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The Governance of Renewable Energy Auctions: A Multidimensional Comparative Policy Analysis

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ABSTRACT *Auctions have become the most important policy instrument for promoting renewable energy (RE). This article offers a conceptual and methodological framework to grasp the variety of national RE auctions' governance arrangements. It presents indices to systematically measure and compare key dimensions of RE auctions and electricity governance: scope of regulation, private operators' influence, coordination, and the concentration of authority. The framework's usefulness is demonstrated via its application to three contrasted cases – the United Kingdom, Mexico, and Morocco, showing the disruption in electricity governance patterns induced by RE auctions and the relevance of the multidimensional approach to understand policy outcomes.*

Keywords: auctions; electricity; governance; Mexico; Morocco; UK; renewables

1. Introduction

Governance arrangements at work in the elaboration and implementation of policy instruments are a key ingredient in policy success. Energy governance is designed and implemented through multiple layers of decisions involving multiple actors, both public and private, located on different governmental levels. We are far from the first wave of reforms that delegated most authority to Independent Regulatory Agencies (IRAs) as we now see the growing importance of system operators, offshore licensing authorities, and specialized renewable energy agencies in choosing the course of future electricity system

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expansion through novel decision-making arrangements. Besides, there are many angles from which these actors' interactions can be analysed. They may coordinate or not, and interact in arenas of varying levels of formality. Decision-making power can be widely dispersed among them or concentrated in the hands of a few. The leading actor of this arrangement may be an IRA, a ministry, or a renewable energy (RE) agency. In short, there are multiple actors engaged in energy governance, and a multiplicity of dimensions that are relevant to analyse their interactions. Energy governance is complex and multidimensional.

In the face of this complexity, we find two types of works. On the one hand, we find works that simplify multidimensionality, which can be done in two ways. One way is to orientate research on one dimension at a time, such as IRAs' independence, polycentricity, or the role of private actors. Single-dimension approaches overlook that these different dimensions interact with each other and that policy output depends on such interactions. Another way to simplify multidimensionality is to fold several dimensions together under an umbrella concept, such as liberalization (combining privatization, market, and IRA creation), polycentric governance (gathering power dispersion and policy instrument diversity), or experimentalist governance (bundling elements of power dispersion with policy feedback and revision processes). The use of such umbrella concepts assumes that the different dimensions bundled are empirically correlated and that they evolve in the same direction.

On the other hand, we find works that provide empirical illustrations of the complexity and multidimensionality of energy governance. These have played an important role in documenting diversity across cases and their variance in the adoption and combination of different features of liberalization, competitive markets, and governance (Sioshansi 2013). For example, there are cases of privatization without IRA and others featuring IRAs without liberalization or privatization (Mathieu 2023), which undo the underlying idea that privatization, liberalization, and IRA do actually go together. These works have also highlighted that features not pertaining to the textbook model of electricity liberalization may also provide effective outcomes (Glachant 2013; Foster and Rana 2020; Benoit et al. 2022). While the diversity of experiences that industrial economists and policy scholars portray in their studies highlights the multiple aspects where variation can occur, they do not conceptualize the coexistence and combination of these multiple dimensions of energy governance.

Between the simplified models overlooking multidimensionality and the case studies empirically describing it without conceptualizing it, there is a gap. We are missing a middle-range approach that provides the conceptual tools to grasp the different governance formulas and patterns emerging from this multidimensionality. Embracing multidimensionality opens a new space for institutional diversity, which is important for both scientific and normative reasons. First, acknowledging the multiplicity of combinations over different dimensions of energy governance – such as the role of private actors, the extent of coordination, or the presence of an IRA – provides new options to describe governance arrangements more accurately. Second, linear (one-dimensional) conceptualization of energy governance sustains views according to which specific policy or institutional blueprints are more effective than others – whether polycentric or liberalized arrangements (Joskow 2006; Sovacool 2011; Goldthau 2014). Yet there is ample evidence of sectoral success achieved in strikingly diverse institutional contexts (Foster and

Rana 2020). State-owned and private companies can coexist successfully (Steffen et al. 2022); IRAs are not the only approach to attract private investment, which can be effectively achieved with a non-independent RE agency (Mathieu 2023); and state intervention on prices is now treated as an effective approach to create business certainty (Reverdy and Breslau 2019; Valenzuela 2023). The multidimensional approach to energy governance is thus not only scientifically needed but also normatively necessary as it reopens the debate about institutional plurality over effective economic governance.

This paper offers a conceptual and methodological framework to embrace multidimensionality and grasp it in a systemic and comparative way. It also makes an empirical application of this framework to illustrate its usefulness for identifying patterns in comparative policy analysis. Following the work of energy policy and public administration scholars emphasizing polycentricity, coordination, and the role of private actors in energy governance (Smith 2007; Goldthau 2014; Mathieu and Rangoni 2019; Rangoni 2019), the article first provides a conceptual framework by identifying relevant variables to focus on: regulation, private regulation, coordination, and concentration of power (Section 2). Then it presents RE auctions, the most widely used instrument for promoting RE energy that serves as an empirical ground to this article (Section 3), before examining in detail the five indices used for measuring the variables in a standardized way to allow systematic comparison across cases (Section 4). The case selection involving the UK, Mexico, and Morocco is then presented together with contextual information about each of them (Section 5). The framework is applied to our cases and the results of the indices are discussed, first index by index individually (Section 6), and then via a multidimensional approach (Section 7). It ends with concluding remarks on the future direction of research on the governance of energy (Section 8).

2. Unpacking the Multiple Dimensions of Energy Governance

Drawing on the public administration and governance literature, we identified five dimensions that we consider relevant in energy governance: regulation, private regulation, coordination, concentration of regulatory power, and type of leading actor. *Regulation* refers to the extent to which the auction process is regulated vs left to the market. Certain decisions pertaining to the auction process, such as the choice of technology, can either be imposed on operators by the auction or left open, leaving this choice to the operators. For example, we can have auctions targeting specifically concentrated solar power and others being technologically neutral. The choice of technology is regulated in the first case and not in the second. Auctions can be highly regulated or not, with important variations across countries. For example, while Brazil has very specific conditions on technology and national content standards, Mexico has no requirement on technology (Hochberg and Poudineh 2018). With regulation, public authorities can better steer how the auction will contribute to their policy objectives. For example, Dutch public authorities increase the degree of regulation of the auction by including a selection criterion specific to the environmental impact of wind turbines, which allows them to better control the environmental impact of new power plants (WindEurope 2022).

Once we know how much of the auction process is regulated, we want to know who regulates the auction. A critical aspect of this question is the involvement of private

operators in the auction design and implementation, which we call the degree of *private regulation* of the auction. Within the general literature on regulation, the major argument in favour of private regulation is expertise. Operators are those actors who better understand their sector and hold the expertise needed to fully grasp the needs for and impacts of regulation. This rationale has been at stake in the involvement of private operators in the governance of the electricity sector since the implementation of neoliberal reforms, as underlined by the literature on electricity governance in Europe (Eberlein 2008; Mathieu and Rangoni 2019; Rangoni 2019). The literature on regulation and public policy also emphasizes that a strong involvement of private actors in sectoral regulation comes with downsides as well. It is detrimental to accountability and democratic legitimacy, and may foster regulatory capture. The extent of private regulation may also reflect public authorities' trust in private actors or their willingness to keep the regulatory process under control.

Another key aspect is the degree of *coordination* involved in the auction procedure. Coordination has been widely recognized as a key factor of policy effectiveness, both in the general public administration literature (Christensen and Lægreid 2007; Bouckaert et al. 2010) and in the literature on renewable energy governance (Smith 2007; Cherp et al. 2011; Marquardt 2014, 2016). Within the public administration literature, coordination is considered important because it fosters consistency (Christensen and Lægreid 2007; Bouckaert et al. 2010). It should, therefore, help design and implement coherent auction processes. Coordination is also very useful for policy integration – to coordinate and align policy objectives and instruments across distinct policy fields (Trein et al. 2021) – which is relevant in view of the interaction of the auction process with other policy objectives, such as socio-economic, industrial, or environmental considerations. Besides, we can also find works suggesting that coordination may reduce administrative burdens for regulated companies (Hampton 2005). This is particularly relevant in the context of auctions, as winning operators have to get different types of permits or licences before they can start producing energy (e.g. offshore seabed licences similar to offshore area oil licences in the UK). Coordination may have some downsides, too. It can considerably slow down decision-making processes, make them more vulnerable to judicial reviews (Mathieu and Aubin 2014), and reduce transparency and accountability (Papadopoulos 2003; Eliantonio 2015).

Then, *concentration* of decision-making power is also important. The multiplicity of actors taking part in the auction process does not necessarily imply that decision-making power is diluted. Often, there is an asymmetry in different actors' influence on auctions' regulatory decision-making, with some actors enjoying a central role in the auction process and others being peripheral. For instance, in South Africa, most decisions were made within a special unit set up by experts from the National Treasury within the Department of Energy, an approach that results in a high concentration of decisions (Eberhard et al. 2014). The concentration of power relates to the extent to which regulatory decision-making power is symmetrical vs asymmetrically distributed among the different actors taking part in the auction process. The literature suggests that the presence of a central actor in the auction process might help steer and coordinate the input of the various participants in the policy process in a coherent direction (Kickert et al. 1997, p. 44; Sbragia 2000; Black 2008, p. 140; Lesage and de Graaf 2016). On the other side, high centralization of decision-making power might also decrease the

inclusiveness that is often said to be important for renewable energy policy effectiveness (Sovacool 2011; Goldthau 2014).

Finally, the *type of actors involved in the auction process* is also crucial. In many cases, ministries are among the most important actors in auction governance. As for electricity regulatory agencies, they are sometimes called to play a role in auctions – for example, in Chile – but they can also be peripheral or simply not involved in the auction process. Other types of agencies, such as renewable energy agencies, can, however, play a role in auction governance. Grid owner companies are also regularly involved in auctions, and other types of operators may also be involved to various extents depending on the cases. For example, where they exist, independent system operators can be central to auction implementation. The type of actor is important because the smoothness of the auction process requires the competences or knowledge of very specific actors from within and outside of the energy sector.

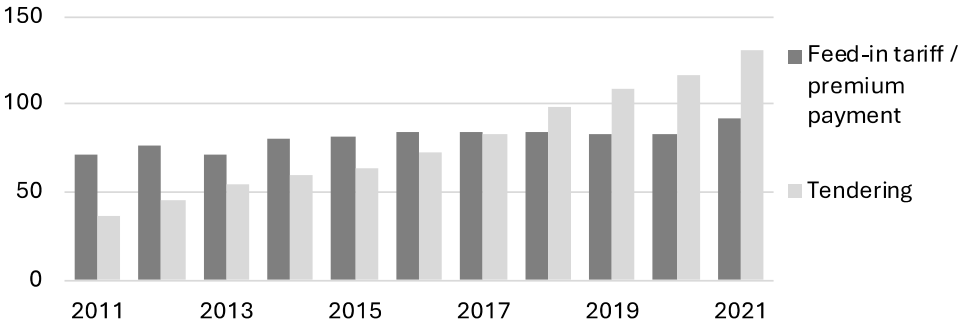
3. What Are RE Auctions, and Why Do They Matter

What are auctions exactly? Auctions are a mechanism for allocating goods given excess supply offers and unknown price *ex ante*, based solely on the bids submitted by participating bidders according to transparent awarding rules (AURES II 2022). A RE auction is a process for the competitive assignment of long-term contracts for the supply of renewable energy with an agreed remuneration. The demand for electricity generation is defined first, and interested generators submit their project bids detailing how they can meet the demand and under which conditions, in particular the price of supply. The most competitive projects are selected, leading to the conclusion of long-term electricity purchase contracts.

And why focus on auctions? Other policy instruments have been deployed to foster renewable energy, such as quotas for renewable energy suppliers, feed-in-tariffs for large and small-scale generators, direct subsidies, tax rebates for capacity investment, and auctions, among others. Besides, auctions are not beyond criticism as they can be considered a distortion to free markets, introducing risk due to the intervention of a central purchase mechanism (Keay and Robinson 2019).

Yet, after two decades of worldwide policy innovation and experimentation, auctions have gradually become the most important instrument in the new RE policy toolkit (Fitch-Roy et al. 2019; Grashof 2021) (see Figure 1). Some form of auction-based centralized purchase instrument with contracts for difference (CfDs) has become "the instrument of choice for the energy transition" (Ason and Del Pozo 2024). A critical advantage of auctions over other policy instruments is their capacity to provide both long-term revenue certainty for generators and competition among generators, allowing them to keep costs in check for the consumer, which is crucial to the public authorities that finance and guarantee electricity prices. Auctions also are a highly flexible policy instrument. Offering a wide variety of calibration possibilities, auctions can easily fit different contexts and objectives. This is reflected in their strong empirical relevance in highly distinct contexts, ranging from highly to non-liberalized countries (Kruger et al. 2021; Valenzuela 2023).

Figure 1. Evolution of the importance of major policy instruments for promoting RE across the world



Source: Authors based on REN21 Policy Database. Global Status Report 2022 Data Pack.
Note: Countries with subnational FiT or tenders are also reported and are considered positive cases.

4. Five Indices to Measure the Governance of RE Auctions

This paper presents five indices to provide a standardized measurement of the five above-presented variables of interest: regulation (regulation index), private regulation (private regulation index), coordination (coordination index), concentration of influence (concentration index), and the type of leading actors (actor influence index). We use and adapt the operationalization tools proposed by Mathieu et al. (2017) for studying multi-level regulatory governance. This allows the systematic empirical evaluation and comparison of auction governance across countries.

The first stage of the database elaboration consisted of setting up a list of all the issues, potentially leading to a regulatory decision involved in the auction process. We have elaborated on this list of issues by systematically reviewing the literature on auctions targeted to practitioners (see Table 1) (IRENA and CEM 2015; Hochberg and Poudineh 2018; IRENA 2019; USAID 2019).

Once we have established the list of issues, the researcher can collect and code the data. First we determine whether a decision is made on the issue, i.e. whether the issue is regulated. For example, if no decision applies to the choice of technology, this issue is not regulated, i.e. left to the market. For those issues subject to regulation, we analyse the decision-making procedure to find out who is involved and how. Each regulatory decision has either a decision-maker or co-decision-makers. Yet other actors may also be involved through being consulted by decision-makers. These may have more or less influence on the decision depending on the nature of their involvement. We use the scale developed by Mathieu et al. (2017) that categorizes actors' type of involvement depending on their influence on the decision and attribute to each of these categories a weight between 0 and 1 (see Table 2). If, for example, the choice of technology is regulated and decided by the ministry on its own, we code the involvement of the ministry in the choice of technology as 1 and the involvement of all remaining actors as 0. If, by contrast, the choice of technology is co-decided by a renewable energy agency and the ministry, after having consulted the system operator, we code both the ministry and the agency's involvement as 0.8,

Table 1. List of regulatory issues composing the auction process

Category	Issues
Defining demand	Product definition (MWh, MW, Certificate)
	Volume or budget cap (either in total volume or total financial budget)
	Frequency of auctions
	Technology choice (specific technologies or technology neutral)
Design	Min. or max. size of project
	Contract duration
	Payment structure (clearing price or pay-as-bid; direct payment or compensation)
	Pre-qualification criteria definition
	Pre-qualification performance evaluation
	Ceiling price
	Definition of the auction procedure
	Auction algorithms to evaluate bids
Liability	Lead time to complete project
	Offtaker responsibility
	Distributing roles on balancing
	Deployment of balancing tools
Integration	Area limitation (approved or excluded)
	Project location
	Grid interconnection investment
	Socio-economic benefits (national content, employment)

Table 2. Scale for the measurement of actors' influence on individual decisions

Weight	Coding	Description
0	Not involved	The actor is not involved in the decision
0.2	Informed	The actor is informed about the planned content of the decision
0.4	Consulted	The actor is consulted or gives non-binding advice
0.6	Binding position	The actor makes a binding opinion or initiates the decision proposal
0.8	Co-decision-maker	The actor is a co-decision-maker
1	Main decision-maker	The actor is the main decision-maker

Source: Mathieu et al. (2017), reproduced.

while the system operator gets a 0.4. The data used to compile this information comes from a combination of analysis of the relevant legislation and interviews with the main stakeholders.

Once the database is completed, we can calculate the various indices. Coding whether issues are regulated or not allows us to calculate the *regulation index*, which corresponds to the proportion of issues being regulated. It is obtained by dividing the number of issues being regulated by the total number of issues composing the auction process. The *private regulation index* aggregates values of another index, the *actor influence index*, which expresses the mean of the influence of each actor across all regulated issues (Mathieu et al. 2017). The private regulation index is the ratio between the sum of the influence of all private actors divided by the sum of the influence of all actors. For the *coordination index*, we rely on the formula developed by Mathieu et al. (2017). The first

step towards the constitution of the coordination index is to indicate the number of actors involved in each decision. For example, those decisions that are only decided by one actor get a 1 here, and those decisions adopted, following the illustration given above, by two decision-makers after having consulted a third one would get a 3 because there are three actors involved in its making. We then calculate the mean of the number of actors involved in each decision, which is subsequently standardized to make sure it is between 0 and 1 in order to allow comparison across cases. The *concentration index* also follows the formula developed by Mathieu et al. (2017) which aggregates the values of the *actor influence index*. It corresponds to the standardized mean of the difference in scores between the most influential actor and the remaining ones. The details of the formulas to calculate the indices are available in the Appendices.

5. Case Selection and Description

We have chosen three cases to apply the indices: the United Kingdom, Mexico, and Morocco. The major consideration driving this case selection is our interest in applying the multidimensional approach and the indices to a diverse set of cases regarding the structure and governance of the entire electricity industry, ranging from highly liberalized to State Owned Enterprises (SOE) monopolistic control. Diverse cases can serve exploratory research as they represent the range of cases in the population (Seawright and Gerring 2008), allowing us, in particular, to assess the capacity of the indices to cover highly contrasted cases while effectively underlying country specificities. The cases are time-bound by the period of development of the auction, with the evidence for the indices collected from the most recent auctions until 2021.

The data collection has combined document analysis (including legislation, technical regulation, official public documents, newspapers), and 61 semi-structured interviews (19 in the UK, 22 in Mexico, and 20 in Morocco) realized between 2018 and 2022. We interviewed national experts including policymakers (ministries, regulatory agencies, and public agencies) and stakeholders (public and private electricity industry actors, international organizations, foreign aid offices, associations, and independent experts). As we adapted to the availability of data, the precise combination of data sources varied across cases, with in particular interviews playing a more important role in Morocco than in the other two cases.

Starting in 1980, the UK fully privatized and unbundled the electricity system, which was accompanied by the creation of an independent regulator and the delegation of important regulatory and planning functions to companies and trade bodies. Thus, the CfD, the UK version of RE auctions, initiated in a fully liberalized context. The adoption of CfDs in 2013 was accompanied by a number of institutional changes featuring the empowerment of a strong ministry and state-owned companies. The 2013 Energy Act was promoted by a still young Department of Energy and Climate Change (established only in 2008 after the Climate Change Act) and created the mechanisms of the CfDs along with the Low Carbon Contract Company (LCCC) (Valenzuela and Rhys 2022). The department of energy plans and runs the auction process, selecting all conditions including on types of technologies, regions where projects can be located, value chain creation obligations, and other requirements. These decisions are consulted with other relevant agencies who play important roles, directly or indirectly, in auctions. For instance, the LCCC, as a state-owned company, is the offtaker (purchaser) of all energy which it then sells to all market participants. Similarly, the Crown Estates is key in

defining the potential areas for project location, as the public organization managing the economic rights over the continental shelf that are essential for offshore wind energy (Kern et al. 2014). This policy has been a frank success, enabling the massive deployment of offshore wind energy, and laying the ground for further policy development along the same lines, in particular with the recent adoption of the 2023 Energy Act.

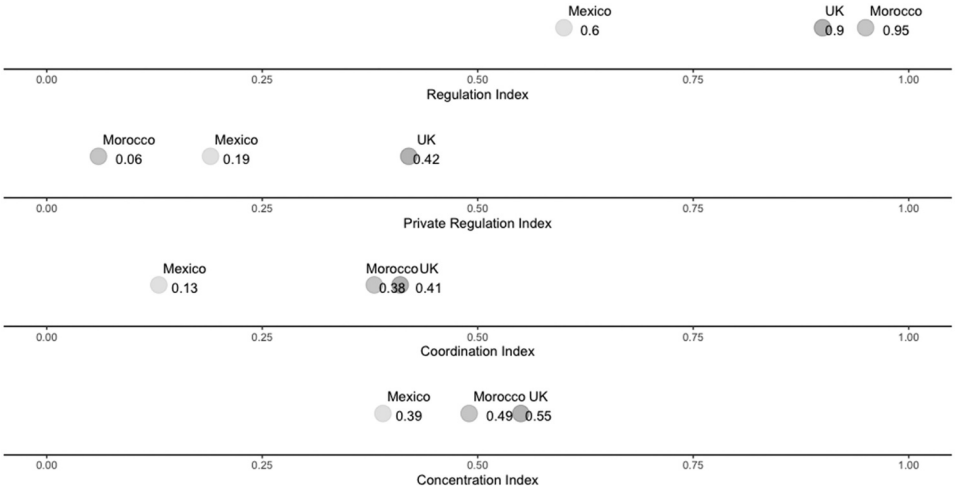
Morocco has, by contrast, hardly liberalized its electricity sector, targeting only big industrial consumers. It also refrained from unbundling and privatizing its incumbent company and it created an IRA only in 2020. RE auctions were thus adopted and integrated in a radically different context than that represented by the UK, dominated by the Office National d'Eau et d'électricité (ONEE), the Moroccan vertically integrated public monopolistic company. In Morocco, RE auctions were set up in 2010, as part of a highly ambitious plan for developing renewable energies, adopted in particular to limit Morocco's dependence on international energy markets. RE auctions were created together with the Moroccan Agency for Sustainable Energy (MASEN), a non-independent public agency that serves as a cornerstone of the Moroccan auction policy regime. The planification of RE auctions – e.g. the identification of volumes and energy sources and criteria for selecting winning applicants – is done in close coordination with the ONEE and the ministry. From there, MASEN takes over and is omni-present in the implementation of the RE auctions regime. Not only does MASEN run the auctions, but it is also part of the joint venture exploiting the energy source, and serves as an offtaker (single buyer) of the energy produced, which it sells to ONEE down the line. The power purchase agreements are backed up by the governments and benefit from a strong commitment by the King of Morocco, which considerably increases the credibility of the whole system and contributed to the internationally recognized success of this policy regime that allowed it to attract many foreign investors (Usman and Amegroud 2019, pp. 42–46; Mathieu 2023).

In terms of degree of prior liberalization, Mexico lies somewhere in between the UK and Morocco, with a dominant state-owned company operating in a very young wholesale market. The creation of an auction mechanism was a component of a larger reform to reorganize the industry through constitutional and legal changes between 2013 and 2015, which created a wholesale market and a system of clean energy certificate obligations. The reform unbundled but did not privatize the state-owned company, CFE, and expanded the role of the Department of Energy (Valenzuela 2023). To promote the expansion of renewable energy, the government approved a system of Clean Energy Certificates for all major consumers and suppliers. However, the state-owned enterprise was obligated to acquire renewable electricity to achieve its certification obligations through long-term auctions. The three auctions completed, before a new government stopped them altogether in December 2018, were planned and coordinated directly by the Department of Energy (SENER) but operationally implemented by the system operator. Unlike the UK or Morocco, there were no value chains or job requirements, nor were there pre-selected technologies. And similarly to the UK, the market regulator played a secondary role only. The auctions were considered a success in attracting private investment, with over 70 contracts signed. Yet they were suspended by a left-wing government which did not consider these to bring sufficient development benefits.

6. Application of the Framework: Results

The results of the data collection are gathered into three databases, one for each country (see Appendices 2, 3, and 4). The results show that the indices are able to underline important

Figure 2. Results of the RE auction governance indices



differences across countries regarding the way auction governance is organized (see Figure 2), which is very useful in the context of comparative analysis. Overall, they indicate a proximity between the UK and Moroccan models, characterized by high levels of regulation, or coordination and concentration, and a distinction of the Mexican case with significantly lower scores on those three indices. This is a highly interesting result, given that the UK and Morocco were placed at either end of the continuum in terms of prior degree of liberalization. That these two countries appear to form a new pattern of governance suggests important disruptions with past policy and governance arrangements.

The *regulation index* is high for the UK and Morocco (0.95 and 0.9), and significantly lower for Mexico (0.6). In the UK, it points at what seems to be a crucial deviation in terms of policy style, which is now more favourable to regulatory control than to markets. In the other two countries, it suggests continuity in two different ways. We observe very strong regulatory control over auctions in Morocco, reflecting the low degree to which Morocco has engaged with liberal reforms and the authoritarian political culture. Mexico shows results that are somewhere in between the UK and Morocco, which is in line with the partial engagement of the country with the liberalization of electricity reforms in the past. In short, in the UK, auctions are used as a means to expand regulatory control, while in Mexico and Morocco they serve as instruments to maintain control of liberalization processes of different depths.

Our data reveal that the difference between less and more regulated systems is due to differences in regulation over technological choices and the integration of auctions in their broader environment (see Table 1, category "integration"), in particular on the geographical location and socio-economic benefits. This indicates, in the UK and Morocco, a higher importance given to auctions' interaction with other policy objectives and the willingness to leverage auction goals like fostering domestic value chains and jobs. By contrast, the Mexican approach to auctions is designed around the exclusive objective of achieving low prices.[1] In other words, the results suggest that the higher the

level of regulation, the less purely market-based and the more politicized the auction process is, as a higher level of regulation embodies political trade-offs between different policy objectives. The cases thus differ regarding the degree of politicization of the auction process, high in the UK and Morocco, and low in Mexico.

The *private regulation index* makes a useful complement to the results of regulation. In particular, it allows us to clearly distinguish the UK and Moroccan cases. Whereas both countries display a very high level of regulatory control, private actors play a very important role in it, but they are nearly absent in Morocco. These results feature a reconciliation of the UK auctions with the historical role of private actors. By contrast, the Moroccan authorities prefer to keep control of regulations and limit the influence of the private sector. This is typical of authoritarian regimes characterized by the concentration of power in the hands of the ruling elite and the atrophy of the private sector (Acemoglu and Robinson 2012). Mexico's very low score is the result of the historically limited role of the private sector in the industry, but expanding it is inscribed in the reform process.

The *coordination index* reflects again the emerging similarity between the UK and Morocco, both featuring high levels of coordination (0.41 and 0.38) and their distance from the Mexican model (0.13). In Morocco, many decisions are co-decided by a few key actors: the renewable energy agency (Masen), the incumbent utility, and the ministry. For the UK, the high level of coordination reflects the country's experience with dealing with power fragmentation via coordination (Chow et al. 2007; Heald and Georgiou 2009) and the strong role played by operators and private actors. The score for Mexico might be interpreted as the effect of emerging coordination structures from a still early liberalization process. These results suggest that strong coordination can be expected in stabilized systems, whether they are non-liberalized or fully liberalized (like Morocco and the UK), while systems in transition like Mexico provide a less stable environment for coordination to flourish.

The *concentration index* indicates once again a pattern grouping the UK and Morocco with similarly high results (0.55 and 0.49) and Mexico apart with a slightly lower figure (0.39). We should, however, be careful in the interpretation here, as with this index the distinction between both groups is not so clear-cut, indicating that concentration is not so critically distinctive across cases. A possible explanation for Mexico's lower score might be the relatively important role of the three public actors, the ministry, the system operator, and the SOE.

The *actor influence index* allows the leading actors in the governance arrangement to be identified (see Table 3). A first interesting finding is the displacement of IRAs, left with a secondary role in RE auctions governance, in all three countries. This is quite understandable for Morocco, where the RE auctions regime was created well before the setting up of an IRA, and the regulatory competences were delegated, instead, to Masen, a specialized RE (non-regulatory) agency. This result is more puzzling for the UK and Mexico, which both delegated regulatory competences to a line ministry. These results are, however, nuanced in Mexico, where the intention of the law was to place the IRA at the centre of RE auctions' regulatory governance after the first three iterations. A second key finding relates to the importance of industrial actors – in particular system operators. In all three countries, the second most influential actors of RE governance are industrial actors: the system operators in the UK and Mexico and the integrated electric company (here coded as grid company) in Morocco. Interestingly, in all cases we see a rupture with the precedent governance patterns characterized by the dominance of either the IRA (in the UK and Mexico) or the vertically integrated state-owned enterprise (in Morocco).

Table 3. Major results of the actor influence index

Actor	UK	Mexico	Morocco
Ministry	0.77	0.70	0.35
Regulatory agency	0.28	0.33	–
System operator	0.46	0.50	–
Grid company	0.31	–	0.68
Supply company(ies)	–	0.28	–
Generation company(ies)	0.38	0.22	0.13
Renewable energy agency	–	–	0.77

The use of RE auctions implies choices about the place of regulatory power, which is not limited to pre-existing institutions, but comes with the balancing of dominant actors (be they IRA or SOEs) with that of new executive or traditional industrial actors.

7. Multidimensional Analysis

In line with the multidimensional approach, we can further analyse how the results obtained on the different indices relate to each other. A first important finding is that the different components of deregulation, private actors, and IRA empowerment, which are conceived as a cohesive pack under the ideal liberalized model, are uncorrelated here (see Table 4). For example, unlike as suggested by traditional models associating depoliticization with privatization, we observe here that highly regulated and politicized auction processes can coexist with both a strong and a weak private sector. To push the exercise further and illustrate the usefulness of the multidimensional approach, we use the results provided by the indices to identify potential patterns in the combination of dimensions.

We note that the actors that are more responsive to government priorities than the IRAs are responsible for the regulatory tasks that result in high levels of regulation in the UK and Morocco. This does not come as a complete surprise. In fact, it makes sense. The high level of regulation allows RE auctions to be politicized by integrating multiple policy objectives including environmental and industrial priorities. Yet IRAs were set up as single-purpose bodies. They are ill-suited to the balancing of various policy objectives, which is more easily handled by politicized administrative bodies like ministries. Mexico's low level of regulation corresponding to a single-purpose auction regime (aiming at achieving low prices only) was intended to be managed by an IRA (after initial full control of government). But auctions were suspended by a powerful executive, in the midst of criticism for not addressing development concerns. A pattern is thus clearly emerging, opposing countries (the UK and Morocco) with

Table 4. Overview of the empirical disconnection between the three key elements of electricity sectoral reforms and auction governance

	Ideal liberalized case	UK	Mexico	Morocco
Liberalization (as opposed to regulation)	+	–	+	–
Private regulatory power	+	+	–	–
IRA empowerment	+	–	–	–

a high level of politicization of the auction regime reflected in both the calibration of auctions (high level of regulation and politicized implementing body) to Mexico's original intended model featuring a low level of politicization visible in both the instrument calibration and the governance arrangement, but which suffered political backlash.

We also find that high levels of regulation are combined with high levels of coordination and concentration for the UK and Morocco – in opposition to Mexico, showing (relatively) low levels on all three dimensions. While Mexico's low levels of coordination and concentration may be related to a recomposition of actors' configuration in a context of an evolving policy regime (see above), there might also be a causal link underpinning the correlation between regulation, coordination, and concentration dimensions. All three dimensions may be different manifestations of a willingness to foster the integration and coherence of the RE auctions policy regime. A high level of regulation fosters the integration of alternative policy objectives (e.g. environmental protection, socio-economic development) into electricity governance. A high level of coordination promotes the integration of all relevant actors' viewpoints into auction governance. And high concentration promotes internal coherence by limiting decision-making fragmentation. All three dimensions contribute to a high degree of both internal and external policy coherence (Mathieu 2023). Their strong correlation in our three cases, clearly distinguishing the UK and Morocco on the one hand from Mexico on the other, might reflect different degrees of policymakers' awareness and attention placed on policy coherence.

These new configurations are not just empirically interesting, they are also important from a normative viewpoint. The configurations that we have identified here are not just deviation from classical visions of the liberalization blueprint; they may turn out to be more effective. The RE auction regimes of the UK and Morocco, both combining a high level of regulation, coordination, and concentration, are very successful in international comparison, featuring massive and nearly unparalleled expansion of solar energy in Morocco and offshore wind energy in the UK (Usman and Amegroud 2019, pp. 42–46; Allan and Nahm 2024). In Morocco, the coordination with the executive, and in particular the political influence and supervision of the auction regime, have guaranteed a policy commitment, credibility, and ultimately a high level of policy coherence to the regime (Mathieu 2023). In the UK, the high level of regulation, strong ministerial leadership and coordination with private actors, new purpose-created state-owned companies and environmental resource management authorities have been critical to the boom in offshore wind energy (Kern et al. 2014; Valenzuela and Rhys 2022; Allan and Nahm 2024). Whereas electricity governance textbook models assume that policy success depends on the joint adoption of liberalization (deregulation), private and IRA empowerment (Joskow 2006), our multidimensionality approach shows that the different dimensions of electricity governance might be effectively combined differently – echoing recent literature emphasizing the compatibility of features such as state-owned enterprises with liberalized markets and renewable energy expansion (Benoit et al. 2022; Valenzuela 2023). It is very likely that these outstanding results were facilitated by the strong degree of policy coherence (Mathieu 2023) conveyed by the high levels of regulation, coordination, concentration, and politicized implementing bodies.

It is interesting to note that the UK and Morocco end up being more similar than expected in many respects, while placed at the opposite ends of the liberalization continuum. This may appear counter-intuitive from a historical institutionalist approach. It suggests that, to a large extent, new functional pressure overwrites institutional legacies.

8. Conclusion

Textbook energy liberalization reforms are conceived as a cohesive package of instruments covering liberalization, privatization, and IRA empowerment by some (Besant-Jones 2006; Joskow 2006), but recognized to be rather diverse by other industry economists (Glachant 2013; Foster and Rana 2020). The way different policy and governance instruments are combined in practice is subject to a wide empirical variety. The capacity to grasp this empirical variety is of utmost importance from a normative viewpoint as we now have overwhelming evidence that sectoral policy success is achievable under different configurations of policy or governance instruments (Foster and Rana 2020; Mathieu 2023; Valenzuela 2023).

Whereas some conceptual works overlook this empirical complexity and variety, more empirically orientated case studies are not accompanied by conceptualization allowing this diversity to be investigated using a more systematic and comparative approach. This paper takes a first step towards closing that gap. It provides a conceptual and methodological framework to analyse renewable energy governance complexity and multidimensionality from a comparative public policy approach. It identifies a series of relevant variables to analyse governance and accompanies each of them with an index to measure them in a systematic way

The overarching argument of this article is the importance of multidimensionality for the analysis of energy governance. The data reveals that the components of textbook energy liberalization reforms are, for RE auction governance, largely uncorrelated with each other. In particular, we find that the prior degree of sector liberalization does not determine the extent of regulation, coordination, and the type of actors in charge of auction governance. High levels of regulation and coordination, and highly politicized policy implementation is observed in both the UK and Morocco – that is, in both highly and hardly liberalized systems. It seems that policy change coming with renewable energy policies has largely followed new pressures instead of further reinforcing institutions and actors coming from liberalization reforms, hence neutralizing positive feedback loops and institutional inertia effects. An important illustration of that is the marginal role played by IRAs in auction regimes by comparison to the empowerment of ministries and state-owned companies, which reflects recent theoretical discussions on the compatibility of state-owned companies with liberal markets and renewable energy expansion (Benoit et al. 2022; Valenzuela 2023).

The multidimensional analysis based on the indices also points at more specific patterns. The data indicates that a high level of regulation corresponds to the empowerment of politicized public administration bodies for the implementation of RE auctions. It is indeed clear that countries concerned about the importance of alternative policy objectives – including for instance environmental impact and socio-industrial development – mobilize both policy instruments and institutions to address these multiple objectives.

Finally, taking into account the various dimensions of energy governance allows us to better understand the regulatory output and outcomes and the conditions for policy effectiveness. The many similarities between the UK and Morocco, including the success of their respective RE auction policies, suggest that effective RE auction regimes might be favoured by high levels of regulation and coordination, and a politicized public administration to implement the auctions, fostering internal and external policy coherence and integration.

It will be up to future research to explore in detail the causes underlying these emerging configurations and their impacts. Are high levels of regulation and coordination necessary for policy success, or might less integrated policy regimes produce similar

policy outcomes? The multidimensional theoretical approach, the range of variables that we identified, and the indices that we developed can be used in a wide variety of research contexts, ranging from the analysis of the causes, manifestations, and effects of the diversity of governance arrangements in energy as well as in other policy fields.

Notes

1. Confirmed by an auction designer (Interview, 15 May 2019).

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Appendices

1. List of decisions composing the auction system

Categories	Issue coding in the article	Hochberg & Poudineh (2018)	IRENA and CEM (2015)	AURES II (2022)	USAID (2019)
Defining demand	Product definition	Auction products	Project size	Auction product & multiple or single unit	Auction products
	Volume or budget cap	Volume-setting responsibility	Volume auctioned	Volume or budget cap	
	Frequency of auctions			Frequency of auctions	
	Technology choice	Technology eligibility	Diversity of technologies	Technology focus & technology differentiation	
Design	Min–max size of project			Min–max size of project	
	Contract duration			Support duration	
	Payment structure		Perception of risk	Form of support auctioned & pricing rule	
	Pre-qualification criteria	Pre-qualification	Entry barriers & reputation requirements	Prequalification requirements: material & financial	Conditions for participating in the auction: technical requirements
	Pre-qualifications performance	Pre-qualification			Conditions for participating in the auction: financial guarantees
	Ceiling price		Ceiling price mechanism	Ceiling price	Ceiling price
	Definition of auction procedure	Auction process	Bidding procedure	Auction procedure	Auction procedure
	Auction algorithms	Auction process	Multicriteria selection process	Evaluation criteria	

(*continued*)

(*Continued*)

Categories	Issue coding in the article	Hochberg & Poudineh (2018)	IRENA and CEM (2015)	AURES II (2022)	USAID (2019)
Liability	Lead time	Lead time	Compliance rules	Realization period	Deadlines and penalties
	Offtaker responsibility	Offtakers	Perception of risk		
	Roles on balancing (incl. curtailment)	Provision for renewables	Compliance rules		
	Deployment of balancing		Compliance rules		Time and location-based incentives
Localized integration	Area limitation		Location constraints		Location signals
	Project location		Location constraints		Location signals
	Grid interconnection		Grid access requirements		Location signals
	Socio-economic benefits		Qualification (socio-economic development)		

2. Indices formula

Equations	Variables description
$R = \frac{ri}{i}$	**R**: Regulation Index **ri**: Number of regulated issues **i**: Number of issues
$\frac{\sum_{k=1}^{apr} AI(APr_k)}{\sum_{k=1}^{a} AI(A_k)}$	**AI(APr_k)**: Actor influence of private actor k **apr**: Number of private actors **AI(A_k)**: Actor influence of actor k
$Co = \frac{\sum_{j=1}^{i} a_j - i}{i(a-1)}$	**Co**: Coordination index **aj**: Number of actors involved in the decision over the issue number j
$AI(A_k) = \frac{\sum_{j=1}^{i} AI(A_k I_j)}{i}$	**AI**: Actor influence index **AI(A_k)**: Actor influence of actor k **AI($A_k I_j$)**: Actor influence of actor k on the issue j
$Cc = \frac{\sum_{k=1}^{a} [AI(A_{max}) - AI(A_k)]}{a-1}$	**Cc**: Concentration index **AI(A_{max})**: Actor influence of most influential actor of the regulatory arrangement

3. UK Database

	Actors / Issues	Public actors						Private actors			Regulated issue	Number of actors involved
		BEIS	Ofgem	LCCC	Crown Estate	Devolved governments	Defra	National Grid	NG ESO	Private generators		
Defing demand	Product definiton	1	0,4	0,4	0	0,4	0	0,4	0,4	0,4	1	7
	Volume or budget cap	1	0,4	0,4	0	0,4	0	0,4	0,4	0,4	1	7
	Frequency of auctions	1	0	0,2	0	0	0	0	0,2	0	1	3
	Technology choice	1	0,4	0,4	0	0,4	0	0,4	0,4	0,4	1	7
Design	Size of the project	0,6	0,4	0,4	0	0,4	0	0,4	0,4	1	1	7
	Contract duration	1	0	0	0	0	0	0	0	0	1	1
	Payment structure	1	0,4	0,4	0	0,4	0	0,4	0,4	0,4	1	7
	Pre-qualification criteria	1	0,4	0,4	0	0,4	0	0,4	0,4	0,4	1	7
	Pre-qualifications performance	0,8	0	0	0	0	0	0	0,8	0	1	2
	Ceiling price	1	0	0	0	0	0	0	0	0	1	1
	Defintion of auction procedure	1	0,4	0,4	0	0,4	0	0,4	0,4	0,4	1	7
	Auction algorithms	0	0	0	0	0	0	0	1	0	1	1
Liability	Lead time	0,8	0,4	0,4	0	0,4	0	0,4	0,4	0,6	1	7
	Off-taker responsibility	1	0,4	0,4	0	0,4	0	0,4	0,4	0,4	1	7
	Roles on balancing (incl. curtailment)	0	0,8	0	0	0	0	0,6	0,8	0,4	1	6
	Deployment of balancing	-	-	-	-	-	-	-	-	-	0	-
Integration	Area limitation	0,8	0	0	0	0	0,8	0	0,4	0,4	1	4
	Project location	0,4	0	0	0,8	0	0,4	0,6	0,6	0,8	1	6
	Grid inteconnection	0,4	0,6	0	0,4	0	0	0,8	0,8	0,8	1	6
	Socio-economic benefits	-	-	-	-	-	-	-	-	-	0	-
Actor Influence Index		**0,8**	**0,3**	**0,2**	**0,1**	**0,2**	**0,1**	**0,3**	**0,5**	**0,4**		
Regulation Index		**0,9**										
Private regulation index		**0,4**										
Coordination index		**0,4**										
Concentration index		**0,5**										
Number of actors		10										
number of issues		20										
Number of regulated issues		18										

4. Mexico database

	Actors / Issues	Public actors				Private act.		Regulated issue	Number of actors involved
		SENER	CRE	CENACE	CFE supply co.	Private buyers	Private generators		
Defing demand	Product definiton	1	0,6	0,6	0	0	0	1	3
	Volume or budget cap	0	0	0	0,8	0,8	0	0	2
	Frequency of auctions	1	0	0	0	0	0	1	1
	Technology choice	-	-	-	-	-	-	0	-
Design	Size o the project	-	-	-	-	-	-	0	-
	Contract duration	1	0	0	0	0	0	1	1
	Payment structure	0,8	0	0	0	0	1	1	2
	Pre-qualification criteria	1	0,6	0,6	0,4	0,4	0,4	1	6
	Pre-qualifications performance	0	0	1	0	0	0	1	1
	Ceiling price	-	-	-	-	-	-	0	-
	Defintion of auction procedure	1	0,6	0,6	1	0	0	1	4
	Auction algorithms	0	0	1	0	0	0	1	-
Liability	Lead time	1	0,6	0,6	0,4	0,4	0,4	1	6
	Off-taker responsibility	0,8	0	0	0,8	0,8	0	1	3
	Roles on balancing (incl. curtailment)	0,8	0,8	0,8	0	0	0	1	2
	Deployment of balancing	-	-	-	-	-	-	0	-
Integration	Area limitation	-	-	-	-	-	-	0	-
	Project location	-	-	-	-	-	-	0	-
	Grid inteconnection	0	0,8	0,8	0	0	0,8	1	2
	Socio-economic benefits	-	-	-	-	-	-	0	-
Actor Influence Index		**0,7**	**0,33**	**0,5**	**0,28**	**0,2**	**0,22**		
Regulation Index		**0,6**							
Private regulation index		**0,19**							
Coordination index		**0,13**							
Concentration index		**0,39**							
Number of actors		6							
Number of issues		20							
Number of regulated issues		12							

5. Morocco database

	Actors / Issues	Public Actors					Priv.		
		Masen	ONE	Ministry TEDD	Government	IFIs	Operators	Regulated issue	Number of actors involved
Defing demand	Product definiton	0,8	0,8	0,8	0,6	0	0	1	4
	Volume or budget cap	0,8	0,8	0,8	0,6	0	0	1	4
	Frequency of auctions	0,8	0,8	0,8	0,6	0	0	1	4
	Technology choice	0,8	0,8	0,8	0,6	0	0,8	1	4
Design	Size of the project	0,8	0,8	0,8	0,6	0	0	1	4
	Contract duration	0,8	0,8	0	0	0	0	1	2
	Payment structure	0,8	0,8	0	0	0	0	1	2
	Pre-qualification criteria	0,8	0,6	0,6	0	0,6	0	1	4
	Pre-qualifications performance	0,8	0,6	0,6	0	0	0	1	3
	Ceiling price	-	-	-	-	-	-	0	-
	Defintion of auction procedure	1	0	0	0	0	0	1	1
	Auction algorithms	0,8	0,6	0,6	0	0	0	1	3
Liability	Lead time	0,8	0,8	0	0	0	0	1	2
	Off-taker responsibility	0,8	0,8	0	0	0	0	1	2
	Roles on balancing (incl. curtailment)	0,8	0,8	0	0	0	0	1	2
	Deployment of balancing	0,8	0,8	0	0	0	0	1	2
Integration	Area limitation	0,8	0,6	0	0	0	0	1	2
	Project location	0,8	0,6	0	0	0	0	1	2
	Grid inteconnection	0	0,8	0	0	0	0,8	1	3
	Socio-economic benefits	0,8	0,4	0,8	0,6	0	0,8	1	5
Actor Influence Index		**0,77**	**0,68**	**0,35**	**0,19**	**0,03**	**0,13**		
Regulation Index		**0,95**							
Private regulation index		**0,06**							
Coordination index		**0,38**							
Concentration index		**0,49**							
Number of actors		6							
Number of issues		20							
Number of regulated issues		19							