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How to manage upcoming challenges in the electricity market?

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More documents related to this discussion can be found at http://www.oecd.org/daf/competition/radical-innovation-in-the-electricity-sector.htm

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1. Introduction

1. The energy market stands at the beginning of an enormous change, activated by decentralised technologies and decarbonisation. In the coming 10 to 20 years the following changes will occur:

- Decentralized sustainable energy is cheaper than central produced energy
- Electrical vehicles are cheaper than fossil based vehicles.
- The cost pattern of energy depends more on time and place than on volumes.
- All appliances and devices can be remote operated
- Sustainable behavior is more common than non-sustainable behavior
- Autonomous energy systems are easy available.

In this document I reflect on these changes and define a framework for a decentralised energy system.

2. Four phases of market maturities

2. Changing to a next level for an energy system, also requires to have a common understanding where we are coming from. Not every country has the challenges at the same time. Energy systems, in a coherent combination of technology, legislation and regulation, go through phases. This chapter describes this development in four phases of maturity.

2.1. Phase 0: no organized energy system

3. In many regions in world people still do not have access to electricity. They heat on biomass, coal and oil. They produce a lot of carbon emissions and air pollution. No power system is available for many households. People spend a lot of time on gathering their energy source.

4. In these regions, hotels, offices and rich people do have access to energy. They produce this energy by themselves, e.g. by using diesel generators.

2.2. Phase 1: Energy as a local public service

5. In developed countries the step from phase 0 to 1 was made in the end of the 19th century. Access to power and gas was seen a way to lift society, in the same way that education opened up for all children and museums were built. The industrial revolution flourished by these steps.

6. Public values regarding to energy were introduced and still are valid: affordable and reliable energy for everybody.

7. The energy system that was built has been replicated throughout the world. The energy is produced and distributed by a company, sometimes with public shareholders but more and more private. There is an intense collaboration with a Ministry of Energy or

Economic Affairs. The energy company has good but regulated income. Market risks are minimized, by using legislation to organize the limitations of rights of costumers.

2.3. Phase 2: energy as a centralized commodity market

8. Around the year 2000 in developed countries, the markets have liberated. Along with all types of public services, markets were seen as a better model to organize services. The public values for the energy system still are affordable and reliable, but adding: the right to choose.

9. In a centralised commodity market, energy is generated in few large plants and distributed. Consumers have a choice to select a retailer. To create a centralised commodity services, the market has been designed into market roles: energy producer, retailer, transmission grid operator, distribution grid operator and metering companies. The market for electricity is also organized in terms of processes: energy exchange on long term, day ahead, intraday and balancing.

10. The model for electricity was copied to gas, introducing and extra market role for a shipper and introducing extra market processes for capacity usage, conversions and storage.

11. Regulators have been introduced, to monitor the market and functioning of the market roles, and to regulate tariffs. Although the market roles are used worldwide, the meaning is not quite the same, because market roles (e.g. grid operator) have different tasks. The type of regulation differs also, where in some countries regulations are based upon rules and in other countries on principles. Tariff regulations differ with that to: regulators who specify which investments need to be done, versus regulators that benchmark on output indicators and use efficiency targets.

12. In fact, you may say that in some countries the words have been adapted, but the model is more or less the same as in phase 1: a public service, intensely collaborating with the government, performed by a company that makes a good but not excessive profit.

13. So what criteria, other than using the same words but with different meaning, can we define to know a centralised commodity market is in place and working? There needs to costumer choice for several commodity supplier, a level playing field for both incumbents and new entrants, an easy market facilitations including automated switching, historical metering data, billing data and good working settlement. The amount of equity needed for a new entrant to get into the market is good indicator.

14. These criteria for a good working market have led to see the market as a separate layer on top of the network, each with their own dynamics. The energy producers and retailers have their competitive playground. The grid operators have turned into system operators that enable the market. In good working markets, the networks have been interconnected. The market facilitation has grown into managing a platform for an open market.

2.4. Phase 3: energy as a decentralized service market

15. With the upcoming changes, the centralized commodity market is at its end. From a public value perspective, there needs to be green light for sustainability. Solar is very much decentralized. Intermittency, due to solar and wind, changes the load profiles used

in the market facilitation. New demand for electrical vehicles may add the need for power for 40% or more. Natural gas cannot be part of decarbonized energy system, thus add new demand on the electricity system for another 100% growth in volumes of more. The change will happen in a period of 20 years or so. Using the old mechanism for adding capacity in networks when needed is not only too expensive, it is simply impossible to realize. There is not enough space, even in the sea, to generate all this power.

16. So instead of viewing the energy system from a commodity perspective, buildings need to be turned into energy producing building. Industry needs to reform, using decentralized producing processes, using IT, 3D printing, circular economy and robotics to create competitive production with a much more limited use of energy. In this zero margin economy, energy is produced where it is used. The energy system is an exchange system. It is the same change as we have seen in IT: from a mainframe system to Internet: an Internet of energy.

17. Where most countries are still struggling with the step to phase 2, using perspectives that fit more in phase 1, the discussion to create the conditions for phase 3 is difficult. For small towns in the United States or Germany, where a local utility services the energy, stepping into phase 3 means quite a loss on the installed fossil generation. For commodity providers stepping into phase 3 means rapid loss of income. Commodity is not the business model of the future, they know, but new business model are not in place yet. On the other hand, countries that come from phase 0 will not have this legacy and may be the first countries to embrace a decentralized market.

18. In chapter 4, I will discuss a framework for a decentralized service market.

3. A model for comparisons

19. When discussing international perspective on energy markets, we often use the same words, meaning something different. The phases of maturity, as described in the previous chapter, is a beginning. But each country or state has slightly different policy goals and instruments. In this chapter I define a model, to be able to compare perspectives based upon two parts: the consumer perspective and the system perspective.

3.1. Consumer / prosumer perspective

20. Each phase has its own major policy goals, as described in table 1, although countries add all kind of specific goals to it.

Table 1. Policy goals

Phase	Policy goals
0: no organized energy system	Energy is not a basic need for society
1: energy is a local public service	Citizens must access to affordable and reliable energy
2: centralized commodity market	Citizens must access to affordable and reliable energy and have the right to choice of supply
3: decentralized service market	Citizens must access to affordable and reliable energy, and have the right to choice of supply and to be active player in the market

21. The missing policy goals in above table, is sustainability. Since most countries have committed themselves to the Climate agreement, decarbonisation is important game changer. Adding sustainability as a policy is different in each phase. In phase 1 and 2 sustainability means phasing out fossil based production of energy. Many countries, with Germany as the leader, have added sustainable production by creating subsidies that are financed through additional costs in the commodity system. When the commodity system is used for collecting taxes and additional charges, off grid solutions will have a business case because of that. These effects on grid defection may create a death spiral (Biggar[1], 2017) and jeopardize the affordability for those who cannot install off grid installations and thus creating a death spiral

22. In phase 3, the policy goals mean the reform of the energy system to an Internet of energy. A first step in that direction is the Winterpackage directive from the EU. Lavrijssen[2] describes this as follows: "All provisions related to consumer empowerment and consumer protection are equally applicable to consumers only using energy and the so-called 'active' customers. Active customer means a customer or a group of jointly acting customers who consume, store, or sell electricity generated on their premises, including through aggregators, or participate in demand response or energy efficiency schemes (..)"

23. Further steps towards phase 3, would include sustainability as a policy, including the energy demand for EV and heating, not only by electricity, but also by decarbonized gas and district heating. When energy is no longer a commodity as such, but a combined installation, decentralized options need to be fully taken into account.

3.2. Requirements of the system

24. The policy goals are reflected in the market roles, the processes and its regulation (see table 2). Again, the ways these are implemented differ highly from one country to another.

Table 2. Building blocks

Phase	Market roles	Market processes	Regulation
0: no organized energy system	No roles	No processes	
1: energy is a local public service	Utility	Wholesale one to one contracts	Concession
2: centralized commodity market	Energy producer, retailer, Program responsible party, Transmission grid operator, Distribution grid operator,Metering companies	Adding:Long term market, day ahead, intraday, balance, reserve capacity, metering, switching, billing data, settlement, capacity market	Adding: Level playing field, retail price regulation, quality regulation, tariff regulation networks
3: decentralized service market	Adding: Aggregator	Stopping: capacity marketAdding: peer to peer supply, flexibility market , EV charging	Adding: Platform regulationConnecting heat market

[1] Biggar, The Transformation of the Electricity Sector in Australia: The Public Policy and Competition Policy Issues, OECD, June 2017

[2] Lavrijssen, Power to the energy consumers, OECD, June 2017

25. After introducing renewables in Germany and the UK, the intermittency that occurred is being solved by adding a capacity market. In a way this means that grid operators buy generating capacity to ensure reliability. In a "centralized commodity"-thinking model, it is a logical way of acting, because centralized commodity market players are compensated for their investment in this capacity. A different perspective is that the TSO shrinks the market and "buys" a production plant. Therefore I reframe capacity market to flexibility market in phase 3.

26. The framework for phase 3 is new, not completed yet. In chapter 4 these new elements are discussed.

4. A framework for a decentralized service market

4.1. Platform thinking

27. Airbnb and Uber are considered as a wake-up call for the invention of a new way of creating a market, by introducing worldwide platforms. These platforms bring together demand and supply on a local decentralized level. By being successful, they manage to become a dominant market player for services that were considered to local. Private equity funds all over the world are looking for more opportunities.

28. Governments are in doubt. Some countries simply forbid these platforms, such as Italy banned Uber. Cities like New York and Amsterdam are teaming up to make a workable regulation for Airbnb. The impact on the city is tremendous, on social housing turning into hotels, the cities lack instruments to spread the growth of tourists and are not able to collect taxes.

29. The decentralized energy will turn into the same kind of platforms. Clearly, if not organized, the government will lack instruments to meet policy goals. Alliander organizes a discussion on the democratic values of platforms and the kind of requirements that are necessary to maintain these values[3]. Regulation needs to change to make sure the instruments for policy makers will be available in the future.

30. In countries where centralized commodity phase has been implemented in a mature way, the basics for these platforms are in place. A platform for electricity is serviced by unbundled TSO and DSO, providing wholesale markets, a centralized connection register with clear and open standards for switching, billing data and settlement and easy procedure for opening up business as a supplier. Part of the platform is the regulation and control by an independent regulator. The platform includes the infrastructure needed to facilitate the market. Platform thinking is that the market facilitation by TSO/DSO is put as primary, where the infrastructure is seen as a means to support this goal.

31. When energy services change, so change the constraints of the platform. Smart metering is an example of an extension, to enable the market for new services.

32. Terms as feed-in, re-supply and inject into the network express a thinking model that fits in a centralized commodity market. Self-production is seen as an exception that needs to be handled as an abnormality. In platform thinking, decentralized production is just supply that needs to be connected to demand in a peer to peer supply (see pf 4.2)

[3] https://www.democracybydesign.org/wp-content/uploads/2016/11/Democracy-by-Design-discussion-paper-07-2016.pdf

33. In this same type of thinking, there is new demand that comes into the market, e.g. solving intermittency and congestion (see pf 4.3)

34. Also new areas that are closely related to the electricity system are coming up. The EV market will boom in the next decade. The charging of EV must be organized as a platform (see pf 4.4), using the same elements as have been developed for electricity.

4.2. Peer to peer energy

35. In the centralized commodity market, energy suppliers sell energy. Using the platform thinking, new entrants have developed a new type retailer. Instead of selling electricity, they offer peer to peer delivery. The consumer chooses the sources where the energy comes (e.g. a specific farmer with a windmill) and pays the retailer for its service to organize this. The current level of service is based upon yearly volumes.

36. In countries with a free choice of supply and a good working market facilitating platform, this peer to peer model does not need any change of regulation. It is just a different type of contract. In the Netherlands there are 4 energy suppliers that offers these contracts to consumers.

37. The next level will have two changes: it will be at real time, and the retail part can be done by a community or, as large user with multiple buildings, the user will be his own "retailer". This requires adjustments to the platform: smart metering, settlement based upon quarterly hours for households, tools that enable consumers to connect their appliances to the energy prices and a mechanism that enables a community of company to become their energy retailer.

38. For enabling consumers to connect their appliances to the energy prices, a different approach is needed than demand response. In the demand response-model, a centralized commodity supplier switches off appliances for a rebate. This new model is called trans active energy in the United States, or referred to as Automated Response technology by Wolak[4]. In the Netherlands and Denmark, it is called Powermatcher. Open protocols[5] for connecting devices have developed, as well as a auctioneer that can optimize between appliances within a building or between buildings. Typical appliances are solar production, heat pumps and fuel cells.

39. A mechanism for creating your own energy retailer, both for businesses and consumers, has been developed by Alliander for the Dutch market under the name of Entrnce. It provides exchange of electricity for all the buildings that are switched to this retailer, add them up to one portfolio and connects to the wholesale market.

40. An alternative mechanism for peer to peer energy exchange, is provided by blockchain. Blockchain is both a technology and a platform. Consumers may be locked in, selling out privacy or become very dependent on an unknown platform owner. For using blockchain technology, some changes need to be made on the platform.

41. This second level creates new options: for a business user with multiple locations, they combine the energy producing building in one contract and optimize them before buying in the market. For citizen communities this creates a platform to exchange within the community before they buy from elsewhere. A consumer with multiple buildings,

[4] Wolak, Efficient Pricing: The Key to Unlocking Radical Innovation in the Electricity Sector, OECD June 2017

[5] For more detail, see: Flexible Power Alliance at www.flexiblepower.org

such as a holiday house, the electricity from solar panels from one building can be used in the other.

4.3. Flexibility market

42. With the surge of sustainable energy, intermittencies and congestion will thread the reliability of the power system.

43. There are several options for stabilizing: buy reserve capacity, or enable (millions of) market players to stabilize the grid.

44. In phase 2, a centralized solution will be chosen to stabilize the grid. In several countries grid operators have started tendering capacity and thereby use power plants to fill in the gaps due to intermittency. In a network with low share of renewables, the reserve capacity is no more than an emergency measure, counting for less than 1% of the total. But in a highly decentralized and renewables market, this could add up to a considerable part of the total volumes. It would not only be highly disturbing the market, it will also be an expensive solution. The tendered capacity would grow to a power capacity that equals the highest load (e.g. the November peak with no wind and sun). There will be hardly any incentives to energy users to optimize their behaviour, so cost will go up more and more.

45. From a platform perspective, intermittency is a new demand, as is congestion. A flexibility market should solve intermittency and congestion. In a good working wholesale market, the predictable load changes can be managed. But the intermittencies and congestion may occur at a local level, need smaller volumes then is custom in the wholesale market. The reaction time for ramping up or down, referred to as inertia by Biggar[6], requires also more speed.

46. A flexibility market couples real time demand to the balance market and intraday market. It enables aggregators[7], such as fleet-owners of electrical cars, service providers for sustainable buildings or energy retailers to make a business. If the need for flexibility rises, these aggregators can unlock this potential either by transactive energy/ powermatcher type of solutions or by more traditional demand response. The platform needs to enable these services by smart metering and settlement on quarterly basis.

47. The aggregator is a new market roles and can be created by two methods. The first is to create multiple meters on one connection and enable the consumer to switch supplier on each meter. The aggregator is in this case just another type of supplier, for example for a heat pump, a solar panel or a home charger for EV. The second method is that the aggregator manages the program responsibility for the costumer. For a centralized commodity supplier it is unthinkable to outsource this program responsibility. But for a peer-to-peer supplier it means risk reduction and use the advantage of scale.

48. The same market mechanism can be used for congestion, if location is added. It that case, it enables small packages that can be shifted from one location to another, in high speed. This requires dynamic grid tariffs. Biggar: "The extension of dynamic network pricing arrangements to the distribution network will almost certainly enhance

[6] Biggar, The Transformation of the Electricity Sector in Australia: The Public Policy and Competition Policy Issues, OECD, June 2017

[7] As explained by Lavrijsen, Power to the energy consumers, OECD, June 2017

the opportunities for market power. As locational marginal prices are determined at increasingly granular locations, the potential geographic size of the market becomes smaller and smaller. It becomes increasingly likely that some customers (generators or loads) will be able to exercise market power at certain times." In most countries, distribution grid tariffs are KWh-based. The service delivered is capacity. Grid prices that do not reflect real cost, may give the wrong incentives (Wolak[8]).

49. For grid operators, it feels too risky to completely rely on a flexibility market. In Germany, grid operators have been given the ability to switch of renewable production if necessary. In the United States and more countries, grid operators use the demand response mechanism to switch off appliances. Instead of switching off customers, it would be more logical to use batteries for solving congestion, reserve capacity or power quality issues, so long as it is temporally and limited.

4.4. EV charging

50. The global electric car stock surpassed 2 million vehicles in 2016 after crossing the 1 million threshold in 2015 (IEA[9]). As of 2018 the full electrical cars will have the same prices as fossil cars. In twenty years, mobility will be highly dependent on electrical cars.

51. Public values for EV must be set in the same way as for electricity: access to charging EV, which is affordable and reliable. And again, the government has the policy choice to see this as a local public service, a centralized commodity or a decentralized service market.

52. EV charging can be seen as a layer upon the power grid, with its own dynamics. Cost drivers affecting affordability are both the power grid and EV-charging market. To keep cost down for power grid, it is important to influence location and time of use. Two electrical cars use on the average as much energy as one residential building, but the grid could handle this if charging takes place in off peak hours. This smart charging needs the same elements in the power platform, as described in pf 4.2 on peer to peer energy and in pf 4.3 Flexibility market.

These smart charging options will not work in an EV market, that is shaped as in phase 0 or phase 1. The automotive sector works global or on continents, but can certainly not be different in each city.

53. In the centralized commodity model for EV-charging, there will be charging stations from OEM's (such as Tesla), corporations (such as Shell) and new entrants.

54. In a platform model for EV, an Information Service Provider is added. This ISP enables charge point operators to open up their infrastructure for an global market, even if this infrastructure is consumer owned. This model makes it possible for municipalities to provide charging infrastructure in places where from a public perspective (access) charging is wanted, but from a commercial perspective not profitable.

55. The ISP also connects the mobility service provider, that offers the services to the driver. These services will grow in time, but should contain the sales of energy and smart

[8] Wolak, 29, Efficient Pricing: The Key to Unlocking Radical Innovation in the Electricity Sector, OECD June 2017

[9] https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf

charging. OEM's are interested to operate as a MSP, to be able to deliver seamless services during lifetime of the car.

56. If the charge point operator chooses to "click" on the underlying power grid by using peer to peer energy and flexibility market, drivers are enabled to use smart charging and choose their own energy source, for instance the power from their own solar panels at home.

4.5. Changing built environment and industry

57. In many developed countries, most of the buildings are heated by a fossil fuel, such as gas or oil. In the path of decarbonisation ultimately in 2050, the first alternative to think of is electric heating. There are more options, including passive buildings. Policies for the power system can no longer be seen separate from heating solutions, building requirements, installation inside the building, decarbonized gas such as hydrogen and collective infrastructure for heating. Heat can be stored in tap water boilers or phase change material thermal storage. Heat by power becomes a thread for the power system, but also a solution for intermittencies and congestion in power to heat.

58. Therefor heat can, as charging EV, be seen as an extra layer upon the power grid. The heat market can use the power platform element peer to peer energy and flexibility market to gain extra value.