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# Scale, governance and net zero: decentralisation vs centralisation in electricity

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**Abstract**

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**Keywords** Scale, scope, governance, net zero, decentralisation

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**Scale, governance and net zero:**
**decentralisation vs centralisation in electricity**

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March 2025

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## Introduction

This paper focuses on the question of what net zero implies for the size distribution of firms in the electricity sector. Our starting point is that generalisations about trends in the size of firms in an industry based on changes in some of the underlying technologies are often misleading.

The starting point for firm size is the nature of economies of scale and economies of scope, often we focus on first, when the second is more profound. This is because economies of scope do not rely only on technology but can also be driven by financial considerations. The exploitation of scale is not just about the ownership of assets it is about transaction costs in the organization of physical production. Teece (1980) points out that economies of scope can be exploited by separate firms agreeing to share assets (e.g. sheep owner and an orchard owner can negotiate to exploit economies of scope in agricultural production from the same land). However, if there are high transaction costs arising in negotiations, scale and ownership must go together. For example, Hart and Moore (1990) explain how the galley and the engine room of a luxury yacht are almost never in separate ownership, even though they could be in theory.

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[1] This paper is a draft of a chapter for a forthcoming edited book entitled: *Are Low-Carbon Futures Decentralised? The Governance of Collective Electricity Systems* edited by Siddharth Sareen, Tor Håkon Jackson Inderberg and Per Ove Eikeland. I want to thank Siddharth Sareen, Tor Håkon Jackson Inderberg and Per Ove Eikeland for their kind invitation to think about the topic of decentralisation and net zero, in the context of their volume. I also wish to thank the Centre on Regulation in Europe (CERRE) and my CERRE colleagues Catherine Banet, Andrei Covatariu, Kong Chyong and Daniel Duma for some of the inspiration behind this paper, which in part, draws on Banet et al. (2021), Chyong et al. (2021) and Pollitt et al. (2024). I also acknowledge the helpful comments of an anonymous referee.

This paper divides into three main sections. First, we discuss how the concept of scale (and scope) applies to firm sizes in the electricity sector. Second, we discuss how governance arrangements in net zero might influence the size of firms in the electricity sector. Third, we discuss the nature of net zero and what this implies for firm sizes in the electricity sector. In each case we question the extent there will be a decentralizing trend leading to smaller electricity companies.

**Scale**

The definition of economies of scale and scope is based on the following formula (see Pollitt and Steer, 2012 for a discussion).

Economies of Scale (*Sca)* can be defined by (Panzar and Willig, 1977):

$$Sca = \frac{C(q)}{\sum_{i=1}^{n} q_i C_i(q)}$$

Where $q_i$ is a division of the total quantity of production q and C(q) is total cost and $C_i(q)$ is the marginal cost of producing $q_i$. If *Sca* > 1 then economies of scale exist and *Sca* describes the extent to which increasing scale reduces costs.

Economies of Scope (*Sco*) can be defined by (Willig, 1979):

$$Sco = \frac{C(q_1, 0) + C(0, q_2) - C(q_1, q_2)}{C(q_1, q_2)}$$

Where $q_1$ and $q_2$ are two types of output. If *Sco* > 0, then positive economies of scope exist and *Sco* describes how much costs would go up if jointly produced outputs were produced separately.

Economies of scope implies economies scale, in total real output (indeed, Panzar and Willig suggest that $q_i$ could represent one type of output in *Sca* above). Energy firms can produce a range of outputs e.g. electricity, gas, mobility, insurance, customer service, production, network services etc. Economies of scope can be exploited by non-integrated firms. Asset specificity is endogenous to scale and scope. This means that scale and scope can drive the type of assets you have, rather than the other way round. Access regulation, which makes shareable assets available on a non-discriminatory basis, can support separation in the presence of underlying economies of scope, because it is easier to comply with regulation than to remain integrated and prove you are being non-discriminatory. Production and governance costs potentially trade-off in theory of the firm (due to Coase (1937) and Williamson (1975)). We return to this later.

Pure scale and scope effects in real quantities of capital, labour and materials can easily be offset by unit price advantages e.g. cheap local labour, reduced regulatory burden due to trust or advantageous use of local capital such as public roads and buildings. This means that firms don't have be large or integrated to be cost competitive. Inertia in organization and ownership can be high because reorganization of assets is expensive and has very high initial costs (e.g. decision to sell a small public company or break up a large one). Large firms may preserve scale due to unfair competition and state protection (and 'corruption'). Scale and scope effects in operations may be different to scale in investment. Thus, the scale required to do a large new investment could be very different to the scale required for day- to-day operations. This implies that firms may exist at small scale until a new larger investment is required, which can only be efficiently delivered by a larger firm (e.g. a major IT upgrade or a new transmission line into a small town).

In what follows, we don't define the boundary between a 'large' firm and a 'small' firm, but focus on the extent to which the energy transition affects the size distribution of firms, and in particular whether larger firms will tend to become smaller and whether very small firms might proliferate, taking significant market share.

*Why scale might change*

In all markets we observe a range of scales and scopes in the market (Hay and Liu, 1997). There might be a tendency to drift to higher or lower firm size over time. This process is slowed down by inertia, or simply that the advantage of size is not significant enough to be worth replicating or that managerial skill limits the size of firms (Lucas, 1978), and the number of competent large-scale managers is low, while the number of competent small-scale managers in high. Theory also suggests that most markets will see a coexistence of large profitable firms and smaller less profitable ones (who form a competitive fringe in many markets). In regulated industries a further complication is that regulation influences scale in preserving existing structures or promoting new ones. The energy regulator Ofgem actively promoted more competitors in the retail electricity and gas market in Great Britain (from 12 in 2010 to a peak of 70 in 2018, down to only 21 in 2024)[2], while many other regulators and governments erect barriers to prevent entry.

Optimal scale and scope changes when relevant parameters change. Such change could be related to ownership, regulation or technology. Privatisation, deregulation or innovation can drive size changes. Privatisation can change incentives, particularly to exploit existing market signals (e.g. to build gas fired power plants or stop hoarding labour). Deregulation reduces entry barriers and encourages cross-entry and scale and scope economies to directly compete (e.g. gas firms enter electricity market trading scale for scope). Innovation can drive scale. Thus a decline in the scale of generation companies might result from a technological change in the underlying scale of investment (and operations) required, such as has happened with the arrival of cheap modular solar panels (PV) and wind turbines.

History matters and we used to have a decentralized energy system which we moved away from as the electricity became ubiquitous and wider industrial structure changed. This resulted in the creation of large electricity companies, such as EdF in France, ENEL in Italy or State Grid in China.

Joskow and Schmalensee's book *Markets for Power* (1983) was about the idea that the scale of power plants was getting smaller relative to the effective size of a potential market. Similarly the emergence of high voltage lines suggests that a separate transmission company makes more sense than it did. Vertical separation in electricity was also about the idea that synergies between networks, generation and retail were much less significant than thought and, that with improved monitoring, IT and contracting there was little cost efficiency or quality of service advantage to joint ownership of networks and competitive elements (generation and retail).

These ideas supported the direction of travel of the European Union (EU) electricity market reforms, which directly implied a breakup of existing companies at the national level (see Vasconcelos (2004) and Jamasb and Pollitt, 2005). Remarkable re-organisations in European electricity have occurred vertically and horizontally, but dominance of certain large firms

[2] See: https://www.ofgem.gov.uk/retail-market-indicators Accessed 15 March 2025.

continues. Large firms still dominate electricity sales, with the top five firms having around 42% of the market in EU 27 plus Norway plus UK (see Figure 1).[3]

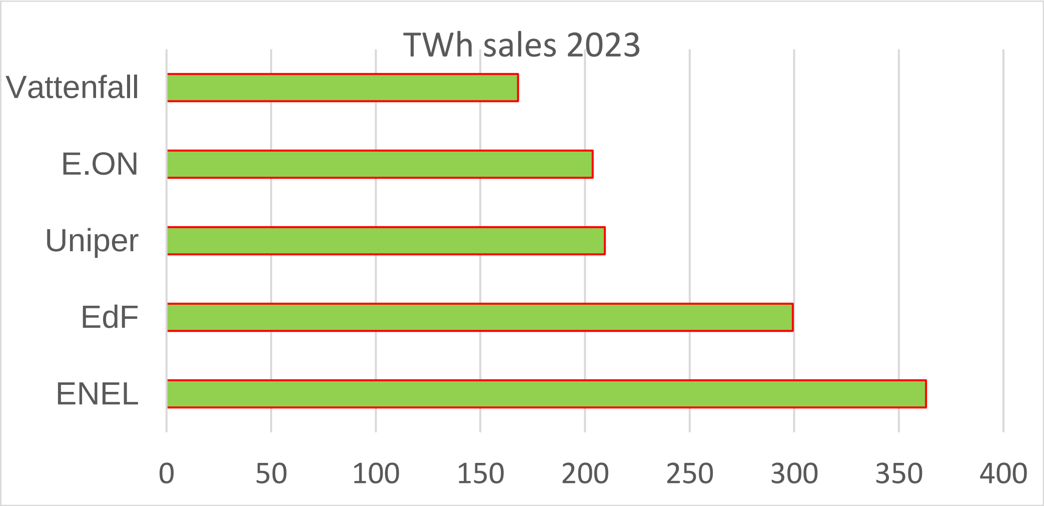


*Figure 1: Electricity Top 5 firms by Sales in EU27+NO+UK*
Source: Companies Annual Reports FY2023, Energy Institute 2024

Meanwhile renewables have grown to 45% of electricity production in the EU-27 in 2023[4] and this has had some effect in reducing the size of firms in the generation segment. However the top five firms in EU 27 plus Norway plus UK still have 26% of generation.[5]

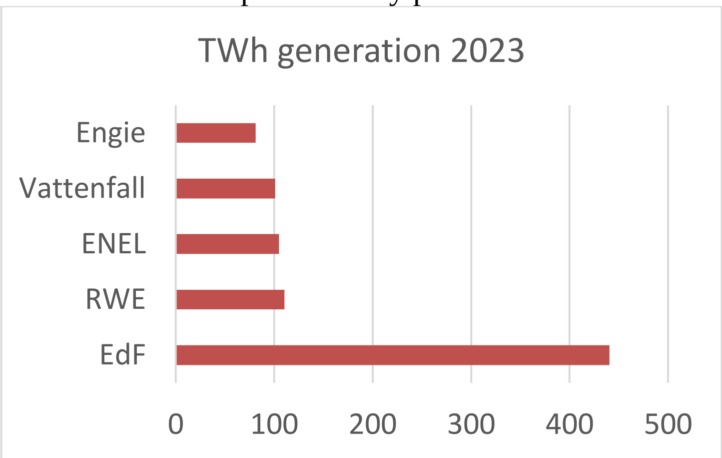


*Figure 2: Electricity Top 5 firms by generation in EU27+NO+UK*
Source: Companies Annual Reports FY2023, Energy Institute 2024

When it comes to the energy transition there can be a tendency to over-emphasise the scalability of PV, wind and batteries as suggesting that we will see smaller scale organization in the electricity sector. However large firm advantages remain strong, in unit costs of skill adjusted labour, capital and materials, R+D (see Bjørndalen, 2025) and the ability to spread fixed costs with respect to regulation and planning and deal with uncertainty. Large multinational electricity companies – made possible by the European single electricity market - can exhibit the typical advantages of transnational firms (and be ’all weather’

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[3] The share of these same 5 firms in 2005 is estimated at 47% (Source: Companies Annual Reports FY 2005, Energy Institute 2024).

[4] Source: Eurostat datasets: nrg_ind_pehcf and nrg_ind_pehnf

[5] The share of the leading 5 companies in generation in 2005 was 40% (Source Companies Annual Reports FY 2005, Energy Institute 2024).

companies (see Pitelis, 2000)). Indeed, only large firms can gain from negotiating the regulatory complexity of different national markets to become multinationals. One can imagine that more data granularity in the energy system in terms of where to place investments and induce local response (e.g. via nodal pricing or local electricity markets) does not imply smaller generation and retail firms. This is because small firms are likely less able to respond to, or manage, more granular signals than a larger firm.

*We see a lot of variety across the world*

We see a lot of organizational variety when we look across the world in the scale of electricity firms. Focusing on distribution we see this may or may not be integrated with other parts of the electricity system. It may also be in public, private or mixed ownership. Globally non-integrated private distribution companies are unusual, even though they are possible. In 67 out of 172 countries in 2020 the largest distribution company was part of a fully integrated publicly owned electricity company which also had generation, transmission and retail. Fully separated private distribution companies existed in only 18 out of 172 countries.

| **Legal Structure** | **Ownership** ***Public*** | ***Private*** | ***Mixed*** | ***Total*** | ***Example*** |
|---|---|---|---|---|---|
| T D | 1 | 1 | 2 | 4 | Japan |
| G D R | 6 | 2 | 1 | 9 | Philippines |
| T D R | 8 | 0 | 2 | 10 | Kenya |
| D | 12 | 18 | 4 | 34 | UK |
| D R | 23 | 13 | 2 | 38 | Nigeria |
| G T D R | 67 | 5 | 5 | 77 | Indonesia |
| Total | 117 | 39 | 16 | 172 | |

*Table 1: Legal structure and type of ownership of largest distribution company in country in 2020*[6][7]
(Note: T=Transmission, D=Distribution, G=Generation, R=Retail)

Distribution firms have always varied greatly in size and degree of integration across the world, partly based on geographic and government administrative areas which defined how they were regulated. Small integrated companies will likely remain in isolated areas and rural settings. Larger (private) companies struggle to get capital and labour to go to these places cheaply, leaving a role for smaller publicly owned companies.

In some countries there is distribution edge competition for grid extensions to new districts and larger developments (e.g. China and UK). This involves letting a non-incumbent distribution company serve new industrial park, housing development or conurbation. New

[6] With inspiration from Trimble et al. (2016) and Kufeoglu et al. (2018).

[7] Type of ownership is categorised as "mixed" only if the private or public shares represent less than 85% of the total.

developments are an opportunity to integrate assets under new bespoke entities (e.g. Dientenbach, Freiberg, see Mahzouni and Schaiach, 2025). These include companies such as GTC, which is an independent distribution network operator (IDNO) in the UK operating multiple small extension networks. Local governments may buy and sell existing distribution assets in response to political priorities. US municipalities have bought 88 distribution companies since 1973 and have sold 88 since 1980[8].

*The continuing advantages of larger firms*

From a retail point of view large companies make sense in terms their ability to manage risk. Retail customers prefer to purchase an insurance product with their energy to partially hedge prices (e.g. by fixing contract prices for a year). Smarter differentiated tariffs are best experimented with and implemented by larger retail firms (in light of Kubler et al., 2025).

Restructuring and new technologies for decarbonisation have given the impression of a move to smaller scale at the individual market level. Independent Power Producers (IPPs), Renewables Auctions, Feed in Tariffs (FITs), Green Certificate markets, Virtual Power Plants (VPPs) offer firms the ability to achieve optimal size by multiple projects, multiple countries, accessing cheap pooled finance, rather than have large shares of individual national markets. Projects may be individually small but sufficient economies of scale and scope are achieved across multiple projects. There are already large firms being formed in market niches such as floating offshore wind (see Gregory, 2025).

Now consumer ownership is an increasing phenomenon in electricity, albeit quite small in energy terms so far. Many consumers will own PV, batteries in vehicles and household energy storage assets to some extent. The issue is whether this will also create new large companies who will extract significant value from information processing and risk management (e.g. to create VPPs and use AI, as in Sioshansi, 2025). Uber does not own taxis, but is a big firm due to collecting 25% of the taxi fare of its drivers. Large energy companies have been useful in creating countervailing market power against equipment and IT providers (e.g. Power Cables Case, National Grid vs ABB, Nexans et al. in 2014[9]), suggesting a role of countervailing market power in the face of market power in the energy equipment sector.

## Governance

Governance (and policy more generally) is an issue for scale. Industries must be governed. Governance imposes transaction costs on firms. Energy regulators need to licence and regulate companies. Electricity system operators need a system which is capable of being controlled. The relevant government energy ministry has to deliver high level targets at reasonable cost, with security of supply.

Governance is a system and one system that has recently been put in place to get to net zero is that in Great Britain (see Figure 3). The real time electricity system operator (National Energy System Operator, NESO, created in 2024) needs to manage system in real time across all industry actors. The relevant government ministry for energy (and climate change) (i.e. Department for Energy Security and Net Zero in Great Britain) sets targets, subsidies, ensures high level security. The energy regulatory agency (Ofgem in Great Britain) needs to oversee financial data, innovation and stakeholder responsiveness. The optimal sharing of

[8] See APPA, American Public Power Association (website accessed 15 March 2025).
[9] See https://ec.europa.eu/commission/presscorner/detail/en/IP_14_358 Accessed 15 March 2025.

responsibilities is an evolving process, with a degree of overlap and is dependent on the political preferences of government, which may care more or less about energy (e.g. pushing through governance reforms).

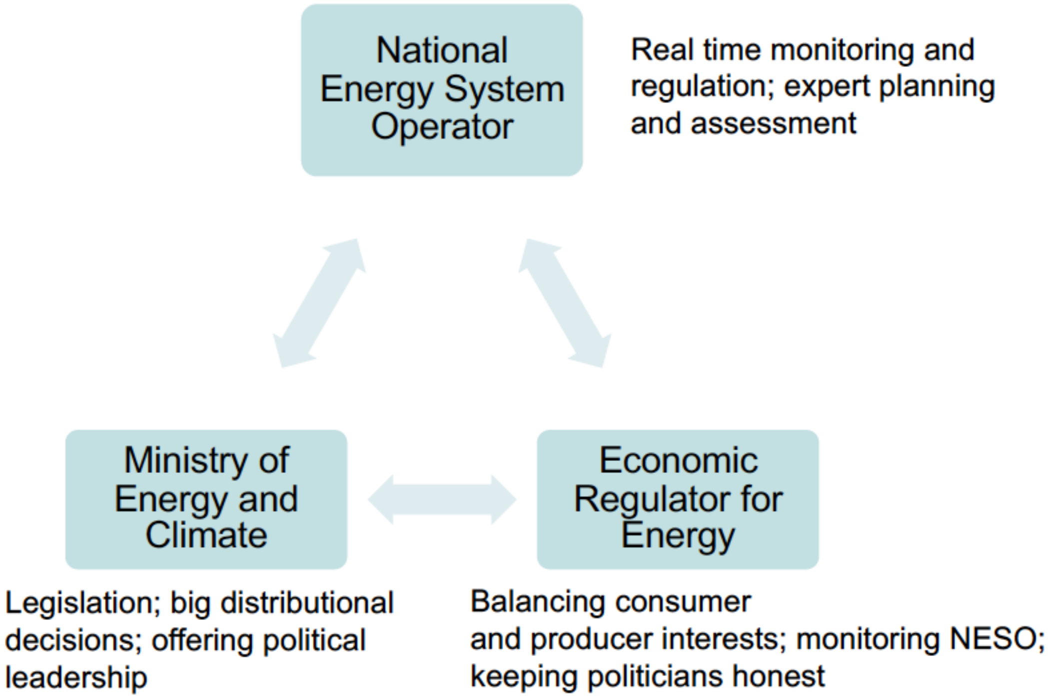


*Figure 3: A future governance triangle in energy (inspired by Great Britain)*

Pollitt et al. (2024) suggest that to handle the system on the path to net zero, the following needs to change with respect to regulation in many countries. They identify seven areas for potential improvement. On **planning [1]**, regulators need to ask networks companies for business plans for a specific period of time, which are subsequently negotiated and then settled. Relatedly, **uncertainty mechanisms [2]** will need improvement. At present, reopeners in regulatory settlements are seen as burdensome even in the most advanced regulatory regimes. **Incentive [3]** based regulation will also need to be adapted to incentivize the achievement of net zero targets. Large investment requirements and higher policy uncertainty will impact **financing [4]** conditions. The emergence of distributed energy resources (DERs) and the high ambition of net zero will mean that regulated network companies will have to deal with a larger and more diverse set of **stakeholders [5]**. Funding and adopting technological and business model **innovation [6]** is more important under net zero. At the **governance [7]** level, there may be several directions of potential change, of which the arrangement in Great Britain is an example.

Pollitt et al. (2024) argue that what is required is a 'learning' regulator with the ability to learn from the past, engage with the current developments and anticipate future key decision points on the path to net zero. This approach draws on the literature on **Dynamic regulation** (f.Agrell and Bogetoft, 2003), **Responsive regulation** (f.Ayres and Braithwaite, 1995) and **Adaptive regulation** (f.Bennear and Wiener, 2019 ). All this literature on more 'dynamic' approaches to regulation emphasises the need for regulatory learning - from the past, in the present and at key points in the future - is visualized in Figure 2. Companies that can be more dynamic, responsive and adaptive will also be at an advantage on the path to net zero. This suggests larger firms will be advantaged by regulation, above the threshold small size that might avoid scrutiny from regulator. Indeed in such an environment it is large firms with the capacity to do analysis (of past data), customer engagement (in real time) and forward planning (anticipating future learning points) that will have an advantage over smaller firms that lack these capacities.

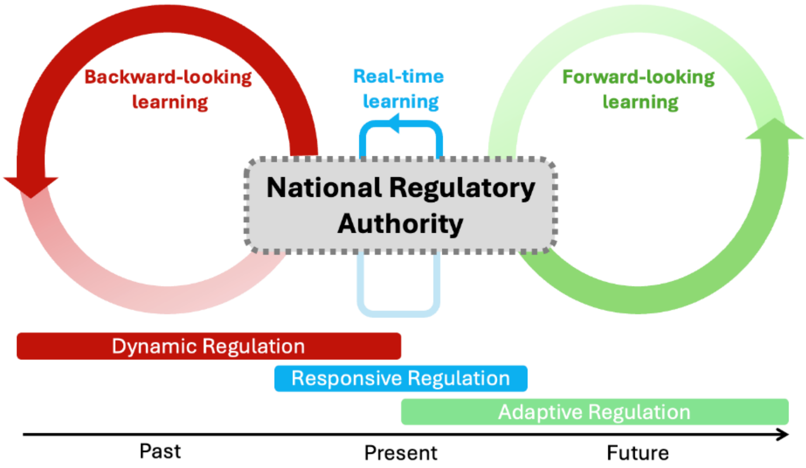


*Figure 4: The Learning Regulator (Pollitt et al., 2024)*

*Decentralisation and Governance*

Decentralisation has limits because it is difficult to govern and has trouble meeting regulatory requirements. The level at which governance occurs is important. There is a tendency to think that governance can be outsourced to algorithms and computer based 'voting' via co-governance. However it is not clear that this is politically acceptable or democratic (Bukovski, 2025). Often financial players are not the responsible party or regulated entity in the electricity sector. Thus, even if financial players can 'efficiently' run small scale legally separate investments regulators do not want to let them do so, because large numbers of small companies are not that great for effective sector governance. The larger the number of firms the greater the likelihood of issues arising with some of them, e.g. unfairness of customer contract terms, security of supply, unresponsiveness, inability to conduct surveys or do effective customer engagement, lack of R+D etc. Hence large firms might have continuing advantages in proving compliance with investor concerns in the area of ESG (Environmental, Social and Governance). This suggests large firms might also be better able to access bank loans and 'green' finance.

Small scale ownership can however work with local governance or state/municipal ownership in lieu of alternative governance arrangements, but this sort of relationship is open to corruption and is a problem for private firms who often struggle to deal with local government (Gleaser, 2001). Effective local energy governance often involves motivated local individuals and is not replicable easily (see Lemon et al., 2015, on the City of Leicester in the UK). New governance arrangements such as Renewable Energy Communities (RECs) have been encouraged by the EU (under REDII in 2018) and other countries such as Colombia. These can promote smaller scale energy companies, but often these are implicitly subsidized or rely on non-economic factors (such as community social capital) for their continuity and success (as noted by Coleandro, 2025, and Heinemann et al., 2025). This is not to deny that small firms can be valuable sources of innovation and experimentation for the electricity system as a whole, only to suggest that the results of innovation and experimentation are often best exploited by larger firms. Thus, if small firms are too pervasive with the electricity supply industry, this is likely to be inefficient.

Political attention on electricity system resilience has focused on the ability of local systems to run in island mode (e.g. Hurricane Sandy in US in 2012 and Russian bombing of Ukraine from 2022, see Saukh, 2025 and Kostyuchenko et al., 2025). Some areas in the energy sector remain inherently large scale, e.g. transmission lines, nuclear power and state companies to advance pet projects (e.g. Great British Nuclear and Great British Energy in the UK). More research is required on the extent to which actual climate change favours centralized production (which may be better prepared) or decentralized production (which limits impacts) of electricity (see Ptak and Brooks, 2025).

Customer investment in energy has to be plug and play otherwise it needs too much governance. There is an advantage to equipment standardization and to in-house management (i.e. large-scale entrants managing standardized equipment, e.g. the competitive retailer Octopus Energy in the UK, with a sophisticated tariff and active market management). IT that involves use of standardized software has a cost advantage. Thus, standards and reporting requirements which encourage data standardisation may drive larger scale as the advantages of cheap bespoke solutions are lost over time (e.g. work on the creation of a digital spine in UK, Arup et al., 2023).

**Net Zero**

The key elements of net zero in Europe are explored in the modelling of what it will take to decarbonise the European energy system (see e.g.Chyong et al., 2021).

The frequently modelled elements of net zero are the following. There will be lower energy consumption compared to business as usual. Final electricity demand will increase. Electricity will additionally be required for the production of hydrogen and synthetic fuel. There will be much more variable renewable electricity (VRE) and hence more investment in electricity grids. The decarbonisation of heating will occur via some combination of electrification, hydrogen, biomethane and synthetic fuel. The decarbonisation of transport will occur via some combination of electrification, hydrogen and synthetic fuel. There will be higher carbon prices; more international trade in electricity using high voltage transmission exploiting high wind and high solar areas (and not just in Europe and North America); and negative emissions are required via bio-energy fitted with carbon capture and storage (CCS).

A number of implications follow from the modelling of net zero (see Banet et al., 2021). Higher unit energy and carbon prices must underlie all sensible net zero policy. More use of pricing and/or control in electricity will be required to match supply and demand in real time. Locational price signals for around energy networks will help manage local congestion issues. Public acceptability of solutions will be challenging in heating (and transport) due to higher unit costs and their replacing cheaper higher service quality current solutions. In transport, smart charging and pricing will be important, and distributional issues of who pays for private transport will need to be addressed. National energy regulators will need to pay attention to local preferences in order to increase options and help with national policy goals.

Self-generation and self-storage will have an advantage in a net zero world, but only above a certain size given their fixed costs. The smallest consumers won’t invest in PV or a large EV. Self-generation and self-supply for EVs will be at a big advantage. Winter peak demand will be a problem, while summer peak demand maybe less so given the availability of PV, though short term grid management may be an issue in summer.

Fairness is also going to be important, in terms of who pays and the need to raise and redistribute ‘tax’ revenue from some electricity consumers to other electricity consumers. The nature of the ‘tax’ regime is important in driving changes in scale. High ‘taxes’ within electricity unit charges will encourage more self-consumption and self-storage. Meanwhile the need for fairness – which suggests charging rich consumers proportionately more - will compete with incentives for flexibility in supply and demand, which will likely favour richer consumers with the ability to respond to those incentives.

*Net zero and scale*

Aggregate efficiency is going to be important, in terms of economizing on expensive fixed costs that then need to be recovered from customers who might not benefit directly from them e.g. data infrastructure, public EV charging points etc. Electrification, renewable electricity supply (RES), CCS, synthetic fuel, hydrogen and demand reduction are all important technologies in net zero modelling. Scale is a big issue in what sort of net zero is likely and what is possible. The scaling up of existing and new industries is required to lower their unit costs. A lot of policy does not add up unless it can be scaled to cover fixed costs. It seems likely that large firms will be required to deliver the aggregate scale required in new energy sectors. It is common to think that multi-vector energy hubs might develop at the regional level (see Hasankhani et al., 2025) or local level to deliver net zero, but in reality this limits scale effects which might arise from specialist hubs linked to wide area or global markets.

Net zero poses challenges for security of supply, which consists of reliability, risk and resilience. Reliability is the idea of handling normal fluctuating operational conditions. Distributed provision might mean more tolerance of slightly less reliability (e.g. if I know power is coming from my own roof/battery). Risk is related to the handling of probabilistic events (such as one in twenty year droughts). Larger players are better at managing this, because they can plan and have their assets sized to deal with known risks. Resilience is thought of as the ability to deal with difficult to predict events (such as hurricane with an unknown path). Here the responsibility for planning is a combination of the industry players and the wider governance system. Regulators and government will likely value larger stakeholders who can help with this.

Energy system modelling tends to underplay the role of scale in net zero and how fixed costs will be recovered, especially as industries expand and as other technologies compete in the context of demand reduction which is itself driven by high unit costs arising from fixed costs. Net zero involves a lot of uncertainty and some organisations are better than others at managing this, but often at a price (e.g. financial firms).

The RES required for net zero is huge relative to today, with large amounts of wind and solar and long-distance transmission and storage (see Pons-Seres de Brauwer and Mahzouni, 2025). This will involve a lot of customer owned equipment but also large individual projects, which do have a cost advantage. Most modelling also ignores management time to deal with customer owned equipment and longer-term cost elements such as battery and inverter wear and tear costs (and hence replacement costs). Distributed solutions are not as cost effective as they appear if time and space are valued correctly (e.g. the cost of a square meter to house a hot water storage tank is £7000 in London[10], while the value of time to install and monitor residential solar is significant).

High fixed and unit costs (and limited self-generation capacity) will limit demand growth and reducing energy consumption radically will be cost effective e.g. moving to much smaller, lighter vehicles with limited storage capacity. Hyper distributed storage in devices (e.g. battery in TV) might be valuable, but these solutions, likely, only make sense if grid

[10] See https://www.plumplot.co.uk/London-house-prices-per-square-metre.html#:~:text=In%20London%20region%2C%20the%20average,property%20is%20£7.3k, accessed 15 March 2025.

interruptions are regular and significant. They don't solve the issue of prolonged wind lulls or nuclear outages which suggest that grid-based solutions can more cheaply handle fat tailed supply risks. Thus, it is likely that even if you were to start from scratch and assume distributed solutions exist in most jurisdictions the fact is that annual peak grid requirements likely get you to a similar grid to one we have now (even in sunny places).

## Thoughts on Implications of Net Zero for Scale

It is important not to generalize about the future scale of the electricity sector. The 4 Ds – decarbonization, digitalization, decentralization and democratization - do not imply that an alien visiting a future net zero earth will not see large firms dominating the electricity industry.

Firm scales will continue to vary at the high level even as wind, solar, EVs and other distributed technologies become more significant, for the same reasons firm scale has always varied.

Large firms will continue in the electricity equipment sector and among electricity IT platform providers. Meanwhile, large scale wind and solar developers have already emerged (e.g. Turkey's 1347MW solar project, noted by Sertsoz, 2025) to compete with distributed renewables. Large firms will be needed to support the benefits of high voltage transmission and wide area trading and energy security based on imports and exports (noted by Wuebben, 2025).

Global governance differences means that certain jurisdictions will have scales appropriate to them and hence the nature of democracy (and autocracy) matters for scale.

Who benefits from digitalization is a big issue in net zero: will it be data companies that benefit or will it be energy consumers? A default assumption is that it will be consumers but this is not a given.

Decentralisation in energy is a trend that might be confounded by other megatrends in AI or Quantum Computing (see Kantsepolsky, 2025).

Market opportunities exist at different scales and a key policy implication is to allow scales to be driven by market processes while maintaining appropriate regulation of competition and quality of service.

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