Co-funded by the Intelligent Energy Europe Programme of the European Union

DIA-CORE POLICY BRIEF

Assessing costs and benefits of deploying renewables

Barbara Breitschopf, Anne Held, Anna Dimitrova and Fabio Genoese[1*]

26 September 2014

Key Messages and Recommendations

- ✓ A comprehensive assessment of the costs and benefits of deploying renewables across all EU member states is needed
- ✓ This assessment must be based on clear definitions of the effects, costs and benefits of the technologies to be examined as well as the models and type of data to be used
- ✓ Misleading messages based on the communication of only selected effects or a wrong classification of effects should be avoided. If only a selection of effects is communicated, this should be stated clearly and be accompanied by a sound interpretation of results and warnings about potential misinterpretation.
- ✓ We recommend Member States to realise assessments on costs and benefits following a common approach in order to get a more complete picture of the costs and benefits associated to different deployment pathways of renewables.

Launched in April 2013, DIA-CORE is carried out under the Intelligent Energy Europe programme. Its main objective is to ensure a continuous assessment of the existing policy mechanisms and to establish a fruitful stakeholder dialogue on future policy needs for renewable electricity (RES-E), heating & cooling (RES-H) and transport (RES-T). Thus, DIA-CORE seeks to facilitate convergence in RES support across the EU and to enhance investments, cooperation and coordination.

---

* Barbara Breitschopf and Anne Held are senior researchers at the Fraunhofer Institute for Systems and Innovations Research (ISI), Karlsruhe. Anna Dimitrova is Research Assistant and Fabio Genoese is Research Fellow at the Centre for European Policy Studies, Brussels.

1 Introduction

In the context of the 2030 energy and climate framework, there have been controversial discussions about the target for renewables and its impact on households, the industry and other actors. There is consensus that the question of correctly assessing the costs and benefits of deploying renewables is a complex one and that a commonly accepted approach on how to do that is currently lacking.

This paper aims to present a comprehensive approach on how to measure the costs and benefits of deploying renewables. Such an analysis, which accounts for a comprehensive list of associated positive and negative effects of building up renewable energy capacity, has not yet been applied at EU-level. Hence, a framework on how to conduct and structure this analysis is offered, while especially considering distributional effects in order to address the common question of "who pays for and who benefits from renewables?".

Three main types of effects are distinguished in this paper:

1. **System-related effects**: all benefits and costs compared to a reference system (e.g. one based on fossil fuels or nuclear energy)
2. **Distributional effects**: allocation of costs and benefits among selected actors or groups from a micro-economic perspective
3. **Macro-economic effects**: gross and net effects in an economy on a macro-economic level

In the following, we will introduce these effect types in more detail and present first results for the case of Germany.

2 System-related effects of deploying renewables

System-related effects of deploying renewables are based on a comparison of a nuclear or fossil fuel based system (also referred to as reference scenario) to a system based on renewables. Thus, these effects are **additional (system-related) costs or benefits**. They reflect the use of resources and do not take into account any policy impacts on costs or benefits. These effects have a system perspective and, hence, are strictly system-specific but **not policy-specific**.

Special attention should be paid in calculating benefits that might have already been internalised in electricity generation. If, for example, CO_2 costs (in terms of CO_2 emission allowance prices) are internalised in the cost calculation (i.e. added to the electricity generation costs), then the benefit from avoided CO_2 emissions must be reduced by the internalised CO_2 costs (see also Breitschopf and Diekmann 2010).

2.1 Additional system-related costs

Additional system-related costs can roughly be differentiated into the categories shown in Figure 1.

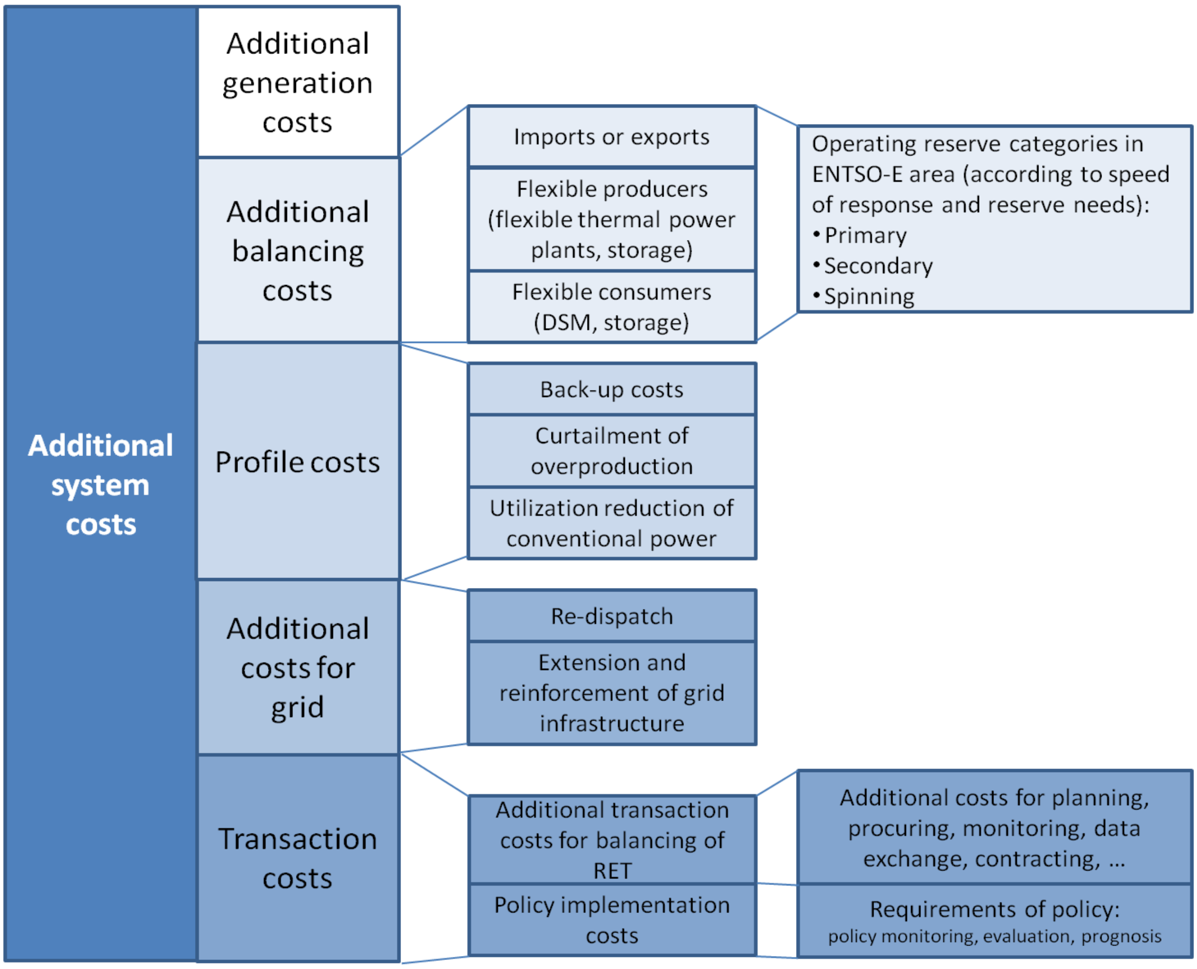

Figure 1: Overview on additional system-related costs (source: Breitschopf and Held, 2014)

Additional generation costs include all additional costs that arise from the installation, operation and maintenance of a facility with the purpose to generate heat or electricity with renewable energy technologies.

Additional balancing costs are system-specific and occur because it is necessary to balance deviations from the originally planned schedule (forecast errors).

Profile costs cover economic costs resulting from the variability of renewables and that are not reflected in grid and balancing costs (see also Ueckerdt et al. 2013). Profile costs may occur due to the following reasons:

- a potential decrease of the utilisation of conventional power plants resulting into lower electricity sales and therefore lower profits;
- the need for back-up capacity that has to cover electricity demand when variable renewables such as wind or solar are not available;
- the potential curtailment of electricity in times of overproduction.

Additional grid costs occur when grid infrastructure needs to be reinforced in order to avoid potential bottlenecks within transmission and distribution grids.

Additional transaction costs encompass all costs that arise due to RET induced market activities and reporting or monitoring obligations.

Other costs refer to both unknown and unpredictable costs such as social irritants and environmental damages such as high noise and light levels, decrease in real estate value, endangerment of flora and fauna.

2.2 Benefits from deploying renewables

Increased deployment of renewables will lead to several positive effects and benefits such as a **reduction of greenhouse gas emissions**, which would reduce air pollution and help alleviate climate change impact. Moreover, as fossil fuels consumption decreases so will **import dependency**. In addition to this, their deployment **will facilitate further technological development** that could have positive impact on the sector and may spill over to other sectors benefiting them too.

Quantifying the impact of greenhouse gas emissions in terms of social costs is a complex process. Thus, existing estimations show a wide range of possible values (from 0 € to more than 200 €/t CO_2). In the context of this project, a damage value of 80 €/t CO_2 is assumed. This corresponds to findings by German agency for Environment (UBA 2013).

3 Distributional effects of deploying renewables

Distributional effects are related to the question of "**who pays for and who benefits from deploying renewables?**" These effects depict changes in costs, prices, quantity or quality, induced by policies for different actors. These actor-specific effects may be beneficial for certain actors in the system, while having negative effects for other actor groups. Thus, actor-specific effects reveal the final costs or benefits of deploying renewables for selected actors such as private households or firms when policies like the Renewable Energy Act in Germany or other support schemes are in force.

In general, one can distinguish between direct and indirect effects. In the first case, actors are directly affected, e.g. consumers paying a levy for supporting the deployment of renewables or producers benefitting from fixed feed-in tariffs or technology developers benefitting from R&D funding measures. These effects are also referred to as **financial effects**. In the second case, burdens or benefits are indirect and result from policies that affect market prices (also known as **price effects**).

3.1 Financial effects

The deployment of renewables is supported by a variety of policy instruments ranging from price or cost-based support to quantity-based support. These support costs must be borne by someone. How these costs are allocated is determined by policy support schemes. Two main schemes can be distinguished:

(i) **Consumer-based financing**
(ii) **Budget-based financing**[2]

Consumer-based financing refers to financing the deployment of renewables by final consumers without any support from public budgets. Budget-based financing refers to financing the deployment of renewables or technology research activities by government or state budget.

Policy instruments can also be distinguished by type: There are **technology push** and **demand pull** instruments. The latter can be implemented in the form of a feed-in tariff or premium, quota obligations, generation or investment subsidies or tax credits. Government spending for research, development or demonstration of new technologies is one major support instrument for technology development, knowledge generation, networking, exchange of know-how, etc. In innovation economics this is classified as a technology push instrument.

3.2 Price effects

The generation of electricity from renewable energy sources affects the power market prices, because the variable generation costs of most renewable energy power plants (all except biomass power plants) are close to zero. Hence, in an energy-only-market, where the marginal cost of the last operating generation plant sets the market price, the supply curve shifts to the right. This shift is the larger, the more low-variable-cost renewable energy capacity enters the market. Thus, the market entry of renewable energy technologies leads to lower power market prices.

---

[2] Private households and firms will be indirectly affected as public spending for other activities decreases or taxes increase to compensate for expenditures related to renewable energies.

This price decreasing effect is called **merit-order effect**, as the order of operating power plants changes with increasing share of electricity generated by renewables. As this effect depends on the consumption and production pattern and on the available supply, it can only be measured with an energy sector model. For that, the electricity market price of a system with a higher and lower share of renewables should be modelled and compared. The price difference between the two systems discloses the merit order effect, either as total (€) or specific effect in €/kWh.

4 Macro-economic effects of deploying renewables

To get an overall picture of the impact of deploying renewables, the effects at the system and actor level should be integrated into a more overall perspective – the perspective from the macro-economic level. Additional generation costs, grid extensions or surcharges of consumers can be measured at the macro-economic level with different macro-economic indicators, e.g. investments, changes in trade, etc., but typically the overall impact on the economy is expressed in general by **changes in GDP or employment**.

One can differentiate between gross and net effects. The following definition is applied to distinguish between gross and net effects:

Gross effects

- show only the effects (direct and indirect jobs) in the renewable energy technology industry and its upstream industry;
- take into account the effects from investments in renewables, their operation and maintenance;
- do not take into account the effects in the conventional energy sector (replacement), of changes in energy prices and income on all other sectors

Net effects

- cover all sectors of the economy;
- take into account all positive and negative effects (direct, indirect, induced);
- rely on a comparison of two different deployment scenarios (no or low share of renewables vs. advanced use of renewables);
- show the net impacts of using renewables

Gross effects show the value added and employment in renewable energy industries and service sectors induced by the deployment of renewables. This includes value added and employment in manufacturing, or project planning, operation of a generation facility, etc. and in its related industries. In principle, gross effects are assessed only for energy systems based on renewables and do not rely on a comparison of two systems (with and without the use of renewables).[3]

As gross impact assessments are related only to industries and service sectors directly involved in renewable energy activities, and as they only look at positive effects in these industries, they are also called sectoral effects at the macro-level. Consequently, gross impact studies are sectoral studies depicting the significance and relevance (e.g. the share of employment) of renewables in an economy. Several indicators are commonly used to illustrate the effects in the renewable energy sector that are induced by the deployment of renewables. They comprise **investments in renewables** and **turnover of** renewable energy technology **manufacturers** in the respective sector, **avoided (fossil fuel) imports**, **jobs** in the sector (plus upstream industry), **value added**, etc.

The overall macro-economic impact on all sectors of the economy can be measured by changes in GDP or net employment. This assessment requires developing two scenarios, e.g. a scenario with a high share of renewables and a reference case. All positive as well as negative effects of deploying renewables should be included (see Table 1) to get a complete picture of the overall effect.

Table 1: Overview of positive and negative effects that should be taken into account when modelling net effects of deploying renewables Source: Breitschopf et al. 2013

Positive effects → job increases	Negative effects → job losses
increase in investment (renewables industry and upstream industry)	displaced investment (conventional power industry and upstream industry)
increase in O&M in generation (renewables industry and upstream industry)	displaced O&M in generation (conventional power industry and upstream industry)
increase in fuel demand (biomass) (renewables industry and upstream industry)	decrease in fossil fuel demand (conventional power industry and upstream industry)
increase in trade of technology and fuel (biomass) (renewables industry and upstream industry)	decrease in trade of technology and fossil fuels (conventional power industry and upstream industry)
higher household income from employment in renewables industry	lower household income from employment in conventional power industry
decreased electricity price for households and industry due to merit-order effect, CO_2 pricing, etc.	increased electricity price for households (budget effect) and industry (cost effect) due to additional generation costs of renewable electricity generation

[3] When employment levels of two energy systems (e.g. with and without renewable energies) are compared without taking into account potential price and income effects on other sectors, then two gross effects (sectoral effects) are compared with each other. It that case, the impact on the whole economy is not assessed.

5 Case study: Germany

The availability of data that is necessary to assess the economic impact of the above effects varies greatly across EU member states. To date, German data on the renewable energy sector are relatively well known. This allows us to make a historic assessment of the sector. Based on the definitions outlined earlier it can be concluded that the highest additional costs are generation costs on a system level and those are mainly consumer-financed. While benefits on a micro-economic level (investments value and new jobs creation) have increased, it is hard to derive conclusions on employment net economic effects.

Table 2: Overview on costs and benefits in Germany (2012) based on: ISI et al. 2013

	Type of effect	power	heat	transport
System-related effects (bn. €)	Additional generation costs	10.3	2.7	2.4
	Grid costs	0.46		
	Balancing costs	0.16		
	Avoided emissions	9.2	1.2	0.1
Distributional effects (bn. €)	EEG-levy	14.2	1.6	
	Tax credits/taxation			
	Special equalisation scheme	2.5		
	Merit-order	4.9		
	R&D (heat and power)	0.8		
Macro-economic effects (bn. €)	Investment (heat and power)	19.5		
	Turnover (heat and power)	21.9		
	Avoided imports	3.9	4.9	1.2
	Gross employment (heat and power)	377,800 (persons)		

Box: Example for the EEG-levy (i.e. the surcharge in consumers' electricity bills used to support the deployment of renewables) in Germany

In general, the communication of costs and benefits of renewables in the media tends to focus on the costs of supporting renewables. For example, the EEG-levy is often referred to as additional generation costs, whilst it rather reflects a distributional effect that has to be borne by consumers. In addition, the trend of a rising EEG-levy over the last seven years is often shown without showing the decrease in wholesale electricity prices (see Figure 2). In this way, the burden for consumers can be overestimated and the incomplete communication may lead to distorted messages. Thus, a comprehensive assessment of costs and benefits including a clear definition of all effects is crucial for appropriately evaluating costs and benefits of renewables.

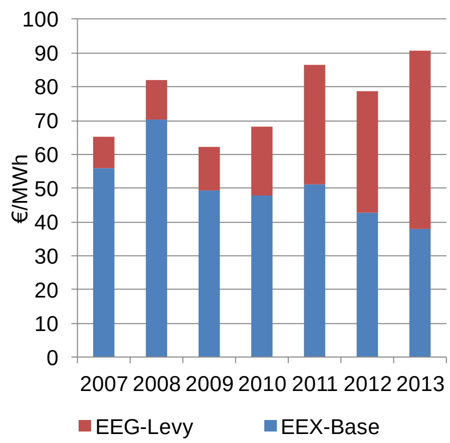

Figure 2: EEG-Levy and EEX-Base (i.e. the average wholesale price) in Germany

6 Conclusions

This policy brief has shown that it is a challenging task to make a comprehensive and appropriate assessment of costs and benefits resulting from an increased use of renewables. The different types of effects can be distinguished into system-related effects, distributional effects and macro-economic effects. The separate discussion of these three dimensions is important and should be standardised in the assessment of costs and benefits of renewable energies in the EU.

Data requirements for the quantification of the described effects are high. For example, they require hourly price data of electricity markets, techno-economic data of conversion technologies such as feed-in profiles of renewables or the costs of different generation technologies. In addition, it is difficult to put a concrete cost value for some of the effects such as the avoided CO_2 emissions leading to high uncertainties regarding their economic assessment.

Moreover, the application of models is needed to appropriately quantify the effects described in this policy brief in order to account for large amounts of data and the existing interactions with the conventional energy system and with sectors outside the renewables sector.

Due to the demanding requirements to realise such a comprehensive study, there are only few examples where a comprehensive assessment of costs and benefit has been realised (e.g. in Germany). We recommend Member States to carry out similar analyses following a common approach in order to get a more complete and clearer picture of the costs and benefits associated to different deployment pathways of renewables.

If such a comprehensive and standardised methodology is used, misleading messages (based on the communication of only selected effects) or a wrong classification of effects can be avoided. The existence of a common methodology would increase the mutual understanding and would allow for a separate discussion of individual elements of the overall analysis. Finally, when communicating individual effects, the type of effect must be clearly defined and explained in order to avoid misleading conclusions. These misleading messages may arise, when only part of the effects is shown.

References

Breitschopf, B., Diekmann, J. (2011): Gesamtwirtschaftliche Auswirkungen des Ausbaus Erneuerbarer Energien, in: Finanzierung Erneuerbarer Energien, Hrsg. Markus Gerhard / Thomas Rüschen / Armin Sandhövel , Frankfurt School Verlag, October 2011

Breitschopf, B., Held, A. (2014): D4.1 Guidelines for assessing costs and benefits of RET deployment, Project Dia-Core, April 2014.

ISI, GWS, IZES, DIW (2013): Monitoring der Kosten- und Nutzenwirkungen des Ausbaus Erneuerbarer Energien (Monitoring of costs and benefits of RET deployment), Studie im Auftrag des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit, Update für 2012, September 2013, http://www.impres-projekt.de/impres-de/content/veroeffentlichungen.php

UBA 2013, Emissionsbilanz erneuerbarer Energieträger, updated annex 1, 2, and 3,Climate Change 15/2013

Ueckerdt, F.; Hirth, L.; Luderer, G.; Edenhofer, O. (2013): System LCOE: What are the costs of variable renewables? In: *Energy* 63 (0), S. 61–75. http://www.sciencedirect.com/science/article/pii/S0360544213009390.