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SYNTHESIS ARTICLE

Beyond shared socioeconomic pathways (SSPs) and representative concentration pathways (RCPs): climate policy implementation scenarios for Europe, the US and China

Richard J. Hewitt [a,b,c], Roger Cremades [d,e], Dmitry V. Kovalevsky[e] and Klaus Hasselmann[f]

[a]Transport, Infrastructure, and Territory Research Group (tGIS), Geography Department, Faculty of Geography and History, Universidad Complutense de Madrid (UCM), Madrid, Spain; [b]Observatorio para una Cultura del Territorio (OCT), Madrid, Spain; [c]Informational and Computational Sciences Group, The James Hutton Institute, Aberdeen, Scotland UK; [d]Wageningen University and Research, Wageningen, The Netherlands; [e]Climate Service Center Germany (GERICS), Helmholtz-Zentrum Geesthacht, Hamburg, Germany; [f]Max Planck Institute for Meteorology, Hamburg, Germany

ABSTRACT

The 2015 Paris Agreement is falling short of its aspirations, as signatory countries are struggling to implement the policies required to meet the targets. The global scenario framework formed by the Shared Socioeconomic Pathways (SSPs) and the Representative Concentration Pathways (RCPs) places little emphasis on the dynamics of climate policy implementation. Social science approaches to understanding these dynamics are not well-integrated into climate scenario research. We apply an implementation research approach to analyse the transition to clean energy in the US and China, as well as two examples from Europe – Germany and Spain – which have shown markedly diverging implementation trajectories. We propose four implementation scenarios (ISs) for clean energy worldwide which relate to different configurations of actors in the policy system. These are: (1) Civil Society Takes Control (IS1) – where ideologically opposed governments are marginalised by citizens and forward-thinking investors; (2) Strong-arm Transition (IS2) – where a single party state drives the transition without the involvement of civil society; (3) Systemic Limits (IS3) – which highlights the need to focus on the whole energy system, not just renewables; and (4) Renewable Austerity (IS4) – where an economic downturn offers powerful anti-transition actors the opportunity to advocate removal of support for climate mitigation, as they did after the 2007–2008 financial crisis. This scenario could be repeated as countries seek to recover from the Covid-19 pandemic. Our study offers a framework for structured analysis of real-world constraints faced by implementing actors, which we argue is urgently needed to help national and international policy makers achieve climate goals.

Key policy insights

- The world is struggling to implement the Paris Agreement, partly because the complex dynamics of climate policy implementation are poorly understood.
- Social science approaches to understanding these dynamics are not well-integrated into climate scenario research.
- Implementation research focussing on the actors and context provides a useful framework for analysis of implementation efforts from major global carbon emitters.
- The approach offers new and distinctive scenario narratives that go beyond

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climate policy implementation; climate scenarios; renewable energy; policy evaluation/feedback; climate targets; international comparison

CONTACT Richard J. Hewitt rhewitt@ucm.es Transport, Infrastructure, and Territory Research Group (tGIS), Geography Department, Faculty of Geography and History, Universidad Complutense de Madrid (UCM), C/ Profesor Aranguren, s/n, Ciudad Universitaria, 28040, Madrid, Spain; Observatorio para una Cultura del Territorio (OCT), Calle del Duque de Fernán Núñez 2, 1, 28012, Madrid, Spain; Informational and Computational Sciences Group, The James Hutton Institute, Craigiebuckler, Aberdeen; AB15 8QH, Scotland UK

Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs).
- These new scenarios can help policy makers evaluate likely outcomes of climate policy implementation based on information about actors and context.

1. Introduction

The broad consensus achieved by the 2015 Paris Agreement has yet to be translated into adequate action to reduce global emissions. Not only do the Nationally Determined Contributions (NDCs) pledged by individual countries fall far short of the Paris goals (Rogelj et al., 2016), but it is unclear whether countries are motivated to meet them. The implementation of climate and energy transition policies has been a major focus of research in the social sciences for decades (e.g. Geels et al., 2017; O'Riordan & Jordan, 1999; Schneider, 1983; Shove & Walker, 2007). Yet there have so far been few attempts to use these analyses to develop structured scenarios to guide the implementation of climate mitigation at the national level. Without such information, which is absent in mainstream scenario frameworks like the Representative Concentration Pathways (RCPs) (Ebi et al., 2014; van Vuuren et al., 2011) and the Shared Socioeconomic Pathways (SSPs) (O'Neill et al., 2014), key policy actors and stakeholders lack the systematic understanding of past successes and failures that is necessary for evidence-based policy-making.

In this paper, we address this research gap by analyzing the implementation of renewable energy (RE) policies in developed economies in Europe, the United States, and China through the lens of implementation theory (Bressers & Klok, 1988; de Boer & Bressers, 2011). Our objective is to provide a more systematic and formalised analysis of the causal links between climate policy actors and outcomes than currently offered by RCPs and SSPs.

The paper is structured as follows. Section 2 (following) describes the background to our research, and Section 3 presents our research methods. Section 4 presents the results of our analysis of clean energy policy implementation in the case study countries and discusses the key roles of the relevant implementing actors. In Section 5, we draw out four distinct scenarios emerging from the implementation experiences of our key case study countries. In Section 6, we describe the key lessons for climate policy that emerge from our scenarios. In Section 7, we discuss the implications of our work for the future efforts to bring emissions in line with Paris goals, and argue for a more explicit inclusion of implementation scenarios like those described here into climate scenario research. In our conclusion (Section 8), we affirm the value of these kinds of scenarios in the quest for a deeper understanding of the complex societal interactions that constrain the implementation of effective climate policies.

2. Research background

2.1 Implementation theory and related approaches

Comparative analysis of different countries' climate policies (see, e.g. Bättig & Bernauer, 2009; Bernauer & Böhmelt, 2013; Höhne et al., 2018; Iacobuta et al., 2018) can help understand how the climate crisis has led to changes in government planning and strategic thinking. Bressers and Klok (1988) observe that key decision-makers (*actors*) do not consider just 'one or a few isolated factors, but rather the continuous joint influence of all relevant factors. These factors (circumstances) do not influence the effectiveness of the instruments independently'. Not only do countries respond to events in different ways, usually for historical reasons (path dependency), they also differ enormously: e.g. in wealth, systems of governance, and cultural affinity to particular practices or behaviours. Neither is the existence of a particular policy any guarantee that such a policy will be carried out in practice (Smith, 1973). For these reasons, the focus in this paper is on policy implementation, not policy formulation. The implementation of RE and the urgency with which the goal of decarbonising energy is pursued are useful proxies for a particular country's approach to climate change. They have been studied from a range of different perspectives exploring the role of actors and context, as the following examples show.

Bressers and Dinica (2003) used a variant of implementation theory known as *contextual interaction theory* (CIT) to unpack the complex relationships between key actors involved in implementing wind energy policy in the UK, Spain and the Netherlands. Alonso et al. (2016) and Hewitt et al. (2017a) adopted related approaches to

study the implementation of RE in Spain after the RE paralysis of 2011. Eikeland and Inderberg (2016) applied *public choice* and *path-dependency* perspectives to investigate Danish energy policy at the turn of the millennium, after the government abandoned public support for the wind sector. Investment in wind predictably declined until public support was reinstated in a subsequent election cycle. In this study, the role of context can be seen in terms of constraints on the range of options available to policy makers as a result of the need to satisfy different constituents whose support had helped their re-election. Jacobsson and Lauber (2006) used an *institutionalist* approach (Andrews-Speed, 2015; Lockwood et al., 2017) to explain the rapid diffusion of RE in Germany after 1990 as a 'battle over institutions' fought by coalitions of advocacy groups in the German parliament. Nilsson et al. (2011) also applied an institutionalist approach to investigate the policy pathways to a low-carbon transition in Sweden by 2050. *Socio-technical transitions* perspectives (e.g. Geels and Schot (2007), Smith and Raven (2012)) have been applied widely to the analysis of the clean energy transition (e.g. Hess, 2016; Saikku et al., 2017). This research strand explicitly recognises the multi-actor nature of transitions, which are frequently characterised as a power struggle between actors in public, private, or 'third sector' domains (Geels et al., 2017). Conceptual weaknesses in socio-technical transitions research have been identified around the role of actors, with the difference between individuals and institutions not always clearly identified, leading to new proposals in which actors are more systematically examined (Avelino and Wittmayer, 2016). The emerging research strand around *social innovation* in energy transitions (Geus & Wittmayer, 2019; Hewitt et al., 2019; Hoppe & De Vries, 2019) is a further step in the evolving recognition of the importance of civil society actors in driving societal transformation.

Unfortunately, despite the clear relevance to climate mitigation policy of social science perspectives like those outlined above, they remain at the margins of mainstream discourse (Kythreotis, 2018; Kythreotis et al., 2019; Lövbrand et al., 2015; Victor, 2015). The present paper contributes novel approaches and insights that partly address this imbalance by covering a major gap in the national implementation of RE. Our principal innovation, going beyond previous scenario-based approaches (e.g. O'Neill et al., 2017), is to develop our scenarios directly from real climate policy implementation experiences in individual countries. Since these scenarios are constrained by practical experience, they offer a better guide to what is feasible within our path-dependent world than more 'open' scenario frameworks like the SSPs and RCPs.

2.2 Scenario development

Scenario planning approaches have become a widely accepted way of understanding and communicating climate change outcomes (Rogelj et al., 2012). The RCPs were developed to provide internally consistent sets of projections of the components of radiative forcing for use in analysis by both climate models and integrated assessment models (IAMs) (Van Vuuren et al., 2011). The SSPs were developed *ex-post* to be consistent with the RCPs by ' […] integrating the descriptions of socioeconomic development with the climate change projections and with assumptions about climate mitigation and adaptation policies' (Ebi et al., 2014). However, neither the RCPs nor the SSPs provide any information about the dynamics of actors in their real-world context.

In the present paper, we address this research gap in the following way. First, we analyse the degree of variability between different case study countries, including some of the world's major emitters, in the implementation of policies to support a transition to clean energy; second, we examine the *context* in which this variability was observed, and roles played by key *actors* in each country case in facilitating, or not, this transition; and third, we develop feasible *implementation scenarios* that capture this variability and translate it into a guide for key policy actors.

3. Materials and methods

3.1 Conceptual framework

To achieve our objectives, we employ a simplified version of contextual interaction theory in which actor behaviour is characterised by two principal characteristics: *Motivation* of the actor to address the policy goal; and *Resources* (or, equivalently, power) at the actor's disposal to enable the actor to realise the policy goal (see

e.g. Hewitt et al., 2017a, 2017b; Kovalevsky et al., 2017). We identify four principal actor groups relevant to the implementation of RE at an individual country level. These are: *national governments*, who may set incentives or impose controls to drive change (see e.g. Mah et al., 2013); *big energy companies*, who may be public, semi-public or private, and include both the most important energy providers by market share (e.g. Germany's Big Four or the UK's Big Six) as well as distribution network operators (DNOs) and utilities (see e.g. Kungl, 2015); *investors*, who may be private citizens or banks (either state-owned or private) (see e.g. Hall et al., 2017); and *civil society*, which includes citizen groups of various kinds, whether formally structured (small-medium enterprises, NGOs) or not (community groups and individual citizens), as well as local and sub-national regional governments who may have their own resources and alliances to promote sustainability transitions (see e.g. Magnani & Osti, 2016).

3.2 Case study countries

Our case study countries were chosen both to illustrate our central idea that context and actors are key in determining the outcome of national policy, and to be broadly representative of the diversity of energy policy responses to the climate crisis. To this end, we looked for (1) the major emitters of greenhouse gases, since the policies and implementation experiences of such countries are of global importance; and (2) countries which have shown markedly different responses to climate mitigation, compared to one another; or (3) countries which have experienced dramatic shifts in implementation – either rapidly moving from a position of opposition or ambivalence regarding RE to strongly promoting it – or shifting in the other direction, suddenly opposing RE and backing fossil fuels instead. With these criteria, we chose the following cases: (1) The United States, the world's second biggest annual emitter, whose governments flipped from providing cautious support to clean energy policies (under Presidents George W. Bush and Barack Obama), to directly opposing them (under President Trump); and (2) China, the world's biggest annual emitter, which has shown strong and consistent support for cleaner energy, but whose projected expansion of coal power risks tipping the world beyond the Paris Agreement (Wang et al., 2020).[1] For Europe, which as a bloc is the world's third largest emitter, we selected two major economies which represent sharply opposing trajectories of European climate policy implementation: Spain, which moved from strongly supporting RE to strongly opposing it (Alonso et al., 2016), subsequently reinstating support following a change of government; and Germany, which moved from a low level of national support and strong dependence on fossil fuels to become Europe's most important advocate of the clean energy transition (Hake et al., 2015).

3.3 Data collection and development of narrative scenarios

To collect information on the implementation of low-carbon energy systems in our four case study countries, we carried out a comprehensive analysis of the available literature, searching by keyword in Google Scholar and Web of Science. We screened the results obtained for relevance to our core implementation theory concepts, and discarded literature that did not address either motivation or resources of key implementing actors (National government, Big Energy companies, Investors, Civil society), or that was more than five years old. Key references are given in the Appendix. This approach allowed us to reconstruct historical implementation trajectories from the extensive, diverse and fragmented literature. Cross-comparison and triangulation of multiple sources for the same series of events (e.g. the German *Energiewende*, the Spanish RE paralysis) allowed master narratives of RE implementation in each country to emerge (Section 4). These narratives were then used to develop scenarios and descriptions of motivation and resources for the key implementing actors (Section 5). The scenario approach provides a means to distil the cause and effect of the individual country narratives into plausible, generally applicable, future pathways.

4. Results: How key actors can drive or block a transition to clean energy

4.1. Case study 1: United States

In the United States, much has been made of President Donald Trump's announcement of withdrawal from the Paris Agreement. However, while the federal government, blocked by corporate donations and embedded pro-fossils lobbying, has moved away from promoting clean energy, individual US states have a high degree of autonomy, and some (e.g. California, Maryland, New York) provide strong policy support for RE and the low carbon transition (Pischke et al., 2019).

In terms of actors' roles in the implementation of low-carbon energy in the US, the study by Hess (2016) on the opposition of utilities in US states to distributed generation (DG) of solar energy is instructive. Unlike in Spain, where a similar process of regime resistance contributed to a nationwide paralysis in RE development, the federalised US system led to many individual state-level negotiations between utilities and pro-solar groups. While utilities managed to block DG solar in some states, they were partially defeated or compromises were negotiated in others, e.g. Arizona and Minnesota (Hess, 2016). Thus, while the US is often taken as an example of how corporate lobbying by fossil fuel groups can end clean energy support, in reality, the country's decentralised legislative structure means that the US may have a much better chance of implementing a successful transition to clean energy than many other, apparently more progressive nations.

4.2 Case study 2: China

China's climate change policy is of great global significance due to its enormous emissions from rapid economic growth driven mostly by cheap coal. Emissions reductions in Europe have mostly come from de-industrialisation; these have now been exceeded by emissions increases from China, where a high proportion of global consumer goods are produced. However, severe air pollution, and a genuine ambition to show leadership on climate, have led to the adoption of far-reaching policies to reduce emissions and promote renewables in recent years. Nonetheless, extensive expansion of the coal industry is still anticipated. If China develops all of its projected new coal mines, the world is virtually guaranteed to exceed Paris Agreement temperature targets (Wang et al., 2020). However, China's recent announcement to achieve carbon neutrality by 2060 (Mallapaty, 2020) implies the need to abandon both ongoing and projected new coal plants.

In terms of the role of specific actors, China is often regarded as monolithic and dependent on specific directions from the State. However, this conventional view of China held by western commentators is out-of-date; Lo (2015) notes that while China's national energy policy appears authoritarian, the implementation context at the local level is more nuanced, with a mix of authoritarian and liberal features in evidence. Li et al. (2019) found that the implementation of renewables portfolio standards in China was initially tightly controlled by policy makers, but over 10 years transformed into a more open system with a more diverse actor network and a flatter hierarchy. The energetic and entrepreneurial nature of civil society also means that grassroots solutions can sometimes emerge, as in the case, cited by Andrews-Speed (2016), of crowdfunding for solar photovoltaic installations when state-owned banks failed to lend. However, Tseng and Habich-Sobiegalla (2020) have noted that the lack of central direction on RE implementation, with a heavy reliance on 'policy pilots' implemented at a local level, has also led to serious problems of energy system integration. In terms of financing, significant investments, e.g. for energy system transformation, would come from the state, not private investors, who are less influential than in Europe or the US.

4.3 Case study 3: Germany

The German energy transformation (*Energiewende*) was motivated primarily by the concern for nuclear safety rather than the climate issue, though the roots of the *Energiewende* are far older than its well-known catalyst, the 2011 Fukushima nuclear disaster (Morris & Jungjohann, 2016). The decision to rapidly decommission nuclear power plants following this catastrophe resulted in the short-term replacement of nuclear power by lignite coal burning, the energy source with the highest CO_2 emissions. Despite strong government support

for RE, its implementation was not adequately planned on a national scale. Strong investments in wind farms in North Germany, for example, led to an oversupply of local RE which could not be transmitted to South Germany because of inadequate power lines (Fuchs et al., 2012). Strong initial investments in solar panel production were furthermore undercut by competitive Chinese solar panel subsidies, leading to a collapse of the national solar panel industry (e.g. Geels et al., 2017). This could have been avoided by balancing national solar panel subsidies (Kovalevsky & Hasselmann, 2016), leading to an overall increase in global RE production. Despite strong government support for RE, Germany has missed its EU targets for 2020 (EC, 2019). The recent Coal Phase-out Act is clearly a positive step, but the schedule of the phase-out – reduction to 50% of current capacity by 2030, with complete phase-out by 2038 – is controversial. While incumbents worry that this timescale is too short, it may not be short enough to meet domestic decarbonisation targets (Klöckner & Letmathe, 2020). With per capita greenhouse gas emissions of 11.1 tCO_2e (above the G20 average), Germany is not in line with the 1.5°C pathway required by the Paris Agreement (Climate Transparency, 2019: Germany).

In terms of the role of specific actors, the national government, despite its early reluctance (Jacobsson & Lauber, 2006), has become a strong driver and supporter of the clean energy transition. Big energy companies were initially opposed to RE, which they saw as a threat to their business model (Kungl, 2015), but eventually moved to a position of broad support for the *Energiewende*. Investors have backed RE in Germany in recent years, but have traditionally been cautious. In the early 1990s, wind farms were financed by citizens because wind power was regarded as too risky by mainstream lenders (Enzensberger et al., 2003). Civil society supported RE strongly and consistently, in part due to German environmentalists' historic opposition to nuclear power (Andrews-Speed, 2016; Geels et al., 2017)

4.4 Case study 4: Spain

Spain was a major European player in RE, particularly in wind power, solar thermal electricity and solar photovoltaic energy, until 2012 (Ruiz Romero et al., 2012), when support for RE was abruptly withdrawn (Alonso et al., 2016; Gabaldón-Estevan et al., 2018; Hewitt et al., 2017a; Solorio, 2016). In 2012, faced with economic collapse following the financial crisis of 2007–2008, a new government with little interest in environmental sustainability made renewables an early casualty of its austerity policy. The impact of the recession on businesses and households drove energy demand down. To protect the profitability of the existing energy sector and the state's own investments in it, laws were drawn up (RD 1/2012, Law 24/2013, RD 900/2015) to halt RE deployment and prevent households and businesses from self-consuming RE (Hewitt et al., 2017a). As a consequence, RE development stalled, and the country missed its targets for 2020.

In terms of the role of specific actors, big energy companies mostly set themselves up in opposition to further development of cheap renewables, seeing them as a threat to their business model, which was affected by declining demand. The national government was also unconvinced about the importance of adding more renewables to the energy mix, since cheaper energy prices to customers would increase its debt to the electricity companies (the tariff deficit), and the country had invested substantially in gas combined-cycle plants in previous years (Hewitt et al., 2017a). Investors took flight after government signalled that it would no longer support RE (Alonso et al., 2016). However, though civil-society environmental movements are not as strong in Spain as in Germany, anti-austerity coalitions, who were strongly supported by environmentalists and pro-RE activists, took control of major cities (Madrid, Barcelona, Valencia, Zaragoza, Cadiz) in local government elections in 2015. Thanks to this success, pro-transition policies began to be enacted at the municipal level, e.g. energy company remunicipalisations (Barcelona) and transition round tables (Cadiz). Eventually (October 2018), the 'sun tax' was struck down by the national government, and energy transition policies were reinstated.

5. Four scenarios for clean energy transition

The experiences of the four countries described above provide a set of four contrasting implementation scenarios (IS 1-4) for transitioning to clean energy, described in order as follows.

5.1. IS1: civil society takes control (Figure 1)

5.1.1 Narrative

Government energy policy is inconsistent and frequently changing to follow the electoral cycle. However, in this strongly federalised governance system, large, powerful autonomous regions drive transformational change despite federal opposition. Market forces are highly dominant in IS1.

5.1.2 Motivation of key actors

National government has weak and inconsistent motivation to drive clean energy due to its dependence on fossil fuel lobbyists, who inject vast sums of money into political campaigns. Big energy companies, however, are duty-bound to follow shareholders, and poor performance of fossil assets means that many are rapidly decarbonising their energy portfolio, and are thus highly motivated to follow RE. In addition, some of the largest and richest autonomous regions are providing strong support for RE through ambitious targets and incentives. Recent polls show climate scepticism in steep decline and support for RE on the rise. As a result, the relevance of national government to achieving national climate commitments is overstated. The prognosis for RE development is therefore quite optimistic, despite the lack of leadership from national government.

5.1.3. Resources/Power of key actors

In IS1, the market – i.e. investors – is a more important driver than the national government, which is mostly subservient to it despite its ideological opposition to RE. The politics of RE are also closely intertwined with global oil production in this case, since this country remains strongly dependent on energy imports. A key question relates to the power of fossil fuel interests to retain their subsidies in the light of a market that is increasingly turning to clean energy.

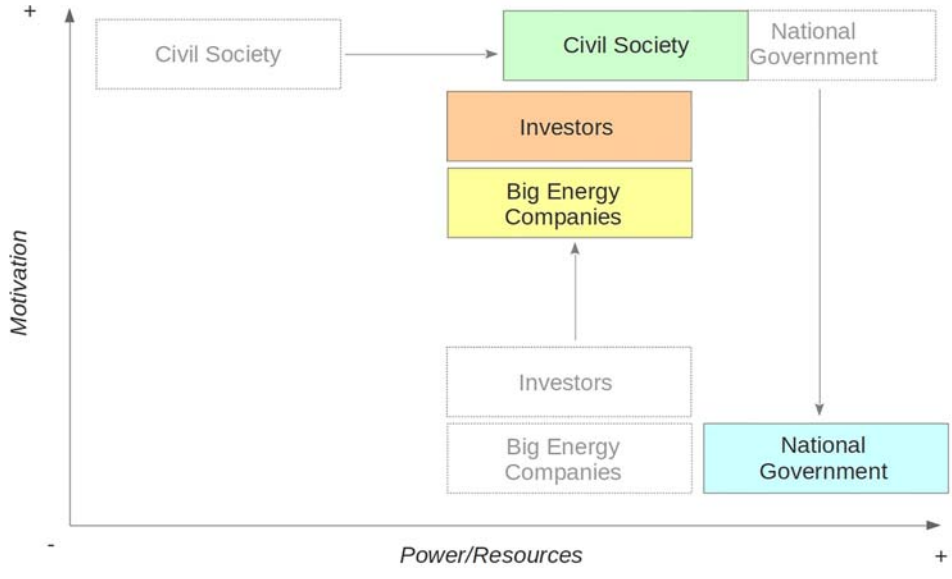

Figure 1. The dynamics of the different actor groups under the 'Civil Society Takes Control' scenario (IS1). Initial actor positions are shown in dashed outline. National government (NG) loses interest in the clean energy transition, and shifts down to the bottom-right corner (high power/resources, low motivation). Nevertheless, this leaves a power vacuum, which is filled by civil society (CS) (citizens, enterprises, powerful regions), shifting right to fill the gap. Investors (INV) and Big Energy Companies (BEN) see opportunities and follow the shifting power dynamic up into the top right to join CS.

5.2. IS2: strong-arm transition (Figure 2)

5.2.1 Narrative

Strong and consistent action to develop renewables from a single party state in a large, resource-rich country with a substantial global economic and environmental impact. Though apparently highly authoritarian, the interaction between different levels of governance provides opportunities for local level actors to develop innovative RE solutions.

5.2.2 Motivation of key actors

In IS2, national government is highly motivated and has driven change through a wide range of measures including subsidies, direct instructions, and forced closures of inefficient and polluting installations and infrastructure. Big energy companies are all state-owned-operators, who, given the direction of the national government, are strongly motivated. However, most electricity is still generated from coal, and coal mining is set to expand, with worrying implications for future emissions. In theory, motivation of civil society is high; in practice there is likely to be considerable discrepancy between regions, depending on local level power dynamics. This leads simultaneously to massive expansion of RE on the one hand, and of coal on the other, because local politicians prioritise short-term economic stimulus provided by building new power plants over other incentives (Ren et al., 2019). In coal-intensive regions, this leads to coal power plant expansion, and RE development elsewhere.

5.2.3 Resources/Power of key actors

The consistency of support, strength of this country's growing economy, and single-minded drive to promote RE has sent a strong signal to investors. Given the strong government-led demand and the vast scale of RE developments, for example in offshore wind, investors see major opportunities. Though citizens are not empowered to drive change under IS2, a high degree of entrepreneurialism in civil society, combined with the reliance of the state on local level actors, means that opportunities similar to those found in democratic states can emerge, such as crowdfunded solar panel schemes.

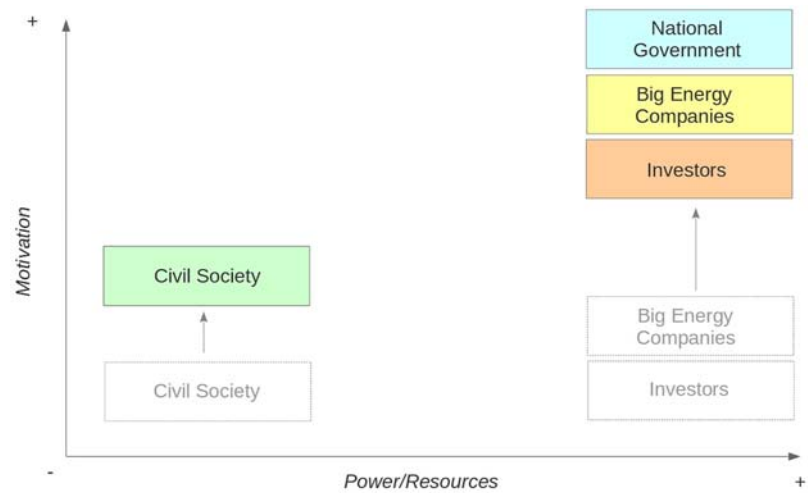

Figure 2. The dynamics of the different actor groups under the 'Strong-arm Transition' scenario (IS2). Initial actor positions are shown in dashed outline. BEN and INV move up to align with NG, creating a powerful coalition with strong motivation and high levels of power/resources, but CS is marginalised, with low resources and little decision-making power. While citizens' motivation may increase over time, they lack the agency to participate meaningfully in the transition.

5.3 IS3: systemic limits (Figure 3)

5.3.1 Narrative

IS3 exemplifies strong and consistent action to develop RE in a medium-sized developed democracy. However, structural changes are difficult to achieve, and despite record levels of RE growth, continued reliance on fossil energy for baseload power means that targets are not met.

5.3.2 Motivation of key actors

National government is strongly and consistently motivated since the country's proportional representation system leads to coalitions and the need to negotiate with advocates of clean energy. Motivation from the private sector is initially insufficient, especially in the case of DNOs, but national government overcomes their opposition by passing new laws. As the boom takes off, big energy companies come on board, in some cases undergoing structural transformations to align themselves with the new energy reality which puts them at risk of collapse (Hörnlein, 2019), eventually making them better prepared for the new age of clean energy. In IS3, citizens are strongly motivated in favour of RE and have high levels of trust in their government.

5.3.3 Resources/Power of key actors

A consistent message and strong incentives from national government, together with a strong, diversified economy, attracts investors and a dramatic increase in RE deployment is achieved in a short time. The country's solar boom drives a worldwide price decrease in solar panels. Civil society is empowered thanks to a strong environmental movement, and RE advocates obtain representation through the electoral system, which favours coalitions.

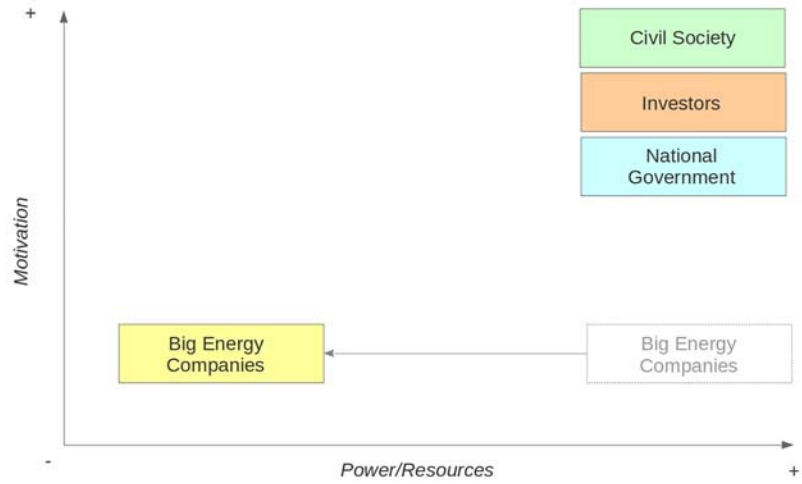

Figure 3. The dynamics of the different actor groups under the 'Systemic Limits' scenario (IS3). Initial actor positions are shown in dashed outline. NG, CS and INV are aligned with strong motivation and high levels of power/resources (upper right corner of diagram), but despite their initiatives, BEN lack motivation to adapt and face economic collapse, shifting to the bottom-left (low power/resources, low motivation), and losing their power to block the transition.

5.4. IS4: renewable austerity (Figure 4)

5.4.1 Narrative

IS4 takes as its starting point a situation of economic collapse, and seems increasingly relevant in the light of the global recession due to the Covid-19 pandemic. In IS4, governments are reliant on foreign aid, which comes

with conditions that make investment in RE more difficult. IS4 also assumes an outdated economic outlook which sees RE as a cost, rather than a necessary investment.

5.4.2 Motivation of key actors

National government has low motivation to promote RE through incentives, as austerity is imposed reducing resources available. Recession and subsequent austerity reduce energy demand, so both government and big energy companies, who may have invested heavily in energy in previous cycles, are opposed to the further expansion of RE. Perhaps government is lightly climate sceptic, and contains some ministers with connections and financial interests in petroleum. Nonetheless, civil society is strongly motivated against the government's decision and pro-RE. Anti-austerity parties adopt a pro-RE stance to increase popular support. The unpopularity of austerity eventually brings down the government and anti-RE laws are abolished. However, the new government is weak, and despite the improved situation, no further action is taken to promote RE for many years.

5.4.3 Resources/power of key actors

National government resources are low, at least compared to the previous non-austerity phase. Civil society has little power – citizens are disengaged with politics, and governance is highly centralised – but becomes stronger as austerity bites. Citizen increase in power is probably connected with economics, not the climate crisis, though climate does influence policies of anti-austerity parties. Because of shared borders with other liberalised economies, big energy companies have become very powerful, so their position on RE is critical. The partly-privatised national grid is a key actor, because increased input of RE requires infrastructure investments which they may be unwilling or unable to make.

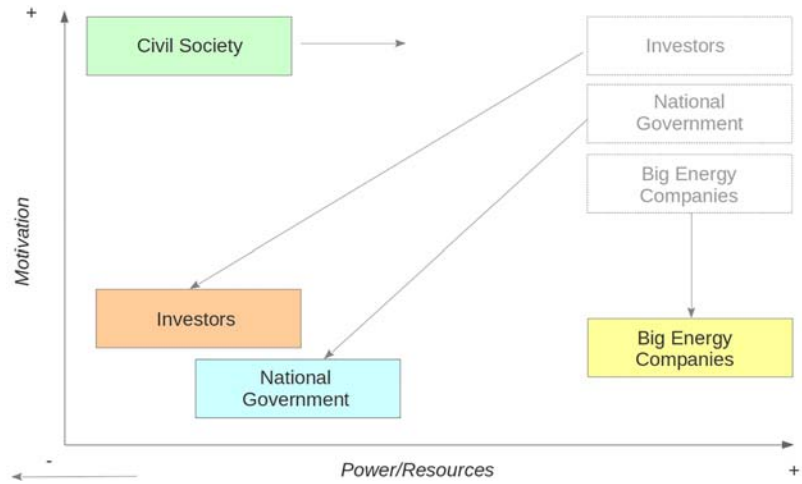

Figure 4. The dynamics of the different actor groups under the 'Renewable Austerity' scenario (IS4). Initial actor positions are shown in dashed outline. NG is faced with declining revenue and loss of independence from international creditors following a recession, and loses its motivation to continue the energy transition, shifting diagonally downwards from the top right (high motivation, high power/resources) to the bottom left (low motivation, low power/resources). INV suffer heavy losses as a result of both the crisis and the government policy U-turn, and also shift diagonally downwards. BEN are deemed 'Too big to fail', and retain their power and resources though public subsidies, but exit RE, concerned that it will affect their profits (shift downwards – low motivation). CS remains motivated throughout the crisis, but is isolated from other actors and effectively disempowered.

6. Lessons for policy implementation

6.1. IS1: civil society takes control

In IS1, a national government keen to prop up fossil fuels would like to impose a nationwide pro-fossils energy policy, but is prevented by powerful regions and markets from doing so. IS1 shows that while supportive

national policy is very important, the lack of such a supportive policy does not in itself guarantee failure. In the US, RE is expanding in spite of opposition from the federal government, and the largest and richest US states (e.g. California and New York) have implemented strongly supportive policies, offering targets, incentives, and reassurance to RE investors (Pischke et al., 2019). IS1, therefore, provides for the economic argument, that an economic tipping point will soon be reached, producing an avalanche of green investment, with fossil fuels finally consigned to the past (Otto et al., 2020). IS1 offers hope for future attainment of Paris Agreement goals through more and better forms of devolved governance. While Europe mostly offers variants of the first-past-the-post or proportional representation styles of politics, which have tended to result in climate policy that either rapidly accelerates in one direction, only to come flying back in the other a few years later (IS4), or becomes endlessly mired in coalitions (IS3), the US shows that progress can be made when responsibility for energy is devolved to regions. At a time when regional identity seems to be on the rise, IS1 offers hope that regions seeking more independence may see local energy autonomy as a way to further their interests, and break away from the constraints of centralising governments tied to the fossil regime. Though based on the US, IS1 seems relevant also to Australia, one of the world's most strongly fossil fuel-dependent economies. Despite continued hostility to climate mitigation policies at the national level, strong support for RE by individual states looks likely to lead to rapid RE growth over the next decade (Li et al., 2020).

6.2. IS2: strong-arm transition

In IS2, we see that in non-or-weakly-democratic countries, governments can potentially implement climate action policies more rapidly and easily than in democratic ones. However, the absence of citizens' voices means that socially-just outcomes cannot meaningfully be delivered, and information about policy implementation failures at the local level is rarely passed up the chain. An outcome where a country meets its emissions targets but does so by repressing its citizens is possible under IS2. A parallel can again be drawn with the Covid-19 crisis, where citizens voluntarily surrender to the state in return for security (from a virus, or from climate breakdown). However, despite the top-down, authoritarian nature of IS2, local dynamics are more important that they first appear, and civil society may enjoy a limited degree of freedom in devising innovative approaches to implementation, as long as the transition aligns with national policy. It seems unlikely that civil society in an authoritarian state would be able to mount effective local energy transitions in opposition to government policy. IS2 offers a counterpoint to the economic argument (see Section 6.1), since the purchasing power of the state under this scenario means that even in a situation of very poor economic perspectives for coal, there is no guarantee that market forces alone will drive it out of existence. Given that a large proportion of the world's consumer goods are produced in developing countries, a satisfactory mechanism needs to be found to equitably share responsibility for the emissions generated between 'producer countries' and 'consumer countries' (see more detailed discussion in Section 6.3, below) elsewhere. Though based on China, IS2-type scenarios are found elsewhere in emerging economies under authoritarian rule, e.g. Thailand (Delina, 2018).

6.3. IS3: systemic limits

IS3 shows that, despite consistent policy and enormous investments, an overly narrow focus on just expanding RE may lead to poor climate mitigation outcomes. Massive expansion of intermittent electricity production without adequate focus on ancillary services (e.g. demand management, energy storage), is a well-documented, though not insurmountable, problem (Brown et al., 2018; Heard et al., 2017). In many countries, not just Germany, energy transition mostly seems to mean more renewable electricity, with much less attention paid to other, arguably equally important, aspects. The UK, for example, has seen a huge expansion of offshore wind, yet the zero carbon home strategy was abandoned in 2015, with no clear successor policy to replace it (Lane et al., 2020). Beyond the Global North, South Africa's energy transformation, for example, faces deep structural problems comparable with an IS3-type scenario (Lawrence, 2020).

A further consideration is that countries in the Global North, especially in Europe, are consumers of goods produced by other countries where emissions-intensive manufacturing is located (see also IS2, Section 6.2, above). Thus, consumer countries, it can be argued, ought to share responsibility for emissions generated by

producers whose goods they import. However, the argument is not as straightforward as has sometimes been presented (see e.g. Helm, 2012). It is true that production-based mitigation approaches effectively let consumer countries outsource their carbon emissions to those parts of the world where their goods are made. On the other hand, a purely consumer-based mitigation approach does not account for the value that accrues to producers (or other actors along the value chain), and moreover, offers them no incentive to switch to cleaner technologies (Tukker et al., 2020).

A second clear lesson is that more robust anti-trust policies are needed to avoid concentrations of power among large, vertically integrated incumbent utilities. In the case of Germany, the lock-in to coal seems to have arisen partly because the incumbent energy companies (the Big Four) failed to adapt, even initially expanding their coal and gas operations (Geels et al., 2017), and subsequently almost collapsed when cheap RE threatened their business model and anti-RE lobbying attempts (so successful in Spain) did not bear fruit (Kungl, 2015). The question of breaking up incumbent power is relevant to the DNOs. Overconcentration, i.e. through a single private operator, is problematic since such actors are likely to be resistant to both grid expansion and decentralisation, as in Spain (Hewitt et al., 2017a). In Germany, this problem was addressed in a range of ways, e.g. by obliging utilities to extend grids, by creating independent grid operators separate from the Big Four, and through an Act of Parliament handing power for grid extension to the federal government (Fuchs et al., 2012).

Thirdly, IS3 shows how pro-RE groups needed to enter into coalitions, in this case to co-opt the anti-nuclear movement, to enable climate action. Coalition-building is usually a slow process, so under IS3, despite an eventual positive outcome, the transition may not arrive in time to stave off the worst impacts of climate change.

6.4. IS4: renewable austerity

IS4 shows that consistent pro-RE policy from governments is needed to drive the transition. It highlights the fact that the existence of supporting policies in the first instance is no guarantee that such policies will be maintained, since, as the German experience shows (Kungl, 2015), powerful actors may struggle to adapt. The Great Recession offered such actors the opportunity to push for withdrawal of support for clean energy policies, citing economic hardship, with success in many parts of Europe, most notably and dramatically in the case of Spain. This has had profoundly negative consequences for the clean energy transition in Europe, with a Europe-wide collapse in clean energy investment after 2012, notably in the UK, Italy and Germany (Galgoczi, 2015). The inevitable economic downturn resulting from the Covid-19 crisis will certainly offer actors who remain opposed a further opportunity to weaken support for climate mitigation. Whether they are successful depends on how much European policy makers are prepared to learn from their mistakes, and how much support anti-transition coalitions can find in the EU administration. The EU post-Covid-19 recovery plan, which underlines the importance of investment in green technology through the European Green Deal, is a positive step in this regard (EC, 2020).

The lessons for policy are clear. Firstly, public incentives for climate mitigation must be tightly ring-fenced, included as a specific clause in any bail-out agreement, like those which followed the European debt crisis after 2009, or, better-still, tied to a 'Green Deal' or 'Green Marshall Plan', where struggling economies with RE development potential are supported by direct investment, low-interest loans, and cross-country skills transfers from stronger partner countries (Creutzig et al., 2014; Hasselmann et al., 2015). It is encouraging that the EU's post-Covid-19 recovery measures are linked, in general terms, to the European Green Deal, and though specific details are lacking, signs of a post Covid-19 recovery boost to clean energy are already emerging in some member states (D'Adamo et al., 2020). Though most clearly applicable to Europe, it may be relevant elsewhere, e.g. Central and South America and Asia, through global financial mechanisms, e.g. the IMF.

Secondly, in economies facing austerity, like Portugal, Greece and Spain after 2009, citizens are likely to be more strongly motivated against the decline in their living conditions than they are in favour of climate policies. Pro-RE political groups will need support from anti-austerity movements. Transition policies therefore need to be delivered as part of a package encompassing social justice values.

Thirdly, the anti-austerity coalitions, on which austerity-hit economies must rely to advance pro-climate policies, often face severe opposition from anti-science, anti-communitarian populist movements allied with the conservative right. In the city of Madrid, a progressive coalition lost power in the 2019 elections, to be replaced by an alliance of the right and the hard right, who immediately set about dismantling pro-environment policies (New York Times, 2019).

Fourthly, the path taken by Spain, on which IS4 was based, was not inevitable. Its neighbour, Portugal, also hit by punishing austerity, remained committed to the goal of promoting RE, though its effectiveness was much reduced (Andreas et al., 2019). IS4 shows what can happen, not what must happen, and serves as an instructive warning. At the same time, while a deep recession is a likely catalyst for an IS4-type scenario, it is not a requirement. A coalition of anti-RE actors can easily argue that the energy transition is 'too expensive' even when there is no real economic hardship being suffered, as shown by Denmark's sudden shift away from supporting RE between 2001 and 2008 (Eikeland & Inderberg, 2016).

7. Discussion

7.1. Where next for the clean energy transition?

Predicting the direction of future policy is a vexed endeavour, as our analysis has shown. The global economic crisis of 2007–2008 was not foreseen, except by a small number of academics who did not have the ear of policy makers. Similarly, the scale and seriousness of the Covid-19 pandemic was not predicted, and while it is likely to have a transformative effect on the drive for cleaner energy systems, it is unclear whether this will be in a positive or negative direction. Our scenarios attempt to manage this uncertainty by showing not what should happen, given certain policies and agreements, but what *can* happen, often in spite of such policies and agreements, and sometimes contrary to apparent logic and accepted wisdom.

In this sense, a key question is whether the rapid and continuous decline in the cost of RE will shift the dynamics of climate change policy from a 'Tragedy of the Commons' dilemma (Hardin, 1968) to a 'First past the post' competition, where the first countries to recognise the change and abandon fossil fuels entirely become the long-term winners, rather than the naïve losers of a short-sighted agreement. However, the costs of transforming large-scale legacy industrial systems are substantial (Davis et al., 2018; Otto et al., 2020), and this even before accounting for resistance from powerful vested interests. Even if these actors ultimately fail, it may be too late to avoid catastrophic climate change (Covert et al., 2016). In this sense, as Otto et al. (2020) have argued, there is a need to pay closer attention to social mechanisms emergent from society over mainstream economic arguments. The results of our study show clearly that we should be wary of single 'one-size-fits-all' solutions to the problem of reducing humanity's climate impact.

For this reason, our analysis has focussed on the role of actors – whether to facilitate or block – a transition to cleaner energy systems, and the political and socioeconomic circumstances that condition their likely response. By systematising this complexity in four key directions we have drawn out useful lessons for policy. IS1 reminds us that noisy opposition from a nation's government does not necessarily mean that nothing will be done inside that country, especially when so much is at stake, and when facilitated by a decentralised, federal system. IS2 shows us that powerful autocracies can make rapid progress, but that this will likely come at the expense of social justice. IS3 reminds us that to be fully successful, we must focus on structural aspects of energy systems, like transmission, storage, and ancillary services, not just on expanding RE generation capacity. If patterns of resource consumption continue to grow into the future, as can be reasonably anticipated, there is virtually no chance that RE can meet the demand simply by increasing capacity (MacKay, 2008). As the Covid-19 crisis plunges economies into recession across the globe, we need to know that IS4, Renewable Austerity, is not the path to follow. Our case studies suggest that some powerful actors will nevertheless try to follow this path.

7.2. Why we need scenarios of climate policy implementation

Neither the RCP nor SSP frameworks include crucial information about the motivations and power of key policy implementation actors or the dynamics that lead to success or failure. The extended SSP narratives (see, e.g.

Appendix A in O'Neill et al., 2017) do offer some potential links with our implementation scenarios which might be explored in future work. For example, echoes of our IS3 (Systemic Limits) can be found in the reference to 'Limits to mitigative capacity' in SSP2, while our IS2 (Strong-arm Transition) has clear parallels with the strengthening of authoritarian regimes mentioned in SSP3. Commonalities between IS1 (Civil Society Takes Control) and IS4 (Renewable Austerity) and other SSP narratives described in O' Neill et al (2017, Appendix A) can also be identified. However, in their present form, the SSPs lack systematic assessment of the causal relationships between specific actors and climate policy outcomes. The work presented in this paper seeks to better guide implementation of the necessary actions by shifting the emphasis in this new direction.

A further key problem is that the SSP and RCP framework gravitates around providing alternatives to RCP8.5, a baseline scenario with no mitigation efforts, and the evaluation of policies that could provide alternatives to this baseline (Hausfather & Peters, 2020). However, as our results indicate, the assumption that RCP8.5 is the baseline scenario is questionable, since, however pessimistic we may be about the delayed nature of effective action, it seems unlikely that nothing at all will be done. The joint dynamics of market forces and of emerging coalitions of regional and local governments with civil society actors in IS1, based on the US case study, strongly contradict this idea, and show the RCP8.5 baseline to be an unnecessary and misleading reference point. Secondly, some of the underlying economic assumptions are also problematic. The idea that anything that deviates from the RCP8.5 baseline is likely to be more expensive than that scenario is highly questionable. It seems to be mainly based on the simplistic argument that any mitigation is more costly than no mitigation. In fact, these measures of value are based on outdated methods of economic equilibrium and on limited measures of the economy like gross domestic product, and hence provide little help on the development of positive futures based on what humanity values in the broader sense (see e.g. Hasselmann et al., 2015). Attempts to account for some of the limitations of the SSPs regarding policy led to the development of a third tier, after RCPs and SSPs, known as 'shared climate policy assumptions' (SPAs), which describe certain policy-making assumptions that help to compare and couple modelling exercises (Kriegler et al., 2014). Unfortunately, the SPAs, which are infrequently used, do not inform about the complex dynamics demonstrated by our scenarios. Our scenarios could, however, be used to inform further development of the SPAs.

7.3. Four implementation scenarios: limitations and future work

The four scenarios discussed in this paper are representative, rather than comprehensive. However, analysis of the policy context of different case study countries might allow our framework to be refined or offer alternative narratives. A focus on emerging economies (e.g. in Asia or Africa) might reveal different policy dynamics and actors not discussed here, for example, donor countries or NGOs.

Secondly, although these scenarios are derived from real-world experiences, this should not constrain the policy lessons they offer to narrow utilitarian or instrumentalist channels (Lövbrand, 2011; Wittmayer et al., 2020). Successfully tackling the climate problem requires deep innovation – open-ended novelty, not politically acceptable metastability (Winder, 2007). Neither is it intended to imply that scenarios represent 'lock-in' to a particular pathway, or that no overlap is possible between them. Instead, they are best thought of as coordinates in a policy landscape, in other words, waypoints that indicate – but do not absolutely determine – future outcomes. By extending the timeline forwards or backwards, the scenarios can be seen to overlap and merge. For example, Spain's vigorous RE policy drive, unbroken between the late 1980s until 2012, is clearly analogous in some senses to the ongoing German *Energiewende*; might the economic decline propitiated by the Covid-19 crisis prompt some national governments struggling with 'Systemic Limits' (IS3) to drop RE (e.g. to back gas instead), shifting into an IS4 scenario (Renewable Austerity), just as Spain did in the years following the global financial crisis?

Finally, though the scenarios aimed to draw general lessons from national level experiences, current norms of global climate governance (see, e.g. Bäckstrand & Lövbrand, 2016) mean that not all are equally likely; effort needs to be made to open up specific policy spaces for particular scenario pathways to thrive. For example, 'Civil Society Takes Control' (IS1) seems unlikely to extend into countries which lack devolved governance to regions, at least in terms of energy planning, if not a fully federalised system. It would also seem to require a stronger global emphasis on empowering bottom-up coalitions of actors if it is to become a global norm. In Europe, for example, despite

cautious support for small-scale, community-driven RE (Krug and di Nucci 2020), policy makers remain wedded to the liberalist paradigm of 'letting the market decide', even though the market remains structured in favour of larger companies (see e.g. Oppen et al., 2017). However, IS1 also leaves room for differing interpretations of 'civil society' – the US case study from which this scenario was drawn sees climate action driven by coalitions of non-state actors from the business sector, rather than the kinds of grassroots initiatives envisaged in the community energy literature (e.g. Hewitt et al., 2019; Seyfang et al., 2013). The fact that liberal democracy has tended to subvert environmental necessities to the demands of economic growth (narrowly defined) resulting in a depoliticisation of climate policy (see e.g. Kythreotis, 2012; Swyngedouw, 2011; Weisser & Müller-Mahn, 2017), suggests a bifurcation of IS1 into 'Big business takes control' and 'Grassroots activists take control' pathways. The former, in the current global climate governance context, seems more likely than the latter.

In this sense, the 'Strong-arm Transition' scenario (IS2), though exemplified by China, has some (disconcerting) parallels in democratic countries, where enormous RE installations are rapidly developed by incumbent multinationals, with minimal assessment of long-term impacts and little citizen participation. Such is the case, for example, of the UK's ongoing offshore wind expansion programme, leading to concerns that policy emphasis has shifted from 'community energy' to energy that is merely 'local' (Devine-Wright, 2019). Current indications are that the energy transition may be succeeding in its narrowest environmental terms (cleaner energy, lower emissions), but failing to bring about the hoped-for democratisation of energy that it was thought to presage (Burke & Stephens, 2017; Szulecki, 2018).

8. Conclusions

By analysing the implementation experiences of the world's two largest emitters (US and China), and representative countries – Spain and Germany – from the third largest emitter (Europe), we have proposed four scenarios which reflect the ability and constraints of key actors to implement energy transition policies within particular contexts. These scenarios are independent from the professed aspirations of governments to 'combat climate change' because they include the constraints that actors face in the real world. They are designed to be applicable to a much wider range of countries than the cases from which they have originally been drawn. Future work might usefully explore the dynamic nature of the scenarios, e.g. through system dynamic, network, or agent-based modelling approaches (see, e.g. Kovalevsky & Hasselmann, 2014). Such work could show how policy shifts driven by different actor coalitions can move around the scenario landscape, giving rise to outcomes that are richer, more unexpected and more regionally diverse than the 'salvation or catastrophe' framing that is prominent in much existing scenario discourse.

Implementation theory approaches can help unpick the complex causal relationships between national contexts, climate policy actors, and outcomes, thus enabling social learning from previous successful and unsuccessful experiences. Scenarios like the ones we propose in this paper are therefore arguably more useful to planners and policy makers than 'implementation-free' scenarios like the SSPs and the RCPs. We hope that these kinds of approaches will play a stronger role in mainstream climate science in future.

Note

1. 65% of China's electricity comes from coal, and more than 200 new coal plants are planned or under construction (Mallapaty, 2020). However, the country's recent pledge to achieve carbon neutrality before 2060 would imply the cancellation of these projects. It remains unclear if this can be realistically achieved.

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ORCID

Richard J. Hewitt http://orcid.org/0000-0003-4169-8647
Roger Cremades http://orcid.org/0000-0002-4514-2462

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Appendix: Selected recent literature on actors' role in implementation of low carbon energy systems

Reference	Summary finding
US	
Andrade & Olivera (2015)	Difference in the way lobbying is carried out between Europe and the US means that 'firms in the United States have been able to contest the scientific rationales for environmental action more openly and directly'.
Hess (2016)	Utilities lobbied at state level to block distributed solar generation. Though they were successful in many states, they were partially or completely defeated in others.
Downie (2017)	Political resistance from incumbent fossil fuel industries can be overcome by strengthening existing interests via targeted sector-specific policies; exploiting inter-industry and intra-industry divisions; and shifting existing interests with policies that induce changes in industry investment and structure.
Pischke et al. (2019)	These authors examine the effectiveness of renewable energy policy in five federal countries (Argentina, Brazil, Canada, Mexico and the United States) focusing on 'policy output', which is defined as a function of policy density (number of policies) and intensity (effectiveness of policies). The US had the highest policy density, but ranked below Brazil and Canada and Argentina in policy intensity. In the US, 'states and provinces have taken a leading role … in the absence of federal government leadership'. Renewable energy development can be supported even where there is no political will or support to enact climate change policies because actors can support RE for other reasons. Some states and provinces (California, Maryland and New York) were found to be more active at renewable energy policy-making than others with multiple policies, targetting various government sectors.
China	
Andrews-Speed (2016)	State-led massive scale funding may sidestep the need for subtle policy instruments. Local governance – some institutional experimentation within state defined limits. Chinese society is energetic and entrepreneurial, e.g. crowd funding to finance solar PV overcomes state-owned banks' reluctance to lend. Civil society organisations and NGOs are tightly controlled – can report implementation failures and raise policy challenges but not engage in policy deliberation or design.
Lo (2015)	Despite highly authoritarian national policy, China's low carbon energy strategy is more flexible than is commonly understood. A high degree of local autonomy has resulted in a situation of de facto liberal environmentalism. Rather than simply assuming 'environmental authoritarianism', the study of China and other authoritarian states requires an understanding of the connections between local and national policy.
Li et al. (2019)	Examines the use of renewable portfolio standards (RPS) to promote large-scale renewable energy integration and consumption in China, using policy network theory to analyse the interactive relationship of stakeholders. The structure of the policy network around RPS was initially very stable, with clear hierarchies and high barriers to entry, but over time the network hierarchy became more horizontal and inclusive. These findings suggest a relaxation of top-down control and the emergence of a renewable energy implementation system based on negotiation between key actors.
Tseng and Habich-Sobiegalla (2020)	A critical perspective on China's use of policy pilots as tools to implement the clean energy transition. It is found that the pilots have effectively mobilised actors to rapidly expand renewable power generation without strong government direction, but integration of renewable energy into power grids has been unsuccessful. Rapid expansion in the wind sector has created overcapacities with high levels of curtailment. Four reasons are identified for the difficulties encountered. (1) The policy pilots' experimental nature tends to exacerbate diverging interests between local and central authorities, (2) local officials are responsible for planning and design of policy pilots often lack technical expertise and capacity to successfully execute them; (3) vested interests and fragmentation of the Chinese energy sector has

(*Continued*)

Continued.

Reference	Summary finding
	prevented successful scaling up; (4) political system prevents reporting of problems, and thus one key advantage, that of revealing policy imperfections, is lost.
Germany	
Kungl (2015)	Examines the response of the Big 4 Germany Energy companies (incumbents) to the German energy transition (*Energiewende*). The Renewable Energy Sources Act (EEG) protected RE providers from incumbents, and increased the share of RE, affecting the incumbents' profits. Incumbents were slow to adapt to the clean energy transition and eventually entered a state of serious crisis. Lobbying activities ultimately failed and the companies were forced to adapt.
Berlo et al. (2016)	The establishment, or re-establishment, of municipal level power utilities (remunicipalisation) is a powerful way of overcoming resistance of incumbent actors (large utilities). The current legal and policy framework around such takeovers is a serious barrier to remunicipalisation.
Andrews-Speed (2016)	Widespread popular support for the *Energiewende* from German society has been key to its success. Maybe rooted in environmental movement and anti-nuclear protests, maybe also roots in romantic philosophy of nature e.g. Schelling, Goethe and Hegel.
Geels et al. (2017)	Underlines the fortuitous nature of key developments, repeated attempts by utilities to block phase out of coal and nuclear, importance of early industrial success (turbine manufacturers) and civil society coalitions, esp. anti-nuclear. Risk of collapse of big energy firms, who adapted late and poorly to the *Energiewende* ('too big to fail') ultimately slowed the transition.
Spain	
Alonso et al. (2016)	RE implementation in Spain has not been resilient, since it is over-reliant on key stakeholders (national government, big energy companies) who can sabotage the system, as happened following the RE moratorium of 2012. Large regional differences in implementation, with more successful regions having more closely linked RE stakeholder communities. Change in national policy required to restart the clean energy transition.
Solorio and Fernandez (2017)	Emphasises the role of the EU as an important actor in driving Spanish RE policy, both for good (EU funding of projects and energy market liberalisation directives) and for bad (imposition of austerity which halted developments).
Gabaldón-Estevan et al. (2018)	Emphasises the excessive power of energy incumbents and suggests that Spanish energy policy has been driven by their demands. Results in a lack of trust by local and foreign investors and limits social innovation potential.
Romero-Rubio and Andrés-Díaz (2015)	Small-scale and locally owned RE providers (Sustainable Energy Communities) face important structural barriers in Spain, when compared to Germany, something that has restricted their uptake. These include a less favourable support regime, structural issues (cooperatives could not market electricity until 2010), and post-2012 policy barriers to small scale RE.