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POLICY BRIEF

The Potential of Distributed Energy Resources to Tackle Climate Change

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Highlights

- Distributed Energy Resources (DER) are decentralised small-scale power generation sources located near end-user consumers that supply part or all of their electricity demand. DER are increasingly seen as key to the development of a sustainable low-carbon power system.
- DER technologies offer opportunities for the development of renewable energy but also pose challenges for their integration in the power system.
- Opportunities have been created by the reducing cost of DER technologies, in particular solar photovoltaic (PV) and by the possibility of using DER for system flexibility. Moreover, DER represent an important vector for the diffusion of electricity in developing countries.
- One of the challenges is the difficulty of managing and designing the electrical grid, which was not designed to have several small-scale power generators connected to the distribution grid.
- Many DER will still need policy support in the coming years, which must be rationally designed.
- A large deployment of DER requires the development of a new framework for the power sector in all areas.

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Distributed Energy Resources (DER) technologies are increasingly seen as a key element to the development of a sustainable low-carbon power system. The rapid development of DER, due to dedicated policies but also to technological development, performance improvement and cost reduction has led to a significant debate on DER and their general implications. The Florence School of Regulation Climate contributed to this discussion by organising an online event with three high-level experts: Santiago Blanco (DNV GL), Richard Schmalensee, (MIT) and Laszlo Varro (IEA).[1] This policy brief presents the debate on DER, highlighting the opportunities and challenges of these technologies.

What are Distributed Energy Resources?

DER are decentralised small-scale power generation sources (typically less than 10MW) located near end-user consumers that supply part or all of their electricity demand. Historically, DER were mostly diesel generations, usually disconnected from the grid, used for back-up capacity or to provide electricity in remote areas. In the past few years, there has been a significant development and deployment of low-carbon DER such as micro turbines, energy storage facilities (that can be considered as power plants running on inexpensive electricity at off-peak times and providing expensive electricity at peak-times) and, in particular, solar photovoltaic (PV). Some of these technologies, such as PV, are already mature, others, like energy storage facilities, are still at the stage of development (DNV, 2014). These DER are, in general, connected to the medium and low voltage distribution grid, where the electricity not self-consumed can be sold in the power system. This has created a new figure, the energy prosumer: the final-end consumer who is also a producer.

Why are they important?

DER technologies offer important opportunities for the development of renewables in electricity. Firstly, the cost of some of these technologies has rapidly decreased. In particular, the cost of PV has fallen dramatically in the past twenty years. In Germany, for example, the prices of a typical PV rooftop-system went down from 14,000 €/kW in 1990 to 1,270 €/kW at the end of 2015, a reduction of 90% (Fraunhofer, 2016). In some regions, like Italy, the south of Germany or California, PV has reached grid parity and it has become competitive with conventional generations on the basis of the levelised cost of electricity (IEA, 2014). This has been the effect of a large deployment of solar capacity in the past few years in Europe, USA and more recently also in Asia, which has been supported by public incentives. Globally, PV installed capacity was only less than 1 GW at the end of 2000, and in less than 15 years it grew to more than 180 GW (IRENA, 2015). This pushed down the cost of solar panels thanks to a learning-by-doing effect and economy of scale that was favoured by the highly modular nature of PV.

Another potential benefit of DER is that they can provide flexibility to the system (SWECO, 2015). With the sharp increase in electricity generated by intermittent renewable sources, such as wind and solar, the system needs to be flexible to cope with the fluctuations of renewable generation. While, on the one hand, some DER technologies (like solar PV) increase the demand of flexibility, on the other hand, other technologies (like distributed storage facilities) are promising solutions to provide local flexibility. Moreover, if DER are pooled together by aggregators, many different DER technologies could provide flexibility to the system, including variable generation (SWECO, 2015). A final important aspect of DER is that micro-grids with DER can facilitate the diffusion of electricity in areas that are far from existing networks. This is of primary importance in developing countries where there are still more than one billion people without electricity (IEA, 2015a).[2] Although the cost of producing electricity in micro-grids is, in general, much higher than using a large centralised system, micro-grids represent a valuable opportunity to access electricity for many communities in rural areas which are unlikely to be reached by the extension of the centralised network in the near and medium-term (Schnitzer et al., 2014).

1. Each expert made a short video presentation and, on the 6th of June 2016, Prof. Xavier Labandeira, FSR Climate Director, chaired an online debate with the three experts. All the presentations and the recording of the online debate are available at: fsr.eui.eu/event/potential-distributed-energy-resources-tackle-climate-change/.

2. For more information on universal access to electricity see the dedicated FSR project: http://fsr.eui.eu/universal-access-energy

What are the challenges?

The integration of DER in the electricity system also presents numerous challenges. Firstly, the costs of many DER technologies, although much lower than only a few years ago, are still high. Furthermore, in most regions of Europe and USA, PV is not competitive with conventional centralised generations due to the geographical and seasonal distribution of solar radiation. In addition, there are intrinsic limitations to solar energy: being available only during daytime, it cannot be a sustainable solution without backup capacity or storage. This means that a large deployment of DER in the short to medium term is not yet economically sustainable without a policy intervention. On the other hand, developing policies for technological deployment with the right balance between effectiveness and cost-efficiency have so far turned out to be very difficult to implement. As the European experience shows, renewable energy policies have been very effective in increasing the capacity of solar PV (especially feed-in tariffs and feed-in premiums, the most used renewable energy incentives). However, they proved to be very expensive for consumers (in the EU the costs are generally paid with a surcharge in the electricity bill). For example, in 2014 Germany faced renewable energy policy costs of up to €23.6 billion (BMWi, 2014). Due to these high costs for consumers, some countries, such as Spain and Italy, decided to drastically reduce the support for renewables, which resulted in a slow-down of the renewable deployment and had a negative effect on the national renewable energy industry.

Secondly, a large penetration of electricity from DER, in particular of intermittent sources such as PV, poses several problems to the management and development of the electrical grid. The electrical grid was designed with a centralised paradigm, where electricity was produced by large centrally controlled power plants, transported across large distances through the high voltage lines of the transmission grid and transformed in the distribution grid to medium and low voltages where end consumers could consume it. In this framework, the power flow is unidirectional, from the transmission grid to the distribution grid, and the distribution network is a passive local system to connect mainly loads. Although the increase of DER may imply a reduction of electricity transmitted (and thus of the cost of electricity losses), there would still be the need for a high capacity network to cope with the variability of PV and other renewable technologies. As a result of the development of DER, there are thousands of small variable generators connected at distributional level which the system was not designed to cope with. There is an increasing complexity to balancing activities both in terms of time, due to the unpredictability of many DER, and space because of their geographic dispersion. Moreover, an extensive use of DER produces bi-directional power flows from the distribution to the transmission network, when DER generation exceeds consumption. Hence, a large penetration of DER, particularly of intermittent generation such as solar PV, needs a reinforcement of the network and a redesign of the system management. This implies higher costs that outweigh the benefit of reducing electricity losses (MIT, 2015). All this challenges the classic regulation of electricity infrastructure. An important example regards the regulation to allocate the costs of the network infrastructure. The common method, with a surcharge per KWh of net electricity transmitted, risks being highly inefficient with a large deployment of DER because the costs will depend more on the peak-capacity and the production and consumption profile (Pérez-Arriaga, 2014). Furthermore, this is also unfair since this type of tariff tends to shift the cost from consumers with DER, who are generally wealthy, to low-income consumers that cannot afford such technologies.

How to best develop DER?

Against this background, it is important to create the best conditions for the sustainable and cost-effective development and integration of DER. Firstly, it is essential to set the right price for electricity that internalises all the costs of generation, transition and distribution. This would enhance an efficient distribution and use of DER and support flexibility tools such as demand response. This means having a dynamic electricity price for consumers that accounts for time and location. As mentioned, it is also necessary to redefine transmission and distribution tariffs in order to efficiently and fairly allocate the cost of the building and use of the infrastructure.

Secondly, the regulation of the power sector, in particular the role of the distributed system operator (DSO) - which, being a natural monopoly, is a fully regulated entity - needs to be reconsidered. In the centralised paradigm, the DSO has a more passive role in the system management, while the transmission system operator (TSO) plays an active role, as it is responsible for operations such as balancing and congestion management. Since more and more DER are connected to the distribution grid, it is expected that the DSO manages its network more actively, also through the use of flexibility services, such as demand response or distributed generation shedding (CEER, 2014). As a result, the activities of the DSO need to be redefined and re-coordinated with the transmission system operator (Hadush and Meeus, 2016). It is also important to foster the development of businesses such as aggregators or ESCO to promote an efficient management of the consumption and production of consumers' energy and the use of DER for flexibility. This implies, among other things, the necessity to redefine the electricity market framework (that was also designed in the context of a central system (SWECO, 2015)), to standardise protocols for the interactions among the DER and between these resources and the grid (EPRI, 2015), and to facilitate access to distribution grid data, whose management will become an important and sensitive task (CEER, 2014). All this, including applying dynamic electricity prices, cannot be done without an upgrade of the hardware of the network with new technologies, in particular smart meters, which needed to be dispersed to consumers on a large scale. This new efficient use of the grid, with smarter technologies and the more active participation of consumers, is called a smart grid.

Thirdly, a considerable development of DER still needs policy support in the near future. It is of primary importance to have rational policies that favour a cost-effective development of these technologies. In particular, renewable incentives should avoid overcompensation, be open to all technologies and sizes, reduce as much as possible the distortion of the electricity market and be explicit and transparent.

Finally, two additional measures are crucial to the development and deployment of DER and of any low-carbon technology in a cost-efficient way. The first one is the investment in R&D, including basic research, to promote new and innovative solutions. Indeed, even for solar energy, which has experienced an impressive development in the past few years, there is still a need for R&D to develop technologies that are to be deployed at a very large scale (MIT, 2015). The second is a growing price for carbon emissions that internalises the cost of climate change and sends a clear signal to investors. This is the most efficient way to incentivise the private sector to invest in low-carbon technologies, including DER.

Conclusions

The energy sector is responsible for approximately two thirds of the global greenhouse gas emissions (IEA, 2015b). If the rise in the global temperature is to be kept below 2°C, it is imperative to move towards a very low-carbon energy system, which implies an almost complete decarbonisation of the power sector, at least in developed countries such as in Europe and USA. This requires the massive deployment of renewable energy. DER have become important means for the development of renewable energy. However, they also present several challenges to sustainable and efficient integration in the electric power system, which needs to be addressed by policymakers and regulators. A large deployment of DER requires the development of a new framework for the power sector in all areas. This transformation has already started in some regions, such as the European Union (Glachant, 2016), where the European Commission will shortly propose a new energy target model to integrate renewable energy (EU, 2015), or New York State, where a complete overhaul and revision of the electricity system with specific action for DER is underway (NYS, 2016). Different countries will adopt different solutions. This is a difficult and long-term task: it will be important to follow the evolution of the different implemented measures to identify best practices and to learn from each of them.

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