Report D7.3a, September 2020

The future of renewable energy auctions

Scenarios and pathways – consultative draft

AURES II has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817619

Report D7.3a, September 2020: The future of renewable energy auctions

Scenarios and pathways – consultative draft

Authors: Bridget Woodman and Oscar Fitch-Roy (UNEXE)
Reviewed by: Vasilios Anatolitis (Fraunhofer)

Submission date: TBC
Project start date: 01 November 2018
Work Package: WP7
Work Package leader: Fraunhofer

Dissemination level: PU (Public)

Contents

1 Your input is needed! ... 6
1.1 Webinar details ... 6
1.2 ... 6
2 Background to this study: a changing role for renewable energy support ... 7
3 Introduction to scenario analysis ... 9
4 Methods and data ... 13
5 Scenarios for the future of auctions ... 15
6 Two dimensions ... 17
6.1 Axis 1: flexibility ... 17
6.1.1 Indicators ... 18
6.2 Axis 2: decentralisation ... 19
6.2.1 Indicators ... 19
7 Four scenarios ... 20
7.1 Top-down tech (High flexibility, low decentralisation) ... 22
7.1.1 Characteristics ... 22
7.1.2 Storyline ... 22
7.1.3 Implications for RES auctions ... 22
7.2 Shiny happy energy citizens (high flexibility, high decentralisation) ... 23
7.2.1 Characteristics ... 23
7.2.2 Storyline ... 23
7.2.3 Implications for RES auctions ... 24
7.3 Leviathan (low flexibility, low decentralisation) ... 24
7.3.1 Characteristics ... 24
7.3.2 Storyline ... 24
7.3.3 Implications for RES auctions ... 25

7.4 Make-do-and-mend (low flexibility, high decentralisation) 26
7.4.1 Characteristics 26
7.4.2 Storyline 26
7.4.3 Implications for RES auctions 27
8 Analysis: pathways and implications for RES auctions 28
8.1 Public RES auction guaranteeing supplements to private revenues 28
8.2 Corporate or community PPA 28
8.3 Return of the feed-in tariff 29
8.4 Merchant contracting 29
9 Conclusions 30
References 31

Table of tables

Table 1: Overview of major qualitative energy scenario exercises 9

Table of figures

Figure 1: qualitative scenario production process 13
Figure 2: Task 7.2 timeline 14
Figure 3: Long list of 'drivers' of electricity system change relevant to RES auctions 15
Figure 4: First list of themes 16
Figure 5: Set of axes and worlds emerging from consortium workshop 16
Figure 6: Flexibility indicators as presented by Papaefthymiou et al. (Papaefthymiou *et al.* 2018) 18
Figure 7: Scenario framework overview 20
Figure 8: components of auction model illustrations 21
Figure 9: a merchant system in which wholesale electricity markets can enable adequate risk management 23
Figure 10: an auction system in which private (or corporate) PPAs are auctioned with little or no public or regulatory input 23
Figure 11: auction system in which privately organised auctions are subject to some degree of regulatory oversight of design – particularly to ensure actor and technology diversity 24
Figure 12: auction system in which private corporations are legally compelled to increase procurement of RES auctions through mandated auction programmes 25
Figure 13: the return of the FiT 26

1 Your input is needed!

This draft document is consultative and we are inviting input from stakeholders from industry, academia, governments and elsewhere to fine tune our scenarios and the conclusions. To this end, we are hosting a webinar and have launched a questionnaire.

1.1 Webinar details

Wednesday 7th October 2020

10.30-12.00 CEST (9.30-11.00 BST)

For more information and an agenda for the webinar, please visit:

http://aures2project.eu/event/aures-ii-virtual-workshop-on-the-future-of-renewable-energy-auctions/

Participation to the webinar is free. To register please go to:

https://register.gotowebinar.com/register/2502778434471134 8 4

1.2

In addition, we have launched an online questionnaire which can be completed by following the link below:

https://exeter.onlinesurveys.ac.uk/scenarios-for-the-future-of-res-auctions

2 Background to this study: a changing role for renewable energy support

In the last few years, auctions have becoming the predominant policy instrument for securing and managing RES deployment in Europe. Auctions simultaneously address a number of market failures, including wholesale electricity remuneration rates that are often lower than production costs and prohibitive risk premia associated with volatile wholesale electricity markets. Auctions also protect society from the immediate costs of over-rewarding renewable generators and system costs of uncontrolled RES expansion.

However, the role played by renewable energy technologies is determined by the broader context in which they are embedded, which is likely to change in the coming decades. The value that renewable generators can realise through participating in markets will influence the type(s) of RES auction, if any, that characterise the future energy system, and this value may be subject to significant change between today and 2030 and beyond.

In particular, evolutions in market design and network regulation will have a profound effect on the cost of producing and integrating renewable electricity in the future electricity system. The products that can be traded and the value assigned to them, and how overall costs are allocated among generators, network operators, consumers and taxpayers and others will shape the 'routes to market' available to renewable generators – and what policies might be needed to keep those routes open.

For example, the future status of issues such as degree of market liberalisation, grid congestion and constrained output, balancing charges and trading arrangements, as well as the system value of renewables generation, will together define the profitability, or otherwise, of renewable electricity production. The future condition of markets and networks is therefore central to the issue of whether subsidies awarded through auctions (or otherwise) can or should be removed, changed or reduced over time.

For that reason, what we understand auctions to be will likely also evolve. Current expectations of who is likely to bid, who the auctioneer might be, and what is being auctioned will shift in the future as a response to changing market and system conditions. For that reason, we have adopted a broad definition of what is meant by 'auction' to include as many potential future configurations as possible. This definition is that an auction is *an agreement giving a route to market for electricity production which is allocated through a competitive, largely price-driven ranking process*.

Increased levels of renewables penetration are already leading to changes in the functioning of electricity markets and the operation and planning of networks. Adoptions of other technologies and practices such as e-mobility, battery storage greater use of demand-side flexibility and improved energy efficiency will accelerate this change. Some of the changes are driven by policy decisions taken at various levels while others emerge from organic, bottom-up processes. Governance arrangements such as the delegation of responsibility to the local level and the scope for action of distribution networks are important factors in enabling, shaping or inhibiting change.

As mentioned in the Winter Package, there are ongoing discussions about future developments such as the emergence of more local energy markets, and more active management of low-voltage distribution networks, both of which could be more supportive of renewable technologies than the current, more centralised model, reducing overall system costs and reshaping routes to market for renewable energy. As a result, there are many uncertainties about what electricity systems may look like in future, and many possible trajectories for the co-evolution of markets, networks and renewable technologies. This task has generated qualitative scenarios as a way of thinking about the future using these drivers to think about future electricity system development. The aim is to inform debates about what the implications of market and network design and operation might be for the future viability of renewables, and therefore how auctions might evolve over time.

The objective of this document is to initiate and structure a debate with stakeholders in RES auction design and implementation in Europe about the future of the instrument through the creation and analysis of qualitative scenarios. It is expected that it will be of use for policy makers and auction designers considering future auction design options, as well as businesses who wish to consider how auctions might evolve in response to future system and market conditions.

As a last note, this report was produced during the Covid-19 pandemic. This means that the degree to which expert stakeholder input into its production has so far been limited. It is hoped that this will be rectified somewhat by a webinar in the autumn of 2020. Comments from this webinar will be taken into account in the content of the final report.

Covid-19 has had a profound impact on electricity systems, both in terms of overall demand and patterns of consumption. It is likely that this will have knock-on impacts on the frequency and size of future auctions in the short term, although the longer term focus of this report (2030/2050) means that we have not explicitly incorporated Covid-19 impacts in the final discussion and analysis.

3 Introduction to scenario analysis

Qualitative scenarios are tools to help decision making about an uncertain and complex future (Wilkinson *et al.* 2013). They are increasingly being used to guide policy making in the context of long-term commitments to reducing greenhouse gas emissions up to 2050.

Scenario analysis is not a prediction about what the future will be, but rather about what a plausible future might be, based on informed judgements about key drivers for system development and – in the context of electricity systems - certain commitments (e.g. 2030/2050 emissions reduction targets). Unlike more quantitative approaches, qualitative scenarios concentrate on possible future socio-economic and -political conditions rather than specific technical or economic parameters (Amer *et al.* 2013; Söderholm *et al.* 2011). The scenarios presented here are developed on the basis of intuitive logics (MacKay and Stoyanova 2017; Wack 1985), based around decision making in uncertain social, economic, technical and political conditions. Once a set of qualitative scenarios has been constructed, quantitative modelling techniques can be applied to examine in detail the technical and economic implications of each storyline (Fortes *et al.* 2015).

Clearly the future can involve infinite different possibilities for change, especially in the medium to long term Scenario analysis tends to reduce the infinite possibilities by identifying key trends and drivers (C. . Varum and Melo 2010; Walton *et al.* 2019). While this can be criticized as limiting the scope of analysis, and can fail to take account of 'unknown unknowns' such as Covid 19, it does at least constrain the range of futures to trends which can relatively easily be accepted by policy makers as 'plausible' (Swart *et al.* 2004). In electricity systems, where change can be slow because of sunk costs and infrastructure commitments, the approach could be seen as appropriate for timescales up to 2050, which is the limit of this exercise.

Scenario analysis is an increasingly common technique used to think strategically about the development of energy systems, not least by enhancing understanding of processes and connections, and by providing a means to challenge conventional thinking (Wright *et al.* 2013). Scenario analysis can be useful for identifying possible future system discontinuities and their implications as well as examining the potential consequences of policy or regulatory decisions over time (Amer et al. 2013). Arguably the application of scenario thinking to energy system development began with Royal Dutch Shell at the end of the 1960s, when their use is credited with positioning the company to take strategic advantage of the 1973 oil crisis (Wack 1985). More recently, qualitative scenario analysis techniques have been employed by the World Energy Council (World Energy Council 2019), ENTSO-E and ENTSOG (Entsog and Entso-e 2020) , and at a national level by the UK's National Grid Company (National Grid 2019) amongst others. Each of the reports presents narrative storylines about what the future energy world might look like, and then considers the technical, economic, social and political implications of this. A brief outline of the scenarios is given in Table 1 below.

Table 1: Overview of major qualitative energy scenario exercises

ENTSOG/ENTSO-E (2020)	Ten Year Network Development Plan 2020 Scenario Report
European focused scenarios exploring the interactions between gas and electricity networks up to 2050 as part of the ENTSOs' Ten Year Network Development Plan process	
Method:	Framed by the 1.5°C Paris Agreement targets. Assumes further development of gas and electricity sector coupling as a route to

	decarbonisation. The key drivers in the scenario storylines are decarbonisation (low to high ambition), and centralization vs decentralization. Scenarios also incorporate national TSO data for short term (up to 2025) developments. The storylines are used as the basis of quantitative modelling of future energy mix, demand and network use.
Scenarios	3 storylines: National Trends Central scenario based on draft Member States National Energy and Climate Plans (NECP) submitted to the European Commission. Complies with the EU 2030 Climate and Energy Framework and the 2050 Long Term Strategy 80-95% CO2 reduction target by 2050. Global Ambition Complies with EU 2030 climate targets and 1.5°C Paris Agreement target. Led by the development of centralized generation, including offshore wind. Distributed Energy Complies with 1.5°C Paris Agreement target and 'considers' EU 2030 target. Led by energy decentralization, strong growth in renewables and the emergence of strong prosumer participation.
World Energy Council	World Energy Scenarios 2019
First introduced in 2016, setting out three 'plausible' scenarios for energy system development up to 2060. The scenarios were updated in 2019 with a focus on the role of innovation up to 2040. The emphasis is on focusing decision makers' thinking towards new consumer behaviours, new business models and the implications of non-energy and/or disruptive innovations.	
Method	Horizon scanning and a workshop in April 2018, followed by a series of interviews and regional workshops to identify emerging trends used to update the 2016 scenarios. The three storylines are used as the basis of quantitative modelling of energy supply and demand.
Scenarios	Modern Jazz Market led, digitally disrupted world led by innovation. Fast but uneven economic growth. Clean energy access on the global and local scales, bringing with it new challenges for system integration, cybersecurity and data privacy. Unfinished Symphony Co-ordinated, policy-led world with long term planning and united global action to develop a low carbon future and meet other challenges. Strong commitment to addressing climate change at the sub-national level, and an increased emphasis on the broader sustainability agenda.

<table>
<tr><td></td><td>Hard Rock

Fragmented world with inward looking policies, less growth and less global cooperation. In the light of the rise of populism and uncertainty about international cooperation this is no longer seen as an extreme scenario in the 2019 iteration.</td></tr>
<tr><td>National Grid Company</td><td>Future Energy Scenarios</td></tr>
<tr><td colspan="2">Framed by the UK Government's 2008 commitment to achieve 80% reductions in GHG emissions by 2050[1]. Although the four scenarios were developed by the electricity system operator, they reflect possible changes across the whole energy system. The framing drivers used for scenario development are the degree to which energy systems become decentralized, and the speed at which decarbonisation is achieved. Two of the scenarios meet the 80%/2050 target, while the other two miss it.</td></tr>
<tr><td></td><td>Community Renewables

Local energy schemes emerge, and consumer engagement is very high. There is a high level of policy support, matched by high economic growth and innovation. The 80%/2050 target is met

Two Degrees

Very high levels of policy support drive the deployment of centralised renewables, as well as carbon capture and storage options. There is very high economic growth, but less consumer engagement and energy efficiency measures than in Community Renewables. The 80%/2050 target is met

Steady Progression

Less innovation and consumer engagement as a result of lower policy support and economic growth mean that decarbonisation progresses slowly, particularly in the transport and heat sectors. The 80%/2050 target is missed

Consumer Evolution

A lack of strong policy means that innovation is low. While there is some shift towards local generation and more consumer engagement from the 2040s onwards, the change is too slow to allow the 80%/2050 target to be met.</td></tr>
<tr><td>SET-Nav</td><td>SET-Nav Pathways</td></tr>
<tr><td colspan="2">Developed to support strategic decision making in the EU's energy systems up to 2050. The key drivers used to frame the four scenarios were the level of cooperation between system actors across the EU and the degree of system decentralisation. The extent to which decarbonisation takes place is assumed across all scenarios and is guided by EU targets and other research.</td></tr>
<tr><td></td><td>Diversification</td></tr>
</table>

[1] This commitment was updated in June2019 to achieving net zero emissions by 2050

	Greater cooperation and integration between EU member states and an emphasis on renewables lead to increased decentralisation and regulatory support for new entrants to challenge the incumbents. Increased digitisation is needed for system coordination. Directed Vision Driven by a shared vision of a greater energy union, the policy and regulatory frameworks for system development is stable and widely endorsed by stakeholders. Priority areas are large scale renewables, CCS nuclear power and energy efficiency. Localisation Decentralisation is a key characteristic, both in terms of resource use and national rather than EU-wide policy and regulation, with competitive advantage emphasised. Priority areas are energy efficiency, decentralised renewables , some nuclear and local CCS. National Champions This storyline emphasises path dependent development in the EU, with national interests and incumbent businesses maintaining their positions as key actors in system development. The emphasis in this storyline is on cost minimisation, large scale developments, and the risk of regulatory capture by incumbents.

The aim and design of each of these varies, and reflects the differing strategic priorities of each of the organisations. However, the storylines have in common the key theme of the complexity of ongoing governance arrangements if system change is to be achieved at the scale and rate required to meet climate change commitments. The ability to outline and unpick the governance arrangements over time is one of the key strengths of the qualitative scenario approach. For this reason, the technique was selected to explore how one key governance arrangement – renewable energy auctions – might develop (and be developed) over time under different conditions of system development up to 2050. Changes in electricity systems and markets will lead to different options for supporting renewables, or other forms of generation. If RE auctions continue into the future, current models are likely to co-evolve with these broader changes and what we expect of an auction – who bids, who auctions, what is auctioned – is likely to be very different in 2030/2050.

4 Methods and data

The use of qualitative inputs into scenarios are useful as a means to analyse complex systems where there are high degrees of uncertainty and inputs cannot easily be quantified (Börjeson *et al.* 2006; C. A. Varum and Melo 2010). There is no one clear methodology for the production of qualitative scenarios, and they all vary in the degree of emphasis and detail given to the different aspects (MacKay and Stoyanova 2017; Rounsevell and Metzger 2010). However, at a high level, there are a number of common steps in scenario production (Figure 1).

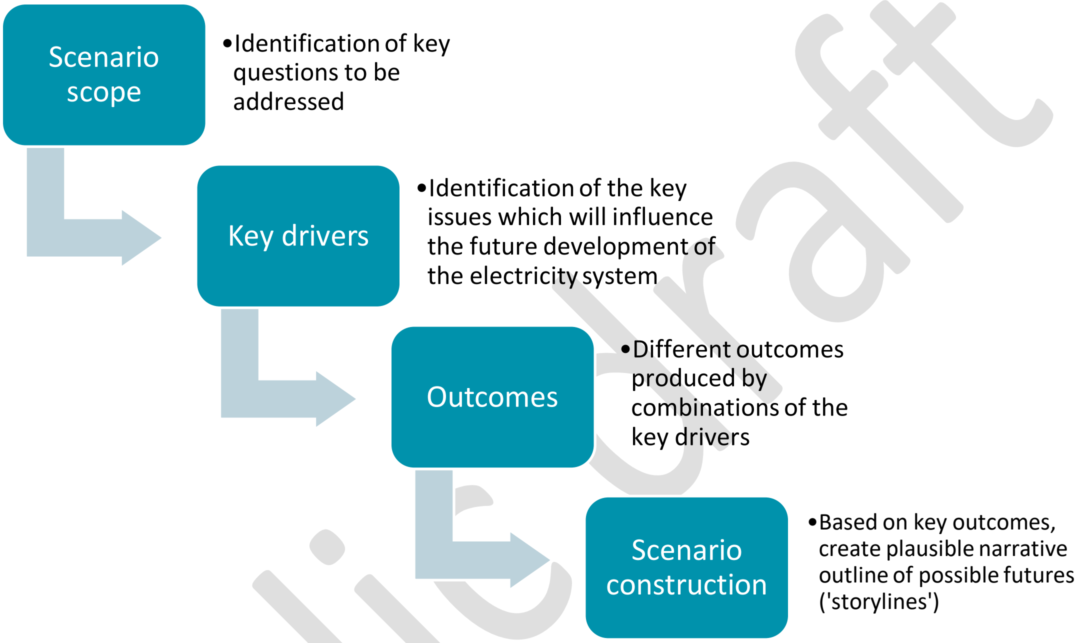


Figure 1: qualitative scenario production process

Narrative scenario processes tend to be built on expert and/or stakeholder input and judgement, particularly in the early stages of the process (Ernst *et al.* 2018; Rounsevell and Metzger 2010). In large part this is to ensure that the resulting scenarios are (Wilson 1998):

- Plausible (there is enough evidence to assume that they can happen (Wiek *et al.* 2013))
- Consistent (there are no intrinsic internal inconsistencies and/or contradictions)
- Useful and relevant (they should contribute to decision making about the future)
- Challenging/novel (they should challenge conventional thinking about the future)
- Differentiated (each should be structurally different rather than variations of each other)

In addition, other authors have added transparency to this list – in other words, why were decisions made, and who made them (Kosow and Gaßner 2008)?

For this project, the general scenario scope was developed and presented in the original AURES-II project proposal. Building on this, project partners worked together to identify key system drivers at a workshop in Vienna in November 2019. Using these insights, the University of Exeter has produced this short briefing outlining four possible storylines for discussion and development at a stakeholder event (webinar) at the end of June 2020.

Input from the webinar will be used to refine the scenarios and add detail to the different implications of each storyline for the future development of renewable energy auctions.

We have chosen to adopt the 2x2 matrix approach which develops four separate storyline quadrants (Godet 2000; Schwartz 1997). Although this approach could be considered minimalist in the sense that it only concentrates on two key uncertainties it was considered appropriate for practical reasons (project constraints) as well as being the approach used effectively in other scenario exercises examining energy system development (Crespo Del Granado *et al.* 2019; National Grid 2019).

While our scenario analysis is essentially descriptive (ie it sets out a range of possible futures and aims to examine broad trends), the inclusion of EU decarbonisation targets as a given means that there is a normative aspect constraining electricity system development.

The figure below outlines the milestones in this particular scenario development process, highlighting the role of this document (marked with *) in the process. Note that the process has been substantially revised from that originally conceived due to the ongoing constraints imposed by the COVID-19 pandemic.

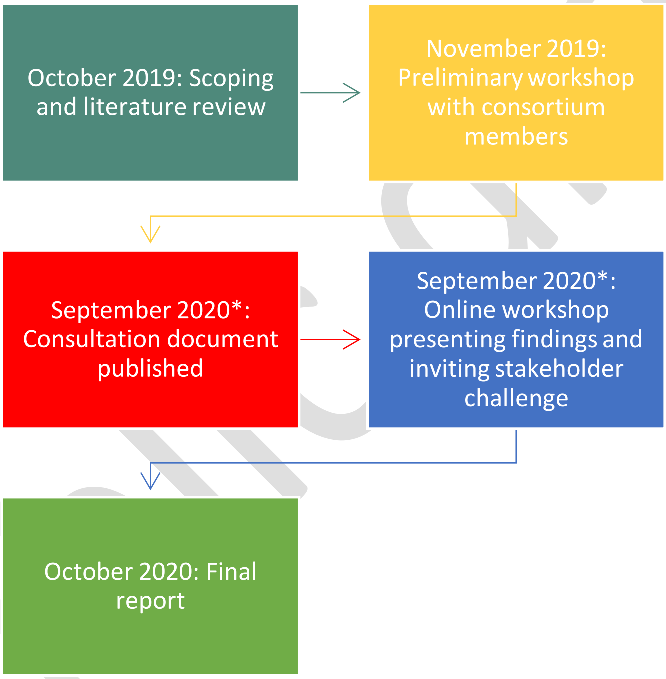


Figure 2: Task 7.2 timeline

5 Scenarios for the future of auctions

This task aims to define four possible qualitative scenarios for the future electricity system. They will explore how important factors may shape renewable electricity routes to market, and the possible role of renewable energy auctions, broadly defined, in each scenario.

Narrative scenarios are often used as a way of stimulating thinking about the implications of different decisions at business or government level. Narrative scenarios are not predictions of the future, but rather plausible stories of how an uncertain future might develop based on key, observable drivers such as different policy and regulatory design. The aim of this task is to provide a framework to inform policy makers, business, and other stakeholders about how decisions taken now on market and network design and operation might play out for the future of renewables.

The aim is to develop narrative, qualitative scenarios to describe plausible visions of what EU electricity markets and networks might look like in the period 2030 to 2050, based on emerging developments in different scales of electricity markets and networks. The first step is the definition of a framework for scenario definition based on the intersection of two conceptual axes. Each axis represents high-level system properties, where the 'system' includes diverse factors such as decision-making, generation, and consumer behaviour and network regulation. Each of the quadrants delineated by the intersecting axes consequently represents a distinct future 'world' in which the electricity system has evolved along a unique pathway.

The objective of this exercise is to select axes such that each scenario encompasses different but plausible implications for the profitability of renewable technologies, and thus for the rate at which they might be viable without subsidy and the likely participants in the auction process (both bidders and auctioneers).

The following figures outline the drivers, themes and possible axes that were identified at an AURES II consortium workshop held in November 2019. Participants were asked to first identify potential drivers of change relevant to the role of RES auctions. Secondly, they grouped drivers into themes for change, and finally they proposed some combinations of independent axes that could be used to describe scenarios that can contribute to understanding our research questions.

Figure 3: Long list of 'drivers' of electricity system change relevant to RES auctions

Figure 4: First list of themes

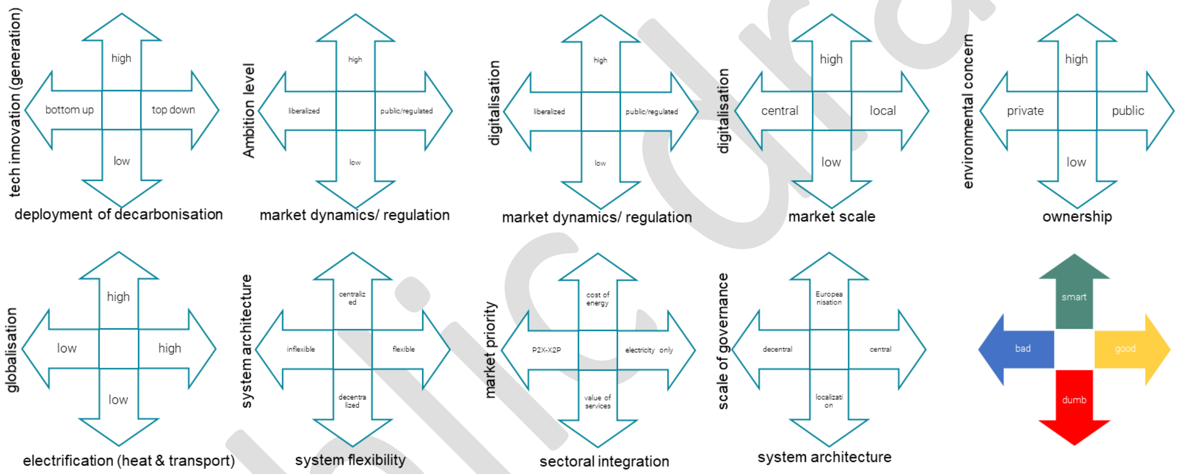


Figure 5: Set of axes and worlds emerging from consortium workshop

6 Two dimensions

From the preliminary consortium workshop, it became clear that the future of RES auctions will be shaped by socio-political factors, as well as technical and economic developments. Some trends operate at the macro-level, for example the overall direction of EU integration. While other are far more electricity sector-specific, for example innovation in new storage technologies and regulation.

The backbone of the scenarios framework is the selection of two 'driving forces' that are intended to be:

i) Decisive – we can be confident that differences in how these phenomena turn out will be significant for our research question. I.e. they will strongly determine the future of auctions;

ii) Uncertain – to realise the greatest analytical benefit, it is important the driving forces can plausibly develop along a range of divergent pathways; and

iii) Independent – to provide four contrasting 'worlds' the drivers should be representing different domains. That is to say that we should be confident that one driver is not a sub-phenomenon of another, or that they might both be the result of some third cause; (van 't Klooster and van Asselt 2006)

Bearing these goals in mind, we propose as our choice of axes the extent of 'decentralisation' and increased system 'flexibility' over the coming decades as the key dimensions of differentiation between scenarios. These drivers in particular address both technological and social change, but differ markedly in which is the source of innovation leading change, and which must adapt to change:

Flexibility ➔ Technological innovation, social adaptation

(De)centralisation ➔ Social innovation, technological adaptation

6.1 Axis 1: flexibility

Flexibility in the electricity system can be seen as the capability to adapt, over various spatial and temporal ranges, to changes in supply or demand, in order to maintain functionality. Increased flexibility is widely seen as an important means of accommodating large volumes of renewable electricity production (Lund *et al.* 2015; Nicolosi 2010; Papaefthymiou *et al.* 2018). Greater flexibility may be the result of numerous innovations within the electricity sector including new technology uptake, market design, regulation, network operation, and consumer behaviour. It may also rely on greater interaction between the electricity sector and the heat and transport systems, potentially through electrification of these systems (Lund *et al.* 2015; Pilpola and Lund 2019; Teng *et al.* 2016). Papaefthymiou *et al.* (Papaefthymiou *et al.* 2018) outline numerous indicators of electricity system flexibility across fourteen domains of flexibility, shown in *Figure 6*.

Flexibility category	Flexibility domains	Relevance of domain	Topics covered by KPIs
Supply	Conventional Generation	With increasing VRE shares, conventional generation faces lower market shares, lower market prices and needs to adapt to more fluctuations in net demand.	• Operational flexibility of conventional power plant fleet • Plans to phase out inflexible generation • Incentives for flexible generation • Generation and flexibility adequacy from all resources
	Distributed Generation & Variable Renewables	Increasing capacities of VRE and DG units are installed in distribution grids. It is important that policies support their development and diversification, so that their integration does not pose a threat to the system. In this context, they also need to take up responsibility and provide system services themselves.	The flexibility inherent in this domain is influenced by a series of aspects, including: • Shares of DG & VRE achieved • Related development plans • Diversification of VRE • Dispatch rules • Forecasting methods • Incentives for geographical and technological diversification
Demand	Energy Efficiency	Not only do improvements in energy efficiency reduce the need for flexibility as they reduce the total load level, but also the interaction of energy efficiency and flexibility will increase in the future. Due to variability of VRE, the value of efficiency measures obtain a temporal component.	• Assessment of energy efficiency measures and future plans
	Large-Scale Demand Side Flexibility	Industrial DSM potential is the most easily accessible due to already existing controllability, often included storage component, load size, network level and rational behaviour of the end-user.	• Potential • Programmes • Participation in wholesale & balancing markets
	Small-Scale Demand Side Flexibility	Demand side management (DSM) constitutes a key potential of low-cost flexibility when operating a system with increasing VRE shares. Future power systems will not be centred around the task to cover the current demand but around the task to operate the system with the currently available VRE in the most efficient way.	• Share of households with smart meters • Programmes • R&D demos • Aggregators • EV share, eHP share • Incentives for flexible demand
Grid	Transmission Grids	Transmission grids are a crucial asset of power systems, a key flexibility enabler and the only option for the spatial balancing of supply and demand.	• Level of congestion • Grid development plans • TSO/DSO coordination • Advanced control measures
	Interconnections	The interconnection of power systems to larger regional clusters can have great benefits, increase flexibility as well as balance out VRE output, as geographical smoothing effects occur.	• Cross-border transmission capacity • Expansion and optimization plans
	Distribution Grids	Distribution grids will play an important role in future electricity grids as increasing levels of distributed generation and prosumers alter the conditions on low voltage levels and are key to enabling local flexibility.	• Capability for monitoring and controlling network • Smart system implementation • R&D • Allowance to procure local flexibility
Storage	Small-Scale Storage	Small-scale storage installed in distribution grids is an interesting flexibility option on the local level.	• Implementation, plans and incentives for small-scale storage
	Large-Scale Storage	Long-term energy storage becomes a vitally important source of flexibility when VRE reach the highest penetration levels.	• Level and further potential of bulk storage
	Sector Coupling	Sector coupling is a great source of power system flexibility, especially in the context of increasingly frequent situations of surplus energy.	• Status and plans for sector coupling
Markets	Wholesale Markets	Appropriate market design is a key enabler of existing flexibility and future investments.	• Temporal resolution: gate closure times, product lengths • Market coupling • Removal of price caps • Liquidity of markets • Spatial resolution • Market barriers
	Balancing Markets	In addition to wholesale markets, balancing markets are of great importance to enable short-term flexibility.	• Temporal resolution: gate closure times, product lengths • Minimum bid size • Allowance of aggregators • Cross-border exchange • Removal of price caps
	Retail Markets	The implementation of dynamic electricity tariffs for end-consumers are a key element to incentivise demand response. Vice versa, tariff structures with large regulated components offer low incentives to adapt consumption patterns.	• Regulation of prices • Dynamic tariffs

Figure 6: Flexibility indicators as presented by Papaefthymiou et al. (Papaefthymiou *et al.* 2018)

6.1.1 Indicators

A scenario with high flexibility can be characterised by alignment with many or all of the indicators above in all of the flexibility categories. In contrast, a scenario in which the system exhibits low flexibility is characterised by poor alignment with most or all of these indicators and is only evident in some categories.

6.2 Axis 2: decentralisation

The topic of energy system decentralisation, both of physical infrastructure and of the human structures that govern the electricity system, has long been a major part of discussions about the transition to sustainability (Brisbois 2020). More dispersed governance is also associated with greater active participation by consumers and citizens through, for example, prosumerism, captured by the concept of 'energy democracy' (Szulecki 2018). However, there remain numerous uncertainties and contestations (Stefes 2020). While questions remain about "what is being decentralised, by whom" (Judson *et al.* 2020), there is broad acceptance that diffusion from the centre towards the periphery in three broad domains will have significant implications for the future electricity system. We determine that these domains are:

1. Energy production/ electricity generation
2. Decision making and authority
3. Ownership and participation

6.2.1 Indicators

A scenario with low levels of decentralisation, therefore, can be characterised by:

- A large preponderance of large, transmission connected electricity production and associated network architecture;
- A generally top-down mode of decision making and low levels of local autonomy in relation to decisions about electricity systems
- Low levels of individual participation and community level ownership of system assets

A scenario with high levels of decentralisation, meanwhile, can be characterised by:

- A high degree of distributed, embedded and small-scale electricity production, often from renewable sources;
- A generally local and bottom-up mode of decision making in matters of electricity systems
- Large amounts of direct participation through, e.g., community ownership of plant, or auto-generation

7 Four scenarios

The two conceptual axes outlined in the previous section delineate and name four possible energy scenarios, as illustrated in Figure 7, below.

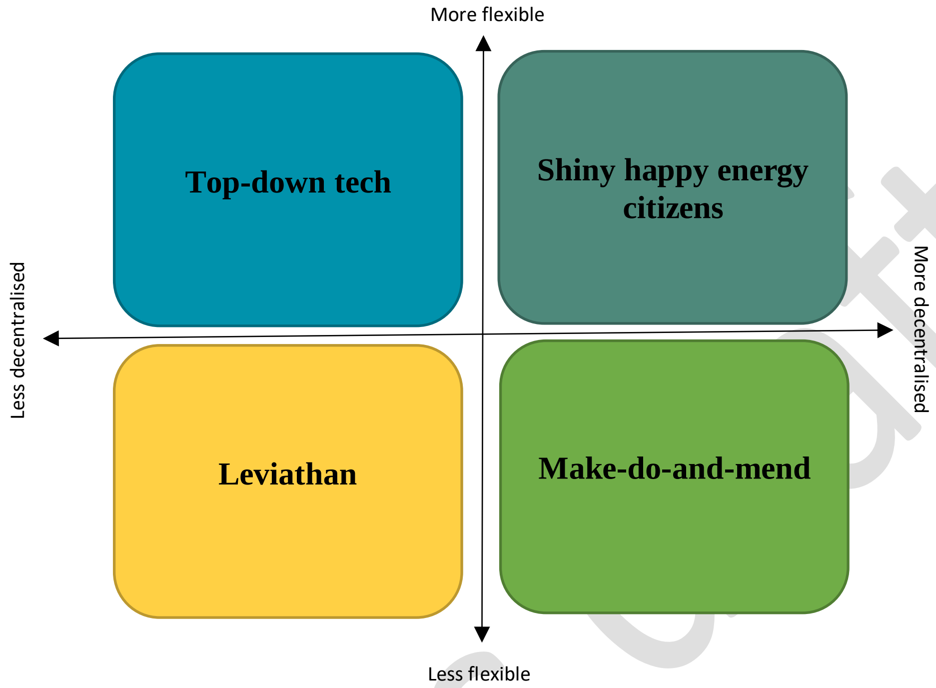


Figure 7: Scenario framework overview

While the scenarios differ along the flexibility and decentralisation axes – and therefore in many indicators – to enable comparison, we assume the following fundamental outcomes and trends are common to all four:

1. The top-line EU targets for energy efficiency, renewable energy and decarbonisation are met or exceeded for 2030[2];
2. In line with the EU's commitment to achieve 'climate neutrality' by 2050 and the terms of the Paris agreement, member states' are assumed to collectively reduce greenhouse gas emission by at least 95% compared to 1990 levels by 2050;
3. It is assumed that popular support for climate policy, including energy policy, is strong and growing between now and 2050 as the manifestations of climate change become increasingly apparent – as a consequence, 'political will' to enact climate policy is adequate to fulfil the goals above

In the following sections we outline the characteristics (based on the indicators outlined in the previous section) and accompanying storyline for each of the four scenarios in turn.

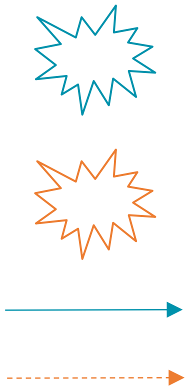
We also provide some discussion about the likely implications of each for RES auctions focused on the route to market for renewable electricity.

Specifically, we identify:

[2] Although we acknowledge that the *risk* of underachievement in this regard is likely to vary between scenarios

1. The source of revenue and destination of risk, i.e. whether offtake and revenue risk is borne by the public or private sector,
2. The mode of exchange, i.e. whether an auction or other market arrangement is in place; and
3. whether auctions are private, public, or regulated.

To illustrate various models, we use a pictorial representation with the following components:



Privately organised auction

Publicly organised auction

Flow of revenue (and/or revenue security)

Regulatory input

Figure 8: components of auction model illustrations

7.1 Top-down tech (High flexibility, low decentralisation)

7.1.1 Characteristics

- National or transnational governance
- Active transmission system management
- Greater demand-side response
- Accurate valuation of system services
- Large role for technology companies
- RES-compatible, national or trans-national markets
- Incumbent firms dominate

7.1.2 Storyline

In this scenario, significant technological innovation and implementation of new technologies enables efficient operation of the electricity system. Top-down planning at the national and European levels allows significant flexibility through sector coupling, e-mobility and electrification of heat services. Smart consumer appliance technology and advanced data analytics allows significant demand-side response and large-scale markets are able to accurately value a range of system services.

Large-scale generation remains the primary source of renewable electricity, owned by a small number of national and increasingly multi-national utility companies. While business model innovation has taken place, particularly in the aggregation of production, data analytics and balancing services markets, the dominant utilities retain ownership of both the firms and the assets. Large technology companies play a large role in forecasting and shaping consumer behaviour to better manage the system. Community renewables projects remain a niche model for generation with routes to market for renewable electricity presenting high risks and barriers to entry for small actors.

7.1.3 Implications for RES auctions

Large-scale renewable electricity generation is the mainstream. Ownership of generation projects tends to be by either large, vertically integrated utility companies, or internationally active specialist developers. System flexibility means that wholesale electricity markets are able to accurately value renewable generation allowing investment without public policy support, leading to an increase in 'merchant' generation.

Nevertheless, significant auctioning takes place for new and repowered generation assets, but the profile of the auctioneers differs. Instead of government led auctions, they are instead held both by utility companies and by major consuming industries. With little regulatory intervention in auction design, however, the auctions' risk profiles all but exclude all but the largest and most sophisticated bidders.

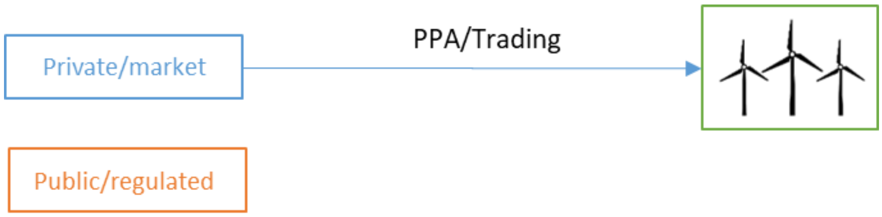


Figure 9: a merchant system in which wholesale electricity markets can enable adequate risk management

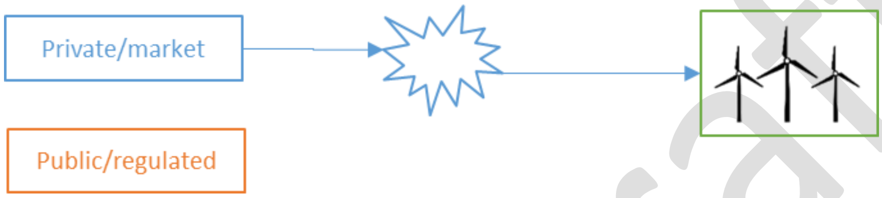


Figure 10: an auction system in which private (or corporate) PPAs are auctioned with little or no public or regulatory input.

7.2 Shiny happy energy citizens (high flexibility, high decentralisation)

7.2.1 Characteristics

- Local governance
- Active distribution system management
- Greater demand-side response
- Accurate valuation of system services
- RES-compatible, local markets
- Broad participation (actor diversity)

7.2.2 Storyline

In this scenario, technological innovation is accompanied by a shift in governance as participation by consumers and citizens increases towards the ideals of 'energy democracy'. The boundaries between the supply-side and the demand-side of the electricity market are blurred by the rise of widespread prosumerism, with domestic participation across storage, transport, heat and generation. The increase in domestic and community scale generation is accompanied and supported by local energy markets, enabled by open-source, peer-to-peer electricity trading and distribution scale load-balancing. Network planning is necessarily locally-led, with the participation in decision making over new energy infrastructure a core task of community-level organisation.

Cooperative and mutual business models for energy production are widespread and form a substantial bulk of the overall generation mix in most parts of Europe. Utility business models increasingly rely on regulated returns from networks and other natural monopolies. Aggregation and data analytics services also become subject to greater regulatory oversight to ensure consumers' data autonomy. Large-scale renewable energy projects such as offshore wind farms, however, are still developed and owned by specialised national or international private developers.

7.2.3 Implications for RES auctions

Diversity is the defining characteristic in this scenario. Electricity wholesale markets are able to value products and services and to allow investment in adequate generation without additional public revenue support. However, a wide range of RES contractual arrangements are still closed through auction as a key risk-management tool. For example, large energy consuming industries seeking bilateral arrangements for long-term supply hold procurement auctions, although these private auctions are subject to regulatory oversight designed to ensure, among other things, actor diversity in generation and alignment with local network capacity. Auctions are also held at a variety of scales. Local public authorities contract for generation to meet specific renewable energy goals and local energy trading between prosumers makes use of online auction formats. City and local-scale auctions for non-electricity products such as domestic energy efficiency improvements are a crucial aspect of long-term demand management.

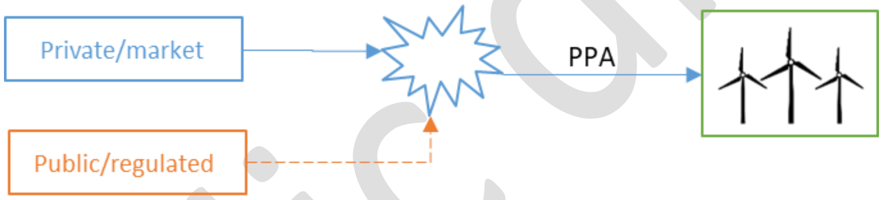


Figure 11: auction system in which privately organised auctions are subject to some degree of regulatory oversight of design – particularly to ensure actor and technology diversity

7.3 Leviathan (low flexibility, low decentralisation)

7.3.1 Characteristics

- National or transnational governance
- More passive, centralised networks
- Less demand-side response
- Poor valuation of system services
- National or trans-national wholesale markets
- Incumbent firms dominate

7.3.2 Storyline

In this scenario, contemporary trends towards energy system decentralisation and greater flexibility stall or are reversed. Governance of (and participation in) the electricity system is dominated by central public and private actors, most likely at the scale of the nation-state.

Decisions about how 2050 targets are achieved are negotiated between governments and a small number of industrial elites on a corporatist basis. The electricity value chain is oligopolistic and dominated by a small number of national or regional companies. Citizen-led investment is almost impossible within the legal and financial framework.

In this rigid and top-down scenario, lack of innovation in system-optimisation technologies means that consumer participation in the energy system is low with little expansion of demand-side flexibility and few opportunities for prosumerism.

Innovation in electricity market frameworks is also poor, leading to poor valuation of system services and few business models viable outside the utility mould. However, demand for new RES capacity to meet targets means that there is scope for 'wildcat' project developers to finance and develop new generation projects either on the basis of a PPA or equity sale on completion.

Over time, utility incomes become increasingly volatile due to growing RES shares, leading to the implementation of wide-ranging subsidy schemes to mitigate the "utility death spiral" (Castaneda *et al.* 2017). In some countries, (re)nationalisation of companies is deemed necessary to maintain security of energy supply.

7.3.3 Implications for RES auctions

The risks of participation in electricity supply (low, volatile prices) are such that almost all new renewable capacity and increasing volumes of existing capacity is under the direct control of the electricity utility oligopoly, many of which are loss-making enterprises. Where private development takes place, projects are often sold in their entirety to the utilities. In some cases, pressure to meet targets for renewables leads to auctions for new capacity, which is auctioned and remunerated on a PPA basis. In some cases, utilities are legally compelled by regulators to hold specific format auctions.

Approaching 2050, the political pressure to comply with climate obligations for some countries becomes so strong to expand production generous FiT programmes are introduced and land-use restrictions relaxed, leading to a 'gold rush' in renewable resources.

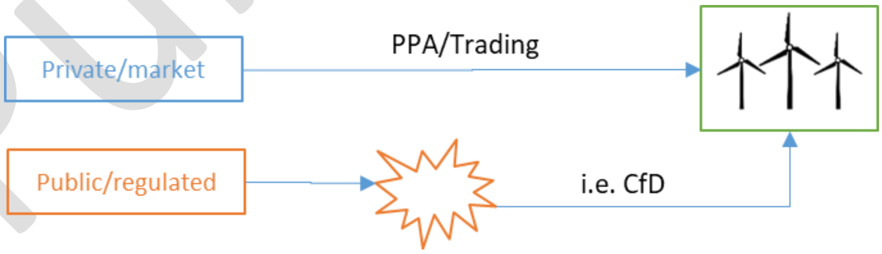


Figure 12: auction system in which private corporations are legally compelled to increase

procurement of RES auctions through mandated auction programmes

Figure 13: the return of the FiT

7.4 Make-do-and-mend (low flexibility, high decentralisation)

7.4.1 Characteristics

- Local governance
- More passive, but locally planned networks
- Less demand-side response but strong incentives to reduce demand through EE
- Poor valuation of system services
- Local markets
- Broad participation (actor diversity)

7.4.2 Storyline

In this scenario, there is a strong divergence between stuttering technical innovation and very active social innovation. Failure to commercialise key flexibility technologies in the heat, transport and large-scale battery storage sectors, and wide-spread rejection of in-home technologies for enhanced energy management due to concerns about privacy and autonomy constrains the degree of technical system flexibility. At the same time, attempts to reinforce transmission and distribution networks to better cope with rising RES share meet with widespread local resistance. Consequently, the mainstream electricity system becomes increasingly unpopular, with rising prices and an inability to meet consumer expectations leading to widespread dissatisfaction.

Nevertheless, an empowered and enabled community energy sector sees a large increase in prosumerism and the emergence of locally planned microgrids and, in some places, local peer-to-peer energy markets. Consumers' and citizens' direct participation in these projects, planning decisions, and markets contributes to a greater awareness of energy use and an attendant development of energy conservation norms. Sharp reductions in energy consumption coupled with a declining share of revenues from energy sales in the mainstream energy system creates a virtuous cycle of increasing energy efficiency, greater awareness of time-of-use and increasing renewable energy production at the local scale. At the same time, locally organised energy groups begin to self-organise and, in some cases, create larger regional-scale syndicates of community owned enterprises that can raise finance to develop and build commercial scale and even large scale RES projects. As with the Leviathan storyline, there is a strong risk of a utility death spiral as consumers and communities rely increasingly on their own production.

7.4.3 Implications for RES auctions

The declining role of centralised decision-making in the energy sphere means that there is little requirement for auctions to elicit market interest in participation in building RES capacity. However, local and community-scale actors may play an increased role on the demand-side, aggregating output from various sources including RES installations. This type of activity could result in contracting forms that may be called 'community PPAs', similar in structure to the corporate PPA model.

8 Analysis: pathways and implications for RES auctions

Across the four scenarios sketched out above, there are five basic routes to market envisaged:

1. Public RES auction guaranteeing supplements to private revenues
2. Corporate or community PPA
3. Return of the feed-in tariff
4. Merchant contracting

Of course, we do not propose that any of these are likely to be the *only* model for buying and selling renewable electricity in a particular scenario (nor, for that matter, do we suggest that *any* of them are inevitable or even that they are more likely than alternatives). However, in order to consider how RES contracting in general, and auctions in particular, may develop between now and 2030 and 2050 the following sections examines each model in turn to speculate about some of the milestones that may lead to its preponderance in Europe in 2030.

8.1 Public RES auction guaranteeing supplements to private revenues

This model is the current 'state of the art' in 2020. In order for it to remain the dominant model for RES contracting, two conditions would need to persist:

i) The sales revenue available to RES producers is not adequate (from the perspective of price and/or risk) to finance projects and/or;

ii) Central public authorities deem 'steering' of RES capacity additions necessary on technological (which technologies are financeable), spatial (where projects are built), temporal (e.g. matching RES build to network expansion), or qualitative (e.g. local content requirements)

The first point suggests that technological cost-reduction slows or stalls, or that electricity (and carbon) markets cannot be reformed in such a way as to allow appropriate risk hedging by RES producers. Given than in many European markets RES technologies such as onshore wind are already cost competitive against fossil fuel generation, this outcome is more likely to be a result of regulatory rather than technological factors.

The second point suggests that government intervention in RES markets intensifies rather than diminishes over the coming decade. The reasons for this may be industrial policy decisions to promote domestic supply chains (subject to state-aid restrictions) or a highly coordinated approach to RES expansion, possibly resulting from time-pressure due to delayed target fulfilment.

8.2 Corporate or community PPA

Private contracts for RES output are an increasingly visible part of the energy landscape. In many (but not all) cases these contracts are let through competitive tendering processes – essentially private RES auctions. These tenders differ from conventional RES auctions in that they are designed as an explicit procurement process rather than a revenue support allocation, but the essential structure remains the same. The primary advantages of arranging these PPA contracts through tenders are cost discovery and reducing the transactions costs through up-front standardisation of terms that would otherwise require substantial bilateral negotiation and associated legal and other professional costs.

Whether this model becomes dominant depends on three factors:

i) Energy buyers' perception of the value of non-market value of RES (i.e. reputation/CSR)
ii) Producer and consumer appetite for benefits of PPAs (long-term price stability) *vis a vis* alternatives – if wholesale markets do not offer sufficient risk management possibilities, producers may value long-term revenue certainty more highly
iii) Balance sheet constraints – in many jurisdictions, accounting rules require PPAs to be treated as a lease liability with knock-on implications for reporting, profitability etc.

The case for direct contracting between consumers and producers is therefore complex and dynamic. In general, however, we can say that the inadequacy of alternative means of managing risk through wholesale electricity trading is a likely prerequisite.

In such circumstances that the CPPA becomes the *de facto* standard model for RES contracting, it is possible to imagine an increased role for regulation of the arrangements. For example, through standardised terms, quotas for certain types of consumer or geographical region based on a register of contracts, offtake volumes, or changes to accounting rules. Indeed, many current CPPAs include a regulated component in the form of certificates or other associated revenue stream bundled with the electricity.

8.3 Return of the feed-in tariff

The dominant model for public policy intervention to promote RES expansion before the increased use of auctions was the feed-in tariff (FIT). In many places it remains in place to support smaller-scale projects. The defining characteristic of the FIT is that decisions about the revenues available to producers are taken outside the market. Decisions about pricing, priority dispatch and the duration of contracts are all made my policymakers. For the FIT to replace current RES auctions would require:

i) Failure of other available routes to market to enable sufficiently rapid RES growth to meet climate targets (perhaps an emergency need to very rapidly 'take the brakes off' deployment
ii) And a willingness to intervene in investment patterns (which, given the nature of contemporary auction design is not such a leap) but also to take on the economic and political risk associated with pricing decisions which could well be higher than previous auction outcomes

8.4 Merchant contracting

For merchant contracting to become the norm for new RES projects, investors would need to have confidence that wholesale markets can provide adequate revenue and risk hedging. Markets would need very high levels of liquidity and the overall electricity system would need to be extremely flexible to allow accurate reflection of marginal costs in prices. Given the nature of most RES projects, however (zero marginal cost, high capital cost) it is likely that producers will seek out long-term contracts such as those offered by RES auctions, CPPAs or feed-in tariffs. We argue, therefore, that even where wholesale markets *could* enable investment, some form of longer term alternative is likely to become available – although novel contracting approaches (e.g. rolling short-term PPAs) to manage issues of merchant risk and price cannibalisation may emerge.

9 Conclusions

How producers realise a return on investment in RES generation is changing and will continue to change. To-date, public policy has played a significant role in determining how revenues and risks are structured and how they are accessed. While the contemporary large-scale RES auction marks a substantial shift in how public intervention is organised, it has not notably reduced the scope of the intervention. Still, in most places, some form of policy, auction or otherwise, is deemed necessary to enable projects to be financed. While there are notable developments such as increased use of corporate PPAs and some merchant generation, by-and-large national-scale policy support represents the mainstream.

There are also other signs that the accepted model of auctions for renewables is shifting. For example, recent auction rounds in several countries have led to contracts being awarded which are below market price, indicating that the value of the agreement is increasingly found in revenue reliability, rather than in a premium price for output. What is auctioned is also changing, notably in relation to recent auctions for access to specified areas of the seabed for offshore wind projects in both the US and UK (Crown Estate 2019; Department of the Interior Bureau of Ocean Management 2014).

Our scenarios show that the status quo model of RES auctions is unlikely to be the dominant route to market by 2030 unless progress in transforming and pluralising energy systems stalls leading to something like our 'leviathan' scenario. That is not to say, though, that the withdrawal of support instruments of all kinds is inevitable, as is sometimes argued. A fully merchant model for RES investment may be possible in a highly flexible system and reformed wholesale trading arrangements, but perhaps alongside other forms of private contracting such as innovative forms of PPA.

That is not to say that the RES auction will disappear entirely. Private, municipal, or community tenders for PPAs, are likely to grow in importance, requiring new and innovative auctions designs that minimise transactions costs. The lessons learned though Europe's roll-out of national scale support auctions may be valuable here.

Finally, given both the urgency of the challenge of tackling climate change and the challenges of coordinating RES build out with supply chain development and grid expansion, a regulatory role of some kind exists in all scenarios. Whether it is standardising auctions models and contracts or directing geographical density, public policy will continue to play a role in the buying and selling of renewable electricity for the foreseeable future.

References

Amer, M., Daim, T. U. and Jetter, A. (2013) 'A review of scenario planning', *Futures* 46: 23–40, doi:10.1016/j.futures.2012.10.003.

Börjeson, L., Höjer, M., Dreborg, K. H., Ekvall, T. and Finnveden, G. (2006) 'Scenario types and techniques: Towards a user's guide', *Futures* 38(7): 723–739.

Brisbois, M. C. (2020) 'Rescaling, reorganization and battles for influence: shifting political power in an era of electricity decentralization', *Environmental Innovation and Societal Transitions* 36(August 2019): 49–69.

Castaneda, M., Jimenez, M., Zapata, S., Franco, C. J. and Dyner, I. (2017) 'Myths and facts of the utility death spiral', *Energy Policy* 110: 105–116.

Crespo Del Granado, P. et al. (2019) *NAVIGATING THE ROADMAP FOR CLEAN, SECURE AND EFFICIENT ENERGY INNOVATION Comparative Assessment and Analysis of SET-Nav Pathways Work Package Coordinator: Norges teknisk-naturvitenskapelige universitet i Trondheim (NTNU) SET-Nav Pathways*.

Crown Estate (2019) *Introducing Offshore Wind Leasing Round 4 Information Memorandum*.

Department of the Interior Bureau of Ocean Management (2014) *Atlantic Wind Lease Sale 4; Commercial leasing for wind power on the Outer Continental Shelf offshore Massachusetts, Final Sale Notice*, available at https://www.boem.gov/sites/default/files/renewable-energy-program/State-Activities/MA/Massachusetts-Final-Sale-Notice-Federal-Register-%281%29.pdf (accessed September 2020).

Entsog and Entso-e (2020) *European Network of Transmission System Operators for Electricity*.

Ernst, A., Biß, K. H., Shamon, H., Schumann, D. and Heinrichs, H. U. (2018) 'Benefits and challenges of participatory methods in qualitative energy scenario development', *Technological Forecasting and Social Change* 127: 245–257.

Fortes, P., Alvarenga, A., Seixas, J. and Rodrigues, S. (2015) 'Long-term energy scenarios: Bridging the gap between socio-economic storylines and energy modeling', *Technological Forecasting and Social Change* 91: 161–178.

Godet, M. (2000) 'The Art of Scenarios and Strategic Planning: Tools and Pitfalls', *Technological Forecasting & Social Change* 65: 3–22, available at http://en.laprospective.fr/dyn/anglais/articles/art_of_scenarios.pdf (accessed June 2018).

Judson, E. et al. (2020) 'The centre cannot (always) hold: examining pathways towards energy system decentralisation', *Renewable and Sustainable Energy Reviews* 118(February 2020).

Kosow, H. and Gaßner, R. (2008) *Methods of Future and Scenario Analysis Overview, Assessment, and Selection Criteria*.

Lund, P. D., Lindgren, J., Mikkola, J. and Salpakari, J. (2015) 'Review of energy system flexibility measures to enable high levels of variable renewable electricity', *Renewable and Sustainable Energy Reviews* 45: 785–807.

MacKay, R. B. and Stoyanova, V. (2017) 'Scenario planning with a sociological eye: Augmenting the intuitive logics approach to understanding the Future of Scotland and the UK', *Technological Forecasting and Social Change* 124: 88–100.

National Grid (2019) *Future Energy Scenarios*, available at https://www.nationalgrideso.com/sites/eso/files/documents/fes-2019.pdf (accessed June

2018).

Nicolosi, M. (2010) ‘Wind power integration and power system flexibility-An empirical analysis of extreme events in Germany under the new negative price regime’, *Energy Policy* 38(11): 7257–7268.

Papaefthymiou, G., Haesen, E. and Sach, T. (2018) ‘Power System Flexibility Tracker: Indicators to track flexibility progress towards high-RES systems’, *Renewable Energy* 127: 1026–1035.

Pilpola, S. and Lund, P. D. (2019) ‘Different flexibility options for better system integration of wind power’, *Energy Strategy Reviews* 26(April): 100368.

Rounsevell, M. D. A. and Metzger, M. J. (2010) ‘Developing qualitative scenario storylines for environmental change assessment’, *Wiley Interdisciplinary Reviews: Climate Change* 1(4): 606–619, doi:10.1002/wcc.63.

Schwartz, P. (1997) *The Art of the Long View: Planning for the Future in an Uncertain World*, John Wiley & Sons.

Söderholm, P., Hildingsson, R., Johansson, B., Khan, J. and Wilhelmsson, F. (2011) ‘Governing the transition to low-carbon futures: A critical survey of energy scenarios for 2050’, *Futures* 43(10): 1105–1116.

Stefes, C. H. (2020) ‘Opposing Energy Transitions: Modeling the Contested Nature of Energy Transitions in the Electricity Sector’, *Review of Policy Research* 1–21.

Swart, R. J., Raskin, P. and Robinson, J. (2004) ‘The problem of the future: Sustainability science and scenario analysis’, *Global Environmental Change* 14(2): 137–146.

Szulecki, K. (2018) ‘Conceptualizing energy democracy’, *Environmental Politics* 27(1): 21–41.

Teng, F., Aunedi, M. and Strbac, G. (2016) ‘Benefits of flexibility from smart electrified transportation and heating in the future UK electricity system’, *Applied Energy* 167: 420–431.

van ’t Klooster, S. A. and van Asselt, M. B. A. (2006) ‘Practising the scenario-axes technique’, *Futures* 38(1): 15–30.

Varum, C. . and Melo, C. (2010) ‘Directions in scenario planning literature; a review of the past decades’, *Futures* 42: 355–369.

Varum, C. A. and Melo, C. (2010) ‘Directions in scenario planning literature - A review of the past decades’, *Futures* 42(4): 355–369.

Wack, P. (1985) ‘Scenarios: uncharted waters ahead’, *Harvard Business Review* 63(September-October): 73–89.

Walton, S., O’Kane, P. and Ruwhiu, D. (2019) ‘Developing a theory of plausibility in scenario building: Designing plausible scenarios’, *Futures* 111: 42–56.

Wiek, A., Withycombe Keeler, L., Schweizer, V. and Lang, D. J. (2013) ‘Plausibility indications in future scenarios’, *International Journal of Foresight and Innovation Policy* 9(2–4): 133–147.

Wilkinson, A., Kupers, R. and Mangalagiu, D. (2013) ‘How plausibility-based scenario practices are grappling with complexity to appreciate and address 21st century challenges’, *Technological Forecasting and Social Change* 80(4): 699–710.

Wilson, I. (1998) ‘Mental maps of the future; an intuitive logics approach to scenarios’, in *Learning from the future: Competitive foresight scenarios.* pp. 81–108.

World Energy Council (2019) *World Energy Scenarios 2019*, available at www.worldenergy.org (accessed June 2020).

Wright, G., Bradfield, R. and Cairns, G. (2013) ‘Does the intuitive logics method - and its recent enhancements - produce “effective” scenarios?’, *Technological Forecasting and Social Change* 80(4): 631–642.

AURES II is a European research project on auction designs for renewable energy support (RES) in the EU Member States.

The general objective of the project is to promote an effective use and efficient implementation of auctions for RES to improve the performance of electricity from renewable energy sources in Europe.

www.aures2project.eu

AURES II has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817619