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Subsidising Photovoltaics in the EU

How does it help to achieve EU climate and energy policy targets?

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- The current support for electricity generation by way of photovoltaics (PV) is failing to meet the EU's climate and energy policy targets: it is not resulting in CO_2 reduction or lower electricity prices nor does it increase security of supply.
- The aim of achieving an internationally competitive industry for the production of PV modules in the EU was also misguided.
- Technologies which are permanently uncompetitive or already established should not continue to be subsidised. Instead, support should be given to research into new energy technology.
- Insofar as PV continues to be subsidised, support should be designed to be competitive and neutral with regard to location so that PV plants are set up in locations with the highest levels of solar radiation and no longer in areas where subsidy levels are highest.

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1 Introduction

In 2013, in order to protect European manufacturers of photovoltaic modules (PV modules) against dumping prices from Chinese suppliers, the EU imposed protective tariffs on Chinese PV modules and their components until 7 December 2015.[1] On 5 December 2015, the European Commission initiated an examination on whether to continue with the anti-dumping tariffs; these will remain in force until a final decision is made.[2]

Irrespective of the decision on the continuation of protective tariffs, the development of the European PV industry in recent years has given rise to the question of how current PV support in the EU is to be assessed. As early as September 2015, the European Commission submitted a Communication criticising deficiencies in the existing support for energy technology in the EU.[3] Among other things it refers to the fact that, despite PV support between 2010 and 2014, the annual production of PV modules in the EU fell from 3 GW to 1.3 GW.[4]

On the other hand, PV support in the EU resulted in a stark increase in the volume of electricity produced by PV systems in the EU: from close to 0 gigawatt-peak (GWp) in the 1990s to 86 GWp in 2014.[5] In 2014, 2% of electricity output in the EU came from PV systems.[6] Every Member State in the EU currently has its own system for supporting renewable energy (EE). As the various systems are not coordinated, renewables development in the EU is very diverse.[7]

Alongside energy efficiency, the EU considers PV and other ways of utilising renewable energies as "important parts of the package of measures" for achieving its energy and climate-policy targets.[8] These targets include a reduction in harmful greenhouse gas emissions by way of the long-term transfer to a low-carbon economy ("decarbonisation"), a secure and affordable energy supply and by supporting growth, employment and competitiveness in the EU.[9]

Based on the example of PV support, this cep**Input** analyses the extent to which existing support mechanisms have been helpful in achieving the targets. It will also contribute to the discussion on subsidising energy technology in general and PV support in particular. For this purpose, Chapter 2 describes the current support both for PV research and for supplying PV electricity into the electricity grid (PV feed-in). Chapter 3 analyses how efficient PV support is and what contributions it can make to achieving the EU's energy and climate-policy targets.

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1 Council Implementing Regulation (EU) No. 1238/2013 of 2 December 2013 imposing a definitive anti-dumping duty and collecting definitively the provisional duty imposed on imports of crystalline silicon photovoltaic modules and key components (i.e. cells) originating in or consigned from the People's Republic of China.
2 EU Commission (2015), Notice (2015/C 405/08) of 5 December of initiation of an expiry review of the anti-dumping measures applicable to imports of crystalline silicon photovoltaic modules and key components (i.e. cells) originating in or consigned from the People's Republic of China.
3 EU Commission Communication C(2015) 6317 of 15 September 2015, Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation.
4 Ibid, p. 5.
5 EurObserv'ER (2015), "Photovoltaic Barometer", p. 9.
6 Eurostat (2015a), "Primary production of renewable energy by type", <link> accessed on 2 December 2015, Eurostat (2015b), "Total gross electricity generation", <link> accessed on 2 December 2015.
7 RES-legal (2015): Renewable Energy Database and Support <link> accessed on 2 December 2015.
8 Recital 1 of Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (hereinafter: Renewable Energy Directive 2009/28/EC).
9 Bonn, M., Heitmann, N., Nader, N., Reichert, G., Voßwinkel, J. (2014), "Die Klima- und Energiepolitik der EU – Stand und Perspektiven", cep**Compass**, p. 1.

2 PV Support in the EU

In the past, due to its high overall cost, electricity generation by way of PV systems was not competitive by comparison with conventional power sources (e.g. coal, natural gas, nuclear energy).[10] In addition, there was for a long time no sufficient incentive for companies to invest in PV research which would have increased the productivity of PV modules. Such investment is only worthwhile if it produces cost reductions so extreme as to suddenly make electricity production by way of PV systems competitive which was not the case in the past.[11]

In order to overcome the lack of competitiveness of PV systems PV technology is supported by three types of measure: Firstly, research to improve PV systems is supported by public funds (2.1). Secondly, the use of PV systems is made more attractive by feed-in premiums, tariffs and similar support mechanisms (2.2). Thirdly, other forms of electricity generation are made more expensive (2.3) such as by way of the EU-wide Emissions Trading System (EU ETS), under which companies, that emit CO_2 during electricity production, have to produce emissions allowances.[12] The last method cannot support any specific technology, however, but only puts certain technologies at a relative competitive disadvantage.

2.1 Research Support

Research and development (R&D) can be divided into several phases.[13] Thus, firstly, fundamental research produces knowledge which can be applied in more than just one specific area. Secondly, "technological research" can be carried out to further develop a specific technology. Thirdly, the product demonstration examines whether a technological concept is fit for use under actual conditions and where necessary adapts the product to them. In practise, the transition from one phase to the next is a gradual one, in particular the transition from basic research to technological research is sometimes hardly noticeable. All three phases are supported in the EU within the framework of PV research support.[14]

In the EU, support for R&D in the PV systems sector takes place primarily by way of the Research Framework Programmes, currently the 7th Research Framework Programme. This EU support has been in existence for more than 30 years.[15] Since 2002, R&D in this sector has received funding of over € 110 million.[16] The funding of PV research in the EU is derived from the EU budget (6%), the Member States (35%) and the private sector (59%).[17] The extent of research support in the individual EU Member States is however very varied. No uniform strategy is apparent in the EU.

Under the EU SET Plan, research support is coordinated by the European Solar Energy Initiative.[18] In its consolidation of the SET Plan in 2009, the Commission's aim was to allow PV and other renewable energies to have fixed shares of the electricity generation market. Thus up to 15% of electricity consumption was to be covered by PV by 2020 with public and private investment

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10 This view does not take account of the costs of environmental damage due to the combustion process.

11 Reichelstein, S., Yorston, M. (2013), "The prospects for cost competitive solar PV power", Energy Policy, Vol. 55, p. 123.

12 Zachmann, G., Serwaah-Panin, A., Peruzzi, M. (2015), "When and How to Support Renewables? – Letting the Data Speak". In Ansuategi, A., Delgado, J., Galarraga, I. (Hrsg.) (2015), "Green Energy and Efficiency", p. 291–332, here p. 294.

13 EU Commission, Communication COM(2012) 341 of 26 June 2012, A European Strategy for Key Enabling Technologies – A bridge to growth and jobs, p. 18, see cepPolicyBrief of 25 January 2010.

14 Photovoltaic Technology Platform (2009), "Today's Actions for Tomorrow's PV Technology. An Implementation Plan for the Strategic Research Agenda of the European Photovoltaic Technology Platform".

15 EU Commission (2015), "EU Support for Photovoltaics", <link> accessed on 24 November 2015.

16 Ibid.

17 Photovoltaic Technology Platform (2009), "Today's Actions for Tomorrow's PV Technology. An Implementation Plan for the Strategic Research Agenda of the European Photovoltaic Technology Platform" (Figures dating from: 2007).

18 EU Commission, Communication COM(2009) 519 of 7 October 2009, Investing in the Development of Low Carbon Technologies(SET-Plan), see cepPolicyBrief of 16 November 2009.

amounting to approx. € 16 billion being made available in this regard.[19] In a Communication published in November 2015, the Commission criticised the SET Plan's existing target, and announced that it would replace technology-specific research support with an "energy-system approach" no longer setting out isolated technology-specific interim targets but focussing on progress over the entire energy system. This progress may refer both to the higher productivity of PV systems and to an improvement in the ability to make use of electricity from PV systems due to progress in electricity storage. The energy-system approach will be adapted to the priority actions of the European energy and climate policy by 2030 ("Energy Union").[20] When it comes to research funding, support for renewable energy is one of the four core priorities [21] of the Energy Union.[22]

Technical progress will allow significant reductions in the cost of electricity generation by way of PV systems. Where production costs for electricity from PV systems in Germany in 2013 were between € 78 and € 142 per MWh (depending on the type and size of the system and solar radiation),[23] production costs for 2030 are expected to be between 55 and 94 euro per MWh.[24] By comparison: The production costs for wind-generated power plants on land are between € 45 and € 107 per MWh, the production costs for electricity from lignite-fired power plants between € 38 and € 53 per MWh, for anthracite-fired power plants between € 63 and € 80 per MWh, for gas and steam power plants between € 75 and € 98 per MWh.[25] Electricity production from fossil-fuel power plants is expected to become more expensive so that PV systems could become competitive by 2030.[26]

2.2 Feed-in Support and Development of PV Roll-out in the EU

In addition to pure research funding, the EU also expressly supports the marketing of renewable energies.[27] In 2007, the European Council decided to increase the renewables share of gross final energy consumption to 20% by 2020 (20% target) and at the same time wants bio-fuels to achieve a minimum 10% share of transport-related petrol and diesel consumption.[28]

The main instrument for renewables support at EU level and for implementing the 20% target, is the Renewable Energy Directive (2009/28/EC).[29] Since the Member States have varying potential for renewables production, depending on climatic and geographical conditions, they are subject to varying national roll-out targets with regard to implementing the 20% target.[30]

Apart from the obligatory 10% bio-fuel target in the transport sector, which every Member State must achieve, the Member States are basically free to determine how they spread their national renewable energy target over the three sectors of electricity generation, heating/cooling and

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19 Ibid.

20 EU Commission Communication C(2015) 6317 of 15 September 2015, Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation (p. 3 and 16).

21 The three additional core priorities are (1) technologies that facilitate the roll-out and use of "smart grids", (2) energy systems that contribute to making the building sector energy neutral, and (3) sustainable transport systems.

22 EU Commission, Communication COM(2015) 80 of 25 February 2015, A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy, see cep**PolicyBrief** No. 08/2015.

23 Kost, C. et al. (2013): Levelized Cost of Electricity. Renewable Energy Technologies. Fraunhofer ISE, p. 2.

24 Ibid.

25 Ibid.

26 Ibid.

27 Recital 6 Renewable Energy Directive 2009/28/EC.

28 European Council of 8/9 March 2007, Conclusions, Doc. 7224/1/07 REV 1 ("20-20-20" Resolution), para. 27-39.

29 On this see also Bonn, M., Heitmann, N., Nader, N., Reichert, G., Voßwinkel, J. (2014), "Die Klima- und Energiepolitik der EU – Stand und Perspektiven", cep**Compass**, p. 90 et seq.

30 Art. 3 (1) in conjunction with Annex I Section A Renewable Energy Directive 2009/28/EC. This burden sharing also takes account of the differences in gross domestic product and in the efforts made so far in renewables development.

transport, which renewable fuels they want to support as a priority and which support mechanisms they want to use in this regard.[31]

The Member States had to prepare national action plans by 2010 setting out how they intended to achieve their binding renewable energy targets by 2020.[32] In this regard, they mainly follow a diversified technology-specific support policy. However, the Renewable Energy Directive also gives them the option to cooperate on renewables support. The possibilities for cooperation range from agreements whereby renewable electricity produced in one Member State is set off against the national development target of another Member State by way of "statistical transfers", through to joint funding systems.[33] Currently, however, these possibilities are hardly being used.[34]

Instead, most EU countries support PV electricity generation by way of national feed-in payments or use market premium schemes whereby the producer receives a fixed amount or allowance on top of the electricity price for every kilowatt hour of electricity fed in. In Belgium and Denmark, on the other hand, the main support mechanism is known as "net metering". In this case, PV electricity generated in private households or small companies is fed into the power grid and set off against the electricity purchased from the grid.[35]

In addition, the support rates differ, which has led to very varied levels of development. In Estonia, Finland, Ireland, Croatia, Latvia, Poland, Sweden and Hungary, the PV share of electricity generation is negligible due to the lack of long-term support. The installed PV output in these countries is below 10 W per capita.[36] In the Member States with high PV capacity, the primary factor for PV development is not the level of solar radiation but the level of funding. Thus, in almost every year since 1990, the funding levels for PV in Germany have been higher than in the more sun-drenched Member States of France and Spain.[37] This is the only explanation for the fact that Germany, with comparatively low levels of sunshine, has by far the highest concentration of PV systems in the EU with 474 W per capita.

This is illustrated in Figure 1. German per capita PV capacity is one and half times larger than in Italy, double that of Greece, four times greater than Spain, six times greater than Cyprus and almost twelve times that of Portugal. At the same time, due to the higher level of solar radiation, systems in these countries could produce electricity for a significantly higher number of hours per year (full load hours) and are thus in fact in much more attractive locations for PV electricity generation. Other countries with relatively low levels of sunshine such as Belgium, Luxembourg and the Czech Republic, have higher per capita PV capacity than for example Spain and Portugal, which is also due to the above-average funding levels.

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[31] Bonn, M., Heitmann, N., Nader, N., Reichert, G., Voßwinkel, J. (2014), "Die Klima- und Energiepolitik der EU – Stand und Perspektiven", cep**Compass**, p. 91.

[32] Art. 4 Renewable Energy Directive 2009/28/EC.

[33] Art. 6-11 Renewable Energy Directive 2009/28/EC, see also in this regard Bonn, M., Heitmann, N., Nader, N., Reichert, G., Voßwinkel, J. (2014), "Die Klima- und Energiepolitik der EU – Stand und Perspektiven", cep**Compass**, p. 92 et seq.

[34] Unteutsch, T., Lindenberger, D. (2014), "Europäische Kooperation bei der Förderung erneuerbarer Energien: Wie geht es nach 2020 weiter?", Energiewirtschaftliche Tagesfragen, Vol. 64, p. 12; EU Commission, Communication COM(2015) 572 of 18 November 2015, State of the Energy Union 2015, p. 5.

[35] Survey of the various renewables support mechanisms in the EU Member States by RES-Legal (2015), "Renewable Energy Database and Support" <link> accessed on 2 December 2015.

[36] Cf. EurObserv'ER (2015), "Photovoltaic Barometer", p. 7 et seq.

[37] Jacobs, D. (2012), "Renewable Energy Policy Convergence in the EU – The Evolution of Feed-in Tariffs in Germany, Spain and France", p. 187 et seq.

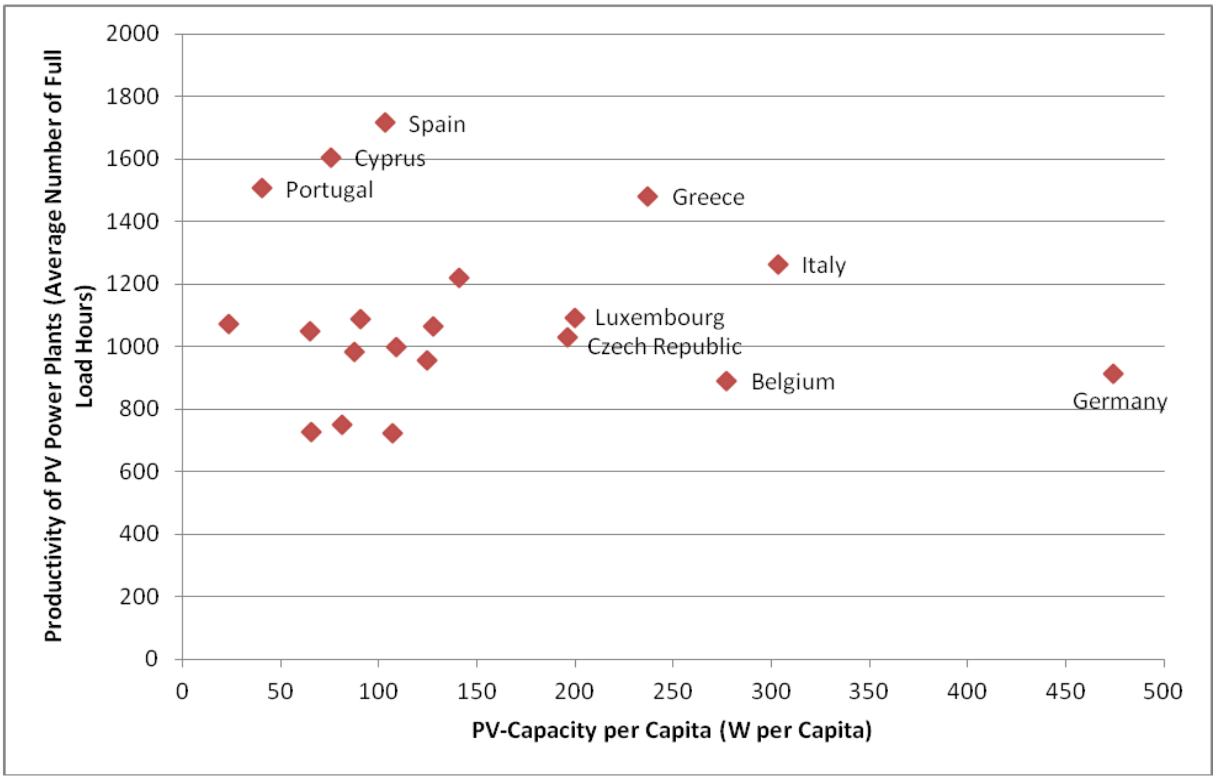

Figure 1: Per capita PV capacity and average productivity of a PV system
Source: own chart based on EurObserv'ER (2015), "Photovoltaic Barometer", p. 7 et seq.

As a buyer of PV systems, the EU is currently losing ground to the USA, China and other countries in East Asia. In 2014, whilst the level of PV development in Germany (+1.899 MWp), Italy (+385 MWp) and Spain (+21 MWp) was relatively low, PV capacity for the same year in China (+10.560 MWp), Japan (+9.700 MWp) and the USA (+6.201 MWp) saw rapid growth.[38]

2.3 The EU Emissions Trading System (EU ETS)

The EU Emissions Trading System (EU ETS) is characterised by a "cap and trade" approach. Fossil fuel power plants and other carbon-intensive companies are subject to an "allowance requirement", i.e. they must hold an emissions allowance for every tonne of CO_2 emitted. As the overall number of certificates is fixed EU-wide ("EU cap"), so the permitted volume of CO_2 from all plants subject to the allowance requirement in the EU is automatically limited. Since the number of allowances issued up until 2020 will be reduced annually by 1.74%, and between 2021 and 2030 annually by 2.2%, this ensures that the required reduction in emissions in the EU ETS will actually be achieved. However, not every individual power plant or industrial installation in the EU ETS is obliged to make the saving in CO_2 themselves. Instead, they can sell allowances to companies for whom CO_2 avoidance costs are lower. This "trade" in allowances means that CO_2 is reduced mainly in companies where it is cheapest to do so.

As a result of the EU ETS, electricity generation in fossil fuel power plants becomes more expensive. This makes PV and other low carbon technologies more competitive on the electricity market. The EU ETS can thus be regarded as an indirect PV support mechanism.

[38] EurObserv'ER (2015), "Photovoltaic Barometer", p. 6.

3 Assessment

3.1 Legitimacy and Efficiency of state PV funding

3.1.1 Research funding

The provision of EU funds for fundamental and technological research as well for the implementation of demonstration projects may be necessary for the development of new energy technologies because companies often have no incentive to invest in technologies, that are not yet ready for the market, without state support. This is primarily due to the fact that such research investment gives rise to individual costs without any corresponding individual financial benefit. Consequently, there may be under-investment in technological research which retards the development of new energy technologies. Since the transition from one support phase to another is a gradual one, it is possible that, in practice, products which are actually ready for the market will continue to receive support. Thus state intervention can also result in over-funding.

The argument for state funding becomes less important as the level of development of a technology advances. The more specific the new knowledge the more easily it can be protected from use by other potential market operators and put to commercial use. Technological support and support for demonstration projects should therefore be applied restrictively.

Abandoning precisely determined technology road maps, as provided for in the existing SET Plan, is appropriate in view of the limited ability to predict the development of new energy technologies. It is not possible either to know in advance what knowledge will be obtained from research, or the extent to which this knowledge will contribute to the ability to pursue effectively EU targets on energy and climate protection. Therefore the allocation of research funding should, in principle, be neutral as regards location and technology. An approach based on the energy system can also use synergies arising from the development of complementary energy technologies – e.g. in the case of photovoltaics, this would be electricity storage and demand response technology.

In recent decades, PV research has led to significant technological progress which has resulted in cost reductions. In the medium-term, this knowledge becomes what is known as a "global public good". Generally, no-one can be excluded from technical knowledge in the medium term.[39] In the context of business-location policy, research funding can have the effect of supporting an environment in which technical expertise becomes consolidated at a local level. This will not, however, ensure that technical knowledge is only available exclusively in the EU and it cannot therefore be expected in the case of support for PV research either.

3.1.2 Feed-in support

In principle, renewable energy such as PV should not be supported beyond the large-scale demonstration project phase. Its share in the energy mix of Member States should not therefore be decided by a policy decision but by way of competition taking account of EU emissions trading because state funding of individual technologies results in distortions of competition on the electricity market and thus in an inefficient and expensive electricity supply.

As targets for the renewables share have already been laid down, both at European and national level, however, it must at least be made certain that these are achieved in a cost-effective way for citizens and companies. This requires the deployment of support mechanisms which are close to

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[39] Patents allow a temporary restriction on commercial use but this typically does not prevent the spread of knowledge.

the market and which also bring about EU-wide competition based on technology and location between renewable energy producers. The requirement for this is firstly technological neutrality and secondly locational neutrality.

(1) Technological neutrality

In many Member States, different types of renewable energy technology receive very varied levels of support. Thus in Germany, every kilowatt hour of electricity generated from wind or biomass is remunerated at € 0.098 or € 0.189 respectively whilst the average PV support rate is still € 0.316 per kilowatt hour.[40] The varying levels of support indicate the varying competitiveness of the different renewables technologies. The less competitive a renewable energy the more it has to be supported.

This sort of technology-specific renewables support policy, however, obstructs competition among technologies in which the cheapest renewables technologies would prevail. Achieving the established renewables targets involves unnecessarily high costs. In future, therefore, renewables development should only be supported by way of technology-neutral mechanisms.[41]

(2) Locational neutrality

Efficient PV funding in the EU would also have to be neutral with regard to location, i.e. support should provide incentives to operate PV systems EU wide in those locations where they are most efficient and thus give rise to the lowest costs. PV roll-out would therefore primarily take place in locations with the highest levels of solar radiation. This – as Fig. 1 shows – is not currently the case in the EU. Instead, PV systems are primarily set up in places where the funding levels are particularly high. It is especially inefficient to use high funding levels to balance out the permanent disadvantage of low levels of sunshine. PV funding should therefore be regulated as comprehensively as possible at European level. Greater use of the possible mechanisms for cooperation under the Renewable Energy Directive 2009/28/EC may, in principle, make this possible. EU-wide convergence of funding would be even better but is politically impracticable.

3.2 Contribution to achieving EU climate and energy policy targets

3.2.1 Impact on climate protection

In principle, technologies for using renewable energy, such as photovoltaics, provide the possibility of reducing CO_2 emissions. Thus, PV support can also be a mechanism for achieving EU-wide decarbonisation targets. However, the climate and energy policy conditions under which PV support takes place must be taken into account in this regard because the electricity generation sector is subject to the EU ETS.

Where there is a drop in electricity generation by fossil fuel power plants as a result of state funded PV development, the CO_2 emissions thereby saved in the electricity sector will only be transferred within the EU ETS. Since the overall volume of CO_2 emissions in the EU ETS is determined by the EU cap, there will be no additional reduction in emissions. The drop in demand for allowances where the supply of allowances remains constant will only result in a fall in the price of allowances. A low allowance price makes investment in other low-carbon technologies less attractive. Thus PV

[40] Federal Ministry for the Economy and Energy (2015), "EEG in Zahlen – Vergütungen, Differenzkosten und EEG-Umlage 2000 bis 2016", p. 7. In the case of new plants the picture is different; here the support levels for PV are largely lower than for electricity from biomass plants, but onshore wind energy remains by far the cheapest form of renewable energy production.

[41] Section 4 Renewable Energy Act 2014.

funding takes away part of the regulatory effect of the EU ETS which means that efficient CO_2 reduction can no longer be assured.

The many years of PV funding, therefore, have not directly given rise to savings of CO_2. It is however possible that, as a result of its influence on the global PV-module price, it has had an indirect impact on climate protection outside the EU because, in fact, most of the build-up of PV systems is now taking place outside the EU. As there is generally no comprehensive, binding emissions trading system outside the EU, [42] an increasing proportion of PV in electricity generation may result in genuine savings in CO_2.

It is probable that PV funding in the EU, and particularly in Germany, was crucial for the development in the price of PV modules because the constantly high demand for PV modules acted like start-up financing for the global PV industry, thereby allowing its development. Learning curves and economies of scale as well as international trade finally led to drastic price reductions in PV modules and thus made PV technology competitive with other forms of electricity generation.

However, now that the EU only has a small share of global PV development, even the mainly Chinese PV industry, and its potential for making global savings in CO_2 by way of PV, are largely independent of PV funding in the EU. Further support for PV feed-in to ensure global PV development is therefore no longer necessary.

3.2.2 Impact on security of electricity supply

Safeguarding an uninterrupted supply of electricity is an important requirement for the prosperity of citizens and the competitiveness of companies. There are two factors in particular which can lead to insecurity of the electricity supply: firstly, dependence on the import of fuels or components necessary for the electricity supply and secondly an unstable electricity supply system.

(1) Dependence on imports

The electricity supply in the EU is still largely based on the combustion of the fossil fuels coal and gas. In 2013, their share of electricity generation was 48%[43] with 42% of the coal and 66% of the gas having to be imported from non-EU countries.[44]

The high level of imports may, at least in the medium term, increase the danger of disruptions in supply, particularly where the exporting countries are in politically unstable regions or where relations between the EU and the export countries deteriorate. Diversifying energy sources to include renewables and therefore also PV can at least reduce the danger posed to the electricity supply by interruptions in the delivery of energy.

(2) Stability of the electricity supply

Unlike nuclear, coal, gas and biomass plants, electricity generation from PV systems depends on solar radiation, which is subject to fluctuations arising from the time of day, season and weather and does not match the load profile of households. On the one hand, it is possible for the timing of solar radiation and electricity demand to coincide. For example in southern European countries, solar radiation and electricity consumption are both particularly high in the summer months due to an increased demand for air conditioning, In addition, during the day, there is a rise in electricity

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[42] ICAP (2015), "ETS Map", <link> accessed on 1 December 2015.
[43] Eurostat (2014), "Electricity production and supply statistics", <link> accessed on 1 December 2015.
[44] EU Commission, Communication COM(2014) 330, European Energy Security Strategy, p. 2, see cepPolicyBrief No. 38/2014.

consumption around midday ("lunchtime peak") when solar radiation is usually at its highest.[45] On the other hand, however, central and northern European countries have the problem that during the less sunny winter months, the low levels of PV electricity are insufficient to cover electricity demand. In addition, all PV electricity generation falls to zero after sunset and cannot therefore contribute to the electricity supply in the evening and at night.

In order to maintain the stability of the electricity supply system, however, it is always necessary to ensure that the physical electricity supply corresponds to the physical electricity demand at all times. Otherwise there may be fluctuations in the network frequency resulting in power cuts. As long as technology is insufficient to enable electricity storage or the shifting of electricity demand ("demand-side response"), the potential for electricity generation by way of photovoltaics will also remain limited in the future.

Since, the electricity supply from other renewable energy sources – particularly wind – is also subject to exogenic fluctuations, conventional power plants – particularly gas-powered plants – must remain in place. Thus the import of fossil fuels will also remain necessary in the future in order to compensate for fluctuations in electricity generation which can have a negative impact on the stability of the power grid.[46]

3.2.3 Impact on the electricity price and revenue from electricity sales

When assessing the financial impact of PV feed-in support it is necessary to distinguish between three groups: Electricity consumers, conventional electricity producers and the PV sector. The latter covers both PV electricity producers and manufacturers of PV modules as well as complementary service companies such as technicians who install PV systems.

When analysing the distribution of PV feed-in subsidies, their effect on the order in which power plants are used and the pricing on the wholesale market must be taken into account. The main factor for determining the order in which power plants are used ("merit order") is the level of marginal costs of the individual power plants. Power plants with low fuel costs and thus lower marginal costs of electricity generation take precedence when it comes to deployment. The merit order thus charts the supply on the wholesale market. The wholesale price (WSP) arises at the point where wholesale electricity supply intersects with demand (see Fig. 2, point of equilibrium 'a'). It thus just about corresponds to the marginal costs of the power plant necessary to cover demand. All electricity producers with lower marginal costs are deployed and attain surpluses from the sale of electricity (areas A, B and C) with which to cover the fixed costs of construction and maintenance of the power plants ("marginal returns").

In order for PV plants to be installed and for PV electricity to be available on the wholesale market, their operators must also generate sufficiently high marginal returns in order to be able to finance the installation of the plant. This generally requires feed-in support whereby remuneration for the electricity is higher than the wholesale electricity price. PV support thus corresponds to the difference between remuneration for PV electricity (PVR) and the wholesale electricity price (WSP).

Once a PV plant has been installed, however, the electricity which it produces always takes precedence when it comes to covering the electricity demand because in the case of electricity generation by PV plants, there are no fuel costs so their marginal costs are zero. As a result of PV feed-in support, conventional power plants are replaced on the wholesale electricity market by PV

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[45] Wesselak, V., Voswinckel, S. (2012), "Photovoltaik – Wie Sonne zu Strom wird", p. 115.

[46] See also in this regard Bonn, M., Reichert, G. (2015), "Capacity Mechanisms – An option for ensuring an affordable and secure electricity supply in the EU?", cepInput No. 15/2015, p. 6.

plants. Power plants with high marginal costs are squeezed out of the market. Of the remaining power plants with more cost effective production, the plant with the highest marginal costs, which are just about required to cover demand, then determines the wholesale price (WSP_2). This will be below the earlier wholesale price (WSP_1).

Fig. 2 illustrates the effect of PV feed-in support - irrespective of the varying designs in the EU Member States - on the wholesale market.[47] At the starting point (black line), the entire electricity demand is covered by conventional power plants. Following the introduction of PV feed-in support (red line), the demand for electricity produced by conventional power plants goes down ("residual demand") The displacement of the "residual demand curve" from left to right gives rise to a new point of equilibrium 'b' and a fall in the wholesale price (WSP_2).

Conventional power plants are negatively affected by PV feed-in support in two ways. Firstly, they lose market share, and thus surpluses from the sale of electricity, to the PV producers (triangle B). Secondly, as a result of the drop in price on the wholesale electricity market, the marginal returns from the remaining electricity sales also fall (rectangle A). They are only left with area C as their marginal returns.

By contrast with conventional electricity producers, as a result of PV feed-in support, PV electricity producers gain market share and thus revenue, with which to finance their PV plants. The extent to which PV producers can make profits by way of PV feed-in support depends on the level of the support as a proportion of the installation costs and on the hours of sunshine and the service life of PV plants. In addition, the manufacturers and local service providers who install and/or maintain modules profit from PV modules. A large proportion of the revenue from the sale of PV modules, however, flows into non-EU countries. Thus, in 2012, the share in the market for PV modules sold in the EU, held by Chinese companies alone, was 84%.[48]

The costs of PV feed-in support in the EU are basically borne by the electricity consumers. In Germany, for example, they are shifted onto the electricity consumer in the form of a levy on the retail electricity price. By comparison with the starting point, they incur additional costs as a result (rectangle D). At the same time, however, they can gain from falling wholesale electricity prices (rectangle A). This requires sufficient competition on the retail electricity markets so that electricity suppliers pass on the lower wholesale prices to the consumers. The higher the remuneration rate for PV, and therefore the direct support costs (rectangle D increases in size), the more likely it is that PV feed-in support will lead overall to additional costs for the electricity consumer (rectangle D is bigger than rectangle A).

47 For the purposes of simplicity, the electricity demand is shown here as completely inelastic.
48 EU pro Sun (2015), "Fact Sheet", <link> accessed on 2 December 2015.

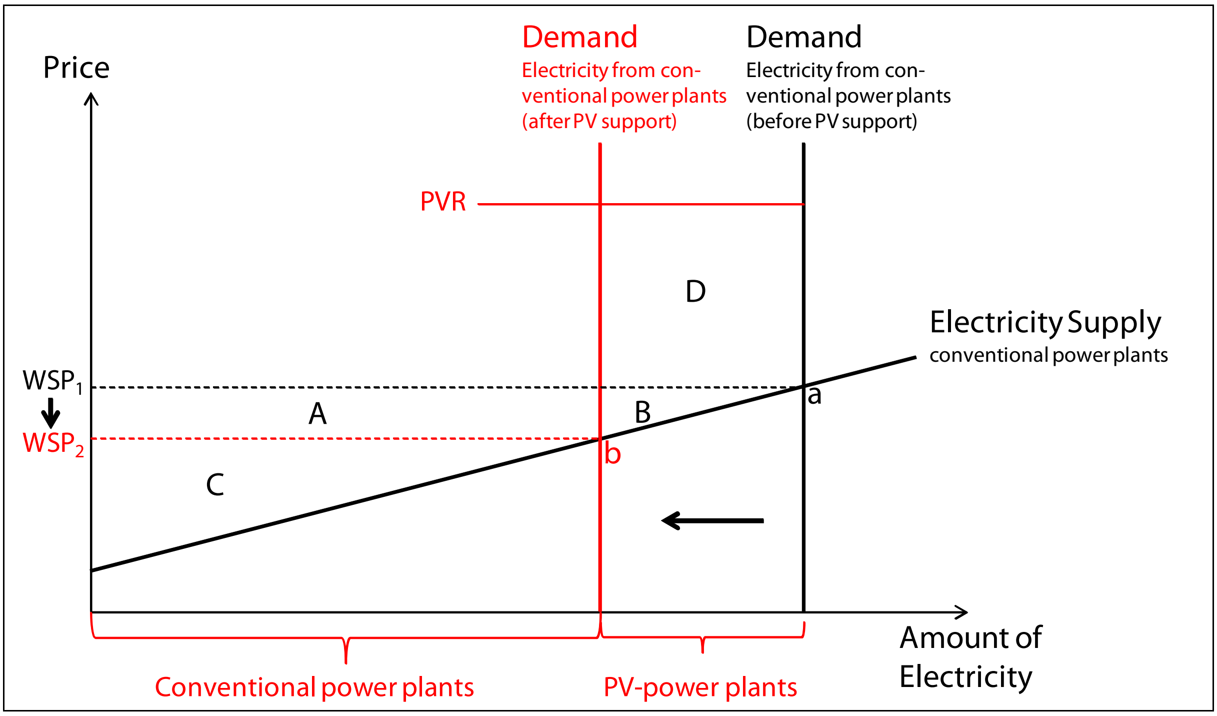

Figure 2: Distribution effects of PV feed-in support
Source: cep

The fall in the marginal returns of conventional power plants may give rise to additional costs for the consumer because there is a risk that it will result in the large-scale shut-down of conventional power plant capacity or in a lack of investment in new power plants. Insofar as this is still required to safeguard the supply of electricity, (see Chapter 3.2.2), however, there is a need for additional subsidisation of power plants – e.g. in the form of the much-discussed capacity mechanisms. In the EU, the costs arising as a result will basically be passed on to the consumer.[49]

3.3 Conflict of objectives: Business location policy and technological support

For many years, European PV support has been regarded as a mechanism with which to promote both PV, over other forms of electricity generation, and the PV industry, over foreign competitors. This harmony of objectives has been lost due to the dominance of Chinese suppliers on the global PV module market. The interests of European PV module manufacturers and those of the customers, i.e. the PV electricity producers and local service providers, are now very different. Whilst the manufacturers want to restrict the import of Chinese PV modules at dumping prices by way of customs tariffs and minimum import prices, customers are in favour of as little restriction as possible on the import of modules.

The dispute about the introduction or extension of customs tariffs for PV modules illustrates on a small scale the general conflict of objectives that exists between a business location policy disposed towards European technology manufacturers, on the one hand, and technological support which is focussed on the global use of technology and therefore also climate protection, on the other. Thus all measures which facilitate trade in low-carbon energy technology lead to cost reductions thereby making technologies more competitive, from which PV electricity producers and local service providers will gain. This does not mean, however, that the European

[49] See also in this regard Bonn, M., Reichert, G. (2015), "Capacity Mechanisms – An option for ensuring an affordable and secure electricity supply in the EU?", cepInput No. 15/2015.

manufacturers will benefit. It is more likely that production will drift away to countries outside the EU with lower manufacturing costs.

It is a similar situation where there is state-funded energy research. On the one hand, insofar as the resulting innovations can be used exclusively by companies within the EU, their competitiveness will increase over companies based outside the EU and thus make EU, as a business location, more attractive to investors. On the other hand, restricting the use of knowledge to EU companies can slow down the development of technologies and the emergence of global industries with a high level of competitive intensity. This in turn reduces the ability to deploy technologies and thus also the chance of reducing CO_2 worldwide.

In addition: In non-EU countries without an emissions trading system, the use of low-carbon electricity production technologies does not simply result – as it does inside the EU ETS – in a relocation of CO_2 emissions but in a genuine reduction in CO_2. When deciding on whether to allow non-EU countries to have access to low-carbon technologies for electricity generation developed in the EU, the contribution to climate protection and the advantages for the buyers of these electricity generation technologies must be balanced against the possible disadvantages for European manufacturers.

4 Conclusion

The existing PV support is not suitable for achieving EU climate and energy policy targets. It cannot contribute to decarbonisation or to security of supply in the EU nor does it give rise to lower electricity prices for the consumer. The aim of achieving internationally competitive PV module manufacture in the EU has also not been achieved.

Instead, the support so far provided has resulted in market share and revenue being redistributed from conventional power plants to renewable energy producers, PV module manufacturers and other complementary service providers. The feed-in support made a significant contribution to the development of a global PV industry which is now based mainly in China. The resulting cost reductions increased the competitiveness of PV for electricity production as compared with other fuels and thereby expedited the global development of PV. In places where there is no ecologically effective and economically efficient climate protection mechanism like the EU ETS, PV expansion can result in genuine emissions reduction, but these may not be cost effective.

However, since the European demand for global PV development will no longer be relevant, there is no longer a need for direct PV feed-in support in the EU. Insofar as the costs for PV plants continue to fall as a result of international competition, they will be profitable even without support.

The example of PV support is a striking illustration of the problems which exist for energy technologies when they are subsidised to an extent which goes beyond fundamental and technological support and the implementation of demonstration projects. Its original aim, of covering the high cost of bringing the technology onto the market, has long been achieved. Now there is a risk that technologies will be state supported over many years when they are already competitive and no longer in need of support or are permanently incapable of becoming profitable. Where the market launch of new technologies is to be supported, it must be bound by special criteria and time limited.

Instead of continuing to subsidise non-competitive technologies, or those like PV that are already established, on a permanent basis without taking account of the market, policy should provide funds for research into new energy technologies – such as a new generation of PV plants. This concerns, in particular, fundamental research as companies themselves have no incentive to invest in it. Innovations thus achieved may, in the medium to long term, result in low-carbon forms of electricity generation becoming competitive and capable of use worldwide.

If, however, PV feed-in continues to be supported in the EU, it will be necessary to ensure that the support is designed competitively and without bias to any particular location. Across the EU, this will result in PV plants being built primarily in locations with the highest levels of solar radiation. Even without a uniform EU-wide PV support scheme, location-related competition for establishing PV plants in the EU can be increased by making greater use of the cross-border cooperation mechanisms already provided for in the Renewable Energy Directive (2009/28/EC).

Europe as a business location will only be competitive in the manufacture of new PV modules where the modules can be manufactured more cost effectively or to a higher quality standard than in other parts of the world. In order to prevent production from drifting away from Europe, in addition to compliance with international trading rules to combat anti-dumping, innovation is required which leads to increases in productivity.

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