Democracy and Electricity: Institutions, Industrial Representation and Technology Deployment Rates

Introduction

In this article we investigate empirically the joint effects of the democratic attributes of countries' formal political institutions and the political influence of industry on electricity preferences and deployment rates. Electricity generation and consumption account for around three-quarters of greenhouse gas emissions worldwide, putting the power sector at the centre of efforts to mitigate global climate change (Ritchie and Roser 2020). It is, therefore, widely agreed that significant emissions cuts need to be undertaken in the electricity sector to meet an ambitious temperature target as set by the 2015 Paris Agreement (IEA 2021). An important part of this effort involves transitioning from fossil fuels to low-carbon energy sources such as renewables; a move which, according to leading energy forecasts, has the potential to provide 39 percent of the necessary reduction in energy-related carbon emissions by 2050 (IRENA 2019).[1]

Yet despite its urgency, the path of global energy transition has been staggered and uneven; while some, such as EU member states, have embraced change and pledged to achieve a carbon neutral economy (EC 2018), the majority have been protective of the core position occupied by fossil fuels in the power sector.

Countries' divergent energy preferences have been attributed to several factors such as, for example, the political influence of interest groups (Marques et al. 2010; Cadoret and Padovano 2016), repercussions of the energy transition on employment and the national economy (Bogdanov 2019; IEA 2017; Teske et al. 2018; Brown et al. 2018), linkages to international issue-areas (Bobrow and Kudrle 1979), the quest for energy security (Gan et al. 2007; Chien and Hu 2008) and the unequal positions that countries occupy in the world economy (Parks and Roberts 2006; Betsill et al. 2006). Yet all of these explanations originate from the assumption that political actors design energy policy with one fundamental goal in mind - to remain in power by deploying the most politically expedient energy sources.

While numerous studies have found evidence that political factors influence electricity deployment (e.g. Henisz and Zelner 2006; Marques et al. 2010; Cadoret and Padovano 2016; Bogdanov 2019; Teske et al. 2018; Bobrow and Kudrle 1979; Gan et al. 2007; Chein and Hu 2008; Parks and Roberts 2010), most quantitative work focuses on cross-sectional differences between countries (e.g. Bayer and Urperlainen 2016; Menz and Vachon 2006; Carley 2009; Yi and Feiock 2014), which creates the possibility that observed correlations might be due to other (unmodelled) factors that vary between-countries or (supranational) regions rather than political drivers.[2] In contrast, we employ a three-level hierarchical model consisting of country-years nested in countries, which are further nested in regions, to isolate the effects of fluctuations in the levels of democracy and industrial strength within the same country and region, thereby eliminating the possibility for country and regional confounding.

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[1] The remaining emissions reductions need to be derived from electrification of heat and transport, improvements in energy efficiency and deployment of negative emissions technologies (IRENA 2019).

[2] Unmodelled factors might include, for example, national culture, risk perceptions, technological know-how, public knowledge of environmental issues and media coverage of climate change.

We make two core novel contributions to the literature. First, we examine how two elements of the domestic political setting influence political actors' energy preferences and deployment rates – (i) the democratic attributes of formal political institutions that shape the political incentives (and disincentives) attached to different energy sources; and (ii) industrial energy consumers who comprise a key interest group with the potential to utilise the democratic pathways available for civil society to influence policymakers. We also subject two of the leading political explanations of electricity deployment – regime type and interest group pressure – to stricter quantitative tests by investigating whether they continue to wield explanatory power when the possibility for country and regional confounding is eliminated.

This paper consists of five sections. The first section draws on the scholarship on the political motives behind energy deployment, political regimes and energy preferences and interest group politics to set out the theoretical approach of our analysis. Section two describes our research design. The third section discusses the results of our empirical analyses and is followed by section four, which evaluates the robustness of our findings when we use different proxies to measure democracy. We conclude by reflecting on the theoretical contributions and empirical implications of our findings.

Theoretical framework

This section draws on three bodies of literature to formulate the theoretical foundation of our hypotheses. The first literature focuses on the political motivation behind policymakers' deployment decisions as well as the factors that underlie expectations about political returns from energy sources. The second part draws on the scholarship on political regimes and energy preferences to identify causal pathways through which democratic political institutions can promote or hinder the deployment of different energy sources, focusing particularly on the distinction between renewables and fossil fuels. The third part discusses the literature on interest group politics to provide a framework for studying the role of an important political actor – industrial energy consumers – in moderating the effect of democracy over energy deployment.

Political motivation behind energy deployment

Electricity deployment is fundamentally a political affair. First and foremost, governments decide which energy infrastructure to finance based on the expected positive return in terms of political support (Henisz and Zelner 2006; Yi and Feiock 2014; Brown and Mubarak 2009), whether this be exercised by the number of votes cast in support of elected governments or quiet acquiesce to appointed rulers. Since the generation, transmission and distribution of electricity require large sunk costs and economies of scale (Bergara et al. 1997), most energy projects start out as government initiatives, making deployment decisions directly traceable back to political actors (Brown and Mobarak 2009).

Which factors determine the political returns associated with different energy sources? Although the precise costs and benefits of deployment decisions faced by political actors are difficult to measure, the scholarship identifies several sources. Perhaps the most obvious is the effect of energy preferences on the national economy (Bogdanov 2019; Teske et al. 2018; Pursiheimo et al. 2018; Brown et al. 2018). Energy is a key input into almost all economic activities, therefore, any change in energy preferences has significant repercussions on operating costs throughout the economy. Deployment decisions have also been shown to affect employment, although there is no consensus on which energies are likely to create more jobs (Ortega et al. 2015; Bohringer and der Werf 2013; Frondel et al. 2010; Yi and Feiock 2014). Whatever the outcome, deployment-driven interference in the economy generates winners and losers, creating strong attitudes towards energy policy, thereby significantly shaping political actors' expectations of political returns. A third political (dis)incentive to deployment is the effect of energy infrastructure on proximate areas. Power plants are land intensive and, depending on the energy source, affect the close environment (e.g. environmental health, aesthetics and noise levels), shaping local attitudes towards deployment (Yi and Feiock 2014). Some scholars explore the role of political ideology in shaping attitudes towards different energy sources. Accordingly, exponents of leftist political ideologies are supposedly more supportive of renewables compared to adherents of rightist ideologies, who are allegedly more supportive of fossil fuels (Chang and Berdiev 2011; Biresselioglu and Karaibrahimoglu 2012). Presumably, then, policymakers' affiliations to political parties determine which deployment decisions are likely to be politically viable among target voters who prescribe to their party's ideology. Other lines of enquiry explore the linkages between deployment decisions and related issue-areas such as energy security (Gan et al. 2007; Chien and Hu 2008) and national competitiveness in the world markets (Fisher 2006).

Building on this literature, we assume that political actors design energy policy to maximise political support by financing electricity infrastructures that balance the (often conflicting) interests of their constituents in energy and other areas. We do not observe political actor's motivations or causal pathways directly; but rather, study the effects of two observable sources of political returns attached to deployment decisions - the level of democracy in countries' formal political institutions and the strength of industrial energy consumers – on energy deployment rates.

Political regimes and energy preferences

Invoking Kant's (1983) well-known thesis,[3] the International Relations literature has become replete with claims that democracy can solve some of the world's most pressing problems such as, for example, war (Schultz 1999; Maoz and Russett 1993), global poverty (Ross 2006) and trade protectionism (Mansfield et al. 2002; Milner and Kubota 2005; McGillivray and Smith 2008). The environmental strand of this scholarship argues that, for various reasons[4], democracies outperform autocracies in the provision of environmental quality (Barrett and Graddy 2000; Burnell 2012,2014; Farzin and Bond 2006; Battig and Bernauer 2009; Bohmelt et al. 2015). Several scholars have extended this argument to the energy sector by arguing that democratic superiority in environmental matters predisposes open political regimes to be more accommodating to greener, low-carbon energy sources such as renewables relative to closed regimes (e.g. Marques et al. 2010; Yi and Feiock 2014; Cadoret and Padovano 2016; Bayer and Urpelainen 2016; Brown and Mobarak 2009). Yet the reluctance of some of the world's strongest democracies to undermine the central role of fossil fuels in the

[3] The democratic peace thesis draws on the observation that democracies do not war with each other and asserts that world peace can be achieved if all countries become democracies.

[4] Burnell (2012) provides an excellent overview of the various reasons why democracies should be better at mitigating climate change than authoritarian states.

electricity sector as well as the unprecedented scale of renewable energy deployed by some closed political regimes suggests that the democracy-energy transition thesis does not always hold. Indeed, a growing body of contradictory empirical findings (e.g. Yi and Feiock 2014; Stepping and Banhlzer 2017; Held and Hervey 2007; Winslow 2005) suggests that democracy also has the potential to obstruct energy transition.

This section draws on these arguments to map out how the democratic attributes of political regimes can affect the deployment of a wide range of energies, with particular emphasis on the implications for energy transition. Specifically, we theorise the influence of democratic political regimes over energy technology deployment by focusing on five core distinctions between democracies and autocratic regimes, namely; accountability, the prevalence of corruption, opportunity for civil society activism, protection of individual freedoms and time horizons. First, an extensive literature claims that democracies excel at providing widely distributed public goods because of the strong incentive that political actors face to secure political support in the next round of elections (e.g. Olson 1993; Brown 1999; Bueno de Mesquita et al. 2003; Brown and Mobarak 2009). Conversely, autocratic rulers only need to satisfy a narrow 'winning coalition' (such as military or economic elites), making it more rational to provide goods to exclusive groups (Wurster 2013). Indeed, several studies have found that democracies outperform autocracies in the provision of environmental public goods (e.g. Barrett and Grady 2000; Battig and Bernauer 2009; Bhattarai and Hammig 2001). Since environmental quality is highly dependent on outputs from the energy sector, the strong political incentives for environmental goods in democracies should presumably create an additional pressure to transition to sustainable energy practices (Burnell 2012,2014; Szulecki 2017). Therefore, when faced with equal demand for environmental goods, elected political actors should be more willing to deploy renewable energy and wean off fossil fuels than appointed officials in more closed political regimes (Bayer and Urpelainen 2016).[5]

Second, owing to its comprehensive system of checks and balances and emphasis on transparent policymaking, democracy is widely regarded as an effective antidote to political corruption (Daimond et al. 1990).[6] Corruption is associated with poor government quality and impairs the responsiveness of political actors to citizens' demands, reducing the efficiency of policy implementation (Cadoret and Padovano 2016). This matters for energy deployment because inefficient governments struggle to implement the fiscal measures (e.g. renewable subsidies and carbon taxes) needed to finance deployment decisions, particularly those that channel resources away from traditional fossil fuel actors to renewable interests (Fredriksson and Svensson 2003; Hughes and Urperlainen 2015) and attract the necessary investment for R&D in low-carbon options (Cheung et al. 2019). Laird and Stefer (2009), for example, show empirically that greater institutional capacity in Germany relative to the US was critical in facilitating its early success in renewable deployment. Furthermore, the nature and scale of change required for the energy transition requires institutional stability over a long period of time - a quality that is not usually forthcoming in authoritarian political contexts (Olson 2000; Gandhi 2008). Compounding this, autocracies also have much greater difficulties transitioning to new political leadership

[5] To be clear, the argument is not that democracies have higher demand for environmental goods, but rather, that democratic politicians are more sensitive to these demands than autocratic counterparts.
[6] Indeed, the V-dem index lists (inverse) corruption as a proxy for the level of democracy.

without experiencing ‘succession crisis’ (Niskanen 2003). In democracies, on the other hand, clear election rules and institutional continuity between successive governments provide politicians with the socio-political stability and policymaking space needed to resculpt the energy sector in line with energy transition (Wurster 2013; Ward 2008).

Third, by promoting freedom of expression and providing increased opportunity for civil society to influence policymaking, democracies create more channels for stakeholders to shape deployment decisions. While this means that environmental activists and low-carbon industries can exert more pressure over energy policy, actors with conflicting interests such as fossil fuel lobbies also gain access to similar channels. Furthermore, local populations, which are most directly affected by energy generation, can also mobilise to influence (and sometime obstruct) deployment decisions. Therefore, by allowing the universe of actors to voice their perspectives, democratic pluralism raises the risk of inaction, constraining deployment all around (Weinberg 1990). In contrast, autocratic rulers forego the complex and time consuming process of balancing different interests, allowing them to reach and implement deployment decisions more efficiently than their democratic counterparts (Feiock et al. 2003). Indeed, various scholars (e.g. Beeson 2009; Wurster 2011) have proposed that ‘autocratic steering’ may be the necessary and logical solution to overcome the opposition of ‘manifold stakeholders who see ecological measures [such as the transition to renewable energy] as detrimental to their short-term economic interests’ (Fliegauf and Sanga 2010:2).

While the complexity of balancing multiple interests gives us reason to expect that energy deployment is more difficult in democracies in general, the precise effect of democratic pluralism on the deployment of different energy sources depends on the relative strength of various political actors in each national context. Thus, for example, countries with stronger fossil fuel industries might face higher political pressure to resist the energy transition and safeguard coal, oil and gas energy whereas democratic pluralism in countries that host stronger low-carbon industries should facilitate relatively easier deployment of wind, solar, geothermal and hydro energy. Furthermore, competing interests might be more obstructive to decision-making when political power is distributed evenly between different interest groups (Olsen 1971).

Fourth, owing to their core emphasis on individual freedoms, democracies are generally reluctant to intervene in markets and interfere with individual lifestyle decisions (Battig and Bernauer 2009). Autocracies, on the other hand, are presumably more comfortable imposing top-down policies and regulating individual behaviour (Beeson 2010; Hobson 2012). We argue that this distinction makes different political regimes more accommodating to different structures of energy source. Specifically, there is an important distinction between the deployment of conventional large-scale sources such as coal, gas and nuclear and renewables such as solar and wind, which can be deployed in different areas on a smaller scale (Szulecki 2015). Given their apparent political capacity to implement centralised projects, it is reasonable to expect that autocratic regimes will be better at deploying large-scale energy sources and open political contexts decentralised, small-scale energy sources (Burke and Stephens 2018).

Fifth, the conflicting time horizons faced by political actors in democracies and autocracies create different incentives for energy deployment. Since the chief priority of elected policymakers is to garner enough political support for the next election round, democratic rulers hold relatively shorter time horizons than appointed political actors (Bluhdorn 2011; Wurster 2013).[7] Shorter time horizons have been shown to cause officials to adopt myopic policies that improve immediate conditions while generating negative long-term consequences (Lipscy 2018). These distinct time horizons can affect energy deployment in two ways; on the one hand, since one of the fundamental incentives for transitioning to renewables is the promise of environmental quality in the future, shorter time horizons can reduce the political motives for elected policymakers to deploy renewables, particularly because they do not expect to remain in office by the time the environmental benefits materialise. In contrast, autocratic rulers generally have longer time horizons and can be expected to support renewable energy from a long-term planning perspective (Yi and Feiock 2013; Beeson 2012).

Yet decentralised, small-scale projects such as installing solar panels on a building roof require less time to deploy than traditional fossil fuels, which involve building large-scale plants. Furthermore, with the appropriate infrastructure and market conditions in place (which usually are in democracies), local producers of energy can also become electricity suppliers, providing additional immediate benefits (Inderberg et al. 2018).[8] Therefore, from a time-incentive perspective, small-scale renewable deployment projects can be more appealing for democratic political actors with shorter time horizons than traditional large-scale options. Conversely, autocratic rulers who do not face similar time constraints can be more open to deploying large-scale energy technologies such as building a fossil or nuclear energy plant.[9]

Table 1 summarises the five theoretical pathways through which democracy can affect energy technology deployment, with an emphasis on low-carbon sources (namely: geothermal, hydro, nuclear, solar and wind energy) that are compatible with energy transition.

[7] Based on data covering the last 150 years, the average time in office for a democratic leader is around five years and twelve years for an autocratic leader (Goemans et al. 2009).

[8] Small scale end-users who generate power for their own use and export back into the electricity system are referred to as 'prosumers' in the literature.

[9] The promise of more immediate benefits could also make decentralised deployment more appealing in closed political contexts.

Attribute	Democratic pathway	Autocratic pathway
Accountability	The desire to secure political support for re-election makes policymakers eager to deliver public environmental goods by, for example, deploying more low-carbon energy sources. On the other hand, in resource rich countries, elected policymakers might have incentives to deploy high-carbon energies that employ large segments of the population.	Autocratic rulers are only accountable to narrow interests and are, therefore, relatively immune to political demands for environmental public goods, removing an important incentive for renewable deployment.
Prevalence of corruption	Democratic checks and balances inhibit corruption, increasing the ability of governments to implement deployment decisions.	The lack of democratic checks and balances makes autocracies more prone to corruption and instability, making it difficult for governments to deploy more energy.
Opportunity for civil society activism	Increased avenues for diverse interests to influence policymaking might obstruct decision-making by involving more (competing) actors.	Autocratic rulers bypass the need to balance competing interests and can therefore 'steer' deployment decisions more efficiently.
Protection of individual freedoms	Democracies are reticent to intervene in individual lifestyle decisions, making it difficult to implement large-scale projects. This open environment is conducive to decentralised, small-scale energy such as solar and wind technology.	Autocracies are more comfortable imposing centralised, top-down projects, assisting the deployment of large-scale energy. Conversely, the closed political environment inhibits decentralised energy deployment.
Time horizons	Because elected officials are unlikely to be in office by the time that benefits of energy transition materialise, there is a disincentive against initiating centralised energy projects in democracies. However, this is counterbalanced by the shorter period required for deploying decentralised energy technologies.	Autocratic rulers have longer time horizons and, therefore, greater incentive to deploy energy projects which require longer times to deliver benefits.

Table 1: Regime Pathways to energy technology deployment.

H1A: Marginal deployment (TWh) of energy sources for electricity generation increases as the level of democracy in a country rises, ceteris paribus.

H1B: Marginal deployment (TWh) of energy sources for electricity generation declines as the level of democracy in a country rises, ceteris paribus.

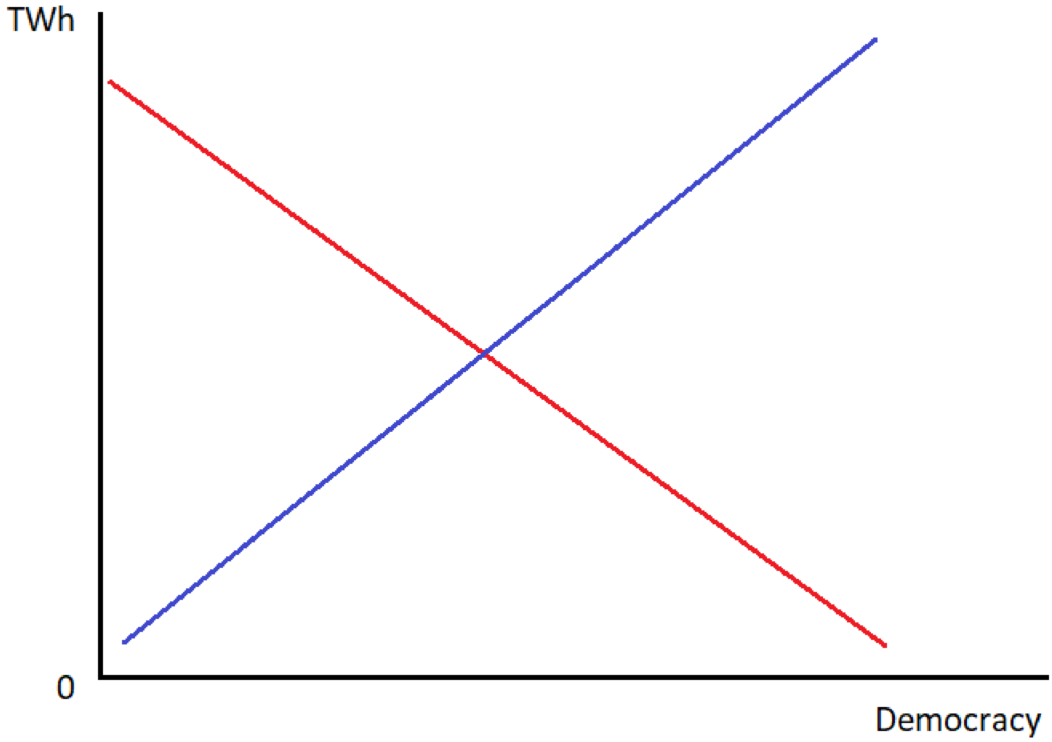

Figure 1: Democracy and energy technology deployment.

Interest group politics and industry

While the political regime shapes the policymaking environment by, for example, determining which channels are open for nongovernmental interests to express their energy preferences, it is ultimately down to stakeholders to exploit the available channels of activism, thereby bringing the political context to bear on policy outcomes. Thus the last part of our theoretical approach draws on the literature on interest group politics and energy security to look more closely at one of the pathways through which, we proposed, democracy affects energy deployment – namely; the opportunity for civil society activism.

A substantial literature explores how distributional conflicts between interest groups shape policy outcomes (e.g. Bueno de Mesquita et al. 2001; Foster and Rosenzweig 2001, Grossman and Helpman 2001). Cohering with the energy deployment scholarship, this approach attributes political actors' decisions to political incentives (Henisz and Zelner 2006). Accordingly, the most powerful groups that wield the greatest political influence are those who are the most concentrated and stand to receive the highest per capita benefits (and losses) from policies, providing them with strong incentive to take advantage of available channels of political influence (Milner 1987). Political influence can take various forms such as, for instance, voting, mobilising other interest groups to influence policymaking and using economic power to pressure political actors. Yet we focus on lobbying as a close approximation of civil society activism.

Which interest groups are salient in energy deployment policy? One can identify multiple diverse energy interests such as, for example, industry, agriculture, environmental actors, residential consumers and local constituents. Yet since industry consumes around 54 percent of energy worldwide (IEA 2018),[10] it is likely that this group will collectively experience most of the benefits and losses associated with energy deployment. So critical are industrial interests to the energy sector that energy security is often operationalised as industrial energy intensity (Sovacool et al. 2011). Furthermore, industry possesses political organizational advantages over other groups as members are relatively concentrated and likely to have pre-established communication channels through trade unions and other associations, allowing its members to lobby effectively for shared interests (Henisz and Zelner 2006).

If industrial energy consumers comprise an interest group in energy politics, it is an extremely diverse one indeed. Moreover, given that many industrial energy consumers (e.g. the fossil fuel and renewable energy producers) champion opposing policies towards energy transition, there might be an argument that industry would be better regarded as separate interest groups.[11] However, we concur with many others (e.g. Henisz and Zelner 2006; Sovacool et al. 2011; Xia et al. 2011; Brown and Mobarak 2009) that, despite their diversity, industrial energy consumers share certain fundamental interests in electricity deployment which warrants their treatment as a single interest group. First and foremost, since industry relies on energy as a critical input into just about all forms of activity, the group has a primary interest in energy security (Henisz and Zelner 2006; Brown and Mobarak 2008). While there is still much debate about the various attributes that constitute energy security, there seems to be an implicit consensus that reliability and stability of energy supply are at the core of the concept, with affordable energy frequently cited as a secondary but integral concern (Sovacool et al. 2011; Lucas et al. 2016).[12]

How does industry's fundamental interest in energy security influence its position towards energy deployment? At first glance, one might assume that energy security drives industry to favour fossil fuels over renewable energy. After all, traditional energy sources are more familiar and tend to be deployed through centralised energy structures, allaying some consumers' concerns about transmission and regulation failures. Such fears are reinforced by the conservative stance of the utility industries, which are generally reluctant to deploy more flexible transmission models that are usually associated with renewable sources (Bouffard and Kirschen 2008). Furthermore, the fluctuating nature of renewable sources means that complete deployment is not feasible when there are non-interruptible energy consumption needs (Lucas et al. 2016). Indeed, such issues are frequently emphasised by fossil fuel lobbies, which no doubt influence other industrial energy consumers and political

[10] The average share of industrial electricity consumption of total electricity consumption in our dataset is 38.23 percent.

[11] Perhaps the first scenario that comes to mind on the mention of industry and energy is the obvious positions of the fossil fuel and renewable energy industries, which hold strong vested interests in promoting the deployment of their own respective energy source. Yet our focus is broader than the energy industry; it is the industrial sector as a whole, which consists of primary (agriculture, forestry, fishing, mining, quarrying and the extraction of minerals), secondary (manufacturing, energy and construction) and tertiary (services that produce intangible goods such as banking, finance, insurance, tourism, education and retail) sectors.

[12] Sovacool and colleagues draw attention to multiple dimensions of energy security (e.g. Sovacool et al. 2011; Sovacool and Brown 2010; Sovacool 2010; Sovacool 2011; Sovacool and Mukherjee 2011).

actors to increase the political appetite for traditional energy sources (Sovacool 2009). In terms of affordability, fossil fuel sources also seem favourable because, in the short-term at least, fossil fuels tend to offer cost advantages due to economies of scale (Aguirre and Ibikunle 2014).

The arguments presented so far seem to suggest that industry's drive for energy security results in an unequivocal win for fossil fuel energy (excluding, of course, the position of the renewable energy industry). Yet, we argue that such a conclusion would be short-sighted as recent empirical experiences of hybrid deployment systems and the energy literature suggests a more nuanced understanding about the performance of both fossil fuel and renewable energy sources in delivering energy security. First, it is important to note that renewable energy sources and centralised energy structures are not mutually exclusive; rather, it is possible for renewable sources to be implemented in the traditional – large-scale centralised – way, which could alleviate some concerns about stability of supply arising from newer, flexible energy structures (Neuhoff 2005). Moreover, there is a strong case to be made that a diverse energy supply, encompassing both fossil fuels and renewable energy sources deployed via centralised and decentralised (hybrid) structures, reduces the risks that arise from relying on a narrow energy mix and supply system (Lucas et al. 2016; Xia et al. 2011; Bouffard and Kirschen 2008; Kuzemko et al. 2016; Burke and Stephens 2018). Bouffard and Kirschen (2008), for instance, argue that shifting from a few centralised energy systems to more numerous modular systems that have the capability to draw on multiple energy sources can significantly enhance supply reliability, especially in the face of natural disasters and geopolitical crises, which usually result in total blackouts. Similarly, energy diversification can enhance resilience in uncertain economic systems (Grubb et al. 2006) and facilitate the substitution of energy (Xia et al. 2011). Apparently, then, industrial energy consumers have a collective interest in deploying different energy sources (particularly renewables which lag behind fossil fuels) to obtain a better mix of benefits (e.g. to stabilise supplies at different times of day or demand spikes) from the different supply characteristics (Doern 2015).

Regarding the affordability concern, while renewable sources are currently costlier than fossil fuels, government interference (e.g. through carbon taxes and renewable subsidies) often adjusts the relative advantages of fossil fuel energy by passing on lower renewable electricity prices to industry (Carley 2009). Furthermore, since renewables do not need fuel to produce power, they are not affected by price volatility, unlike fossil fuels, rendering the former more secure from a price stability perspective (Lucas et al. 2016). Moreover, assuming that industrial energy consumers are likely to favour lower electricity prices, the deployment of additional energy (whether it be fossil fuel or renewable) is likely to drive down prices by increasing supply (Aguirre and Ibikunle 2014).

Thus, if the industrial lobby is driven by the desire for energy security, it should support the deployment of more energy all around (as represented in figure 2). This is because a diversified energy portfolio would result in a more stable and reliable energy supply and increased energy generation would increase supply and reduce electricity prices. Collectively, these arguments suggest that stronger industrial lobbies wield more political power and, therefore, have the capacity to use the civil society pathway more efficiently to exert greater influence over energy policy. Hence our industry-hypothesis is as follows:

H2: As industrial representation in a country rises, the effect of democracy on the marginal deployment of energy sources for electricity generation (TWh) increases.

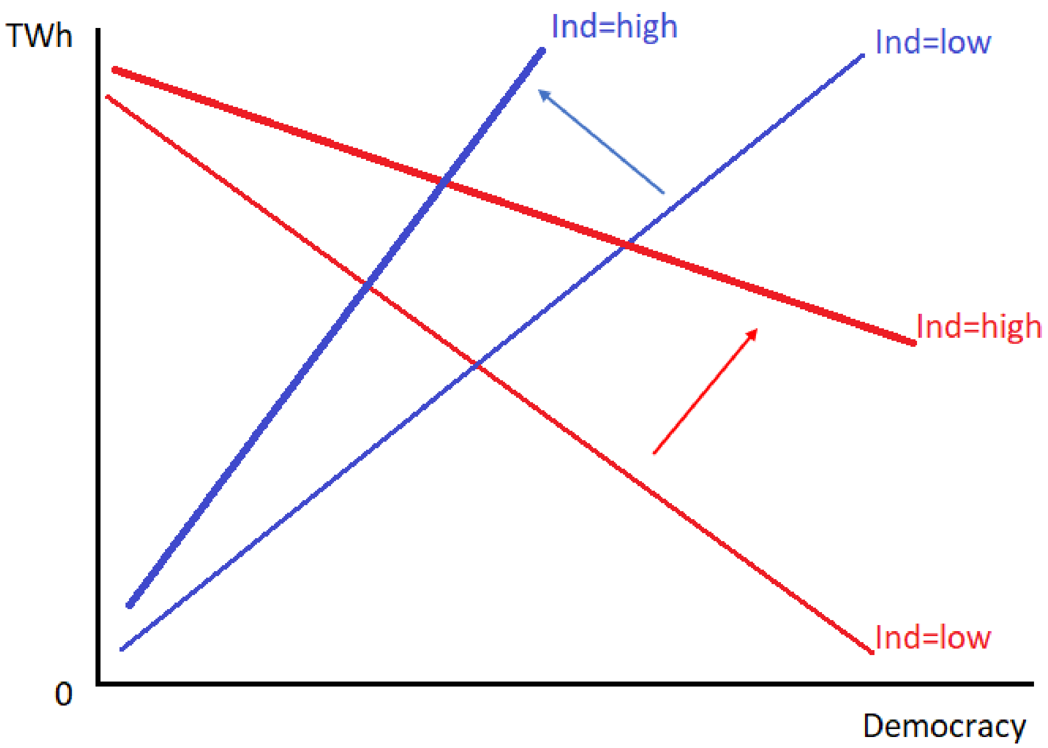

Figure 2: Democracy, industrial representation and energy technology deployment.

Research Design

This article uses country-year data to analyse the electricity deployment rates of 131 countries from 1990 to 2018. The spatial domain was cast as widely as possible to minimise the possibility that correlations are due to regional factors rather than political variables. The sample spans 19 geographical regions as defined by the Carbon Brief negotiating groups in the Paris climate talks.[13] A country was excluded from the dataset if two or more independent variables were missing for the entire time period under investigation, resulting in a maximum of 3,799 observations per energy technology.

The temporal dimension of the sample represents a vibrant period in energy deployment. By the 1990s, the deployment of the modern renewable energy technologies was well underway. Moreover, global warming had secured its central place on the international agenda and mitigation efforts began to be regulated by the global climate regime with the adoption of the 1992 UNFCCC and 1997 KP, creating important incentives for energy transition. 2018 is the last year for which complete data are available.

[13] The negotiating groups can be found at: https://www.carbonbrief.org/interactive-the-negotiating-alliances-at-the-paris-climate-conference.

Most quantitative research on the drivers of energy deployment employs single-level ordinary least squares (OLS) regression (e.g. Lucas et al. 2016; Aquirre and Ibikunle 2014; Marques et al. 2010; Wurster 2013; Henisz and Zelner 2006; Cadoret and Padovano 2016; Bayer and Urpelainen 2016). Yet a fundamental assumption of OLS analysis is that residuals are completely independent from each other. We argue that, due to a host of factors (only some of which are explicitly accounted for by energy models), observations of electricity deployment rates from the same country or region are more likely to be similar to each other than observations from different countries or regions. Indeed, the literature is replete with examples of group-level factors that have been found to impact energy preferences such as social norms (Fornara et al. 2016), national culture (Stephenson et al. 2015), regional institutions (Papiez et al. 2018), national and regional economic conditions (Andreas et al. 2017) and even conflicts between national and regional factors (Bohne 2011). Thus we employ multilevel modelling to explicitly account for group clustering, thereby isolating the effects of political variables from those of group-level factors. Specifically, we build a three-level model consisting of country-years nested in countries, which are further nested in supranational regions. The proposed hierarchical data structure is shown in figure 1.

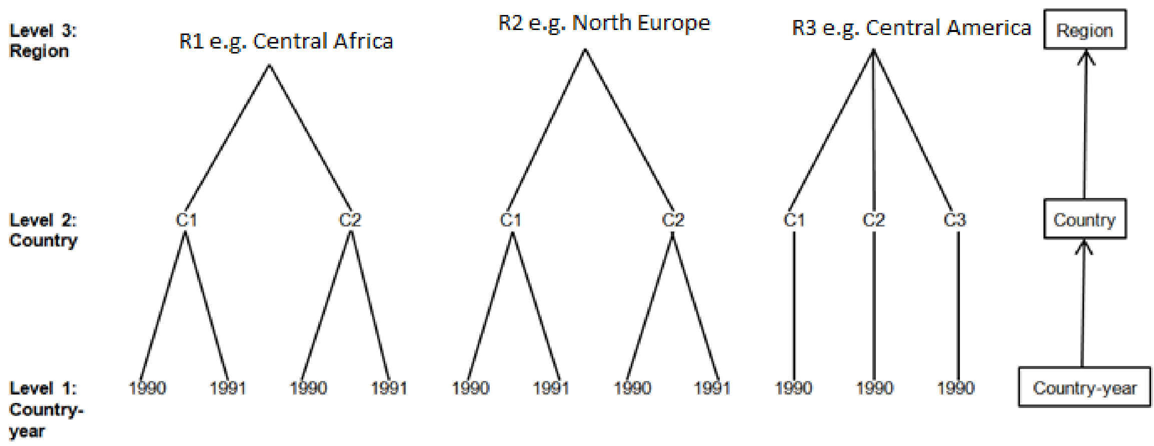

Figure 1: Unit and classification diagram showing the proposed three-level clustering structure.

In order to validate our claim that energy deployment rates are clustered in countries and regions, we fitted our deployment data to a null version of the proposed three-level model.[14] While omitted from this paper due to space constraints, the results show for all energy technologies, most variation in energy deployment rates occurs at the country and regional levels, providing strong justification for modelling country and regional clustering.

Table 2 summarises the variables and data sources. We operationalise the dependent variable, marginal change in annual deployment of coal, oil, natural gas, nuclear, geothermal, solar and wind and hydro energy for electricity generation, as the logged annual change in electricity generation (in TWh) from each energy source. Deployment data

[14] Null models do not include any independent variables, but are informative in multilevel model design as they show how much variation in the dependent variable of interest (in this case, energy deployment rates) is distributed across the different levels.

come from the 2020 International Energy Agency (IEA) World Extended Energy Balances and Summary database.

Variable	Definition	Source
$\Delta \ln DEP_{(source\ x)ijk}$	Logged annual marginal change in electricity generation (TWh) from energy source x.	International Energy Agency World Extended Energy Balances and Summary
$DEMOCRACY_{ijk}$	Level of democracy in a country-year.	V-Dem polyarchy index. Scores range from 0 (low) to 1 (high).
$INDUSTRY_{ijk}$	Share of industrial to total electricity consumption in a given country year.	International Energy Agency World Extended Energy Balances and Summary
$\ln LAGDEP_{ijk,(t-y)}$	Lagged electricity generated from energy source x y years ago.	International Energy Agency World Extended Energy Balances and Summary
TOTALENERGYCONS	Growth in total energy consumption as a percentage change from the previous year.	International Energy Agency World Extended Energy Balances and Summary
POPGROWTH	Population growth as a percentage change from the previous year.	World Bank Development Indicators
GDP	Per capita GDP (in US$).	World Bank Development Indicators
RESREV	Share of natural resource rents of total GDP.	World Bank Development Indicators

Table 2: Variables and sources.

Data for democracy come from the V-Dem polyarchy index, which assigns scores from zero to one to reflect the fulfilment of the electoral ideal of democracy based on aggregate performance in a range of core democratic dimensions – namely: freedom of association, clean elections, freedom of expression, elected executive and suffrage - in a country year.[15] V-Dem scores range from 0 to 0.93, respectively denoting the lowest and highest levels of democracy recorded in a country over the period under investigation. We also employ Freedom House political rights and civil liberties data to provide an alternative high-level measure of democracy which ranges from 0 (very undemocratic) to 1 (very democratic). In our sample, these measures are correlated at 0.96.

Industrial representation is operationalised as the share of industrial to total electricity consumption in a country year. Data for this variable come from the IEA database and range from zero to 0.93, respectively denoting the weakest to strongest levels of industrial representation in our dataset.

[15] Interested readers are referred to the V-Dem codebook for a detailed discussion of the index methodology at: https://www.v-dem.net/media/filer_public/e0/7f/e07f672b-b91e-4e98-b9a3-78f8cd4de696/v-dem_codebook_v8.pdf.

While not discussed here, we also include a number of controls to isolate the effects of democracy and industrial representation from the influence of other potential determinants of energy deployment rates (listed in table 2).

Our econometric specification is:

$\Delta lnDEP_{(source\ x)ijk} = \beta_0 + \beta_1 DEMOCRACY_{ijk} + \beta 2lnLAGDEPijk_{,(t-y)} + \beta_3 TOTALENERGYCONS_{ijk} + \beta_4 POP_{ijk} + \beta_5 GDP_{ijk} + \beta_6 INDUSTRY_{ijk} + \beta_7 RESREV_{ijk} + \beta_8 INDUSTRY_{ijk} XDEM_{ijk} + \beta 9lnLAGDEPijk_{,(t-x)}$ X $DEMOCRACY_{ijk} + \beta 10lnLAGDEPijk_{,(t-x)}$ X $INDUSTRY_{ijk} + \beta 11lnLAGDEPijk_{,(t-x)}$ X $DEMOCRACY_{ijk}$ X $INDUSTRY_{ijk} + u_{1jk} DEMOCRACY_{ijk} + v_k + u_{jk} + e_{ijk}$

where $DEP_{(tech)ijk}$ is the annual change in the deployment of energy source x for electricity generation (GWh) in country-year i (i = 1,…,3,799) in country j (j = 1,…,131) in region k (k = 1,…,19) and v_k, u_{jk} and e_{ijk} denote country-year, country and regional residual error respectively.

The specification includes four interaction terms between DEMOCRACY, INDUSTRY and LAGDEP, which enables the statistical evaluation of the conditional effects proposed above. The interaction between INDUSTRY and DEMOCRACY flows directly from our theorisation of industrial energy consumers as an interest group that seeks to influence energy deployment by utilising democratic channels to influence policymaking such as lobbying. Yet it is also possible for democracy and industry to affect deployment indirectly. Drawing on Henisz and Zelner's (2006) approach[16], we model these indirect effects by including three additional interaction terms. The separate interactions between LAGDEP and DEMOCRACY and INDUSTRY model the possibility that previous deployment patterns interact with current prevailing levels of democracy and industrial representation to influence present deployment rates. For example, industry might exert a stronger positive influence on this year's solar energy deployment rates when deployment levels were higher x years ago than if solar energy was negligible. The three-way interaction between LAGDEP, DEMOCRACY and INDUSTRY allows f0or higher-order multiplicative effects between the three variables.

Results

Table 3 reports the results of our core specification alongside a variant of the model that shows the 'pure' effect of democracy on the deployment of each energy technology. Model 2 shows the results of the core model including the interaction terms and model 1 shows the results of the equivalent model without interaction terms to demonstrate the explanatory value of the interactions.

[16] The authors use a similar set of interaction terms to study the effect of veto points and industrial strength over electricity infrastructure deployment.

Variable	Coal		Oil		Gas		Nuclear		Geothermal		Hydro		Solar and wind	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Fixed effects														
DEM	0.38	0.66	-0.23	-1.35	0.23	1.35	0.52*	1.46**	0.26	0.41	0.10	5.57***	-0.13	1.66*
IND	-0.12	-0.84	-0.61	-4.10**	-1.33*	0.17	-0.09	-0.12	0.05	-0.08	0.48	-1.31	-3.68***	-1.76*
lnLAGDEP	0.36***	0.53***	-0.02	-0.11	0.07**	0.18*	0.04*	0.58***	0.23***	1.16***	0.59***	0.27**	0.23***	0.60**
TOTELECCONS	8.81E-6***	8.42E-6	-2.49E-6	-2.24E-6	0.12***	1.23E-5*	1.38E-5***	1.15E-5***	3.63E-6***	3.16E-6***	8.89E-6***	9.92E-6***	2.21E-4***	2.06E-6***
POP	-0.03	-0.02	0.05	0.04	-0.03	-0.03	-0.01	-0.01	-0.02*	-0.03*	-0.02***	-0.01	-0.22***	-0.22***
GDP	-6.41E-6T	-7.42E-6	-2.88E-6***	-2.51E-5***	3.99E-6***	3.97E-4***	-5.97E-7	-2.81E-7	7.13E-6***	7.23E-6***	-0.02	4.50E-6	1.09E04***	1.09E-4***
RESREV	0.11	0.05	1.67*	1.64*	-0.72	-0.72	-0.26	-0.23	-0.05	-0.01	5.01E-7	0.05	-2.82***	-2.69***
DEM*IND	-	1.70*	-	4.16T	-	-2.19	-	0.09		0.28	-	1.39	-	-4.10**
lnLAGDEP*DEM	-	-0.16T	-	-0.06	-	-0.14	-	-0.75***	-	-1.05***	-	-0.84***	-	-0.42T
lnLAGDEP*IND	-	0.06	-	0.35T	-	-0.20	-	-0.57**	-	-1.17***	-	0.10	-	-0.33
lnLAGDEP*DEM*IND	-	-0.31*	-	-0.04	-	0.22	-	0.63**	-	1.21***	-	0.05	-	0.24
Random effects														
DEM random effect (u_{1jk})	4.07***	5.68***	5.53***	6.10***	18.27***	20.02***	4.90***	11.69***	2.27***	3.11***	0.19	16.01***	9.75***	10.15***
Regional variance	2.09 (67%)	2.16*** (66%)	2.40** (-95%)	2.01*** (0%)	2.95 (29%)	2.95 (29%)	1.62*** (57%)	0.87*** (77%)	0.05 (84%)	0.01 (97%)	0.17 (90%)	1.27 (25%)	0.03 (99%)	1.99E-8 (99%)
Country variance	2.81*** (71%)	2.04*** (80%)	4.69*** (9%)	4.57*** (11%)	8.86*** (18%)	8.51*** (21%)	5.39*** (37%)	3.07*** (64%)	0.87*** (74%)	0.27*** (92)	0.72*** (89%)	5.16*** (25%)	2.13*** (33%)	1.89*** (41%)
Country-year variance	1.32*** (8%)	1.32*** (8%)	1.77*** (12%)	1.75*** (13%)	1.94*** (14%)	1.94*** (14%)	0.37*** (12%)	0.36*** (14%)	0.22*** (12%)	0.22*** (12%)	1.24*** (0%)	1.01*** (19%)	2.58*** (33%)	2.56*** (34%)
LR test	478.75***	1.30***	464.63***	459.42***	758.64***	750.81***	1650.32***	1667.37***	678.50***	653.02***	282.82***	333.63***	753.81***	750.94***
N	2406	2406	1732	1732	2018	2018	2945	2945	2980	2980	1911	1911	2282	2282

Table 3: Democracy, industrial strength and interaction effects on electricity deployment rates.

Consider the first model. A significant (fixed or random) democracy coefficient indicates that democracy influences the deployment rate of the energy source in question. Only nuclear energy growth is associated with a significant fixed effect; the positive sign of the estimate indicates that a one-point increase in democracy, which corresponds to a shift from an authoritarian to democratic political regime, is associated with a significant increase in the deployment of nuclear energy (p-value =0.05), suggesting that for this energy source, the positive pathways set out in hypothesis 1A outweigh the democratic characteristics that could otherwise inhibit energy deployment (hypothesis 1B). While none of the other energy sources are associated with significant fixed democracy effects, democracy is found to have significant random effects on the deployment of all energy sources other than hydro energy (at a p-value of less than 0.001). Collectively, these results provide strong evidence that the pooled average effect of democracy on energy deployment is a poor indicator of the democracy effect within individual countries. As a visual illustration of this phenomenon, figure 3 shows the variation in the random effects of democracy on coal energy deployment across countries. Strikingly, democracy has positive effects on coal energy deployment in countries that are located above the x-axis and negative effects on countries that fall below the x-axis, rendering the fixed-effect estimate (x=0.38) a poor indicator of the democracy effect for most countries that are not located near the dashed line.

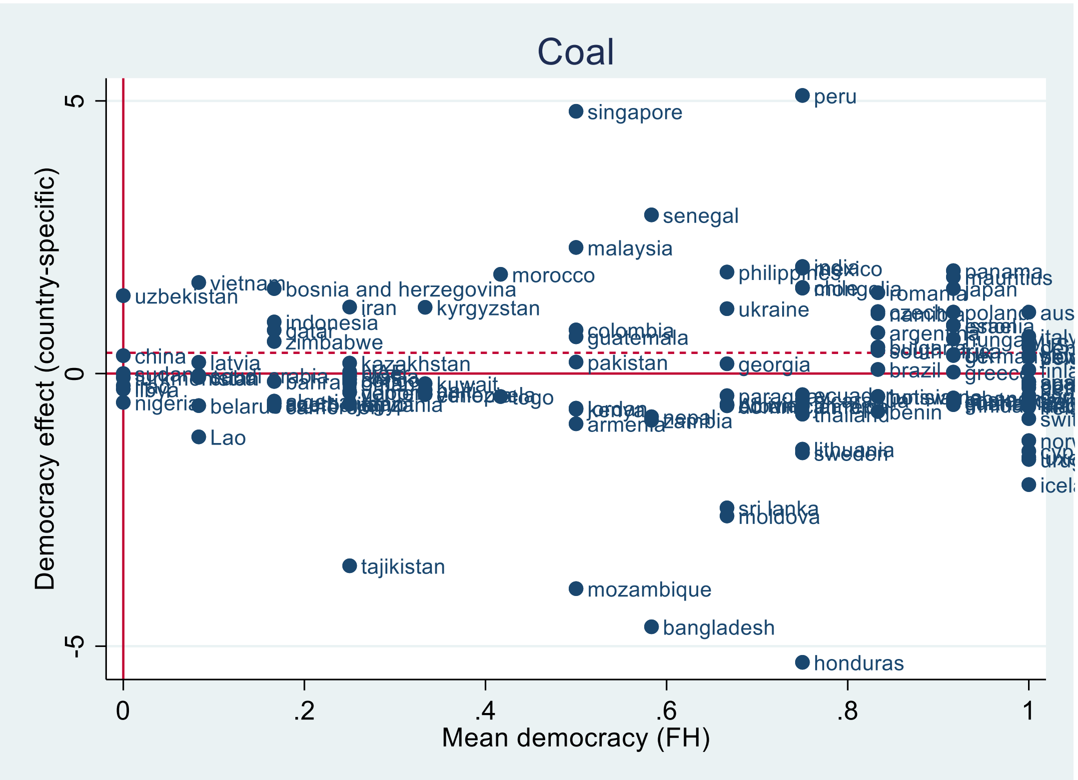

Figure 3: Random democracy effects on coal energy deployment.
Note: Points represent country-specific effects of a one-point increase in democracy on coal energy deployment for electricity generation.

The second model facilitates an evaluation of our core hypotheses relating to the effect of democracy on the deployment of different energy sources and role of industry in moderating these effects. The interaction terms of primary interest - DemXIndustry and lnLAGDEPXDemXIndustry) – are individually significant at a p-value of 0.05 or less for coal, nuclear, geothermal and solar and wind energy deployment. The interaction between lagged deployment, democracy and industry approaches significance (p=0.055) for oil energy and is therefore also of interest. By contrast, the lack of significance of the interaction terms in the gas and hydro models suggest that industrial representation does not appear to play a role in moderating the effect of democracy the deployment rates of these energy sources.

The inclusion of the interaction terms renders the coefficients of the primary independent variables of interest – democracy and industry – meaningless. Therefore, following conventional practice, we investigate the interaction effects of democracy and industry (and lagged deployment) on energy deployment rates by estimating the marginal effects on deployment at different values of the independent variables using the estimates from table 5 to inform the following estimators for each energy source:

$$lnDEP_{(source\ x)ijk} = \beta_1 + \beta_8 INDUSTRY + \beta_9 LAGDEP_{ijk,(t-x)} + \beta_{11} LAGDEP_{ijk,(t-x)}\ X\ INDUSTRY_{ijk}$$

at different levels of industrial representation, and:

$$lnDEP_{(source\ x)ijk} = \beta_6 + \beta_8 XDEM_{ijk} + \beta_{10} LAGDEP_{ijk,(t-x)} + \beta_{11} LAGDEP_{ijk,(t-x)}\ X\ DEMOCRACY_{ijk}$$

at different levels of democracy.

Table 4 shows the predicted marginal effects of democracy on energy generation when lagged deployment is set to the sample mean and industrial representation is made to vary from low (sample mean minus one standard deviation) to high (sample mean plus one standard deviation).[17] All entries except oil at strong (mean+1SD) industrial representation are negative, suggesting that an increase in democratic process consistently inhibits energy deployment rates. In accordance with our expectations, growth in industrial representation is always associated with a decrease in the absolute magnitude of the point estimates, suggesting that industrial strength counteracts the inhibitory effect of democracy on energy deployment. These interaction effects are illustrated visually in figures 3-

Value of industry	Coal	Oil	Gas	Nuclear	Geothermal	Hydro	Solar and wind
Mean – 1SD	-0.07	-0.83	-2383.09	-11208.10	-334.16	-18374.80	-1044.16
Mean	-0.04	-0.25	-1503.45	-9457.46	-255.41	-18208.21	-941.66
Mean + 1SD	-0.01	0.34	-632.79	-7706.82	-176.67	-18041.60	-839.17

Table 4: Point estimates at different levels of democracy and industrial representation.

[17] The marginal effect referred to here is the estimated effect of a one-point increase in the stretched V-Dem polyarchy score on energy deployment rates when there is a one-point increase in the per unit GDP level of industrial representation. It can also be thought of as the gradient of the DEM – DEPRATE equation at a defined level of industrial representation.

Note: All independent variables other than democracy and industrial representation are held at their sample mean.

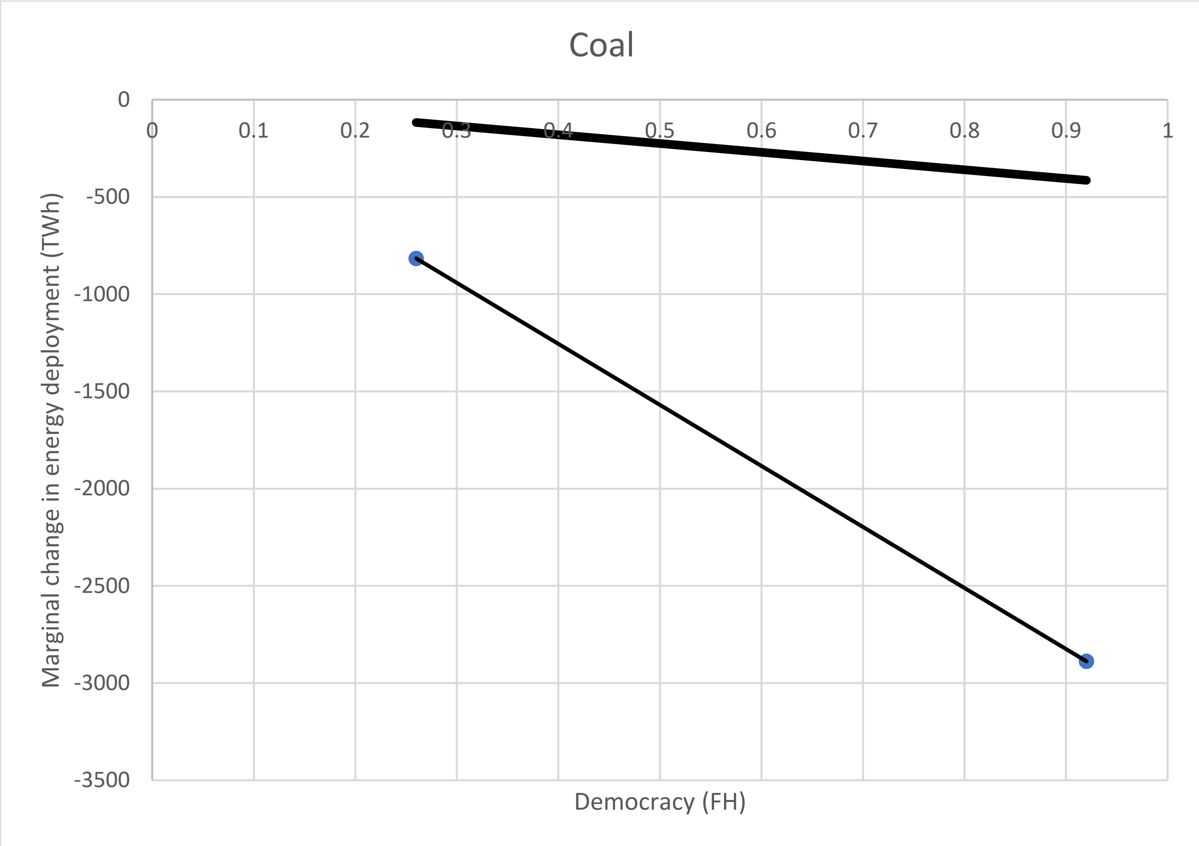

Figure 3: Marginal effect of democracy on coal energy deployment for electricity generation at low and high levels of industrial representation.

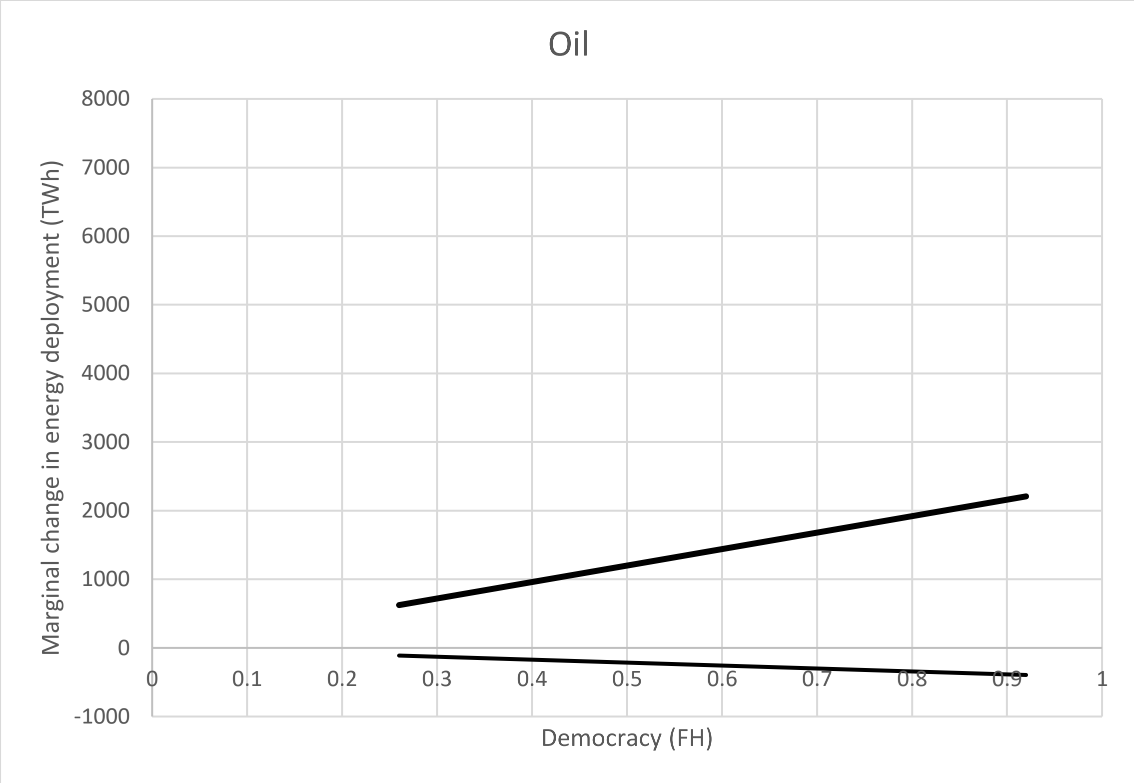

Figure 4: Marginal effect of democracy on oil energy deployment for electricity generation at low and high levels of industrial representation.

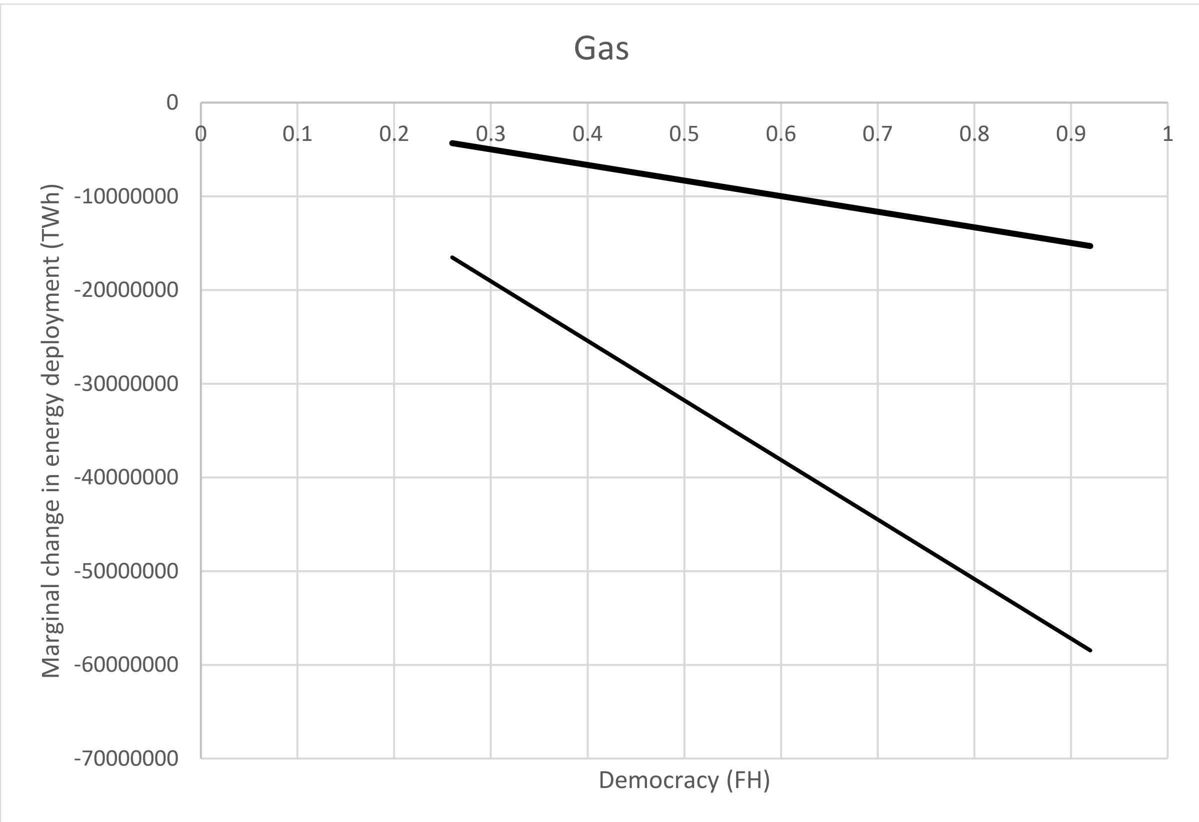

Figure 5: Marginal effect of democracy on gas energy deployment for electricity generation at low and high levels of industrial representation.

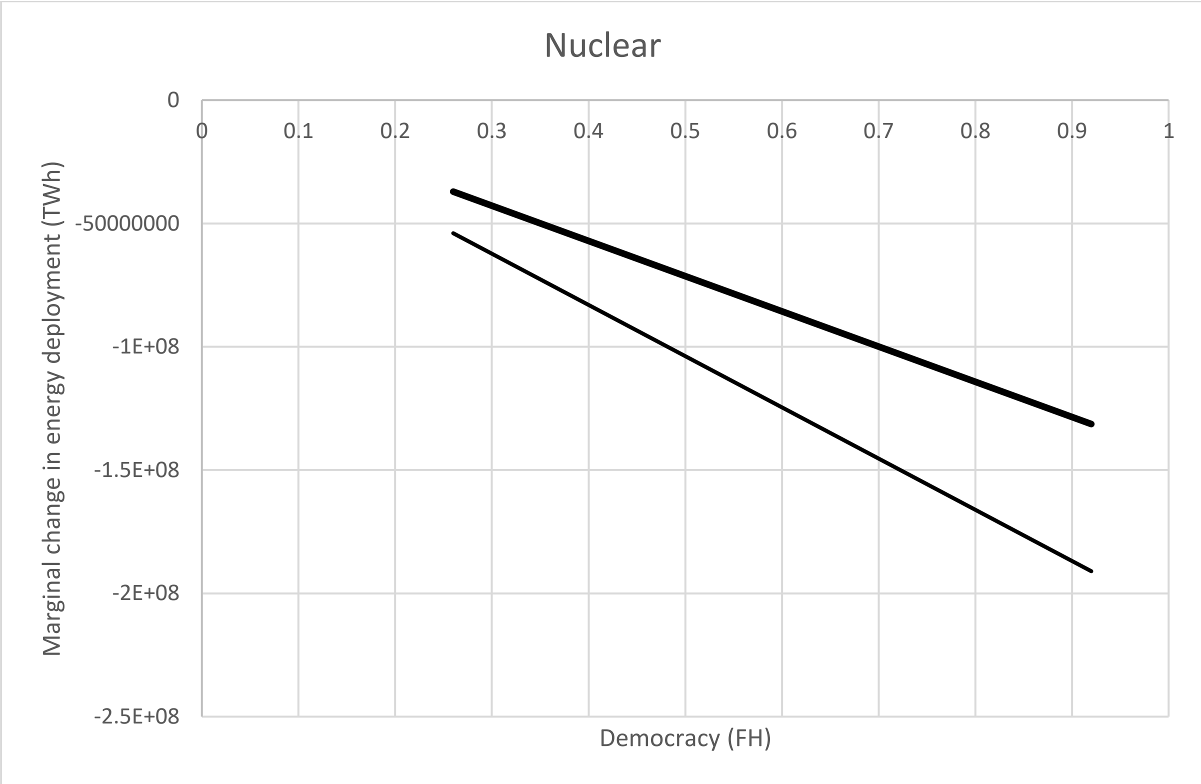

Figure 6: Marginal effect of democracy on nuclear energy deployment for electricity generation at low and high levels of industrial representation.

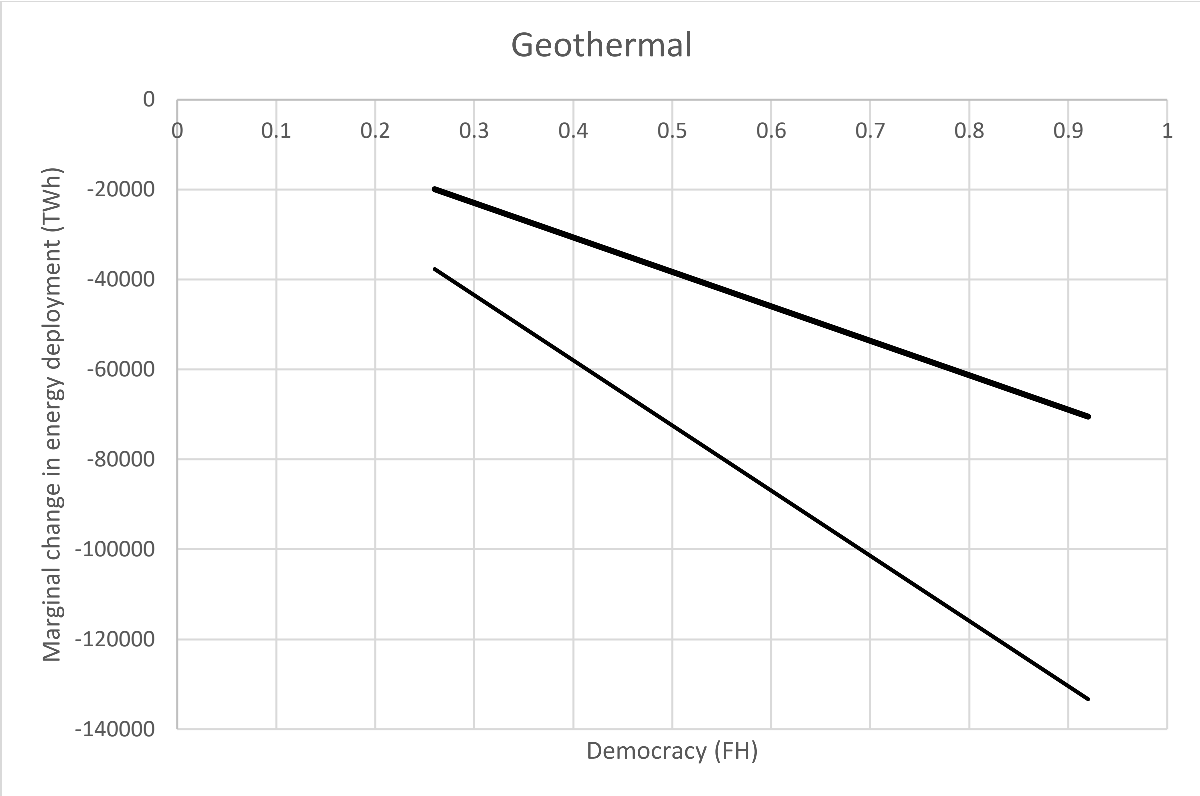

Figure 7: Marginal effect of democracy on geothermal energy deployment for electricity generation at low and high levels of industrial representation.

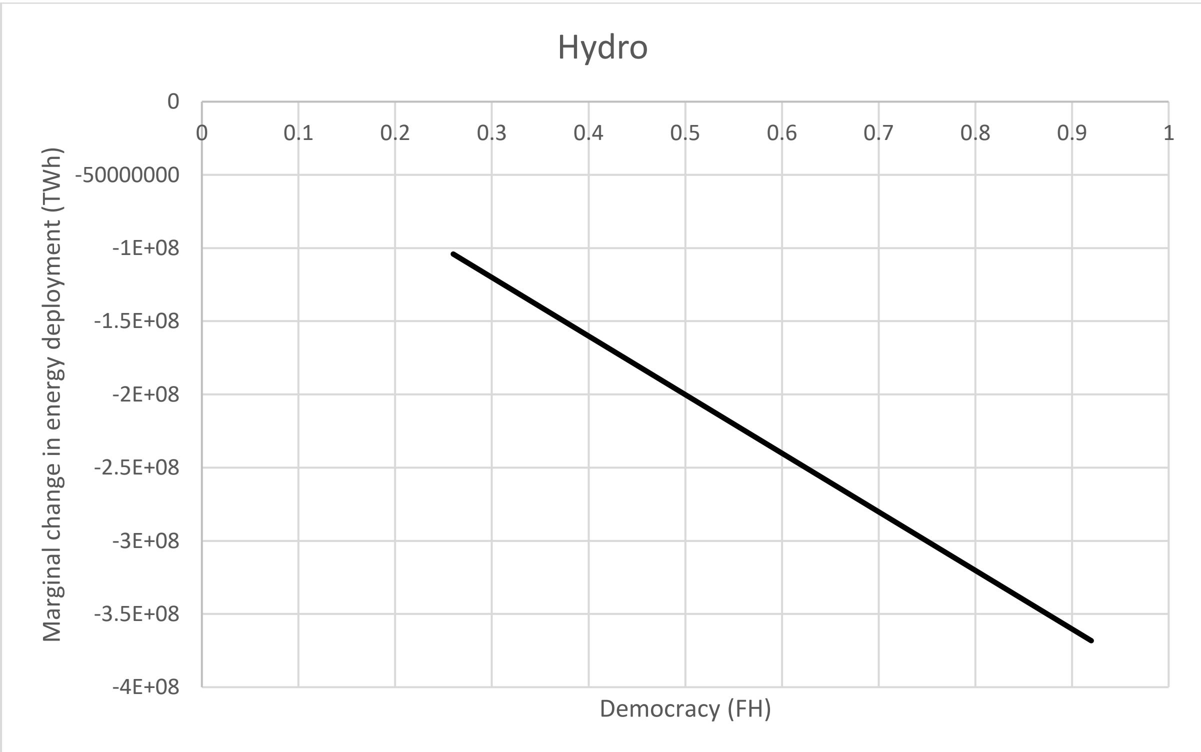

Figure 8: Marginal effect of democracy on hydro energy deployment for electricity generation at low and high levels of industrial representation.

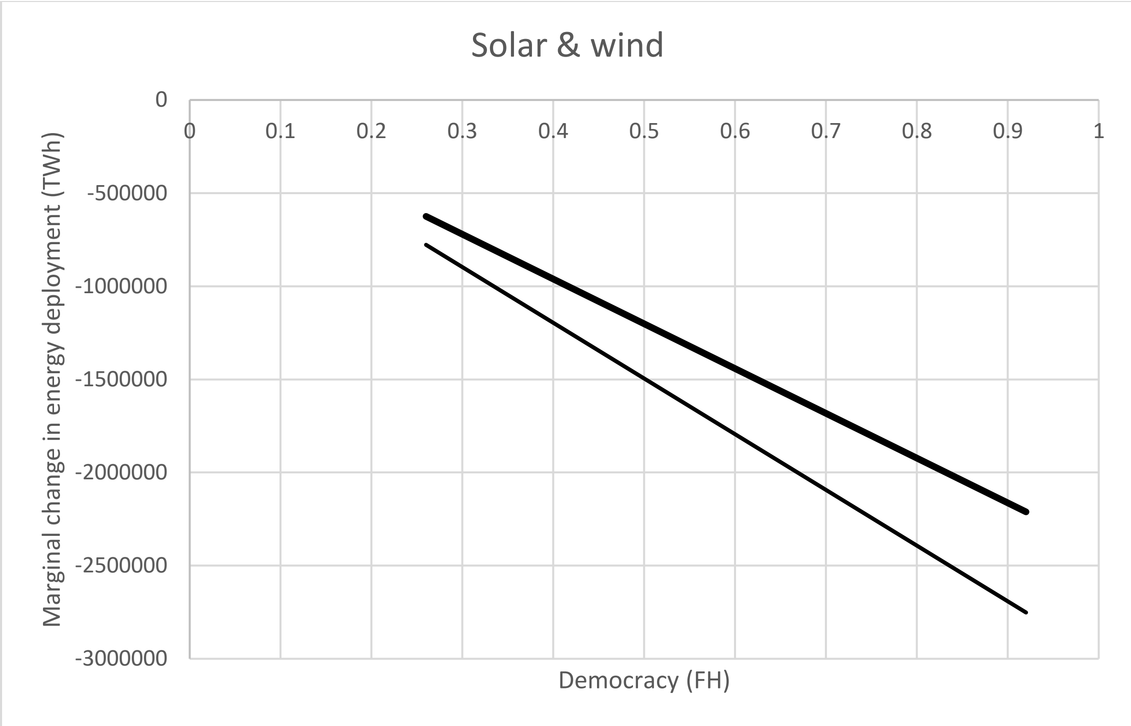

Figure 9: Marginal effect of democracy on solar and wind energy deployment for electricity generation at low and high levels of industrial representation.

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