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Technology legitimation and strategic coupling: A cross-national study of floating wind power in Norway and Scotland

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ABSTRACT

Building upon recent work in sustainability transitions studies and economic geography, this paper is concerned with the process of legitimation by which emerging technologies are aligned with broader societal rules and norms. Challenging the assumption of earlier research that legitimation occurs within regional and national borders, the paper views legitimation as set of transregional processes whereby the actors behind emerging technologies seek support from different regional and national organizations on an international basis. Inspired by the Global Production Networks (GPN) approach, the paper argues that technology legitimation can be understood as a *trans*-regional process of strategic coupling between the strategic needs of the industrial actors advancing new technologies and the efforts of national and regional organizations to promote their territories as leading nodes in emerging production networks. Empirically, the paper adopts a micro-level focus on the legitimation of a particular renewable energy technology: the Hywind floating wind power (FWP) technology, developed by the Norwegian energy firm, Equinor. The paper shows that the FWP technology was gradually legitimated in a pragmatic sense over the three stages of Hywind. The demonstration phase generated a temporary and conditional form of legitimacy at an intra-national scale, while the next phase, Hywind Scotland, generated a stronger and more durable form of legitimacy as the world's first floating wind farm. This led to the internalisation of legitimacy from outside into the Norwegian energy regime (absorption) in the third stage of Hywind Tampen.

1. Introduction

Research on energy transitions is framed within the sustainability transitions literature, which is concerned with shifts of socio-technical systems towards sustainable technologies (Elzen et al. 2004; Köhler et al. 2019). One influential conceptual framework within transitions studies is the Technological Innovation Systems (TIS) approach which is concerned with the processes that influence the development, diffusion and use of new technologies (Bergek et al. 2008; Rohe and Mattes 2022). The formation of a TIS requires the creation of four critical system resources: knowledge, market formation, financial investment and technological legitimacy (Binz et al. 2016). New technologies emerge out of this resource formation process, based on the interactions between actors, networks and institutions (Bergek et al. 2008).

In common with transitions research more broadly, TIS is primarily concerned with socio-technical transformations over time rather than across space. Empirical research on emerging cleantech industries has largely adopted an implicit focus on national system boundaries (Heiberg and Truffer 2022). In recent years, however, researchers have sought to open up a broader multi-scalar understanding of innovation system dynamics (Binz and Truffer 2017; Heiberg and Truffer 2022; Njøs, et al. 2020; Rohe 2020). Rather than focusing on a specific spatial scale, leading TIS researchers emphasize "the role of multi-scalar networks and systemic differences between the innovation processes in various industries" (Binz and Truffer, 2017: 1284). The operation and understanding of Global Innovation Systems (GIS) is a key concern of this literature. Yet, whilst the adoption of a multi-scalar understanding of innovation processes is a welcome advance, there is a danger of regional and national processes being reduced to subsystems within GIS research, subordinated to the concern with the international operation

Abbreviations: GPN, Global Production Networks; FWP, Floating Wind Power; TIS, Technological Innovation Systems.

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and integration of system elements (Binz and Truffer, 2017). At the same time, another, more empirically-based, strand of TIS research that seeks to incorporate the regional dimension still seems to rely on the bounded and territorialised approach that characterised earlier research on regional innovation (Rohe and Chlebna 2021; Rohe and Mattes 2022), clashing with the broader multi-scalar understanding advanced by GIS researchers (Miörner and Binz 2021).

This paper is underpinned by a relational and cross-regional conception of space. It focuses on the process of legitimation by which emerging technologies are aligned with broader societal rules, norms and beliefs (Suchman 1995). Challenging the assumption of earlier research that legitimation occurs largely within regional and national boundaries (Heiberg et al. 2020; Rohe and Mattes 2022), this paper views legitimation as set of *trans*-regional processes whereby the actors behind emerging technologies seek support from different regional and national organizations on an international basis. Inspired by Global Production Networks (GPN) research in economic geography on the evolving linkages between firms and territories (Coe and Yeung 2015: Yeung 2021), this paper argues that technology legitimation can be understood as a transregional process of strategic coupling between the strategic needs of the industrial actors advancing new technologies and the efforts of national and regional organizations to promote their territories as leading nodes in emerging production networks. Compared to the TIS notion of structural coupling (Binz and Truffer, 2017), strategic coupling provides a more active and strategic sense of the cross-regional dynamics of legitimation related to the agency of firm and state actors.

While much of the TIS literature is concerned with overarching processes of resource formation at the industry or sectoral level, this paper adopts a micro-level focus on the legitimation of a particular Renewable Energy Technology (RET): the Hywind floating wind power (FWP) technology, developed by the Norwegian energy firm, Equinor, with support from the Norwegian state. It examines the question of whether different stages of the technology development and legitimation process may be located in different regions, depending on the availability of institutional support. Building on Heiberg et al. (2020), the paper assesses the evolution of the Hywind technology, framing Equinor's strategy as partly 'export-driven' (in terms of trade and/or Foreign Direct Investment) and the Scottish Government's approach as 'challenge-driven' whereby it sought to attract external actors to help to meet its ambitions for the development of marine renewables.

The reminder of the paper is organized as follows. The next section presents the conceptual framework, followed by the methodological approach. The paper then outlines the context of national energy regimes and FWP technology before assessing the legitimation of the Hywind technology in terms of the three main stages of its development. This is followed by a discussion. The final section concludes the paper.

2. Legitimation and strategic coupling

The TIS approach is based on three main building blocks: actors, including firms, entrepreneurs, universities, government departments, intermediaries and end users; networks, for example, industry alliances, technical committees, working groups, regional innovation fora and cluster organizations; and, institutions, comprised of the formal and informal rules that enable and constrain the behavior of actors (Bergek et al. 2008; Binz et al. 2016: 179). The process of innovation requires the successful mobilization of the four system-level resources highlighted earlier (Heiberg et al. 2020). First, knowledge creation and combination encompass codified and tacit dimensions, which are transferable across space and concentrated in particular locations respectively (Binz et al. 2016; Boschma 2016; Maskell and Malmberg 1999). Second, market formation since markets for novel products and technologies do not simply pre-exist, but have to be actively created, often requiring government intervention (Bergek et al. 2008; Binz et al. 2016). Third, financial investment to support the development costs of new technologies and industries, requiring firms and entrepreneurs to raise funds from financial institutions, markets and venture capitalists (Binz et al. 2016; Musiolik et al. 2018). Fourth, legitimation enables emerging technologies to overcome their 'liability of newness' and secure alignment with broader institutional rules and societal norms (Geels and Verhees 2011), serving as a pre-requisite for "the mobilization of financial, human and material resources as well as regulatory support" (Markard et al. 2016: 331).

Suchman (1995) defines legitimation as "a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions." Informed by this influential definition, we adopt a strategic legitimacy approach that focuses on the 'pragmatic legitimacy' which stems from an organization's capacity to obtain practical solutions in its environment, based on the mobilization of its operational assets. From this perspective, the focal organization and its audiences are interdependent, where pragmatic legitimacy relies on the parties' self-interested calculations (Suchman 1995). In the context of sustainability transitions, legitimation focuses attention upon the strategies and narratives advanced by proponents of emerging technologies (Bork et al. 2015; Raven et al. 2016). Key legitimation narratives for RETs include: combating climate change and achieving 'net zero' emissions; promoting energy security through the exploitation of domestic resources and reduced dependence on imports; increasing cost reduction to make RETs affordable over time; and, the generation of economic value and jobs, particularly at the regional scale (Authors 2021, Gibbs and Jensen 2021).

Two strands of research on the geography of legitimation can be identified. First, studies that seek to insert the regional dimension of legitimacy into TISs, focusing on regional differences and place-specific influences (Rohe 2020; Rohe and Chlebna 2021; Rohe and Mattes 2022). While these studies make an important contribution to the development of a more spatially differentiated understanding of legitimation in TIS research, they tend to present a rather territorial conception of regions as bounded and discrete units of analysis.

The second strand of research rejects this 'containerized view' of space in favour of a relational and multi-scalar approach (Miörner and Binz 2021). Accordingly, the subsystems of a GIS are "not based on predefined territorial boundaries, but based on the actor networks and institutions that are involved in creating specific system resources" (Binz and Truffer 2017: 1285). Here, subsystems pertain to the actor networks and institutional contexts involved in the creation of system resources (ibid). The process of structural coupling refers to the interactions between subsystems (Tsouri et al. 2021), whereby actors, networks and institutions span different spatial scales, enhancing the flow of resources between regions (Heiberg and Truffer 2022). While this multi-scalar conception of innovation systems represents an important advance over the spatially bounded thinking of earlier research on regional innovation, it risks relegating regional and national influences to a subordinate position as subsystems within global innovation networks (Binz and Truffer 2017), notwithstanding substantial empirical evidence of the continuing territorial embeddedness of some innovation and transition processes (Reichardt et al. 2017; Rohe and Mattes 2022; van der Loos et al. 2020).

In this paper, we adopt a middle-ground position that recognises the cross-border and multi-scalar scope of innovation and legitimation processes, whilst retaining a focus on regional and national influences. In so doing, we build on a recent analytical framework for investigating *trans*-regional sources of knowledge and industrial path creation (Heiberg et al. 2020). This identifies three main *trans*-regional processes of legitimation. First, absorption involves regional actors' internalising legitimacy from elsewhere, particularly with reference to cases of success or failure in other parts of the world (ibid: 477). Second, attraction refers to the drawing in of external actors to help create favourable market conditions for new technologies and products in a region. Attraction can occur passively, if a region offers a conducive environment for innovation, or more actively when actors in the host region create the conditions to attract external firms and organisation. Third, export is based on generating legitimacy by serving external markets and influencing institutional environments outside the home region.

Understanding of transregional legitimation processes can be further enhanced by engagement with GPN research, which is explicitly concerned with coupling processes between territories and transnational networks, although focusing on foreign direct investment and outsourcing rather than knowledge transmission (Yeung 2021). From a GPN perspective, territorial economic development is based on a process of strategic coupling between GPN actors – lead firms, subsidiaries, suppliers, customers – and regional assets (natural assets, infrastructural and material assets, industrial assets, human assets and institutional assets) (Boschma 2016; Coe and Yeung 2015). Regional institutions play a crucial role in mediating and brokering linkages between territories and global production networks, harnessing and moulding regional assets to the strategic needs of GPN actors (Coe and Yeung 2015). The concept of 'regional' institutions being utilized here is multi-scalar, incorporating national and supra-national organisations such as government agencies, labour organisations and business associations (Coe et al. 2004). This GPN equation of institutions with concrete organizations is somewhat at odds with the broader TIS conception of institutions as formal and informal rules, leading us to distinguish between organizations as sets of actors and resources that pursue common objectives and institutions as the broader 'rules of the game' (Bathelt and Gluckler 2014; Zukauskaite et al. 2017).

GPN actors' ability to meet their strategic needs will reflect, in part, their ability to mobilize their assets (van Mossel et al. 2018). Four sets of firm-specific assets can be identified: technological assets in the form of protected knowledge; infrastructural assets required to operationalize infrastructure-dependent innovations; complementary assets such as distribution channels, marketing and production facilities; and reputational assets derived from alignment with prevailing norms and values (Wesseling et al. 2015: 520). Reflecting our pragmatic conception of legitimacy as property, these assets can be understood as dynamic capabilities orchestrated and mobilized to achieve particular objectives (Phelps and Fuller 2016).

While somewhat narrower than the distributed sense of multiple actors in TIS research, the conception of actors in GPN research in terms of the *relationships* between firms and regional organizations can be seen as more relational and structured than TIS notions of entrepreneurial experimentation and institutional alignment (Bergek et al. 2008; Binz et al. 2016). The GPN approach emphasizes ongoing bargaining and negotiation processes between these two sets of actors, often involving considerable power asymmetries (Dawley et al. 2019). Advancing beyond the pre-occupation with actors in TIS research, the concept of strategic coupling is underpinned by a more theoretical sense of agency, involving intentional action and active intervention (Dawley et al. 2019; Yeung 2009). By contrast, the analogous TIS concept of structural coupling is rather under-theorised in terms of agency, meaning that the types of agency involved in connecting subsystems across borders remain rather opaque (Binz and Truffer 2017; Tsouri et al. 2021).

Integrating TIS and GPN thinking, we develop, theoretically, a new understanding of technological legitimation as based upon a process of strategic coupling between GPN actors and regional and national organizations. As a relational process, legitimation may transcend territorial boundaries, shaped by the spatial mobility of firms in global production networks which enables them to search for support on an international basis, involving bargaining with regional authorities in multiple locations (Dawley 2011). These firms possess dynamic firm-specific capabilities, but require institutional support and protection to orchestrate these capabilities and mobilize system resources. By contrast, national and regional organizations can harness regional and national assets to attract firms and use their regulatory and legal powers to support technological innovations that fit with their wider socio-political agendas and strategies (Raven et al. 2016).

Based on the above discussion, we draw together the central elements of *trans*-regional legitimation processes in TIS and strategic coupling in GPN into a theoretical framework to inform our research. This framework is based on the argument that (pragmatic) legitimacy can be seen as the outcome of a process of strategic coupling between regional and national assets and spatially mobile system resources, brokered by regional and national organizations (Binz et al. 2016). The three forms of *trans*-regional legitimation identified above are underpinned by distinct strategic coupling processes (Fig. 1). First, absorption involves a strategic coupling between regional and national assets and extra-regional legitimation processes, based on regional actors' knowledge of cases of success and failure, transmitted through mobile actors such as consultants and policy entrepreneurs. Second, attraction involves regional and national institutions drawing external actors into a region, involving the coupling of regional and national assets to the strategic needs of these actors. Third, export can be seen as the opposing process whereby mobile TIS actors serve external markets and influence external institutional environments, fostering a process of coupling between the strategic needs of these actors and the assets of the country or region to which they export, which may be supported by home country assets in a more indirect and distinct way. This formulation, we contend, provides a richer understanding of the transregional coupling processes associated with legitimation than the still "rather vague … conceptualization of interdependencies between various territorial subsystems at an international level" in TIS research (Binz and Truffer 2017: 1284), particularly in terms of identifying three processes of coupling between countries / regions and global innovation systems.

This framework can be further specified by reference to a typology of industrial path creation (ibid). This is based on two analytical dimensions: the strength of related knowledge and capabilities in a region; and the resistance of the established sociotechnical regime against a newly emerging industry. Sociotechnical regimes refer to semi-coherent sets of rules embedded in a range of institutions, infrastructures, knowledge, practices and procedures (Rip and Kemp 1998). They provide much of the stability of socio-technical systems, fostering path dependence (Elzen et al. 2004). Four ideal-type configurations are identified (Heiberg et al. 2020). First regions characterized by high level of related knowledge and relatively weak regime resistance against an emerging industry provide lead-market constellations. Second, regions with high level of related knowledge assets but strong regime constraints are defined as export driven. Third, regions lacking related knowledge and with weak regime influences are termed challenge-driven, relying on external actors to develop products, create markets and build a knowledge base. Fourth, regions that lack related knowledge, but have strong regimes, are defined in terms of regime lock-in. As these concepts are not scale-specific in principle, we extend them to the national scale where innovation processes are strongly shaped by established regimes and related knowledge.

3. Research methods

This paper provides a qualitative case study analysis of the legitimation of a specific RET over time and across two countries by following the Hywind technology. Inspired by 'following the thing' methods, we adopt a cross-regional 'distended' case study approach (Peck and Theodore, 2012). Rather than representing a multiple or comparative case study of two countries, this is a single case study of the specific technology undergoing legitimation (Hywind). This approach involved investigating how the technology is harnessed and legitimized over a couple of decades, based on data collected from different national and international sources, produced at different phases and at different sites. The project examined Hywind as an evolving process, offering the opportunity for a longitudinal study covering three stages: Hywind I, Hywind Scotland and Hywind Tampen.

Drawing on the TIS and GPN frameworks, it was important to cover both firms and regional and national organizations (policy makers, support organizations and regulatory bodies). For the purposes of this

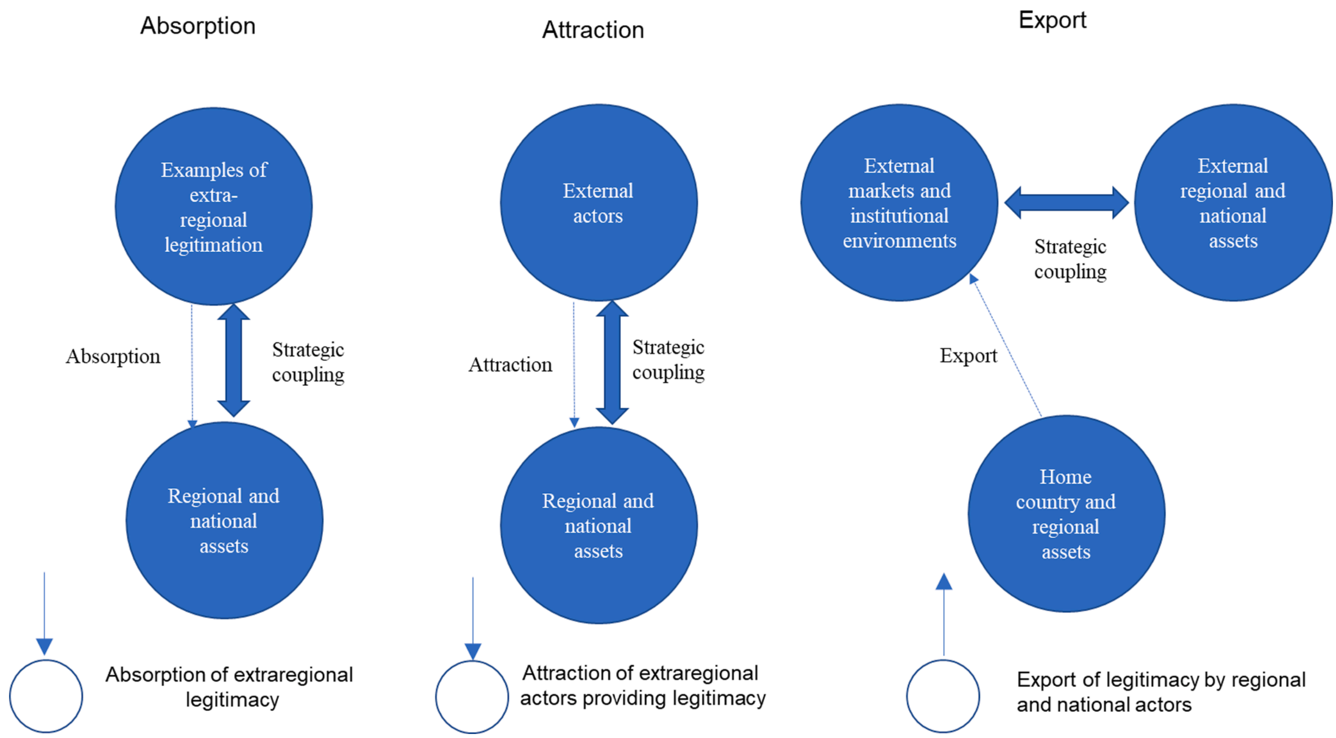

Fig. 1. Extraregional legitimation processes. Source: adapted from Heiberg, J., Binz, C., Truffer, B. (2020) The Geography of Technology Legitimation: How Multiscalar Institutional Dynamics Matter for Path Creation in Emerging Industries, *Economic Geography*, **96**:5, 470–498, Figure 1, p.477.

paper, we conducted 20 semi-structured interviews in Norway and Scotland in two rounds, synchronized with the development of Hywind stage II and III (13 in 2016–17 and 7 in 2020).[1] We conducted interviews with representatives of the lead firm and its main subcontractors, ports, cluster organization, technology and innovation research centers, government officials and representatives, industry experts, local and regional development agencies and research institutes. The interviews covered topics of technology development, firm and government strategies, extra-firm bargaining, market regulation and subsidy schemes, and supply chains and local content. This primary interview data is complemented with a wide range of secondary data sources: company reports, industry databases, websites, media archives, scientific journal articles and FWP-related industry reports, and public policy and strategy documents.

The analysis of legitimation processes began with the extraction of key quotations and statements from source documents, principally interview transcripts, policy documents, press releases and media reports. These were organised separately with regard to the three distinct projects taking place over time and at different sites. These extracts were thematically coded according to the topics of technology development, knowledge generation, legitimation narratives and strategies, firm assets and strategies, harnessing of regional assets, market regulation and subsidy schemes, supply chains and local content, and bargaining and lobbying processes between firms and regional and national institutions. These themes were then linked back to the analytical framework outlined above, particularly in terms of quotes and statements that illuminated the transregional legitimation processes of absorption, attraction and export, as well as the largely intra-national focus of the first phase (see below).

[1] The primary data was collected as part of a larger research project focusing on offshore wind (OFW) sector development in Northern Europe (including UK and Norway), involving around 50 semi-structured interviews undertaken between 2016 and 2020.

4. Global floating wind power technology and the Norwegian energy regime

The growth of the OFW industry is part of the expansion of RETs, representing an increasingly important sector, with rapid rates of growth and investment (GWEC 2021). The OFW industry has been characterized as based on the ‘doing, using and interacting’ (DUI) mode of innovation reliant on tacit knowledge, in contrast to ‘science and technology-driven’ (STI) innovation which is more codified (Binz and Truffer 2017). Accordingly, the OFW innovation system is regarded as spatially ‘sticky’ and territorially embedded (ibid), although firms with a background in the O&G sector are also likely to engage in STI forms of innovation (Tsouri et al. 2021).

The position of OFW in Norway is shaped by the national energy regime, which in turn reflects Norway’s existing natural asset base of hydropower and oil and gas (O&G). First, the Norwegian electricity market is entirely dominated by hydropower. Second, Norway is one of the leading exporters of offshore technology, based on its O&G sector, led by the state-owned enterprise, Equinor (formerly Statoil).

The hydrocarbon-based energy regime has sought to respond to growing climate change concerns in two main ways: the decarbonization of the O&G sector through electrification of domestic offshore installations; and the development of adjacent renewable energy sectors, particularly OFW, based on technology push instruments and R&D support, rather than domestic market formation (Authors, 2021; Dahl et al. 2022). Legitimation strategies for OFW have emphasized its benefits in providing opportunities for industrial diversification and export, particularly for the dominant O&G sector (Steen and Hansen 2018). Accordingly, the policy instruments established to support OFW have been weak and unpredictable (Van der Loos et al. 2021. Based on the combination of the strong path dependencies of the O&G-oriented regime and the strength of related knowledge from O&G and the wider maritime sector, Norway can be characterised as an export-driven configuration for OFW, prompting supporters of this emerging technology to search for legitimacy in overseas markets (Heiberg et al. 2020).

The growth of the Northern European OFW market from 2010 has seen Equinor become an important player, particularly through the acquisition of OFW projects in the UK. Equinor's involvement reflects its firm-specific assets that enable it to meet the growing levels of complexity involved in developing larger wind farms in deeper waters, further from shore (Authors 2022; Bento and Fontes 2019). This shift to 'bigger, deeper and further' (EWEA, 2011) is providing O&G firms with diversification opportunities by leveraging their existing O&G-based capabilities in offshore marine and subsea operations, as well as in managing large complex projects, for the emerging OFW market (Steen and Weaver, 2017).

In a maturing OFW sector, FWP has emerged as a nascent technology. While OFW developers have hitherto relied on foundations fixed to the seabed, these cannot as yet be installed in sites with water depths of over 45 m, which often have better wind resources (WindEurope, 2018). FWP is still far from being cost competitive with bottom-fixed technology which has experienced marked cost reduction in recent years, although it has the potential for rapid cost reduction in future (WindEurope 2021). Europe has a pipeline of FWP pilot and commercial projects with Hywind Scotland the first FWP project to be commissioned in 2017 (Table 1).

Sensing the market imperative of energy transition, Equinor has been working to strategically diversify its business and complement its O&G portfolio with renewable energy projects in order to seize the growing opportunities in the sector (Equinor 1, authors' interview, 2017). Its emblematic renaming in 2018 signifies the company's transformation from O&G to a broad 'energy company' (Equinor 1, authors' interview, February 2017). Reflecting its embeddedness in the Norwegian regime – virtually all its energy generation still comes from O&G (Becker 2022) – Equinor has adopted an export-driven strategy towards the OFW sector, taking major stakes in four wind farms in the UK, one wind farm in Germany, and two wind farms on the East Coast of US. Its investment in FWP reflects Equinor's relatively late entry into the OFW sector and efforts to gain a first mover advantage in this emerging technology (Authors 2022).

5. Legitimation of the Hywind technology

This section examines the evolution of the Hywind floating wind power technology developed by Equinor with support from the Norwegian and Scottish governments. The paper follows the evolution of the technology across the regions of Western Norway and Northeast Scotland. While the technology was developed in Norway, it was demonstrated and tested in Scotland, before being returned to Norway for commercial application. Informed by the TIS approach and GPN thinking, our analysis unpacks the territorial institutional and political processes, particularly the interactions between the lead firm and public agencies, which shaped the legitimation of this innovative technology in Norway and Scotland.

5.1. Hywind demo (2001–2009): intra-national legitimation

Originally developed by two Norwegian engineers at Norsk Hydro – the large Norwegian energy and aluminium company – in 2001, Equinor acquired the Hywind concept as a result of its takeover of Norsk Hydro's O&G division in 2008. Hywind relies on an established technology from offshore O&G operations, the spar buoy, modified to fit the FWP context (Equinor 1, authors' interview, February 2017). To verify the concept, Equinor invested in R&D, model testing, and deployed a full-scale demonstration unit. This Hywind Demo, comprised of a single 2.3 MW Siemens turbine, was deployed off the south-west coast of Norway in 2009.

The process of legitimating the Hywind Demo technology was intra-national in geographical scope, coinciding with a period in which Norwegian regime actors were articulating increased support for OFW (Normann 2015). The Demo received a total of NOK59 million in state support from Enova in line with the technology push approach of the Norwegian regime (Bento and Fontes 2019; Steen and Hansen 2018). The mobilization of these system-level resources reflected the strategic coupling between the needs of Equinor for institutional support and the Norwegian state's commitment to funding emerging green technologies as drivers of future industrial innovation. Enova's financial investment coincided with a marked contraction of the O&G sector, fuelling the national legitimation narrative of 'life after oil' (Hansen and Steen, 2015). In this post-financial crisis conjuncture, political expectations of OFW becoming Norway's next industrial adventure were articulated (Steen and Hansen, 2018).

This technological relatedness to O&G is perceived as being stronger for FWP than bottom-fixed wind, based on the scope for transferring knowledge and competencies (Dahl et al. 2022). In the context of a technology-push approach (Normann, 2015; Steen and Hansen, 2018), the deployment of the Hywind demo was an important milestone given previous attempts to launch demonstration sites. Demonstrating an excellent production capacity, the demo was successful in confirming and validating the feasibility of the Hywind FWP concept.

Yet the growth of FWP and the domestic OFW market more broadly in Norway remained dependent upon conditions in the O&G sector. Efforts to legitimize OFW technology through the narratives of energy security and climate change proved ineffective due to Norway's reliance on clean, domestic hydropower resources for electricity and the strong vested interests of O&G actors (Authors 2021; Van der Loos et al. 2021). In addition, the development of OFW was hampered by weak networks, evident in a lack of collective action (lobbying) by OFW technology advocates, who were unable to agree on a single proposal to submit to the Norwegian authorities (Normann 2015). Accordingly, coupled with the revitalization of the O&G sector from 2010 to 11, expectations of domestic OFW market formation subsided. This drove Equinor's export-oriented approach as it sought alternative sources of support overseas.

5.2. Hywind Scotland (2009–2017): trans-regional export and attraction

Based on its export-driven strategy, Equinor carried out a selection process of alternative geographical sites (Norway, US (the Gulf of Maine), Scotland) for the next stage of technology legitimation, based upon a scaled-up technology demonstration. Two Scottish sites were under consideration. The choice of the one off the coast of Northeast Scotland was influenced by the availability of natural assets, including wind resources and water depth, and infrastructural and material assets such as proximity to the national grid and proximity to a deep-water navigation route. Of equal importance were the strategic needs of Equinor for conducive institutional and regulatory conditions, particularly the availability of market support (Authors 2019). The UK energy regime provides price support in the form of subsidies for OFW, in contrast to the Norwegian regime (Steen and Hansen 2018).

We define Scotland as a 'challenge-driven' innovation configuration, based on limited related knowledge and weak path dependencies from the existing energy regime (Heiberg et al. 2020). While it has some related knowledge from O&G, Scotland lacks the strong domestic industrial capabilities of Norway, reflecting the dominance of large, often foreign-owned, production companies and, more recently, independent operators and private investors in the UK O&G industry (Bridge and Dodge 2022; Cumbers 2012). It is part of a UK-energy regime that was privatized and liberalized in the 1990s, with the subsequent introduction of market support measures leading to the rapid growth of RETs from the mid-2000 s (Geels et al. 2016). Reflecting the wider UK regime, the development and legitimation of RETs in Scotland is dependent on the attraction of external actors to provide technological solutions and financial investment and to build a stronger knowledge base through cooperation with indigenous institutions (especially universities) and suppliers (Authors 2019a).

Asymmetrical devolution grants the devolved Scottish Government a substantial set of policy-making powers in areas such as economic

Table 1
List of commissioned and announced FWP projects in Europe.

Wind Farm Name	Lead developer(s)	Country	Capacity (MW)	Commissioning date
Hywind demo	Equinor	Norway	2,3	2009
Hywind Scotland	Equinor	UK	30	2017
Windfloat Atlantic	EDP group	Portugal	25	2020
Flocan 5 Canary	COBRA Group	Spain	25	2020
Nautilus	NAUTILUS Floating Solutions	Spain	5	2020
SeaTwirl S2	SeaTwirl	Norway	1	2020
TetraSpar Demo	Shell, RWE, Stiesdal	Norway	3.6	2020
Forthwind Project	2B Energy	UK	12	2020
Kincardine	KOWL, COBRA group	UK	40	2021
PivotBuoy (PLOCAN)	PLOCAN	Spain	0,2	2021
DemoSATH	RWE, SAITEC	Spain	2	2022
FLAGSHIP (Metcentre)	Iberdrola & Olav Olsen	Norway	10	2022
Eolink Demonstrator	Eolink	France	5	2022
Groix-Belle-ille	Ferme Eolienne Flottante de Groix & Belle-Île	France	28,5	2022
PGL wind farm	EDF, Enbridge	France	24	2022
Katanes Floating energy park-Array	DP Energy + Floating power plant	UK	32	2022
AFLOWT	Frunhofer, CaLiCyA, University College Cork, SEAI	Ireland	6	2022
Hywind Tampen	Equinor	Norway	88	2022
EolMed	Quadran/Ideol	France	30	2023
EFGL	Ocean Winds	France	30	2023
Pentland floating Demonstrator	CIP and Hexicon	UK	100	2024
GOFIO	Greenalia	Spain	50	2025
Parco Eolico Offshore Bel Canale di Sicilia	Copenhaguen Infrastructure Partners	Italy	250	2025
Canary island 2025 target part I	PLOCAN	Spain	125	2025
Canary island 2025 target part II	N/A	Spain	125	2026
Floating commercial 175 MW	N/A	Portugal	175	2026
Erebus	Total & Simply Blue Energy	UK	96	2027
South Brittany floating offshore wind	Ocean Winds and Principle Power	France	250	2027
Dolphyn ERM pre-commercial	ERM	UK	9,5	2027

Source: WindEurope. (2021) *2030 Offshore Wind Outlook tool.* Available at: https://windeurope.org/intelligence-platform/product/2030-offshore-wind-outlook-tool/. [accessed 19 May 2022].

development, research and development, planning and transport related to energy transition (Cowell et al. 2017). Run by the Scottish National Party (SNP) since 2007, the Scottish Government has been keen to position itself as 'world-leading' in its commitment to the growth of renewables, particularly marine renewables, based on Scotland's abundant OFW resources (Scottish Government 2009).

FWP has been identified as a suitable OFW technology for Scotland given that bottom-fixed foundations have been constrained by its deep waters and rough seas (Scottish Government [SG], 2018: 13). Accordingly, Scottish authorities have sought actively to attract and embed FWP projects in Scotland in order to develop domestic industrial capabilities and position the country as a key node in the global OFW industry. This approach underpinned the process of strategic coupling that took place between the strategic needs of Equinor for a suitable deep-water location and grid access and the Scottish Government's provision of institutional and political support, alongside the availability of the natural and material assets identified above.

Scotland's early interest in hosting the next stage of the Hywind technology development was cemented by the then First Minister during an official visit to Stavanger and Oslo, when he discussed the concept with Equinor (Statoil) (Philip 2010). This led to detailed negotiations between Scottish Government minister and Equinor from 2013 over the level of financial incentives that would be required to attract the project (Scottish Government official, authors' interview, June 2017). The availability of such market support attracted Equinor to Scotland, as it sought to mobilize the system-level resources required to develop and legitimize the upscaled Hywind technology.

The Scottish Government's capacity to provide financial support was based on its powers under the Renewables Obligation (RO) support scheme, established in 2002 as the principal support scheme for renewable electricity generation in the UK (Toke and Lauber 2007). From 2009, the RO scheme was banded to provide higher levels of support for emerging technologies such as OFW than for more established technologies like onshore wind (Ćetković and Buzogány 2016). This approach was extended to attract Hywind Scotland by providing support at a rate of 3.5 Renewables Obligation Certificates (ROCs), equivalent to £190 per MWh, approximately-four times the wholesale price of electricity in October 2017 (Ofgem, 2018). Following consultations with Equinor and other prospective FWP developers, this was judged to the price required to attract and realize projects (Scottish Government official, authors' interview, June 2017).

Yet the Scottish Government's ability to support Hywind Scotland was constrained by the UK-wide transition from the RO to a new auction-based Contracts for Difference (CfD) support scheme (Fitch-Roy 2016). This meant that Scotland would lose its powers to offer higher levels of support to renewables projects, potentially undermining its capacity to attract external actors. As part of its protracted multi-scalar negotiations with the UK government, however, the Scottish government was able to agree an eighteen-month extension to the ROC scheme, providing a window of opportunity for Hywind Scotland, alongside two other FWP projects in Scotland (Scottish government official, authors' interview, June 2017).[2]

Equinor deployed the Hywind pilot park off Northeast Scotland in 2017 as the world's first floating OFW farm. The park is comprised of five 6 MW Siemens turbines with a generating capacity of 135 MW of electricity per year, also incorporating testing of 1 MW of grid-connected battery storage through the BATWIND initiative (Equinor, 2018). In addition to further verifying the viability of the Hywind technology, the Hywind pilot park increased existing technical competencies by demonstrating capital cost reductions of around c.70 % per MWh compared to Hywind Demo (Equinor 2021a), and a capacity factor better than bottom fixed technology (Equinor 3, authors' interview, March 2020). In other words, the Pilot Park proved the reliability and commercial potential of Equinor's Hywind technology, contributing to

[2] Kincardine, based on a semi-submersible design, now party owned by the Spanish company Cobra, which was installed in 2021; and Dounreay, another semi-submersible design, owned by Hexagon AB, a Swedish firm, which has not gone ahead.

its further legitimation within the international OFW market. At the same time, it proved central to the legitimation of FWP in Scotland, providing a focus for press coverage and public discussion (Fig. 2), with the First Minister describing it as "placing Scotland at the forefront of the global race to develop the next generation of offshore wind technologies'' (quoted in Bussey 2017: 1). The legitimation of FWP is evident from the results of the new Scotwind leasing round, which awarded option agreements for 17 sites, 10 of which are to be based on FWP (Crown Estate Scotland 2022).

Reflecting the challenge-driven Scottish approach, political, industrial and media actors have expressed concern about an over-reliance on the importation of equipment and materials and a perception that Scottish firms are losing out from the awarding of contacts (Scotsman 2019). Regarding Hywind Scotland, Equinor utilized its existing networks with most of the suppliers also involved in supplying the Hywind Demo (see Authors 2019b). Despite the 50 % domestic content target for the UK OFW industry (HM Government, 2013) – subsequently increased to 60 % - and the organization of events to support local suppliers, it proved difficult for Scottish firms without a track record in OFW to compete with established international suppliers. Scotland also lacked suitable deep-water ports that could accommodate the assembly and sinking of the spar buoy structure, which was assembled and sunk at Stord off the west coast of Norway before being towed to the installation site at Buchan Deep.

5.3. *Hywind Tampen (2019-): trans-national absorption*

The deployment of the Hywind Scotland pilot park sent a strong signal that FWP technology should be how Norway positions itself in the global OFW industry. The period after 2017 is characterised by a growing absorption of legitimacy from outside by Norwegian actors (see below), based upon the increased acceptance and normalisation of OFW and FWP internationally and the success of Hywind Scotland in particular. After a difficult post-financial crisis period of austerity when opponents of RETs questioned the affordability of subsidies, a process of radical cost reduction supported the accelerated legitimation of OFW internationally (Authors 2021). Between 2014 and 2019, the global weighted average levelized cost of energy (LCOE) for OFW fell by 37 % as the industry matured rapidly, driven by technology improvements, economies of scale, increased experience, the standardization and industrialization of design and manufacturing and the improved sophistication and speed of installation practices (International Renewable Energy Agency (IRENA) 2020: 84, 76).

At the same time, the success of Hywind Scotland in demonstrating the performance and commercial feasibility of the technology, alongside large-scale cost reduction (see above), was highly influential in increasing political support for FWP in Norway (Dahl et al. 2022). Interestingly, Dahl et al. (2022) suggest that FWP is more compatible with the Norwegian energy regime due to its relative immaturity giving more scope for R&D support (technology-push) and closer fit with the capabilities of O&G producers. Measured by coverage in domestic press articles, the legitimation of FWP and Hywind increased markedly from 2018, based on discussions of the Hywind Tampen project (see below) (Fig. 3).

This period witnessed an increase in the number of OFW technology advocates in Norway. Equinor ran a comprehensive advertising program in Norwegian media on Hywind Scotland and further ambitions for FWP. The sector started to get actively promoted by influential industrial actors, reflecting difficulties in the O&G market, including both O&G incumbents led by Equinor and the (revitalized) OFW cluster, as well as public agencies, industry associations and trade unions, often in unison with longstanding advocates of OFW, including prominent environmental organizations. This created a more supportive institutional and political environment for the legitimation of OWP in Norway compared to the previous two phases. The key narratives associated with this effort to legitimate the FWP technology in Norway are a combination of emission reductions and/or decarbonization of the O&G sector, and industrial value creation, providing a diversification opportunity for petro-maritime firms and new green jobs (Authors, 2021). These complementary narratives add legitimation to the technology both in the political and industrial domains. According to Equinor's head of floating wind development: "It's great to see the results Hywind Scotland and the floating technology keeps delivering […] floating offshore is not only an efficient way to generate electricity from wind, this exciting technology can also provide jobs and value creation for the countries supportive of floating. In the UK alone, we are talking at least 17,000 jobs and £33bn GVA by 2050″ (Sebastian Bringsværd, cited in Equinor 2021a).

The success of Hywind Scotland in particular has significantly contributed to the legitimation of FWP by proving its potential, subsequently paving the way both for the further development of the technology in Norwegian waters with the Hywind Tampen project, the first full scale FWP farm (Equinor, 2021b). As emphasised by one of our informants: "For Equinor and for the wind energy sector generally, I will say that this is of significant strategic value as well….That we obtain further acceptance for, and further trust in floating wind. One sees that it actually works and performs well…operationally better than bottom fixed" (Equinor 3, authors' interview, March 2020). We interpret this emphasis on performance as a pragmatic type of legitimacy.

Hywind Tampen has been under development since 2019, with the aims of electrifying two O&G platforms in the Norwegian continental shelf, Snorre and Gullfaks. The costs are estimated to be around NOK 5 billion and 45 % of this is covered by the state through Enova, which previously funded the Hywind Demo (see above). This public support was instrumental for the realization of the project (Enova, authors' interview, April 2020; Equinor 3, March 2020). "For us this commitment deals with bringing floating wind one step closer to commercialization. Including all the positive externalities this could have both for the global climate challenge and Norwegian industry in the long run. It is exactly such initiatives Enova has to support to fulfil our role as a driver for the transition to the low emission society" (Enova 2019). In addition to these climate change and industrial development narratives, Enova also framed its investment in Hywind Tampen in terms of the expectation that the costs of FWP would fall as the technology matured.

In this way, Hywind Tampen was underpinned by strategic recoupling between Equinor's need to shield and further legitimize its FWP technology in this commercial application phase and Enova's mandate of strengthening Norwegian industry's international competitiveness through the adoption of green technologies with the potential to spread globally (Enova, authors' interview, April 2020). This process of strategic recoupling was strengthened by the particular application of Hywind Tampen, whereby FWP is used for the domestic decarbonization of O&G extraction, a key priority for Norwegian energy regime actors (Authors, 2021). Equinor was able to obtain support (NOK 566 million) from Nitrogen Oxide (NO_x) fund[3] and a favorable petroleum taxation regime, securing advantages both from more recent climate change mitigation elements of the Norwegian regime and older elements favouring O&G incumbents. In order to accommodate the project, the Norwegian authorities have consented to the extension of the productive life of the Gullfaks field to 2036 and the Snorre field to 2040, up to 20 years longer than when the fields were originally planned (Equinor 3, authors' interview, March 2020). This support for Hywind Tampen as a means of decarbonizing and extending the lifespan of O&G production indicates that the project is not only legitimizing FWP, but also continued O&G production.

Compared to Hywind Scotland, Hywind Tampen involves a scaling up from 5 to 11 turbines and the use of larger 8 MW turbines, with

[3] The fund was introduced around 2008 to accelerate efforts to cut NOx emissions by the Petro-maritime industry by granting financial support to implement green technology.

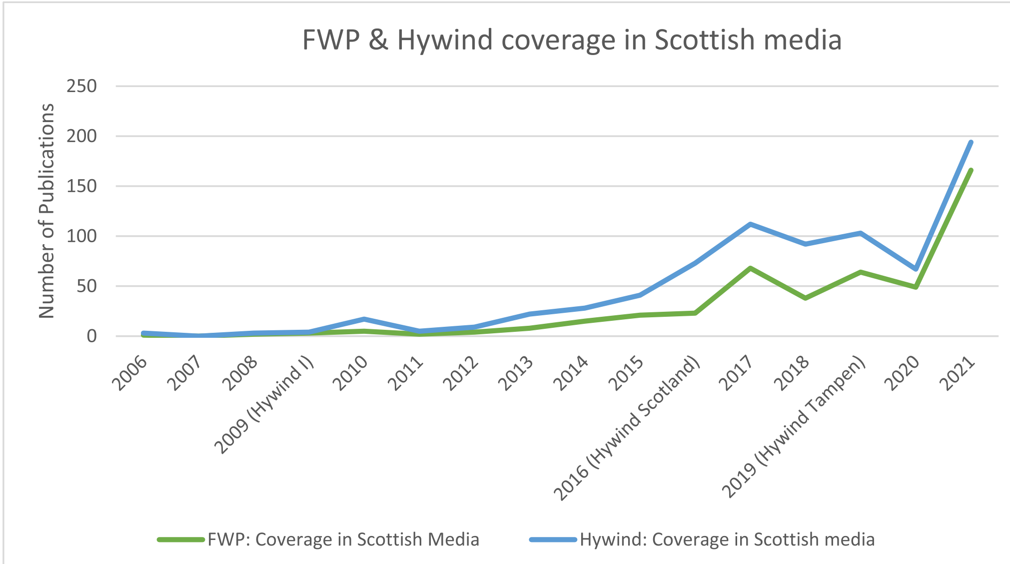

Fig. 2. FWP & Hywind coverage in Scottish media.

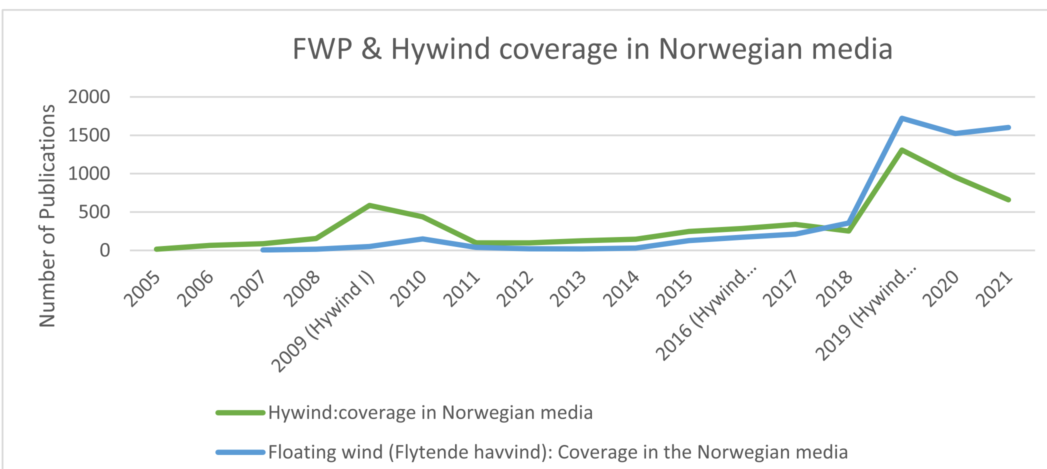

Fig. 3. FWP & Hywind coverage in Norwegian media.

Equinor aiming to reduce capital costs by 40 % (Equinor 2022). The project is expected to meet around 35 % of the annual power demand of the five Snorre and Gullfaks platforms. While representing a commercial application of the Hywind FWP technology, the project aims to demonstrate the use of OFW in the electrification of O&G operations.

In 2020, reflecting growing support for OFW, the Ministry of Petroleum and Energy decided to open two new areas for development (one floating, one bottom fixed), making it possible for developers to instigate large scale commercial OFW projects on the Norwegian continental shelf for the first time. The government also put in place the Marine Energy Act regulations, establishing a regulatory framework for OFW development in Norwegian waters.

Equinor subsequently announced in 2021 its plans to develop a FWP farm at Utsira Nord in a joint venture with Vårgrønn[4] with the aim of positioning FWP as a new industry contributing to the energy transition in Norway (Equinor, 2021b). This indicates that Hywind Tampen should be seen as part of a larger strategy of FWP development beyond the electrification of O&G platforms. In addition to such electrification, the Hywind Tampen provides a test facility for further development of FWP technology, focusing particularly on industrial solutions and cost reduction (Equinor representative cited in Teknisk Ukeblad 2021).

Based in part on the increased legitimacy of the technology, Norway's OFW commitment was further bolstered in 2022, with the announcement by the Norwegian government of plans to carry out the next round of awarding licenses for OFW in 2025 following on from the previously announced Sørlige Nordsjø II and Utsira Nord sites (4Coffshore, 2022). This is part of the government's ambitious plan to support the development of a large-scale (30,000 MW) OFW production capacity in Norway by 2040.

Nevertheless, no new price subsidies were planned as the general belief of the Norwegian government is that energy production should be market-based (Paraskova 2019). In the context of the Norwegian energy regime, economic and political pressures to adhere to existing market rules in terms of subsidy avoidance and technological neutrality and existing industrial strategies in relation to O&G diversification have tended to prevail over broader sustainability values.

[4] Joint venture between the global energy company Eni and the Norwegian energy entrepreneur HitecVision.

6. Discussion

We have used the Hywind project to elaborate on the concept of technology legitimation. In general, it demonstrates processes of pragmatic legitimation (whereby the project has largely been aligned with prevailing institutions in both Norway and Scotland). While new elements have been added to the Norwegian energy regime to support green innovations, it remains characterised by a technology push approach and a continuing aversion to market support to shield emerging technologies. Reflecting an absence of domestic market formation policies and related capabilities from O&G, Norwegian firms involved in OFW have chosen an export-driven strategy. Nonetheless, the strategic coupling between Equinor's need for funding and policy support for the Hywind technology and Enova's mandate of supporting the development of green technologies in Norway with the potential to spread globally provided the resources required to implement the Hywind Demo and Hywind Tampen. For the legitimation of the Hywind Tampen project, Norwegian actors were able to absorb successful experiences from Hywind Scotland. By contrast, the market-led UK energy policy regime provided the financial incentives required to attract and support Hywind Scotland. In the context of the evolving UK regime, the Scottish Government was able to extend an element of the previous market support regime for a limited time window, based on an agreement with the UK government.

The legitimation of emerging technologies is promoted through the strategies and narratives of their advocates (Raven et al. 2016). The growth of FWP and OFW more broadly has been closely associated with the broader societal discourse of combating global climate change and, more recently, 'net zero' (Yap and Truffer 2019), alongside domestic energy security, affordability, and the generation of economic value and jobs (Authors 2021). In the Norwegian context, these broader narratives have assumed a particular expression shaped by the hydrocarbon-based energy regime and the strength of related capabilities in the O&G sector. The fact that the domestic electricity market is served by domestic hydropower has meant that the climate change and energy security narratives have lacked traction until recently. Instead, OFW and FWP in particular have been promoted as providing opportunities for diversification, export and innovation for the dominant O&G sector as part of a recurring 'life after oil' discourse (Hansen and Steen 2015), in what can be seen as a distinct national version of the economic value and jobs narrative. By contrast, climate change considerations have been uppermost in Scotland, reflecting its challenge-driven innovation configuration, based on the weak constraints exercised by the wider UK energy regime and limited related knowledge capabilities. The devolved Scottish government is strongly committed to energy transition, identifying its abundant marine renewables resources as assets for industrial development. In the absence of strong domestic industrial capabilities, however, this has fostered a dependence on the attraction of external actors such as Equinor.

The two countries confront distinct legitimation paradoxes for FWP. While the climate change narrative has become increasingly prominent in Norway, FWP is focusing on the decarbonization of O&G. Somewhat paradoxically in light of the broader (global) sustainability transitions imperative, the Hywind Tampen project supports business as usual for large O&G interests like Equinor, facilitating continued O&G extraction by reducing the use of fossil fuels and thereby meeting the regulatory obligations of decreasing carbon emissions (Hannon et al. 2019). As such, the O&G decarbonization imperative is legitimating not only the FWP technology, but also continued domestic O&G exploitation. The focus on decarbonization represents a classic form of pragmatic legitimacy in terms of self-interested conformity with the norms and interests of the Norwegian energy regime, but can be seen as weakening the legitimation of FWP in terms of the wider imperative of combating climate change. Yet, Equinor's FWP technology can also be used solely as a general producer of electricity, as it intends for Utsira Nord and future international projects. This makes FWP an alternative to O&G energy over the longer term.

By contrast, the principal legitimation paradox for FWP (and OFW more broadly) in Scotland concerns the lack of domestic industrial content, reflecting its reliance on external actors for technological solutions and knowledge development (Williamson 2022a). This criticism, levelled by industry representatives, trade union and some politicians, is symbolized by the collapse of the prominent Scottish-based manufacturer, Burntisland Fabricators (Bi-Fab), in December 2020 after missing out on contracts for Scottish windfarms (Scottish Parliament Economy, Energy and Fair Work Committee 2021). While the SNP government has exerted increasing pressure on developers to provide Scottish jobs, doubts remain over its ability to deliver such jobs in the face of a potential EU challenge, on competition grounds, to local content policy at the World Trade Organization, and the UK's Government control over the provision of financial support through the CfD process (Williamson 2022b).

In the first phase of Hywind, technology legitimation was national in scale, with a brief moment of coupling between Equinor's needs for financial support and Enova's support for emerging green technologies as part of Norway's technology-push approach. As political and industrial support for OFW in Norway waned, the lack of domestic market formation fueled Equinor's export-driven approach. This ushered in a period of *trans*-regional legitimation with Scotland's natural asserts and financial incentives attracting the scaled-up Hywind demonstrator project. Whilst analytically distinct, Hywind Scotland indicates that processes of export and attraction can occur simultaneously from the perspective of home countries/regions and host countries/regions respectively. Here, our engagement with GPN approach underpins the incorporation of the host region dimension (Yeung 2021), compared to the home region focus of the path creation literature on legitimation (Heiberg et al. 2020). Absorption of extra-regional legitimacy was evident in all three phases, but particularly marked for Hywind Tampen, when the success of Hywind Scotland and cost reduction in OFW more broadly generated a new level of political support for OFW and FWP in Norway.

Informed by a GPN approach, the paper has recast *trans*-regional legitimation as a process of strategic coupling, based upon the complementary assets of firms (van Mossel et al. 2018) and national and regional territories (Coe and Yeung 2015). In line with our 'pragmatic' conception of legitimacy as property, we understand these assets as dynamic capabilities that was deliberately mobilized by the lead firm and state agencies. Each stage of Hywind involved coupling between the capabilities of Equinor (see above) and specific territorial assets (for example, offshore locations, wind resources, ports and sites, supplier capabilities, skills). Beyond this, Equinor sought institutional and political support on an international basis, driven by the availability of financial incentives from regime actors. Thus, high levels of market support attracted Equinor to Scotland for the upscaling of the technology in a wind park setting, alongside the availability of a suitable site off the North East coast. The subsequent return of Hywind Tampen to Norway is underpinned by a process of strategic recoupling underpinned by natural, infrastructural, industrial and human assets and the strategic agenda of regime actors to decarbonize O&G production and support green technology development in order to enhance Norwegian industry's international competitiveness.

7. Conclusions

This paper makes two principal contributions to the burgeoning literature on legitimation in economic geography and sustainability transition studies. First, through the focus on a specific emerging technology, it has provided a grounded and process-based illumination of the operation of intra- and *trans*-national/regional legitimation processes. The paper shows that FWP technology was gradually legitimated in a pragmatic sense over the three stages of Hywind. The demonstration phase generated a temporary and conditional form of legitimacy at an intra-national scale as FWP achieved a moment of competitiveness within Norway's O&G-dominated regime. The operational and technological success of Hywind Scotland, alongside its international prominence as the worlds' first commissioned floating wind farm, generated a stronger and more lasting form of legitimacy. In the context of the growing maturity of OFW and an explosion of interest in FWP internationally (GWEC 2022), the successful experiences of Hywind Scotland led to the internalisation of legitimacy from outside into the Norwegian political and industrial environment (absorption). As the Hywind case has shown, there may be substantial empirical overlap between the analytically separable processes of absorption, attraction and export, which economic geography research on legitimation should assess from the perspectives of both the home and host territories. Reflecting the middle ground position adopted in this paper, intra-regional and extra-regional process of legitimation are also likely to intersect and overlap. This observation underlines the need to avoid creating a false dichotomy between 'bounded' territories and globally open innovation systems (see MacLeod and Jones 2007). The spatial scale and geographical scope of innovation processes is, to a large degree, an empirical question, and is likely to vary by technology and sector.

Second, the paper has reconceptualised technology legitimation as a *trans*-regional process based on the strategic coupling of the commercial needs of lead firms and the transition objectives of state actors seeking to exploit domestic energy resources and position their territories within renewable energy production networks. Even though lead firms possess dynamic firm-specific capabilities, the legitimation and development of their technologies often requires state support and protection against competition from established technologies. Here, the GPN approach provides a more theoretical and 'centred' sense of agency than the distributed notion of actors in TIS research. In the Hywind case, 'export' was based upon process of strategic coupling between the lead firms' need for technological demonstration and institutional support and the availability of financial incentives from the Scottish Government, as well as the underlying natural, infrastructural and institutional assets. Conversely, attraction involved the devolved government drawing Equinor into the region, strategically aligning its objectives of harnessing its marine energy resources and positioning itself as an important node within FWP production networks with Equinor's goal of securing and reinforcing its first mover advantages within the FWP sub-sector. Absorption was predicated on the coupling between Norway's natural, infrastructural and industrial assets and the increased extra-national legitimacy of FWP derived from the success of Hywind Scotland and expectations of further cost reduction, cemented by the application of the technology to the regime-driven imperative of O&G decarbonization. This reconceptualization of *trans*-regional legitimation in terms of strategic coupling, emphasizing the role of key actors (firms and state organizations) in harnessing and mobilizing firm and territorial assets and needs, represents an advance over the rather mechanical and underdeveloped concept of structural coupling between territorial subsystems or specific resources in TIS literature (Tsouri et al. 2021).

Whilst offering grounded insights in the unfolding process of technology legitimation at the micro level, our focus on a single technology also represents a limitation of this paper with regard to its empirical breadth and representativeness. The study is confined to a specific renewable energy sector, wind, characterized by a predominantly DUI mode of innovation associated with territorial embeddedness. An obvious line of extension would be to undertake a comparative analysis of the legitimation of multiple renewable energy technologies across several sectors and territorial contexts, generating a more differentiated and nuanced understanding of legitimation strategies and outcomes. In addition, there is a need for further research on *trans*-regional legitimation processes that incorporates both home and host region perspectives, following the actor-networks that link them (Peck and Theodore 2012). Furthermore, absorption seems more opaque than attraction and export, requiring further in-depth research into the mechanisms by which legitimacy is internalized by actors from other places (Heiberg et al. 2020). Finally, informed by GPN thinking, future research should aim to 'get inside' the bargaining and negotiation processes between firms and states, aiming to capture the effects of agency and context (see Pike et al. 2016) in shaping legitimation outcomes.

CRediT authorship contribution statement

Danny MacKinnon: Conceptualization, Investigation, Writing – original draft, Writing – review & editing, Supervision. **Samson Afewerki:** Conceptualization, Methodology, Investigation, Writing – original draft. **Asbjørn Karlsen:** Conceptualization, Methodology, Investigation, Writing – review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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