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Ecologies of participation across cultures: Cross-national comparisons of public engagements with energy and climate change

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ABSTRACT

This paper compares ecologies of participation with energy and climate change in the UK, Norway and Germany. Given the limitations of mainstream approaches that view public participation as highly specific and occurring in discrete one-off processes linked to particular decision moments, new theories, studies and methods are emerging that view participations as diverse, constructed and interrelating in wider systems. While these novel approaches have been explored in specific local, national and institutional settings, we present one of the first international comparative studies of participation systems across cultures. We applied the ecologies of participation framework and comparative case analysis method to map stabilities and diversities of public engagement with energy and climate change occurring between 2015 and 2023 in the UK, Norway and Germany. Our analysis shows how diverse public engagements are co-produced with distinct sociotechnical systems in each country. We empirically identify culturally specific 'participation-ways' in each country - i.e. collectively held criteria through which societies determine good or credible forms of participation - which emphasise representativeness of 'the public' in the UK, formal political processes and consumption in Norway, and interest group representation through invited consensual 'dialog' in Germany. Around these closures and dominant forms of participation exist diverse, emerging and excluded public engagements that overflow institutional framings, and translocal circulations of participations within, between and beyond the three countries. These findings suggest that improving understandings and qualities of public participation depends on attending and responding to these stabilities, diversities, interrelations and exclusions in systems and ecologies of participation.

1. Introduction

Public participation and democratic engagement are seen as crucial to effective, just and legitimate sociotechnical transformations in addressing public problems including those of energy and climate change. Yet, existing practices and institutions of participation have often failed to attend to the increasing multiplicity of public engagements, public issues and the systemic nature of the challenges faced [1,2]. This is evident with long criticised but persistent 'deficit model' assumptions of a public lack of understanding [3] - often co-produced with traditional views of objective value-free science and representative democracy - which can lead to public exclusions or an emphasis on better communication to and incentivisation of 'the public' to gain their acceptance and accelerate 'the transition' [4,5]. This is also the case with moves to democratise science and participatory democracy, partly in response to limitations of technocratic governance, that assume a disengaged public that needs to be invited by institutions to participate in discrete, often one-off, engagement processes relating to individual decisions, through opinion surveys, deliberative processes, behaviour change initiatives, community action, and so on.

In times of increasing difference, polarisation and diversity these traditional representative and participatory forms of science and democracy have struggled to represent social concerns, avert crises of expertise, democracy and public trust, and ensure equitable and just

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transitions [6,7]. In response, new ways of seeing, knowing and doing public participation and engagement in addressing collective public problems, including energy and climate-related issues, are emerging. Work in the social sciences, humanities and wider fields of practice is moving to more constructivist and systemic perspectives on participation [1,7–9]. This sees publics and participation not as discrete and pre-given but as constructed through collective practices, already existing and highly diverse - including but going beyond institutional spaces to span those that are citizen-led, uninvited, oppositional, resistive, emergent and mundane - and interrelating in wider systems [10–13].

In science and technology studies (STS) and related fields this agenda has been taken forward through new relational co-productionist theories, studies and approaches of participation [7] and the ecologies of participation framework [12]. This includes new ways of studying and understanding the opening up and closing down of publics, objects and forms of participation as they are constructed and co-produced through the performance of collective practices, as they become technologised and circulate, and in their diversities, interrelations and stabilities as part of wider systems, constitutions and political cultures [14–17]. This has also brought forward new methods and practices of participation - that can underpin more public- or people-centred approaches to energy and climate change - through mapping diversities of participation, experiments in participation that are more distributed and open to exclusions, emergence and uncertainties, and new forms of societal and institutional responsiveness to diverse public engagements, values and concerns [18–20]. Such work articulates an additional perspective that encompasses participations occurring within existing representative and participatory forms of science and democracy as well as those that overflow them in diverse ways, and considers how they interrelate as part of wider systems and ecologies. It therefore goes beyond but also works with and adds to these existing institutions of science and democracy [7].

While initially developed in the context of UK energy system transitions, the ecologies of participation framework and associated methods for mapping participation have been applied, explored and advanced in other settings including on the orchestration of participatory collectives in energy transitions in Norway [21], public engagement with onshore wind energy in the Netherlands [22], wind energy developments more widely [23], societal transitions in Ireland [24], and food waste transitions in Singapore [25]. These constructivist STS approaches to participation have also featured in state-of-the-art reviews of energy social science and sociotechnical transitions [26,27] and in recommendations for public engagement practices in European energy projects [28].

In this paper we extend this framework to compare ecologies of participation across cultures in multiple national settings for the first time. We report on a study that mapped ecologies of participation with energy and climate change in the UK, Norway and Germany occurring between 2015 and 2023. These countries provide a sound basis for comparison because they are all representative democracies that have developed forms of participatory democracy and programmes for public engagement as part of their leadership in developing national strategies for net zero and energy system decarbonisation, while they have contrasting material energy infrastructures and systems of governance. The paper focuses on two main questions and related contributions.

First, we ask what are the comparative differences, as well as commonalities and circulations, between ecologies of participation with energy and climate change in the UK, Norway and Germany? Most existing comparisons of participation between countries focus on specific forms and methods of public engagement in isolation to better understand how they can be made more effective across different contexts or otherwise measure differences in public views and behaviours. This is the case in existing studies between our three comparison countries that have, amongst others, measured public attitudes [29] or sought to understand domestic prosumer action [30] relating to energy and climate change. We move beyond specific forms of public engagement to compare the wider systems of participation with energy and climate change in each country, including the diverse public engagements that exist and the dynamics of how they interrelate within and circulate between national settings. Through this we reveal differences and similarities in dominant, emergent and excluded public engagements between ecologies of participation in each country and consider the explanations and implications of this.

Second, we ask how sociotechnical constitutions shape and are shaped by ecologies of participation in these different national settings? Here we move beyond work that views the credibility and legitimacy of participation in terms of the internal effectiveness of discrete public engagement processes, their linear impacts, or how they are 'integrated' into policy, political and societal contexts [31–34]. We show how the forms of participation and constructions of publics that become established and authoritative or not are co-produced with sociotechnical constitutions and their associated political cultures in particular settings, in this case in relation to national energy systems as socio-material assemblages including their forms of governance, market configurations and social arrangements. Through this we shed new light on how in any setting or polity (whether at the level of a nation state or at other scales and spatialities) some forms of participation and publics become more credible and legitimate than others. We empirically explore and further develop the notion of collectively held *'participation-ways'* [14] – i.e. collectively held criteria through which societies judge and determine good or credible forms of participation. In doing this we extend work on civic epistemology [35] to consider the credibility and authority of participation not only in an epistemic sense but also through ontological ways of being with energy and climate change.

We begin in the next section by introducing the ecologies of participation framework and its potential for comparative studies between participation systems in different settings. We then present our analysis of ecologies of participation with energy and climate change in the UK, Norway and Germany. Finally, in discussion and conclusion we synthesise the comparative insights between ecologies of participation and collectively held participation-ways across the three countries, drawing out the theoretical and empirical contributions that form the focus of the paper while also reflecting on implications for practice.

2. Ecologies of participation in comparative perspective

Work in STS to develop a relational co-productionist theory of participation [7] has set out the theoretical basis for conceptualising 'ecologies of participation' [14]. This theory was also developed in relation to diverse forms of participation in low carbon energy transitions [2]. The ecologies of participation concept has been further empirically verified and articulated in work which mapped diverse forms of participation and how they interrelate across the UK energy system [12,18,19].

This 'ecologies of participation' framework conceptualises how diverse collectives of participation with sociotechnical change are co-produced, interrelate and circulate in wider spaces, systems and constitutions. It comprises three relational spaces of participation that interrelate to form a system of participation with sociotechnical change. First, participation happens in diverse "socio-material collective [practices] through which publics address collective public problems" (p.33) [14]. Rather than existing a priori, the participants (who), objects (what) and forms (how) of participation are actively constructed and co-produced through the performance of situated collective participatory practices [2]. This takes a symmetrical approach that is open to the diverse participations that might exist in any one situation or around any object. This includes but goes beyond participatory collectives that are institutionally sanctioned, invited, public or discursive (such as deliberation, dialogue, consultation and public opinion elicitation) to encompass those that are citizen-led, uninvited, oppositional, emergent, mundane, or otherwise unrecognised, hidden or invisible (which can range from forms of protest, activism, grassroots innovation and everyday practices, through to active forms of non-participation).

Second, these diverse situated participatory collectives connect up, interrelate and circulate in wider spaces of participation [12,14]. These wider spaces include: (i) translocal zones of participatory standardisation and prescription that connect similarly formatted technologies of participation across space and time (such as citizens' panels or behaviour change interventions); (ii) spaces of negotiation, controversy and difference within which diverse and often conflicting collectives of public engagement intermingle (for example in controversies over particular energy technologies, climate change more broadly or democracy itself); and (iii) spaces which prescribe and reproduce particular public identities (such as consumers or innocent citizens), including in institutional settings. These wider spaces intersect and circulate between the places, situations and settings in which participations are performed and intermingle.

Third, these diverse participatory collectives and wider spaces of participation interrelate in a situated sociotechnical system as constitution: "made up of established institutions, regulations, laws, political economic arrangements, socio-material infrastructures, policy cultures, participatory mechanisms and so on… in which certain participatory collective practices and knowledge-ways become seen as authoritative and are endowed with legitimacy and meaning" [14 p.47 & 55].

This sociotechnical constitution of participation exerts powerful systemic constitutional stabilities and closures that have become established over historical time while being open to moments of transformative change. In addition to being an assemblage of socio-material collectives, it emphasises the importance of the political culture and constitutional relations between citizens, science and the state which shape and are shaped by ecologies of participation in a given setting. This constitutional setting of participatory coherence can be at the national level or above and below the nation state (for example at international, local or organisational scales), depending on the analytical framing.

This builds on Jasanoff's conceptualisation of constitutional moments - where rules of political practice are rewritten altering the relations between citizens, science and the state [36] - and 'civic epistemology' [35]. Jasanoff defines the latter as collectively held and culturally grounded "tacit knowledge-ways through which [members of a given society] assess the rationality and robustness of claims that seek to order their lives" [35 p.255]. While Jasanoff's focus is on the credibility and legitimacy of knowledge claims, including those grounded in science and expertise, Chilvers and Kearnes suggest that this can apply just as much to participation – not only "participatory knowledge-ways" (i.e. knowledge about and from public participation) but also forms of participation in "how some collective participatory practices become established and others struggle to achieve relevance or become endangered in particular settings" [14 p.53]. This extends work on civic epistemology to consider the credibility and legitimacy of participations not only in an epistemic sense but also ontologically in terms of ways of being with public issues. In this paper we empirically explore this notion of collectively held 'participation-ways' – i.e. collectively held criteria through which societies judge and determine good or credible forms of participation.

A relational co-productionist theory of participation and the ecologies of participation framework do not prescribe a pre-given model of participation but instead understand how different meanings and normativities of participation are co-produced through situated practices in different times and places. A key sensibility of this theoretical orientation is therefore to remain reflexively open to 'other' – dominant, excluded, emergent or hidden – formats, forms and normativities of participation. It is thus attuned to studying the closing down and opening up of participations across cultures and different time-spaces. The ecologies of participation framework is intentionally comparative, forming the basis for comparative analyses between diverse participatory collectives, constitutional settings in which they interrelate, and the trans-local spaces of controversy and standardisation that intersect them. The framework is thus intended to be used for comparative studies across cultures, in different national settings (or other settings above and below the state), and to help draw out the circulations that occur between them. We take this form of comparison forward in this paper for the first time, through the cases of public engagement with energy and climate change in the UK, Norway and Germany.

Existing comparisons between these three countries focus on specific forms of public engagement in isolation rather than studying a wider system or ecology of participation. For example, Böhm et al. [29] undertook a large-scale questionnaire survey to measure public views and emotional reactions to climate change, finding that beliefs in human causation and negative impacts are more evident in Germany and that confidence in technological solutions are more prevalent in Norway and to some extent the UK. Other studies have compared domestic prosumer action in the form of household solar energy between the three countries [30], and public perceptions of local planning processes relating to electricity transmission grid projects in Norway and the UK [37] with concerns over insufficient information and influence on decision-making evident in both countries.

What these existing studies do not show is how the specific forms of public engagement form part of wider diversities of participation, how they interrelate, and are co-produced with political cultures and the sociotechnical constitution in each country. Some insight into the latter is provided by Jasanoff's [35] work on civic epistemology in the case of biotechnology in Britain and Germany. In Britain she identified a historically situated commitment to demonstration through empirical science and a communitarian service-based style grounded in embodied expertise. In terms of participatory knowledge-ways, this has been conducive to participation experts taking up service roles and claiming to 'speak for the people' through organising invited engagement processes that seek to be representative of 'the public' [see 38]. This contrasts with a more consensus seeking culture of public knowledge making in Germany which is corporatist and institution-based, emphasising expert rationality and negotiated reasoning through formal positions, institutions and structures [35].

Further insight into relations between social movements, citizens and the state in the UK, Norway and Germany has been provided by Dryzek et al.'s [39] comparative study. Through exploring histories of environmental social movements since the 1970s the authors show how the three countries differ in citizen-state relations on two dimensions: whether states are *exclusive or inclusive* of civil society and interest representation; and whether they are *active or passive* in affecting the range of interests, groups and movements that exist in civil society. Norway is presented as a case of an *actively inclusive* state, which seeks to proactively anticipate and organise interests and groups in social movements into the state [39]. The strong corporatist state in Norway has a history of working closely with - and importantly funding and resourcing - organisations and groups in civil society in a system that values consensus. In the period up to 2003, the authors show how this means that grassroots mobilisation has been relatively weak with public protest less evident, although notable exceptions occur, such as protests against large dam developments in the 1970s.

Dryzek et al. [39] suggest that the UK, especially during a period of authoritarian liberalism in the Thatcher years, exemplifies the *active exclusion* of civil society through trying to undermine the conditions in which oppositional social movements are likely to form and flourish. This continued into the 1990s and beyond with the passage of the Criminal Justice Act in 1994 and further anti-protest legislation since. This lack of openness and an oppositional relationship with civil society and social movement interests has not necessarily been challenged, and may well have been assisted, by the rise of institutionally sanctioned and professionalised invited public engagement since the 2000s. In the case of Germany, Dryzek et al. [39] suggest *passive exclusion* of civil society is evident whereby the state does not try to undermine wider movements, interests and groups in civil society, whilst providing few opportunities for them to have influence. Social movements in Germany have held oppositional relationships with the state, including through the anti-

nuclear movement. This, coupled with a legal corporatist policy style which favours rational legal procedures and scientific expertise, limits citizen participation and the inclusion of political and societal concerns of civil society groups.

These works by Jasanoff [35] and Dryzek et al. [39] provide a view into the political cultures and constitutional relations between citizens and the state on issues of science and the environment in our three study countries. While these studies were undertaken over two decades ago and describe relations that are always in flux, they also relate to stabilities in sociotechnical constitutions which remain durable over time.

3. Mapping ecologies of participation with energy and climate change in the UK, Norway and Germany

We mapped ecologies of participation with energy and climate change in the UK, Norway and Germany occurring between 2015 and 2023. The three national settings were selected because they are representative democracies in Europe that have developed participatory forms of democracy and public engagement programmes as part of their leadership on climate policy and energy system decarbonisation during the study period, although they differ in the technological and material make-up of their energy systems and their systems of governance. The study period covers significant developments in the three countries. The period began with the signing of the Paris agreement in December 2015, and corresponding civil society and popular culture-led efforts to promote climate action (from the Live Earth concerts and the Global Climate March to the Pope's encyclicals on climate change). All three countries subsequently adopted legally binding climate targets in this period - the UK and Germany setting net zero targets in 2019 and Norway setting a low carbon target in 2017 - introducing a range of new policies to transform energy infrastructure and governance. The mappings were focused on energy systems and their decarbonisation because energy (including electricity and heat production, transport, and industrial processes) is responsible for the majority of CO_2 emissions in Europe [40].

Research teams located in each of the three countries undertook a two-stage methodology and developed the comparative analysis through a series of online collaborative workshops over the course of a two-year period. The methodology followed that developed in an initial study of ecologies of participation relating to the UK energy system, involving documentary analysis of the sociotechnical constitution and mapping diverse forms of public engagement using the comparative case analysis method [see 12,18,19]. The comparative study was led by the Public Engagement Observatory of the UK Energy Research Centre [41], which has taken forward these mappings in the UK as part of its ongoing work and extended them to Germany and Norway through collaborative research with research teams in these countries for comparative purposes.

First, we undertook documentary analysis of key policy documents to understand the sociotechnical constitutions of participation in relation to energy systems and their decarbonisation in the three countries. A scoping review was undertaken to identify *nationally significant* policy documents, strategies and statements on energy and low carbon transitions in each country. While focused on government and state-centred accounts, documents were also selected to attend to *diversity*: across sectors (through the inclusion of additional sources from business and non-governmental organisations), over time (through selecting sources from across the study period), and in sociotechnical focus (with the focus of sources ranging from technical to social dimensions). The resulting corpus of policy documents (see Supplementary Material, Tables S1.1, S1.2 and S1.3) included 17 sources from the UK, 10 from Norway, and 16 from Germany. The document corpus for each country was subsequently subject to qualitative analysis which operationalised the definition of sociotechnical constitutions introduced in section 2 by coding: (i) the dominant framings of publics, participation and the objects/issues in low carbon transitions; and (ii) key aspects of the sociotechnical constitutions, including their material infrastructures, governance arrangements, political cultures and roles of society.

Second, we undertook a mapping of diverse instances of public engagement with energy and climate change occurring in the three countries between 2015 and 2023. This followed the main steps of the comparative case analysis method [see 12,18,19,42] which combines systematic searches of academic databases and web-searches with qualitative case study analysis. Search terms and multiple synonyms were developed for the forms ('how', 72 synonyms), subjects ('who', 24 synonyms), and energy/climate-related objects ('what' 40 synonyms) of public engagement. A full list of the search terms used is provided in the Supplementary Material (Tables S2.1, S2.2 and S2.3). English language terms were used across all three countries and translations of these terms were also used to ensure local relevance of searches in the Norwegian and German contexts. These search terms and synonyms were searched for on academic and non-academic search engines (Web of Knowledge, Google Scholar, Google and Ecosia) by research teams in each of the three countries to identify cases of public engagement in the academic literature, grey literature and media.

Search results were subsequently screened to identify diverse cases which contained sufficient material for analysis and comprised some form of collective practice through which publics engaged with energy and climate change in each country, producing a final corpus of 661 cases across the three countries (UK $n = 283$ cases; Norway $n = 119$ cases; Germany $n = 259$ cases). A key principle in screening these exemplifying cases was to attend to both diversities and stabilities in patterns of public engagement in each country. A key criterion for screening was that there was sufficient data to allow a case to be analysed according to the ecologies of participation conceptual framework. Further information about these cases, including titles and data sources, is provided in the Supplementary Material (Tables S3.1, S3.2 and S3.3). The corpus of cases was then qualitatively coded by the research teams in each country based on the 'who', 'what' and 'how' of public engagement co-produced in each case study. The analyses were shared and collectively reviewed by the research teams in collaborative workshops to ensure intercoder reliability and draw out comparative insights between the three countries.

This comparative analysis of ecologies of participation is now presented for the UK, Norway and Germany in turn. For each country we identify the key characteristics of the sociotechnical constitution of participation in relation to the energy system and its decarbonisation - including the material infrastructures, governance arrangements, political culture and citizen-state relations - and its established collectively held participation-ways. For each country we then present the mapping of public engagement collectives - and their co-productions of forms, publics and objects of participation - based on whether they are dominant (central), diverse (established), or decentred (emergent or overflowing) in relation to the sociotechnical constitution through an illustrative mapping space (as developed in [12]) in Figs. 1, 2 and 3. This qualitative interpretive analysis combines the documentary analysis of dominant framings of publics, participation and public issues with the comparative case mapping of diverse public engagement cases. An ecologies of participation perspective emphasises how all mappings and representations of participation are partial and never complete. It is therefore important to note that the mappings presented here are limited to diverse collectives of participation that have been documented and publicised in some way.

3.1. Ecologies of participation in the UK

3.1.1. Sociotechnical constitution

The UK energy system has historically been highly centralised - with a past emphasis on centralised supply through fossil fuels and nuclear - and continues to be so despite a low carbon transition and rapid increase of renewable energy generation in recent years [43,44]. This predominantly centralised system architecture begets visions of net zero futures

dominated by nuclear, large-scale renewables with associated expansive grid upgrades, low-carbon hydrogen production, coupled with carbon capture and storage technologies in industrial super clusters [45–47].

The UK system is characterised by a state-market hybrid model of governance and is framed around an 'energy trilemma' [48]. Whilst different private energy companies have played an important role in determining the energy generation mix [44], this is framed within the government's decarbonisation targets [49] and shaped by regulatory and market interventions, including the introduction of carbon pricing [50,51]. This is reflective of how successive governments have strived for green economic growth and sought to show UK climate leadership through new laws such as the 2008 Climate Change Act and establishing government advisory bodies like the Climate Change Committee [52–54]. Such aspirations are matched by strong policymaker preference for market-based and non-technology specific policy instruments and cost efficiency – creating barriers for new entrants, prioritising close-to-market and large-scale technologies [44,55], and a pragmatic culture of getting decarbonisation done at speed [52].

A preference for technocratic knowledge and a reverence for empirically demonstrated technical expertise, often from particular individuals with a long track record of public service [35], is a key feature of UK political culture, with policymakers often engaging experts as policy advisors and inviting public participation through formal, often narrowly defined, channels [56]. These tendencies are reflected in a range of contemporary policy documents. For example, the UK's Net Zero Strategy [49] almost exclusively frames the transition as a technical and expert-led activity, with an emphasis on a neoliberal market economy stimulating innovation, economically profitable competition, and green economic growth. This technocratic expertise also shapes framings of the social dimensions of the energy system, with dominant organisations and practices of market research and deliberative engagement explicitly elevating expert authority over citizen knowledge, through survey-based research which mainly seeks to measure public understanding or attitudes, or government-supported deliberative processes where expert facilitators seek to represent citizen perspectives in response to expert-framed questions related to specific decision moments [12].

These features of the sociotechnical constitution contribute to a continued citizen-state relationship in the UK defined by the active exclusion of civil society [39] and the construction of publics as a 'threat' to accelerating decarbonisation [57]. This is reflected in a focus on getting the public to accept decisions or technologies as prescribed by experts through information provision, and downstream consultation and deliberation, in order to "take citizens with us" [58] and gain their widespread support [59]. Mobilisations of civil society and grassroots groups have continued to occur and in some cases grow [52] - such as in community energy initiatives, transition towns [60,61] and more recent climate activist mobilisations [42] - which have gained popular attention but lack recognition and support from governing institutions. A case in point is community energy where initial government support through Feed-In-Tariffs and the 2014 Community Energy Strategy quickly became an ephemeral and short-lived initiative [62]. The exclusionary relationship is also evident in authoritarian responses to protest and activism, for example through the 2022 Police, Crime, Sentencing and Courts Act [63] as well as recent planning reforms [64], which further reduce opportunities for civil society engagement in the interests of accelerating the transition to net zero and green economic growth.

3.1.2. *Mapping public engagements*

These constitutional stabilities are co-produced with distinctive

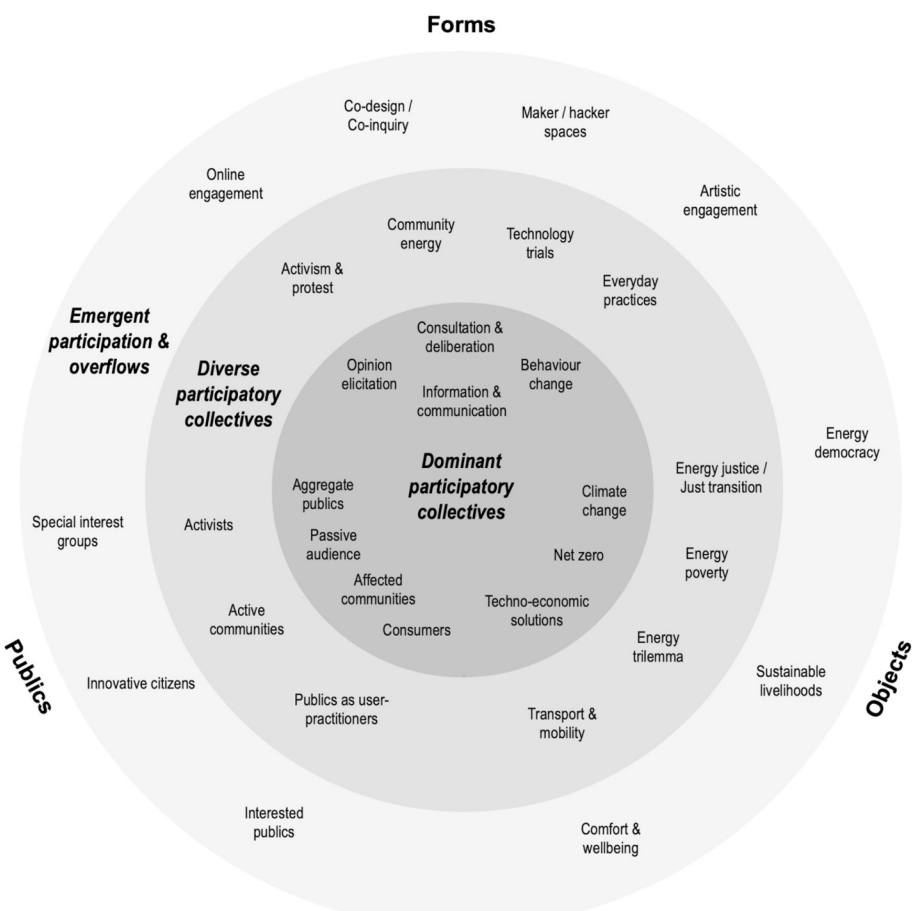

Fig. 1. Ecologies of participation with energy and decarbonisation in the UK.

ecologies of participation, with public engagement being principally framed as necessary to generate public acceptance of largescale technological and policy changes or to engender behaviour change [65]. This reflects entrenched UK institutional imaginaries of publics as possessing deficits in understanding, engagement and trust in relation to energy and climate change. We thus characterise the UK's collectively held participation-ways in relation to energy and climate change as defining the quality and legitimacy of participation in terms of its apparent representativeness of 'the public', and through relationships to key institutions and trusted experts of participation.

Specifically, as shown in Fig. 1, amongst the most predominant forms of participation identified in our mapping are invited approaches for eliciting 'representative' public views, including through surveys, focus groups and interviews ($n = 63$ cases of public engagement), and consultations or deliberative processes such as public dialogues and citizens' assemblies ($n = 39$ cases). Also predominant are behaviour change initiatives that are often coupled with technology demonstrations in attempting to align public attitudes and action with the net zero agenda through the provision of information on largely predefined energy technologies ($n = 14$ cases). Across these dominant forms, representativeness of 'the public' and trust in particular mediators of participation are positioned as guiding principles to establish the legitimacy of public engagement.

These dominant forms of participation are co-produced with dominant framings of publics (Fig. 1). The most widespread framing of publics produced in UK cases is that of an aggregated, demographically representative public through elicitation, most often surveys ($n = 39$ cases). This is followed by broader framings of publics as either a barrier to the energy transition – as exemplified by cases focusing on passive, information-deficient and unengaged audiences needing to be brought on board ($n = 14$ cases) – or as generally passive communities affected by infrastructural projects ($n = 21$ cases) and passive consumers whose behaviours need to change to enable the net zero transition ($n = 21$ cases). Furthermore, dominant participatory collectives are often narrowly framed, for example around purely technocratic understandings or techno-economic approaches to energy transitions, net zero and climate mitigation ($n = 84$ cases), thus foreclosing more radical models of social change and concerns around decarbonisation as a sociotechnical challenge across society.

Beyond this, the UK mapping reveals a wider diversity of forms, publics and objects of participation that exist around these dominant participations (see the outermost circles in Fig. 1). While less centred in the sociotechnical constitution, diverse participatory collectives include more bottom-up and citizen-led forms of engagement such as community energy schemes ($n = 39$ cases), activism ($n = 21$ cases) and protest ($n = 5$ cases), in addition to instances of mundane energy engagement associated with routine everyday practices ($n = 22$ cases) and the domestication of green and smart technologies, typically as part of technology trials ($n = 8$ cases). Such diverse forms of participation are co-produced with more varied framings of publics, including more positive constructions of publics as members of active and innovative communities ($n = 36$ cases), as well as more nuanced identities linked to (green) energy technology users or practitioners ($n = 35$ cases) and activists ($n = 20$ cases). Framings of the objects, issues and visions associated with energy and climate change are also more diverse within these cases, not only opening up to additional sectors including sustainable transport and mobility ($n = 20$ cases) but also highlighting issues of energy justice ($n = 21$ cases) and energy poverty ($n = 17$ cases). A substantial number of community energy schemes (e.g. Brighton Energy Coop, Bristol Community Energy, Energy4all) and activist engagements (e.g. Extinction Rebellion (XR), Just Stop Oil, Fridays For Future) included in our UK mapping are prime examples of contemporary engagements with energy and climate change which, in line with a largely exclusionary technocratic culture, remain unsupported – despite productively addressing climate change and broadening-out problem framings around transitions that are socially just.

Participatory collectives that are emergent and overflowing in relation to the sociotechnical constitution (see the outermost circle in Fig. 1) are also evident in the UK mapping. These cases demonstrate how particular publics engage with energy and climate change on an ongoing basis online and through social media ($n = 11$ cases), and can directly support the transition through developing new models of participation, such as artistic and media engagement ($n = 9$ cases), maker/hacker spaces ($n = 4$ cases) and forms of co-design or co-production ($n = 11$ cases). These cases, in turn, challenge dominant views of a disengaged and knowledge-deficient public and co-produce more active public identities, as interested publics ($n = 16$ cases), special interest groups ($n = 26$ cases) and innovative citizens ($n = 2$ cases). They also produce alternative public issues and concerns which further emphasise the social dimensions of energy and net zero transitions – as exemplified, inter alia, by engagements focusing on energy democracy ($n = 2$ cases), radically alternative forms of sustainable living ($n = 6$ cases), and comfort and wellbeing ($n = 5$ cases).

3.2. Ecologies of participation in Norway

3.2.1. Sociotechnical constitution

One of the most significant and distinctive features of Norway's energy system is that electricity is almost exclusively produced from renewable sources, mainly from hydro-power, enabling electricity generation with nearly zero emissions [66]. This has supported the substantial electrification of energy demand in the country. Norway's energy system is thus highly centralised, like the UK, being embedded in a coordinated market economy that aims to balance state intervention with market mechanisms to ensure efficient resource allocation while combining economic competitiveness with public welfare objectives [66]. Unlike the UK, though, the government maintains significant control over energy production and distribution through state ownership of hydro-power energy companies, through regulatory bodies like the Norwegian Water Resources and Energy Directorate (NVE) that enforce policies on grid management and renewable energy integration, and through market institutions such as the Nordic electricity market (NordPol) that facilitate competition [67].

Historically, Norway has been a global frontrunner in implementing national CO_2 reduction targets, being the first country to follow up on the UNs "Our Common Future" report with national commitments in 1989, and subsequent cross-political agreements on national emission reductions and the implementation of a national climate law in 2017 [68]. Norway's decarbonisation strategies have been, and remain, closely linked to societal development objectives, emphasising national industrial interests and focused on aligning climate policies with an economic growth agenda [66]. This includes electrification of oil and gas extraction processes, supporting new green industry development and technology, and energy efficiency-oriented policies [68,69]. Despite these commitments, Norway is a major carbon exporter through its lucrative and expanding offshore oil and gas industries, which government policies ensure the country benefits from [70].

Norwegian climate and energy governance emphasises a political culture characterised by high levels of trust in political decision-making, which forms the basis for resolving conflicts within existing institutional frameworks, relying on governmental expertise and established legal procedures. In this national context, expertise in relation to energy and climate change is taken-for-granted and embedded into the governing bodies, with an expectation of the public trusting and delegating decision-making responsibility to established institutional procedures that draw on state supported knowledge production [67].

Within this coordinated market economy and political culture, citizen-state relations continue to reflect an actively inclusive state featuring what Dryzek et al. [39] characterise as processes of assimilation whereby alternative and critical perspectives in civil society are often diluted and absorbed into dominant discourses or narrowly framed policy processes such as public hearings. Assimilation is also visible

where policy discourse highlights maintaining a "social contract" between society at large and affected local communities, and ensuring all segments of the population are well represented in the political system [71,72]. Moreover, a central argument is that the challenges of climate change necessitate a concerted effort from all sectors of society, and policy discourse emphasises the need to foster a sense of shared responsibility [71,72].

However, this assimilation faces increasing disruption. For example, the push to increase electricity production [66] has brought an influx of private capital and foreign ownership within the energy sector, particularly in onshore wind generation. This situation has led to disputes over land use, underscoring the competing interests of nature conservation, the indigenous Sami people's land rights, and national energy priorities [73]. Such conflicts have shifted policy discourse to emphasise the significance of more genuine local participation in considering environmental impacts and local interests during planning processes, also allocating direct decision-making power to local authorities. Recent policy discourse frames this social resistance as a key 'barrier' to the Norwegian energy transition and calls for measures to enhance societal acceptability [74]. Again, participation is mainly presented as an instrument for aligning publics with national climate and energy objectives.

3.2.2. Mapping public engagements

This sociotechnical constitution is co-produced with collectively held participation-ways that favour and emphasise public involvement through formalised state-led political procedures and as consumers. This reflects entrenched institutional imaginaries of publics as integral yet relatively passive actors in an energy system that largely relies on trust to expertise and institutions as well as the importance of engaging citizens and users in electrifying the energy system.

Our mapping of public engagements in Norway shows dominant participatory collectives in the centre of Fig. 2 that emphasise a techno-economic approach to energy and climate change focusing on green energy technologies – namely renewables ($n = 12$ cases of public engagement), smart energy ($n = 6$ cases), and green transport for electrification ($n = 40$ cases) – with publics typically framed narrowly as rational, economically-motivated consumers or end users of technologies ($n = 32$ cases) exercising "free choice" towards sustainable energy alternatives. This goes hand-in-hand with major technology-driven trials ($n = 12$ cases) and market-oriented initiatives from government which are focused on shaping consumer purchasing decisions and technology adoption though the provision of financial incentives ($n = 6$ cases) and information ($n = 3$ cases). Such initiatives include a series of coordinated government-led programmes seeking to stimulate the mass-adoption of electric vehicles, domestic efficiency retrofit programmes, and the mandatory countrywide roll-out of smart meters (as exemplified by the EV smart charging pilot, the ENOVA Low Energy Programme, and the 'Fleksibilitet i Energisystemet' energy flexibility programme). From the government's perspective this should result in a public that actively participates in flexibility markets, demand-response and which, over time, becomes more energy literate, making economically rational choices. Growing policymaker interest in the electrification of the energy system through increasing, amongst others, the uptake of electric vehicles is part of the rationale for these developments, illustrating how the materiality of the sociotechnical constitution is being co-produced with new dominant modes of participation.

In parallel, given this emphasis on pushing new technologies and green consumption, public engagement through formalised political procedures tends to be orchestrated primarily in the interest of

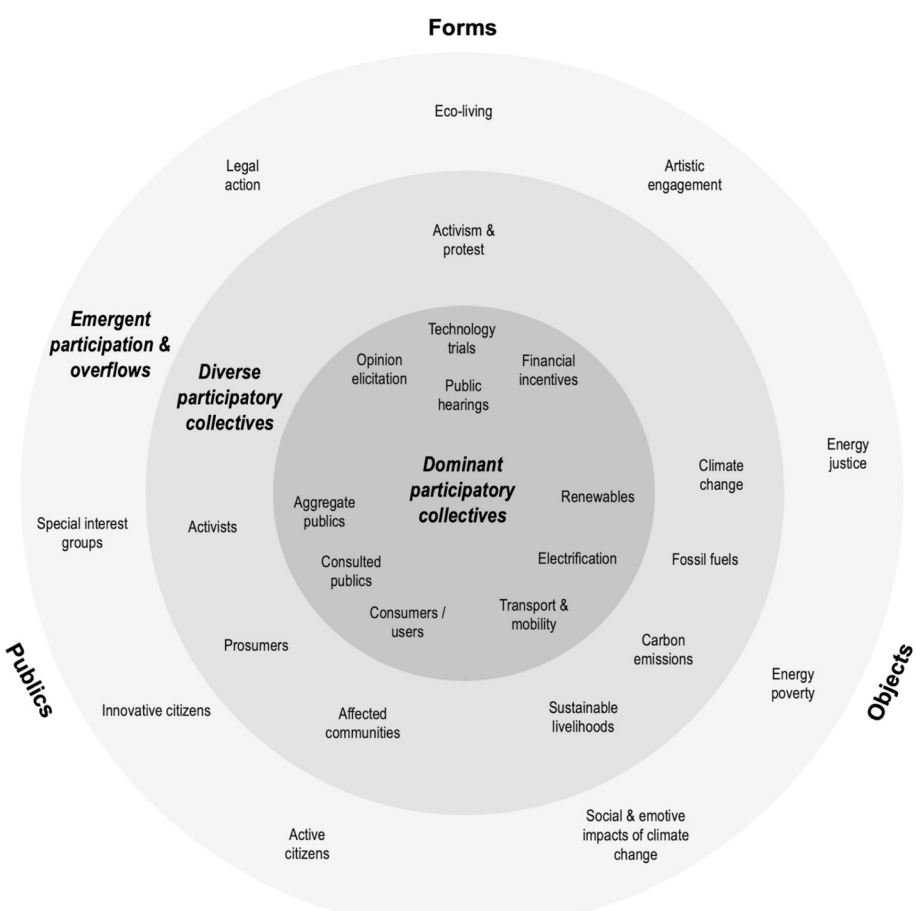

Fig. 2. Ecologies of participation with energy and decarbonisation in Norway.

understanding public views and subsequently strengthening the legitimacy of specific energy infrastructure projects, like onshore wind projects or grid upgrades. These dominant participations take several forms (Fig. 2). First, as in other countries, surveys and other public opinion elicitation techniques ($n = 52$ cases) are widely used to gain an understanding of aggregate publics' ($n = 22$ cases) opinions and understandings of potentially controversial topics such as car sharing and wind energy. Second, there is a strong emphasis on organising legally-mandated participatory consultations and open public hearings ($n = 8$ cases) once initial plans have been made. The prime goal of such processes is often to prepare the ground for future discussions – informing local publics about forthcoming plans and soliciting initial reactions to such plans. As plans become more formalised and detailed, projects also tend to conduct more formal consultations, where publics are primarily framed as either consulted publics linked to specific civil society organisations ($n = 7$ cases), or as lay innocent publics with no pre-existing interest in energy transitions ($n = 7$ cases). Such hearings tend to be characterised by a form of place-bound technical rationality and framing, where implicated publics can express views on decisions such as the placement of cables and the size of infrastructures.

The technologically narrow, place-bound and often economic and market-oriented character of dominant forms of participation in Norway means that many issues and publics tend to be excluded or externalised. These issues and subjectivities are instead brought forth in diverse or emergent participatory collectives (see the outermost circles in Fig. 2). First, diverse participatory collectives associated with climate-oriented protest movements and organisations as well as manifestations of emerging civil disobedience ($n = 13$ cases), co-produce and direct attention to broader objects of engagement such as climate change ($n = 19$ cases), fossil fuels ($n = 3$ cases), carbon emissions ($n = 2$ cases) and sustainable livelihoods ($n = 5$ cases) that are typically overlooked by dominant participatory collectives. In doing so, they also co-produce more active framings of publics linked to affected communities ($n = 7$ cases) being shaped by and responding to infrastructural developments in action, activist networks ($n = 6$ cases), and prosumerism ($n = 4$ cases).

Second, whilst further decentered in relation to the sociotechnical constitution, emergent participations and overflows (see the outermost circle in Fig. 2) serve to illuminate the oversights of dominant, technocratic participatory collectives and how public assimilation in decision-making leads to the marginalisation of a number of publics and of alternative problem framings. In particular, de-centered participatory collectives associated with special interest groups ($n = 21$ cases) such as the indigenous Sami, innovative communities ($n = 2$ cases) and active citizens ($n = 2$ cases) oftentimes seek to challenge dominant energy policies and constitutional stabilities of participation even further by focusing on otherwise overlooked issues including, inter alia, energy justice ($n = 4$ cases), energy poverty ($n = 1$ case), sustainable living ($n = 1$ case), and the social and emotive impacts of climate change ($n = 1$ case). Accordingly, there has been notable yet typically overlooked emergent trends of bringing forth new, often more radical and creative, forms of engagement associated with: (a) legal (activist) action ($n = 1$ case), such as the legal battles associated with the Fosen Vind project; (b) eco-living ($n = 1$ case) as a form of emergent participation focusing on citizen-consumers and co-producing alternative problem framings and role distributions, like a focus on consumption reductions and sufficiency-oriented thinking (e.g. Hurdal ecovillage); and (c) forms of artistic engagement ($n = 1$ case) associated with sustainability-oriented festivals where public engagements focus on objects that are seemingly outside of, but act on, energy and climate systems including sustainability, biodiversity and environmental protection ($n = 1$ case).

3.3. Ecologies of participation in Germany

3.3.1. Sociotechnical constitution

A core feature of the energy system in Germany is how it has historically mirrored governance and regulatory arrangements that have favoured centralised provision and slow diffusion of decentralised alternatives [75–77]. More recently, though, the system has become increasingly diversified and decentralised. In light of strong policy emphasis on expanding renewables since the early 2000s, energy supply has undergone a structural shift from centralised fossil fuel and nuclear generation to distributed renewable production [78]. In policy discourse, Germany's energy transition is largely framed in relation to the 'energy trilemma' [79]. While Germany was slightly slower than the UK or Norway to adopt binding climate goals, the 2019 Climate Protection law provided a commitment to climate neutrality by 2050 (later revised to 2045), with key sector implementation plans set out by the Climate Protection Programme 2023 [80].

The increasingly decentralised nature of German energy supply is reflected in energy governance, which remains state-led but with an increasing diversity of actors involved [81–83] nested in a liberalised energy market [79]. Historically, the German energy market was dominated by large privatised utilities, but since the beginning of the 'Energiewende' (energy transition) policy, the ownership structure has shifted significantly. Today, a substantial share of renewable energy production is owned by new actors like private individuals, energy co-operatives, farmers and municipalities.

The German energy constitution and its sociotechnical stabilities are reflective of the historic division between the Federal Republic of Germany and the German Democratic Republic, and the differing energy infrastructures and energy policy arrangements remain relevant. For example, renewable energy supply is concentrated in less populated rural regions to the North and East of the country, while energy demand remains highest in densely populated industrialised urban centres such as the Ruhr, Frankfurt and Munich. This spatial imbalance requires extensive investment in transmission infrastructure to ensure a stable supply across regions [84–86]. German energy governance is strongly influenced by both supra- and super-national federalism, with many federal states setting their own energy transition targets or climate protection laws [87,88], whilst national energy policy is also deeply intertwined with the EU's energy framework.

The development of energy policies and implementation at all levels is driven by scientific, technical and industrial expertise [88,89]. Germany's consensus-oriented and corporatist political culture [35] reinforces this expert dominance, embedding decision-making within technocratic and institutional channels. While civil society movements were historically important drivers of sustainability agendas in Western Germany [82], they are mainly sidelined in decision-making today which tends to be dominated by corporate and institutional actors with high levels of technical expertise, strong organisational capacity and alignment with dominant policymaker discourses [89]. Public inclusion thus remains highly limited and selective, with a strong emphasis on formal, invited participatory events that primarily engage technical experts, organised stakeholders and special interest groups.

Despite this technocratic configuration, policy documents emphasise the importance of public engagement for successful energy transitions. They state that all stakeholders should be involved in decision-making – explicitly mentioning citizens, trade unions, churches or civil society organisations, stressing the role of consumer decisions and individual sustainable behaviour, and calling on science for implementation advice and cultural and media professionals to "provide blueprints" for a future sustainable society [90 p.367]. However, this inclusive rhetoric is often accompanied by an instrumental logic: public participation is framed primarily as a means of reducing conflict and as an "acceptance-providing factor" for predetermined government policies and decisions [91]. Accordingly, opponents of government proposals are typically portrayed as obstacles to the efficient implementation of energy agendas and as illegitimate players in democratic deliberation. Citizen-state relationships in the German energy system therefore continue to align with Dryzek et al.'s [39] characterisation of passive exclusion of civil society from policy decision-making. Whilst participation is formally open, it is practically constrained as many groups - especially those

lacking technical expertise, organisational capacity or alignment with dominant discourses - find themselves marginalised or unable to engage meaningfully [88].

3.3.2. Mapping public engagements

The constitutional stabilities outlined above are co-produced with distinctive ecologies of participation in the German setting, with collectively held participation-ways emphasising the legitimacy of interest group representation in invited dialogues in addition to the representation of aggregate populations. Alongside a range of participation formats that seek to elicit public views (n = 147 cases of public engagement) and examples of communication and information provision (n = 10 cases) mandated under laws such as the Environmental Impact Assessment Act (UVPG) [92] to ensure affected publics are informed, 'Dialog' events (n = 10 cases) manifest themselves as some of the most constitutionally significant forms of participation (see Fig. 3).

Such Dialog processes are highlighted in key governmental energy and climate initiatives such as the German Sustainability Strategy [90,93], the national action plan on energy efficiency [94], the 2020 Climate Protection action plan [95], the 'Dialog' climate adaptation [96], the Network Development Plan Electricity [97], and the National Hydrogen Strategy [98], amongst others. Whilst seemingly pushing towards the democratisation of decision-making, these Dialog processes primarily define legitimacy and structure participation around invited representatives of stakeholder or interest groups acting as proxies for civil society to the exclusion of wider publics.

These dominant practices of participation are co-produced with dominant constructions of publics. The most prevalent framing constructs an aggregate public (n = 54 cases) represented through forms of expert-led elicitation. Other widespread constructions frame publics as special interest groups (n = 27 cases) or stakeholders (n = 18 cases) involved in deliberative 'Dialog' processes at different federal levels, and affected publics or audiences (n = 26 cases) for whom information provision is a legal requirement. Reflecting their predominantly state-led orchestration, these dominant forms of participation are typically framed in techno-economic terms, tied to policy priorities linked to addressing key aspects of the energy dilemma, namely addressing climate change, net zero and energy security (n = 28 cases), and the expansion of renewables (n = 30 cases).

Whilst these dominant forms of participation passively exclude and disempower lay publics in energy-related decision-making, our mapping also reveals a broader diversity of participation collectives (see the outermost circles in Fig. 3). A key example of this is the presence of almost 3000 registered energy communities across Germany [99], with the sector represented in our mapping by 16 distinct cases. These energy cooperatives have played an important role in the German energy transition, as major contributors to a contrasting view of publics as active communities (n = 25 cases) either investing directly in municipal energy projects or offering bottom-up and citizen-led development of renewable energy under the Energiewende [100]. Nonetheless, their comparatively less central positionality within national ecologies of participation is evidenced by community energy losing momentum in recent years due to a lack of financial incentives and supportive policies, growing local resistance to new renewables projects which has made them more risky and costly [101–103], and growing concerns around social inequality and spatial justice [104].

Alongside community energy, our mapping identifies additional diverse yet less central forms of participation (see Fig. 3). These include cases focusing on everyday behaviours or behaviour change initiatives (n = 20 cases) and forms of protest and activism (n = 19 cases). Public

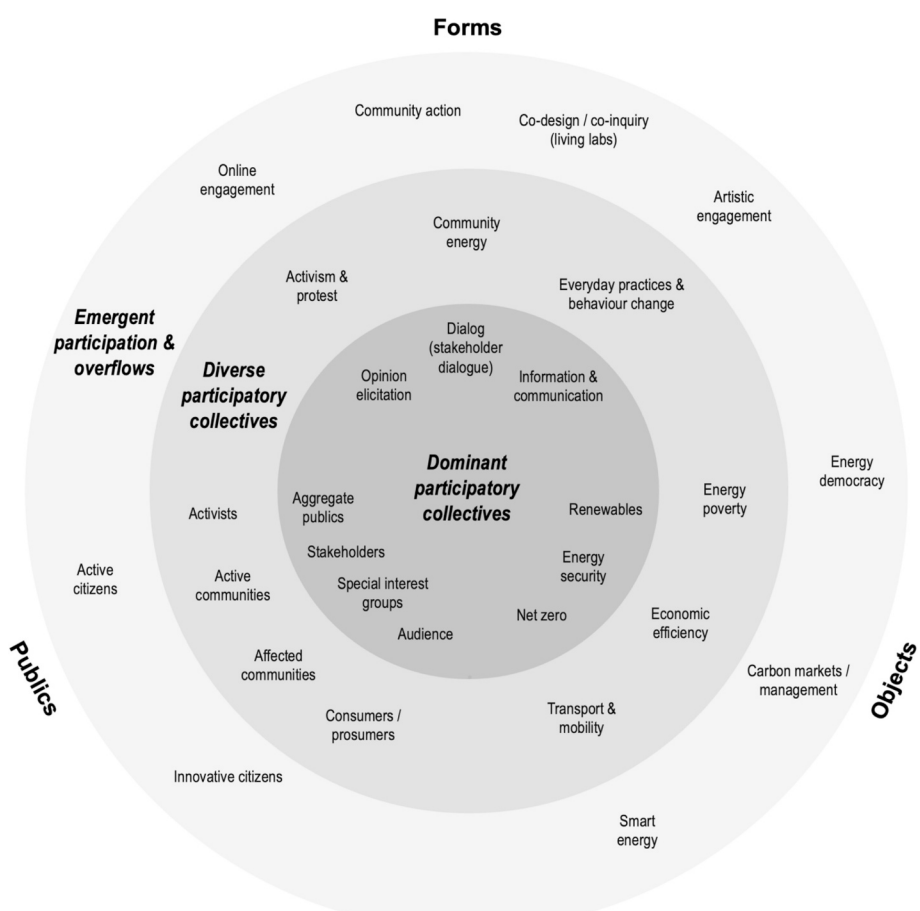

Fig. 3. Ecologies of participation with energy and decarbonisation in Germany.

behaviour-related cases typically focus on energy efficiency in everyday domestic practices ($n = 14$ cases) and transport and mobility ($n = 8$ cases). Energy and climate-related protest and activism have diversified in recent years, with traditional pro-environmental and sustainability protests ($n = 9$ cases) being increasingly countered by protests against windfarms, solar installations and grid infrastructures ($n = 10$ cases). These antagonistic dynamics now span both calls for a faster transition and anti-renewables or anti-transition sentiments [105]. These diverse forms of engagement co-produce more varied but also generally more active public identities as consumers ($n = 22$ cases), producers or prosumers ($n = 4$ cases) and activists ($n = 8$ cases). They also produce wider and more diverse framings of energy and climate change that go beyond dominant policy framings to include issues such as sustainability ($n = 6$ cases), energy poverty and affordability ($n = 4$ cases), and transport and mobility ($n = 70$ cases).

Less prevalent are a range of more emergent forms of participation (see the outermost circle in Fig. 3) that help reveal the particularities and partialities of dominant German participation-ways. Although community energy has waned in recent years, alternative decentralised citizen groups continue to experiment with and help to develop new technologies through citizen science ($n = 2$ cases), living labs and other co-design and co-inquiry processes ($n = 7$ cases), as well as forms of online ($n = 15$ cases) and artistic engagement ($n = 2$ cases). Scientific institutions and municipal actors often play a key role in initiating and orchestrating these engagements, thereby pre-framing an 'experimenting public' – one that is ostensibly open to failure and surprise yet frequently guided by pre-defined goals and expectations [106,107]. Still, many of these initiatives seek to develop alternatives to incumbent imaginaries whether through co-designing and trialling new technologies ($n = 6$ cases), creating new artistic visions of energy futures ($n = 5$ cases), or embodying more active forms of citizen and community-led engagement in decision-making ($n = 2$ cases). They reveal additional public concerns and interests emphasising forms of carbon accounting, trading and management ($n = 8$ cases), digitalisation and smart technologies ($n = 7$ cases), as well as emerging concerns over the need for a just transition and just climate futures ($n = 5$ cases) that are marginalised in dominant energy and climate discourses in spite of their critical importance given the uneven distribution of energy technologies and consumption (noted in section 3.3.1 above). In doing so, they also challenge dominant imaginaries of the public as a barrier by co-producing more creative publics as either innovative ($n = 17$ cases) or active citizens ($n = 2$ cases).

4. Discussion and conclusions

In this final section we synthesise comparative insights on ecologies of participation with energy and climate change in the three countries and relations between them, as summarised in Table 1. We first consider how public engagements with energy and climate change are differently shaped by and co-produced with the situated sociotechnical constitution in each national setting (features of the sociotechnical constitution are summarised in the first four rows of Table 1). Each country exhibits distinct collectively held 'participation-ways' through which the quality, relevance and legitimacy of different forms of participation are viewed. Second, we compare the diverse and emergent forms of participation, publics and public issues that overflow - and are potential sources of responsiveness and transformation of - dominant constitutional and institutional framings in each national setting. Third, we caution against reifying the national scale as a unit of comparative analysis and show how ecologies of participation in each national setting do not work in isolation but are interrelated through circulations between the three countries and beyond, including circulating formats of participation. Finally, we consider the implications of our findings for theory, research and practice.

First, despite a number of similarities - as European representative democracies that are developing more participatory forms of democracy as part of national strategies for net zero and energy system decarbonisation - our analysis shows the UK, Norway and Germany to have notable differences in dominant forms of public engagement and what counts as legitimate participation. In the UK, collectively held participation-ways favour forms of public engagement that can claim representativeness of 'the public' and also inform these publics to gain acceptance or shift their behaviours through consumer choice (see Table 1). Our analysis suggests that this is closely tied to stabilities and durabilities of the sociotechnical constitution - the materiality of a centralised energy system, state-market governance arrangements, and a technocratic policy culture favouring techno-economic solutions and the embodied expertise of participation experts who can 'speak for the people' [38,108]. Dominant forms of participation include opinion surveys and deliberative processes that seek to provide definitive evidence about representative publics in supporting a representative parliamentary democratic system, whereas oppositional or grassroots participation in civil society is actively excluded.

This contrasts with Germany where our analysis has shown long-established participation-ways favour interest group representation in

Table 1
A comparison of participation-ways and ecologies of participation with energy and climate change in the UK, Norway and Germany.

	UK	Norway	Germany
Sociotechnical energy system	Centralised, state-market hybrid, mix of gas, renewables & nuclear	Coordinated market economy, almost all renewables with electrification	Mixed energy system with increasing renewables, state-led with civil society role
Citizen-state relationship	Active exclusion of civil society	Assimilation of civil society	Passive exclusion of civil society
Political culture (civic epistemology)	Embodied, service-based, empirical science	Legal-procedural, trusted expertise, institutional trust	Corporatist, institution-based, expert rationality
Collectively held 'participation-ways'	Representativeness of 'the public', institution-led representation through participation experts	State-led formalised political procedures, citizens as consumers	Interest group representation in invited consensual dialog
Dominant participations	Opinion surveys, consultations, public deliberation	Public hearings, stakeholder consultation, technology adoption	Stakeholder 'Dialog', community energy, opinion elicitation
Emergent and decentred participations	Citizen and community-led action and innovation, activism and protest	Eco-living, protests, legal action	Activism and protest, living labs, co-design, digital and artistic engagement
Circulating participations		Opinion surveys, deliberative processes Community energy, activism and protest	

invited dialog while being more open to community-based participation at local and regional levels (Table 1). This is co-produced with a sociotechnical constitution centred on a mixed energy system that is state-led with a civil society role, Germany's federal parliamentary republic which divides power between the federal government and individual regional states, and its corporatist policy culture based on expert rationality and negotiated reasoning through consensus. Dominant forms of participation include 'Dialog' processes where organised groups represent the interests of others, while more passive relations with civil society allows for greater recognition of community-based energy initiatives.

In comparison, public engagement with energy and climate change in Norway is more constrained through its co-production with a highly centralised energy system dominated by the 'solution' of low carbon hydropower electricity production, a coordinated market economy, and a corporatist state with a legal-procedural political culture grounded in trusted expertise and institutional trust (Table 1). Collectively held participation-ways thus favour public involvement through formalised political procedures and as consumers, with dominant forms of participation being public hearings, stakeholder consultations, and technology adoption linked to electrification. While the assimilation of civil society into the state and governance arrangements indicates a potential responsiveness to society in Norway, it can also mean that matters of concern and grassroots mobilisation are less evident or more distant from centres of power and popular consciousness. A case in point is the country's dependence on oil exports which have continued for decades but have become a source of controversy and legal challenges by groups in civil society more recently [73]. Across all three case study countries, then, our analysis has shown how sociotechnical constitutions and established participation-ways exert stabilities, durabilities and closures formed over time that shape and co-produce the forms of participation that come into being, are deemed legitimate and recognised, or are otherwise excluded, hidden or denied.

Second, our analysis has shown that around the constitutional stabilities and dominant participation-ways in each country exist diverse, emergent and overflowing public engagements with energy and climate change (Figs. 1, 2 and 3). These decentred forms of participation are less recognised, established or credible and extend beyond dominant institutional framings of problems, participations and publics in each national setting. In the UK, diverse and emergent participations - such as community-led action, grassroots innovations, and activism and protest - bring forward alternative framings and issues of the transition including concerns over social justice, energy poverty and sustainable living which extend beyond and challenge dominant techno-economic framings of net zero and climate change. In Germany, our analysis has shown how diverse forms of participation such as activism and protest, living labs, co-design, and digital and artistic engagement, overflow dominant institutional framings which centre on core objects of policy concern such as net zero, energy security or the expansion of renewables. Whereas, in Norway, while comparatively less evident, decentred participations include eco-living, protests and legal action, bringing forward issues relating to human rights, energy justice and alternative energy futures which challenge incumbent framings of centralised technological solutions around the electrification of power and transport. So, while durable, sociotechnical constitutions and participation-ways are not fixed and change over time in relation to wider diversities in ecologies of participation.

Third, even though our study has compared ecologies of participation in different national settings, our findings caution against reifying the national scale as the spatiality and unit of analysis of participation systems. While we have shown participation-ways can be identified nationally, these spaces of participatory coherence also form above and below the state. For example, in our analysis we identified regional variations in participation with energy and climate change, such as differences between East and West Germany discussed in section 3.3. All three countries in our study are situated in or relate to wider spaces of participatory coherence, such as the European Union which has its own closures around legitimate and relevant energy participations [cf. 28].

In addition, our analysis has highlighted how ecologies of participation with energy and climate change in each national setting are not bounded but are connected and interrelate, including through circulations that occur between countries in wider spaces of participation. For example, translocal and international circulations of formats and technologies of participation are a key kind of interrelation between countries (Table 1), connected through relational spaces of standardisation, scientisation and expertise including in social scientific communities. This is shown by the dominant forms of participation that exist in all three countries (Figs. 1, 2 and 3), including technologies of elicitation like public opinion surveys and deliberative processes. These formats circulate between the three countries and beyond in wider spaces of standardisation, technologisation and expertise, such as opinion surveys that are replicated or used as a basis for comparison between countries [e.g. 29,109] and deliberative processes like citizens' assemblies on climate change that have established networks for exchanging blueprints, knowledge and 'best practice' across borders [e.g. 110,111]. Our study also reveals circulating forms of participation that are decentred to differing degrees in each national setting (Table 1). We see this with examples of climate activism that rose during the study period, such as cases associated with Extinction Rebellion and the Fridays For Future climate movement, and the circulation of imaginaries relating to them [cf. 112]. Community energy is another case in point, where exchange and circulation of visions and expertise has occurred between Germany and the UK but, as shown in sections 3.1 and 3.3, these forms of participation have become materialised quite differently in each country [see also 113,114].

In this paper we have sought to advance constructivist approaches to participation and extend the ecologies of participation framework to international comparisons for the first time, through a focus on public engagement with energy and climate change. At a time when established democratic practices and institutions of participation are struggling to represent an increasing multiplicity of publics and maintain public legitimacy and trust under intensifying conditions of polarisation and difference, there is renewed interest in what constitutes good or legitimate participation. A major finding of our study is how it shows empirically that this already exists de facto in situated ecologies of participation through revealing national participation-ways that are collectively held, culturally situated, and tied up with the sociotechnical constitutional stabilities of the three countries studied. Rather than being universal, pre-given and externally imposed, what counts as (good) participation is shown to be established in situated ecologies of participation. This draws attention to systemic inequalities and exclusions that occur and also suggests that public engagements that appeal to collectively held criteria in each national setting (Table 1) are more likely to gain power and become authoritative in these contexts. A related insight from our study is that the qualities, performance and legitimacies of participation are systemic and co-produced through diverse, intersecting and interrelating ecologies and thus cannot be reduced to individual forms of participation or discrete one-off participation processes linked to particular decision moments as mainstream approaches do. This suggests that attempts to understand and analyse or develop normative approaches to the design and evaluation of participation should move to consider how its performance and legitimacies are produced through interrelated ecologies of participation and how they play out in particular settings.

Yet, while it is important to understand the configurations of power and closures of systemic constitutional stabilities that shape what and how participation is in all three countries, how things are is not good enough. Our analysis has revealed diverse, emerging and excluded forms of public engagement that overflow dominant institutional framings of participation, publics and issues relating to energy and climate change. Ecologies of participation encompass formal institutions of science and of democracy - both representative and participatory - but also extend

beyond them revealing excluded, hidden or unrecognised public concerns and engagements. While it is analytical and empirical in emphasis, a more practical implication of our comparative study is that socio-technical constitutions, incumbent institutions and system actors need to be more reflexive about the powers and closures of dominant participation-ways and more responsive and accountable to the diverse public engagements that lie beyond dominant institutional framings of participation, publics and public issues [12,19,115]. This is essential to ensuring effectiveness, public legitimacy and trust in transitions to more just and sustainable futures in our three study countries or any other setting for that matter [6,116]. New approaches, practices and organisational entities that map diverse public engagements, work with and connect distributed ecologies of participation, and prompt greater institutional responsiveness to society - like participation observatories - show much promise in this regard [41]. While this paper has focused on energy and climate participation in the UK, Norway and Germany, it opens up paths for further comparative studies, research and practice to understand ecologies of participation, map participations and their circulations, and prompt societal responsiveness in other national settings, globally, or at local, regional and organisational scales.

CRediT authorship contribution statement

Jason Chilvers: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Phedeas Stephanides:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Data curation. **Helen Pallett:** Writing – review & editing, Writing – original draft, Methodology. **Tom Hargreaves:** Writing – review & editing, Writing – original draft, Methodology. **Elliot Honeybun-Arnolda:** Writing – review & editing, Writing – original draft. **Danny Otto:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Gisle Solbu:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Marius Korsnes:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Tomas Moe Skjølsvold:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation.

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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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.erss.2026.104951.

Data availability

Research data for this article are available in the supplementary material.

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