in 2009 did it make a difference to the economics of OSW (interviewees 6; 8; 9) and therefore stimulated significant interest by industry. For example in 2010-11 OSW received support of £256m through the RO (Ofgem 2012).

Most recently , a range of initiatives have actively shielded offshore wind, including funding schemes to bring together actors, provision of incentives for upgrading port facilities and funding to increase the capabilities of the supply chain. The research councils also started to put significant funding into the engineering skills base (see Table 2 for a list of initiatives).

Table 2: Dedicated offshore wind funding schemes

Initiative (Funder)	Years	Funding	Aims & Activities
Offshore Wind Accelerator (Carbon Trust)	2008-2010 (stage I) 2011-2014 (stage II)	stage I: £1.5m stage II: £10m for R&D; £30m demo projects	Joint industry RD&D programme involving nine offshore wind developers that aims to reduce the cost of offshore wind by 10% by 2015 through innovation; often using international competitions.
Offshore wind manufacturing funding (DECC/BIS); similar scheme in Scotland	2011-2015	£60m from DECC/BIS; £70 from Scotland	Business investment grant funding for the development of wind manufacturing facilities at ports to exploit supply chain opportunities (turbine and component manufacturing).
Offshore Wind Component Technologies Development and Demonstration Scheme (DECC, TSB)	2011-	£15m	Provides competitive calls for funding aimed at helping companies to test and demonstrate devices and develop component technologies that can cut the costs of offshore wind energy in the run up to 2020 and beyond.
Offshore Renewable Energy Catapult (TSB)	2012-2017	£50 (across all offshore renewables, incl. tidal and wave power)	The Catapult aims to bring together knowledge, expertise and state of the art facilities to help UK businesses innovate and find new ways to capture and use the power from offshore renewable energy sources. One focus area is establishing a sustainable supply chain for the offshore wind sector in the UK.
SUPERGEN Wind Energy Technologies Consortium (RCUK Energy programme)	2006- 2010 (phase I) 2010-2014 (phase II)	Phase I: £2.55m Phase II: £4.83m	Consortium of 7 research partners led by the Universities of Strathclyde and Durham with active support from 18 industrial partners; its mission is to undertake research to achieve an integrated, cost-effective, reliable and available offshore wind power station.
UK Wind Energy Research – Doctoral Training Centre at University of Strathclyde (EPSRC)	2009-2014	£5.8m	Funding scheme for developing highly skilled doctoral students working in multi-disciplinary research teams and with industry collaborators to gain competencies in wind energy systems engineering and understand the socio economic impact of wind energy systems in order to meet the needs of the wind energy industry.
Industrial Doctorate Centre in Offshore Renewable Energy at University of Edinburgh (IDCORE) (ETI, EPSRC)	2012-	£6.5m	Funding for doctoral training in offshore renewable engineering as well as developing commercial and entrepreneurial skills; training provided by leading Universities in collaboration with business partners such as EDF Energy, E.ON, BP, Shell, Caterpillar and Rolls-Royce.
Offshore Wind Programme (ETI)	2009-	£40.23m (excluding funding for IDCORE)	Programme provides competitive funding for projects which have promise of achieving significant cost reductions, enhancing reliability and reducing technical uncertainties. Funding for an indoor test rig capable of testing complete drive trains and nacelles up to 15MW at NAREC.
Environmental Transformation Fund Offshore wind capital grant scheme (DECC)	2009-2011	£26m	Under this programme three calls for capital grant funding for offshore wind were undertaken. The programme was launched to encourage the development of OSWF and to understand wind farm equipment and technology and develop the supply chain.
Crown Estate	2009-	£70m co – investment; £30m 'enabling actions'	The Crown Estate co-invests alongside project developers up to the award of consent and also has a programme of enabling actions including work on health and safety, supply chain and skills, project economics and finance, grid and technology and planning and consenting.
Funding for offshore wind cost reduction (DECC)	2011-2015	£30m	DECC announced in its 2011 Renewable Energy Roadmap to provide up to 30m of direct government support for offshore wind cost reduction. The funding is aimed at fostering collaboration between technology developers and support innovation.
		Total: £452m	

Source: authors own; data from a variety of sources, including interviews, public announcements

Looking at the impact shielding processes had on OSW developments, the argument is that the nature of the shielding provided by the policy framework (especially the RO) made a difference to the way offshore wind developed. The 'protective space' mainly provided shielding for a particular socio-technical configuration: large scale installations by big utilities or energy companies which were able to take on the risks and deliver the required scale of the activity and fund projects on their balance sheet whereas many of the smaller firms active in earlier phases struggled to do so. This also had an effect on turbine manufacturers. Companies like Daywind, which had developed small wind turbines mainly sold to cooperatives, small businesses and farmers in Germany, struggled to break into the UK market: "the people interested in wind were big developers or big construction companies" (interviewee 12) looking for large projects with large wind turbines –mainly provided by Vestas and Siemens. The analysis also showed that shielding initiatives have grown both in terms of funding and in numbers over the last few years which has given a substantial boost to innovation activities aimed at reducing costs and upscaling the size of the turbines (see next section).

5.2 Nurturing offshore wind

In terms of learning processes, a number of observations can be made. Actors were learning lessons from projects abroad such as Horn's Reef in Denmark (interviewee 5) but UK pilot projects like Blyth were also important. One of the lessons learned was that increasing the turbine size was important to offset high costs and access higher wind speeds (interviewees 1; 5; 11). The harsh operating conditions meant that turbines and foundations had to be much more robust than onshore. Firms are currently experimenting with a variety of different solutions (e.g. developing turbines without gearboxes or alternative foundations). Neither of these problems have been resolved and there is no consensus about what the best solutions are (interviewee 11). Several of the publicly funded R&D schemes are trying to address these challenges (interviewee 1).

The analysis also suggests that while technical learning was important, learning about other aspects of the socio-technical configuration was as crucial. Interviewees pointed to the importance of learning about suitable contractual arrangements across consortia (interviewees 7; 8; 12). Cost overruns on fixed price contracts led to a number of small contractors going bankrupt in the initial projects (interviewee 8). While cost data from the early OSWF in Denmark were supportive of the idea of a downwards learning curve, costs started to go up during the mid-2000s. Research identified several factors behind price rises (for example Greenacre, Gross et al. 2010; ENDS 2006; BWEA, 2009). Arguably, without the political clout of OSW advocates as discussed in section 4, these cost increases could have threatened the future of OSW. Instead of cutting funding though, the government increased support and developers and public sector organisations started to work together ever more closely to nurture cost reductions.

The analysis showed that during the earlier periods expectations for OSW were relatively low. However, this changed for a variety of reasons as argued above. The government's Technology Innovation Needs Assessment contained indicative deployment scenarios for OSW ranging from 20-100GW in 2050 (LCICG 2012). The document also voices expectations that the OSW industry could contribute between £7bn and £35bn to UK GDP by 2050 (cumulative). According to interview evidence, the government targets for renewable energy deployment, the specific scenarios for OSW and the scale of Round 3 projects helped to produce credible expectations of a sizeable OSW market leading to increased commercial interest (interviewees 1; 7; 8). The banding of the RO also led to a much better business case (interviewee 9). Several interviewees pointed to the shared sense developing across actors that in order to fit alongside conventional power stations and to be economical, OSW had to be bigger (interviewees 3; 5; 7; 8; 9; 10). To deliver on this expectation research projects such as Supergen as well as industry R&D focussed on scaling up wind turbines (interviewees 7; 11).

Section 4.1 already showed the broadening of OSW networks from a few interested academics, NGOs and small engineering firms to include utilities, energy companies, civil engineering contractors as well as a range of public sector organisations. These networks were again broadened by turbine manufacturers' interest in setting up production facilities in the UK (interviewee 1). Siemens is planning to build a turbine manufacturing plant in Hull and has received local planning permission for the £210m investment in May 2012. The factory is to produce 6MW turbines for Round 3 projects (Murray 2012). Turbine manufacturer Gamesa has signed a Memorandum of Understanding with Forth Ports, Leith, Scotland to build a manufacturing facility (BBC 2012a). Areva has signed an agreement with Scottish Enterprise to site a new nacelle and blade manufacturing facility in Scotland (BBC 2012b).

The analysis above already showed the increasing resource commitment in terms of investments (see Table 1) and in terms of public support for OSW (see Table 2). The broad membership and the deepening commitments by these networks had a positive impact on the development of OSW activity.

5.3 Empowering offshore wind

Empowering involves networks of actors representing niche configurations to the wider world in an attempt to mobilise resources for niche development and to help change the selection environment. Because the processes of representing niche configurations and mobilising resources have been covered in section 4, the analysis here focuses on changes to the selection environment. Arguably, actors have been quite successful in portraying OSW in a positive way and have received significant resources, but for OSW to become competitive with incumbent regime technologies either OSW improves up to a point when it can fit into the existing electricity regime ('fit and conform') or the selection environment is adjusted to accommodate OSW ('stretch and transform').

The analysis reveals that there are a number of ways in which technology advocates, powerful business actors and policy makers shaped the selection environment to make it more amenable to OSW. The most important development in this context is the Electricity Market Reform . This represents a radical overhaul of the electricity markets rules in order to empower investment in low carbon generation by introducing long-term feed-in tariffs for a number of low carbon electricity technologies including OSW (Kern, Kuzemko et al. forthcoming). The contracts-for-difference guarantee investors an above market price for the electricity generated and will replace the RO by 2017.

Another important instance of empowering is a change of rules implemented under the EU Third Energy Package (European Commission 2007). This EU policy did not allow OSW developers to build and operate transmission cables connecting the wind farm to the grid[2]. Several interviewees mentioned this rule as an obstacle to investment because any delay in

[2] Because of the separation of generation and transmission for competition reasons.

grid connection will lead to a loss of revenue. Following pressure Ofgem addressed this concern by allowing the 'generator-build option' (Crown Estate 2011b).[3] In the words of a government minister: 'we had to get Ofgem to stop being pedantically market driven' (cited in: Toke 2011: 528) which addressed industry concerns (interviewees 6; 8; 12).

A third example of change in the selection environment is an alteration in the planning rules for Round 3 projects. Special procedures were set up for large wind farms which were given precedence ahead of other considerations including the allocating of Natura 2000 conservation sites (Toke 2011: 528). This was addressing industry concerns that planning processes were cumbersome and introduce delays (interviewees 3; 6; 8; 12).

In addition to these examples of 'stretch and transform' empowering, advocates also utilised 'fit and conform' strategies. For example the recent emphasis on cost reductions is part of a strategy to make OSW at least competitive with other low carbon options if not conventional generation.

In summary, we argue that these empowering processes have contributed to the further development and deployment of OSW by helping to overcome some specific barriers but also by providing 'political signposts' that the government is serious about OSW. As a renewable energy developer put it: "That's made quite a difference I think, just generally because it gives people more confidence in the higher risk development stage to invest. So planning reforms and electricity market reforms which have been much more heavily dominated towards offshore wind than ever before" (interviewee 8).

[3] Under this model, the OSW developers build the transmission infrastructure as part of the overall project and then sell off the asset once the OSWF is up and running.

5.4 Summary of shielding, nurturing and empowering processes

Table 3 provides a summary of the main findings of the analysis.

Table 3: Summary of empirical findings regarding shielding, nurturing and empowering

	looking for evidence of activities aimed at…	Empirical Findings
Nurturing	broad and reflexive learning; articulating specific and shared expectations; building broad and deep networks	Evidence of activities aimed at learning-by-doing (roll-out) as well as learning-by-R&D to reduce costs in the future but costs were rising Pilot projects were important in generating lessons (both technical as well as about contractual arrangements and costs) Offshore wind advocates built a broad coalition (incl. policy makers and non-departmental public bodies, firms, environmental organisations) sharing positive expectations about the potential for offshore wind giving credibility to technology Expectations about size of turbines needed to be economic and fit alongside conventional power stations shaped technology development
Shielding	mobilising pre-existing support; implementing innovation in favourable (geographic) locations; creating financial support, temporary rule exemptions for innovation; tolerating 'poor' economic/technological performance	Offshore wind actors first mobilised pre-existing support (e.g. generic research council funding; tax credits; EU funds); then successfully lobbied for dedicated public support schemes (for innovation as well as deployment), and have chosen favourable locations for pilots (e.g. Blyth harbor, less than one mile off the coast); 'poor' economic performance was tolerated and led to increase in policy support through RO
Empowering	'fit and conform': arguing and promoting that innovation will be competitive under conventional criteria; arguing that no radical change is required; framing shielding as temporary; framing nurturing as targeting performance improvement 'stretch and transform': arguing for and achieving institutional reforms; framing shielding as manifestations of sustainable values; framing nurturing as learning processes towards sustainability	Concerted effort towards cost reductions to make technology competitive at least with other low carbon options (involving DECC, other public bodies, Crown Estate, technology providers, project developers) Offshore wind advocates achieved several institutional changes to the electricity regime to make it more favourable to offshore wind (electricity market reform; transmission connections allowing 'generator-build option'; streamlining planning) which increased confidence and removed barriers

It was not always straightforward to categorise certain empirical phenomena as exclusively contributing to only one of the three processes. For example in section 5.1 several initiatives such as the provision of R&D support or the establishment of doctoral training centres have been categorised as contributing to the shielding of the OSW niche (as they create financial support for OSW without which there would have been little interest). However, the same initiatives also contribute to nurturing processes as they help to build networks and stimulate learning processes. While the framework separates these processes, it is important to acknowledge that empirically they are much more intertwined – indeed, smart policy would seek to stimulate all three.

6. Discussion

Section 4 analysed the activities of the actor networks advocating and negotiating support for OSWF. A key feature of that work is the recursive nature of outward-oriented socio-political processes (for securing discursive and material support for OSWF) with inward-oriented socio-technical processes (investment, technology development and deployment). Analysis in section 5 indicates that these actor networks and their narratives have constructed a fairly effective space for shielding, nurturing and empowering OSWF.

OSW has also benefitted from a number of wider contextual developments. An obvious example is the political commitment of the UK government to addressing climate change combined with challenging EU renewables targets. However, this only became helpful to OSW through actor networks and narratives positioning the technology as contributing significantly to achieving these goals. This did not happen automatically – other ways of meeting the targets are conceivable.[4] What is striking is the way OSW advocacy has actively negotiated alignments between the sector and shifting contexts. The socio-technical potential

[4] For example the UK transition pathways consortium developed a number of scenarios and the 'Thousand flowers' scenario contains a very small share of OSW only and instead relies much more on distributed generation and energy efficiency (Foxon 2013).

of OSW has had to be argued and demonstrated on various terms, but the general strategic line has been to stress the potential of OSWF to generate large quantities of low carbon electricity far from peoples' local amenity concerns.

Our analysis focuses on how OSW actors in the UK made use of these external developments (e.g. EU politics around renewables targets) and how their agency subsequently shaped developments in the UK. The framework is not designed to explain these wider political processes within the EU. There may be other external influences (e.g. electricity market and policy developments in Germany leading to a re-assessment of investment priorities of utilities like RWE)[5] which are beyond the scope of our analysis but which might disempower OSW advocacy in the UK. Further conceptual work is necessary to explore how such external influences can be included within the suggested framework of shielding, nurturing and empowering.

The fruits of aligning work became even more visible when OSW advocates had to confront developments that did not smoothly fit prevailing narratives, and where action was needed to 'stretch and transform' selection environments. Rising costs, for example, run counter to concerns for the deployment of lowest cost technologies and assumptions about costs coming down. A significant political turning point was the government's 'emergency response' to rising costs through the banding of the RO and enhanced incentives for innovation. RO reforms demonstrated government commitment to OSW, which increased market confidence that triggered investment. When it became apparent that costs were stubbornly refusing to

[5] For example in November 2013 the German utility RWE announced its withdrawal from a planned large offshore wind farm in UK waters (Atlantic Array) which was interpreted by commentators as a blow to UK OSW ambitions. To what extent this decision was driven by OSW politics in the UK (e.g. the change of deployment support instrument from RO to contracts-for-difference) which is part of our analysis, or (external) policy and market developments in Germany (which is beyond the scope of the analysis) is an open question.

fall, OSW advocacy was able to maintain momentum by organising task forces and other activities to demonstrate increased efforts to reduce costs to maintain political support.

Economic difficulties in the UK have further cast OSWF costs in a critical light. However, OSW networks are actively addressing these concerns. For example providing subsidies at a time of recession prompted attempts to identify what percentage of these subsidies were benefiting the UK. In 2011 E.ON commissioned a report examining the economic benefits of the Robin Rigg wind farm which concluded an average of 32% UK content (BVG, 2011). In response the Offshore Wind Developers Forum announced an ambition of 50% UK content for future OSWFs in February 2012. The Forum recognised that this was a crucial political issue: "I think it will be a real struggle for [offshore wind] to survive politically if it doesn't increase its UK content" (interviewee 8; also interviewees 4 and 12). This commitment will shape the socio-technical configuration of the industry in the future.

Indeed, such is the strategic fit with political concerns that institutional reforms to electricity markets and land use planning have been made to facilitate OSW deployment alongside CCS and nuclear power. Here the socio-technical scale of OSWF helps: it fits with other centralised forms of electricity generation. Critical to all this has been the alignment of political and economic interests around OSWF. The analysis demonstrated that it is not just what is being said, but who is saying it that matters. Investment and interest in OSWF comes from incumbents in the energy and utility sectors. After smaller and less powerful actors struggled for many years to establish a protective space for OSW, in the mid-2000s OSW became a project of joint interest of a variety of powerful actors who each saw OSW as being to their advantage: For the Crown Estate, this was an opportunity to develop an additional revenue stream; for DECC OSW contributes to meeting renewables and climate change targets, circumventing contested onshore wind while potentially creating jobs; for the turbine manufacturers, contractors, developers and the supply chain OSW is a new market with growth potential; for investors this is a potential new field to make a return and for the utilities OSW is one way of meeting decarbonisation targets while preserving their business model.[6] All of these actors are highly resource interdependent, meaning that they rely on each other to meet their respective interests. We argue that it is this resource interdependency in terms of investment, capabilities and skills, policy frameworks and legitimacy which provided the glue for the OSW network and which was absent in the earlier phases.

Our analysis demonstrates how the close alignment of economic and political interests of key actors within the specific context of the UK has led to the rapid deployment of OSW – by circumventing anti-onshore wind protest in the short term and meeting 2020 renewables targets in the medium term but at potentially high economic and political costs when the further deployment of OSW adds up to a significant impact on electricity bills.

7. Conclusions and policy implications

This paper has sought to explain the recent burst of activity in OSW in the UK by examining the dynamics of the development of 'protective space'. We showed that a variety of public and private actors were involved in the creation of a 'protective space' for OSW since the 1970s, initially with very limited effect. To create support for the niche actors strategically linked OSW to a variety of policy goals. While initially supporters had a hard time to enrol powerful private and public actors, developments abroad (Denmark and Germany) as well as changing contexts (including renewables targets and the recent focus on manufacturing jobs)

[6] Indeed a strong alliance between political actors and utility incumbents who realise that renewables cannot be suppressed any more is not unique to the UK but has also occurred in Germany with Vattenfall and E.ON being interested in developing OSW (Michaelowa 2004). We would like to thank one of the reviewers for alerting us to this parallel.

provided a window of opportunity for OSW advocates. An important role in this process was played by the Crown Estate who took the lead in bringing together actors.

The analysis also suggested that processes of shielding, nurturing and empowering shaped the development of OSW in specific ways. For example early niche learning processes led to a shared understanding that OSW turbines needed to be larger and much more robust. Public and private R&D investment was channelled towards addressing these problems. We suggest that empowering OSW in this case was aided by the fact that the niche (at least in the later phases) was created by relatively homogenous networks of powerful actors promoting one socio-technical configuration (large scale offshore wind farms). The research showed a distinct lack of disagreement among advocates of OSW about the strategic direction although technical details vary. In addition, credibility was bestowed onto this technology by the interest and investment of utility companies, large manufacturing firms, oil and gas firms as well as DECC and the CE. In terms of the actors interested in OSW, these are closely associated with the existing regime as the configuration of multi-MW wind parks fits well into existing electricity regimes.

We argue that the framework suggested by Smith and Raven explains the recent burst of OSW deployment in the UK through embedding these developments into a longer process of political struggles around the desirability and feasibility of the technology. The protected space enabled early processes of socio-technical configuring to take place by experimenting with the technology and different contractual arrangements but most importantly by building broad and powerful coalitions and aligning political and economic interests of key actors. When political pressure for the expansion of renewable electricity mounted, these coalitions were able to respond and rapidly deploy several GWs. The analysis provides a different kind of deeper and historical explanation for the development of OSW compared to policy or economic analysis. In how far these lessons from the UK relate to developments in other countries remains to be seen, but the paper has at least demonstrated the usefulness of the perspective to explain UK OSW developments which is of relevance to other countries given the leading role of the UK.

In terms of policy implications, two points can be made:
First, the analysis shows that substantive change can happen ('from laggard to leader') when renewable energy policy ambitions link up with interests of powerful regime actors and tie in with economic concerns about growth, jobs and energy security, state revenue, and investment by manufacturers. The alignment of interests led to an increased legitimacy of the technology despite rising costs and thereby enabled the large scale deployment. For renewables advocates and policy makers, the analysis therefore points to the importance of building such coalitions in order to strengthen the case for RET.

Second, the analysis shows that the existence of a 'system builder' was very beneficial for the development of offshore wind in the UK. The Crown Estate took a very proactive and multi-faceted approach to OSW. In many other countries administrative bodies responsible for granting licenses are dominated by bureaucratic practices rather than an entrepreneurial mind-set. We argue that countries that are serious about the large scale deployment of offshore wind should look at the UK model and see whether the kinds of functions the Crown Estate fulfils (e.g. in terms of providing a platform for industry and government actors to come together, co-investing up to the point of consent, having a commercial mind-set and performing facilitative actions e.g. with regard to the supply chain) are present and if not, what kind of body might be set up to fulfil these functions.

Future research should analyse developments in OSW within the wider dynamics of energy transitions as different pathways interact with one another: both positively in terms of synergies (like the ones observed between offshore and onshore wind developments) but also in terms of competition (e.g. between centralised nuclear power and decentralised solar PV pathways).

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Appendix A: List of interviewees

Interviewee	Position and Organisation
1	Representative of Energy Technologies Institute
2	Representative of Technology Strategy Board
3	Senior Official from BIS
4	Member of DECC offshore wind taskforce
5	Engineering Manager at wind energy technology company
6	Strategy and Stakeholder Coordination Manager at a large utility company
7	Commercial manager at a renewable energy centre
8	Manager at renewable energy developer
9	Former DONG employee involved in economic and financial evaluations of offshore wind
10	Senior researcher involved in wind energy research
11	Senior researcher involved in wind energy research
12	Professor involved in wind energy research; also involved in European Wind Energy Association
13	Senior Official from DECC

Appendix B: List of important OSW actors and abbreviations used

Actor	Abbreviation	Timing of their involvement in OSW
Firms and business associations		

Alstom		Alstom acquired existing Spanish wind turbine manufacturer in 2007; started developing dedicated OSW turbines in late 2000s
Areva		Interest in establishing manufacturing presence in UK since late 2000s; signed an agreement with Scottish Enterprise to site a new nacelle and blade manufacturing facility in Scotland in 2012
Balfour Beatty		Active since late 2000s
Borderwind		Active from the mid-1990s; involved in Blyth wind farm in 2001; later taken over by AMEC
British Wind Energy Association; later RenewableUK	BWEA	Active promoter of wind energy since 1978 (initially mainly onshore wind); since 2002 dedicated OSW conferences
Central Electricity Generating Board	CEGB	Explored OSW in the 1980s; abolished in 1990
Centrica		Invested since 2000s
Danish Oil and Natural Gas	DONG	Invested since 2000s
E.ON		Invested since 2000s
Gamesa		Interest in establishing manufacturing presence in UK since late 2000s; singed memorandum of understanding in 2012 to build manufacturing plant in Scotland
Haldens		
Mainstream Renewable Power		Active since the 2000s
McAlpine		Active in the 1980s
Renewable Energy Systems	RES	Active since the 2000s
RWE		Invested since 2000s
Scottish and Southern Energy	SSE	Invested since 2000s
Scottish Power		Interested since early 2010s; trying to develop several UK OSWFs
Siemens		Provided turbines since late 2000s; received planning permission for turbine manufacturing plant in 2012
Statoil		Invested since 2000s
Tecnomare		Active from the mid-1990s

Vattenfall		Invested since 2000s
Vestas		Provided turbines since early 2000s
Wind Energy Group		Active since the 1980s; taken over by Vestas
Windmasters		Active from the mid-1990s
Public actors		
Carbon Trust	CT	Established in 2001; initially focussed on small-scale technologies but supported OSW since late 2000s
Committee on Climate Change	CCC	Existed since 2008
Crown Estate	CE	Actively promoted OSW since 2000
Department for Energy and Climate Change	DECC	Established in 2009
Department of Business, Innovation and Skills	BIS	Has taken an interest in OSW since late 2000s when Low Carbon Industrial Strategy came out
Energy Technologies Institute	ETI	Launched dedicated OSW programme in 2009
Engineering and Physical Sciences Research Council	EPSRC	Provided limited funding for wind research since the 1980s
National Renewable Energy Centre	NAREC	Established in 2002; active in OSW since late 2000s
Office for Gas and Electricity Markets	Ofgem	Established in 1990
Technology Strategy Board	TSB	Established in 2007; active in OSW since late 2000s
Private public bodies/networks		
Offshore Wind Cost Reduction Taskforce		Set up in 2011
Offshore Wind Developers Forum	OSWDF	Set up in 2010

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