Efficiency of the Support Schemes for RES-E in the EU Member States: Comparison of Feed-in tariff, Premium and Quota

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Abstract

In this paper we investigate the evolution of the cost efficiency of support mechanisms applied by EU Member States on promotion of renewable electricity. We assess the main drivers of this change with the use of Konus input price index decomposition (Grifell-Tatjé and Lovell, 2013). The index is decomposed into cost efficiency, technology and activity effects. We look at the three main support instruments feed in tariff, premium and quota in 24 EU Member States. The observed period 2009-2012 is an initial period of the legal ambition to promote renewable energy sources triggered by 2009/28/EC Directive.

1. Introduction

European energy sector is facing many challenges such as a climate change, uncertainty of fossil fuels prices, risks related to the nuclear power plants and energy security. In order to address these issues, in 2009, the European Commission came with the Energy and Climate 2020 package, including the 2009/28/EC Directive on promotion of renewable energy sources setting 20% target for the share of renewable electricity in the total EU energy consumption.

This overall EU target has been translated into individual national targets, imposing an obligation on EU Member States to produce more renewable electricity. Introduction of new RES capacity into the system is challenging and costly exercise. Among the main challenges belong integration of renewable energy technologies and their cost competitiveness.

Integration of high levels of new installed volatile solar and wind production requires grid expansion, more flexible generation in conventional power plants and demand-side control (Trumper et al., 2014). On the other hand, social and environmental advantages of RET have been acknowledged and in order to boost otherwise costly renewable electricity production, EU Member States implemented different support schemes.

In this paper we analyse the efficiency with which EU Member States implemented policies for the promotion of renewable electricity. This is done based on a data set of total expenditures on support for renewable sources by countries and renewable electricity production per RET and per country for a time period of 4 years between 2009 and 2012. More specifically, we investigate the cost-efficiency of the three main support schemes implemented by EU countries in order to achieve their renewable targets.

The three main support schemes used by the MS are feed-in tariff, feed-in premium and quota obligation. One, or a combination, of these support schemes is used as primary tool by the EU Member States in order to promote renewable electricity (Jager et al., 2011).

A good and complete evaluation of the efficiency of the implementation of support schemes by the MS is crucial. If a more cost-efficient method can be identified, future policies can be adapted and made more efficient themselves, allowing Member States and the European Commission to achieve their targets with smaller budgets and/or achieving more challenging targets. For this reasons several recent papers have already discussed the efficiency of the different support instruments (Hubera et al., 2006, Menanteau et al., 2003, Fouquet and Johansson, 2008 Butler and Neuhoff, 2008, Boomsma et al., 2012). The goal of this paper is to go further and look at the root reasons of why a certain support scheme works better than another. We assess cost-efficiency and then we apply decomposition of Konus input price index (see also section 4) to assess price and quantity (respective cost-efficiency, activity and technology) effects (Grifell-Tatjé and Lovell, 2013), allowing us to determine factors driving the in/efficiency.

The structure of the paper is as follows. The section 2 describes the 3 main support schemes for renewable electricity policy implementation. Section 3 offers a literature review of the current research on the efficiency of the support schemes. Further on, in chapter 4, the methodology chosen to analyse the efficiency of the various support schemes is detailed. Paragraph 5 presents data set used as basis for the analysis. Finally in paragraph 6 the results are presented and discussed. The paper ends by giving an overview of the primary conclusions and some proposals for further research.

2. Main support schemes

"Support scheme means any instrument, scheme or mechanism applied by a Member State or a group of Member States, that promotes the use of energy from renewable sources by reducing the cost of that energy, increasing the price at which it can be sold, or increasing, by means of a renewable energy obligation or otherwise, the volume of such energy purchased." Article 2, 2009/28/EC Directive

This chapter provides an overview of the main support instruments used by EU MS. The basic description of the main characteristics of FIT, FIP and quota are to be found in Table 1, we elaborate on each of the support instruments further in the text.

Table 1: Characteristics of main RES-E support instruments

Support scheme	Risk for investors	Market dependency	Driven by
Feed in Tariff	Low	Independent	Price
Feed in Premium	Medium	Partly dependent	Price
Quota obligation	High	Dependent	Quantity

Source: Menanteau et al., 2003, Canton and Linden 2010

2.1 Price driven models

2.1.1 Feed-in tariff

Feed in tariff (FIT) guarantees fixed payment for each unit of electricity generated/installed independent from the market price. This governmental guarantee creates stable investment environment, which attracts greater diversity of investors (Lipp, 2007). More investors on the market lead to higher RET deployment and thus to the effectiveness of the incentive (Klessman, 2014). At the same time it also facilitates lower cost of capital, which means higher cost-efficiency of the RET deployment (De Jagger and Rathmann, 2008).

On the other hand FIT is not dependent on market prices and it can distort competitive electricity price. If, for example real electricity prices rapidly decrease, RES-E producers will continue to receive guarantee payments. This would result into higher average prices (Lesser and Su, 2008). Additionally, the same payment is secured regardless the time of the day, which can lead to higher cost to utilities, hereunder ratepayers (Lagniss et al.,2009). Despite the fact that FIT is currently considered to be the most efficient instrument promoting deployment of RET in the EU (Jager et al. 2011), it can cause high burden on consumer, if not properly designed. It is suggested that well-designed FIT shall be frequently reviewed. In addition, aim at internalising externalities (such as pollution, energy security and learning effect) is not likely to make RET competitive (European Commission, 2010).

2.1.2 Feed-in premium

Feed-in premium tariff (FIP) provides an additional payment on top of the market price, but it does not guarantee a purchase of the RES-E. Producers have to market their electricity generation. This makes FIP more compatible with competitive electricity market, but it also expose investors to the electricity market price fluctuations (Klessman, 2014). Additionally, the total remuneration is not determined in advance, because it is dependent on market demand. (Klein et al.,2008).

Higher risk of FIP, in comparison to FIT causes higher policy costs (Regawitz et al. 2007, Held et al.,2007, IEA, 2008). But on the other hand, it also requires lower administrative intervention, as only premiums are set, rather then entire payment (Gonzalez, 2008). European Commission (2010) suggests that FIP shall be used for technologies at early stage of their market deployment, rather then FIT.

2.2 Quantity driven instruments

The system in which suppliers (consumers) are obliged to supply (consume) certain amount of renewable electricity is called quota obligation. Such obligation is combined with tradable green certificates (TGC).

Renewable electricity producers are exposed to the electricity market price fluctuations as well as the TGC price risk. While support level for price driven instruments are determined administratively, usually based on estimated production cost (LCOE), the revenues from TGC are determined based on the competitive market (Klessmann, 2014).

In comparison to price driven support mechanisms, which are usually being contracted for expected life of the project (15-20 years), TGC can be phased out fast. Additionally, TGC are less likely to have negative impact on energy prices (Komor et al.2005). It can be also caused by the fact that TGC reflect the RES-E value at the given time, thus learning process is represented in the price (Jager et al., 2011). European Commission (2010) advocates that TGC are suitable option once RET becomes more competitive.

National decision-making shows convergence tendencies when implementing RES-E support schemes (Kitzing et al., 2012) and well-discussed topic on the current developments on the RES support is possibility of harmonized EU-wide TCG market. The implementation of such instrument depends on political acceptance and objectives.

On one hand, estimations show that creation of such market will decrease total cost of promotion RET deployment by 70% (Aune et al.,2011). On the other hand, there is a concern that environmental and regional benefits will not occur in the country granting the support (European Commission, 2010). Additionally, common certificate might lead towards support focused mainly on mature RET and price volatility, created by regulation uncertainties might occur during transition period as demonstrated on Swedish/Norwegian example by Fagiani and Hakvoort (2013).

If the political priority focuses on local RES-E benefits, then market harmonization is not advantageous option, but if the main political objective is cost-efficiency of the RES target achievement, then harmonization is a good strategic objective (del Rio,2005).

2.3 Support scheme design options

Concrete specifications of policy driven support design have a crucial impact on its effectiveness. It is important to take into account technical and economical features of each RET when deciding on remuneration amounts. According to the European Commission (2010) in many countries compensation for wind energy is too high, while compensation for PV does not reach its cost-efficiency potential, because it is not targeted well enough. High degree of differentiation between different RET is important for well-designed price driven support instruments (Verbruggen and Lauber, 2012).

For illustration Table 2 presents an overview of some design possibilities of main support instruments together with their advantages and disadvantages.

Table 2: Design options for support instruments

Support scheme	Advantages	Disadvantages
FIT: Fixed price	Stable investment environment	Exclusion of inflation has negative impact on the real value of the revenue (Fell, 2009).
FIT: Fixed price (inflation adjustment)	Additional security for investors	High level of inflation adjustment creates additional burden to ratepayers.
FIT: Front-end loaded tariff	Avoiding overcompensation; Greater geographic dispersion;	High average FIT payments to projects in areas with less RES potential.
FIT: Spot market gap	Increases RES market integration	Ratepayer -> taxpayer (budgetary risk).
FIP: Premium price	More compatible with competitive electricity markets	Constant payment amounts leads to over/under compensation
FIP: Variable premium FIT (caps and floors)	Reducing risk for investors (cap) and society (floors)	Complex to design
FIP: Percentage of retail price	Proved effective in large projects.	Risky: payments dependent on uncontrollable market factors
Quota obligation	Competitive electricity market; Reflects learning process of RET;	Involves market price risk for electricity and for TGC. Decreases costs for consumers.

Source: Couture and Gagnon, 2009; Jager, 2011

2.4. Primary support scheme per EU Member State

Each MS applied own support scheme system. As there are always small local differences, it is not an easy task to make simple comparison. Nevertheless for the scope of this research a generalisation is made based on the primary choice of support scheme applied in a MS. The overview of the main support instruments per MS is illustrated in the Table 3.

Countries that are marked with star have been excluded from the analysis, because they applied retroactive changes of their RES-E support system. Including such data would lead to a misleading efficiency scores as a lot of RET has been implemented as a reaction on incentive and NPV of the investment that are no longer in place. However installations have been made. For example, despite that FIT applied on wind production before 28/2009/EC in Spain proved efficient (Miera et al., 2008), FIT design as a reaction on the Directive let to such cost, that government decided to change it, and thus expected revenues of RET investors decreased.

Table 3: Overview of the main RES-E support instruments in the EU-27

FIT	FIP	Quota
AT, CY, CZ*, DE, EE, ES*, FI, FR, IE, HU, LT, LV, LU, MT, PT, SLO, SK	DK, NL	BE*, IT, PL, RO*, SE, UK

*Countries that are excluded from the analysis, because of the retroactive changes

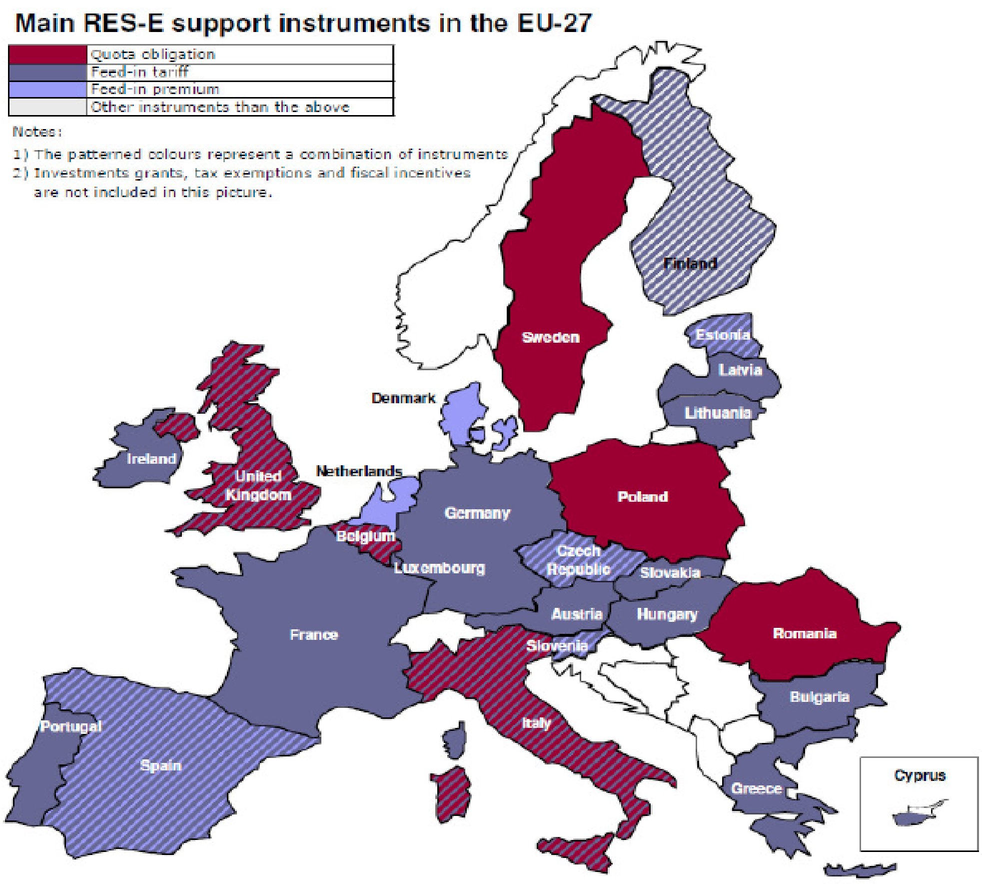


Figure 2: Main RES-E support instruments in the EU-27, *Steinhilber et al.,2011*

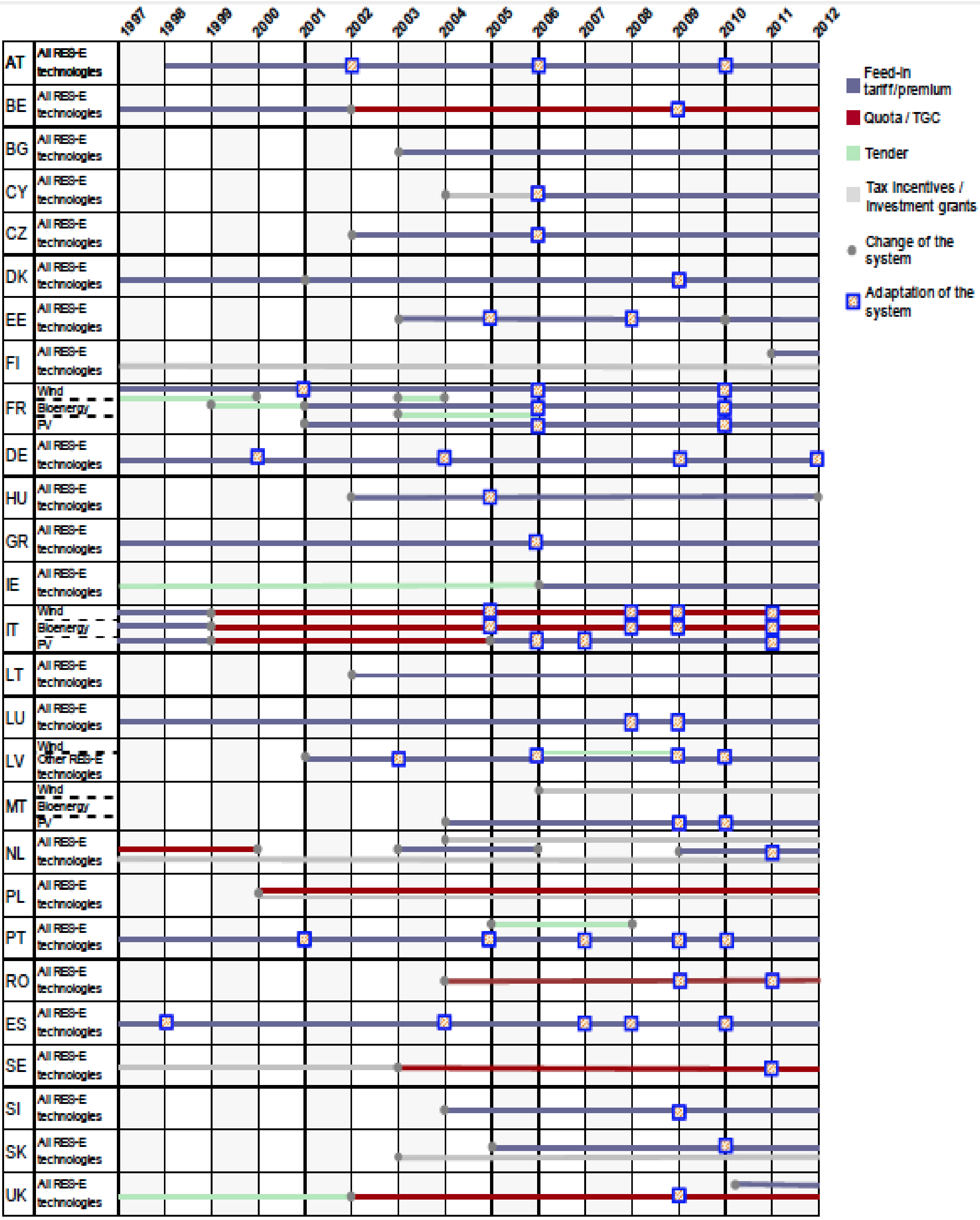
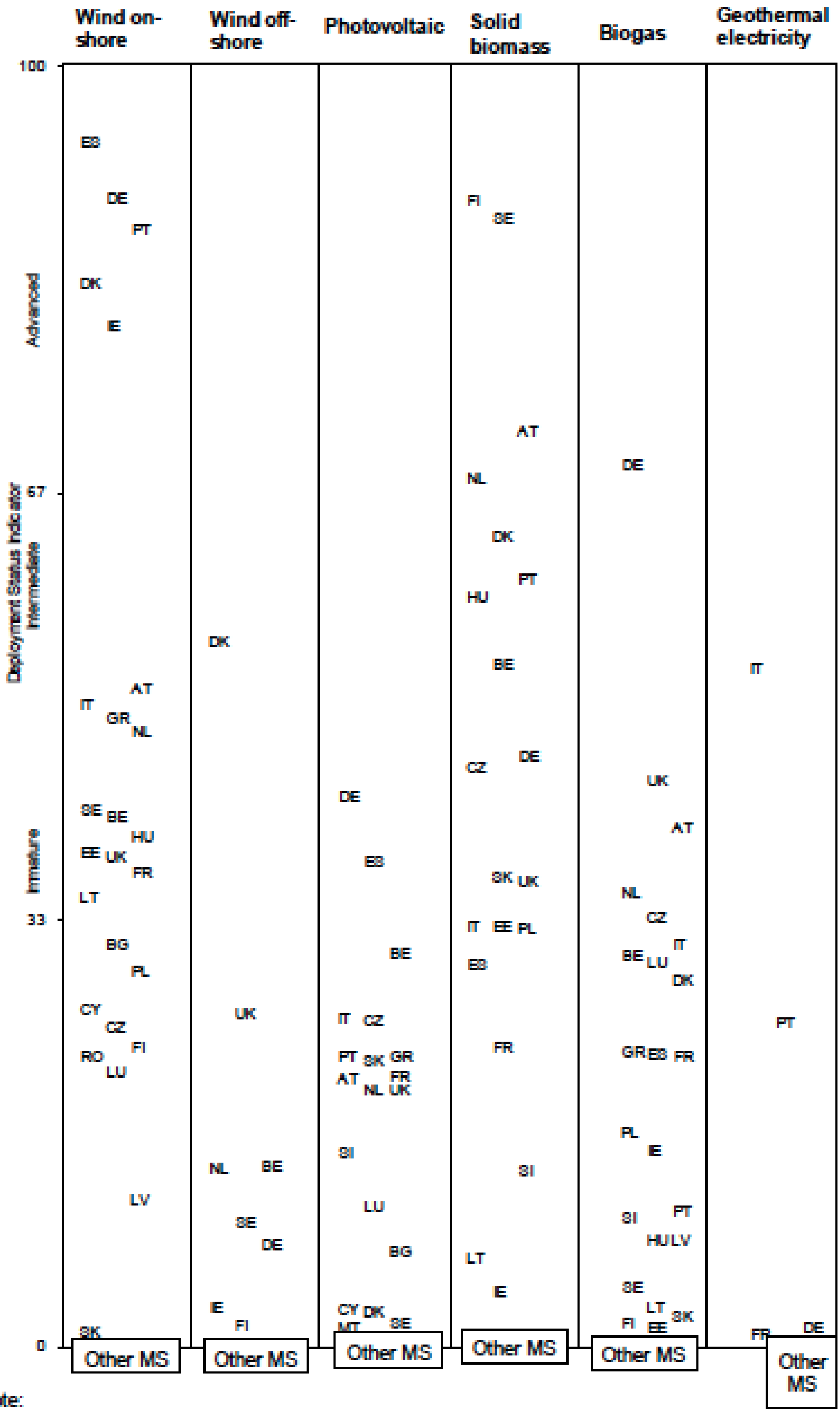


Figure 1: Evolution of the main RES-E support instruments in the EU-27, *Steinhilber et al.,2011*

As a part of the RE-Shaping project, European Commission (2011) published a D17 report, assessment of the performance of RES support in EU 27 MS. The study suggests that, when assessing cost-efficiency of MS support instruments, it is important to take into account two factors RET deployment status market integration. RES Deployment indicator and Electricity Market Preparedness indicators have demonstrated these two factors.

RET deployment indicates at what stage of deployment (immature, intermediate, advanced) of concrete RES is (see Figure 3) and it can be used to demonstrate risk related to the increased market integration. Electricity Market Preparedness indicator shows maturity of the market. More liberalised market is, easier is RET deployment (see Figure 4).



Note:

Figure 3: Overview of Deployment Status RES-E technologies in EU-27, *Steinhilber et al.,2011*

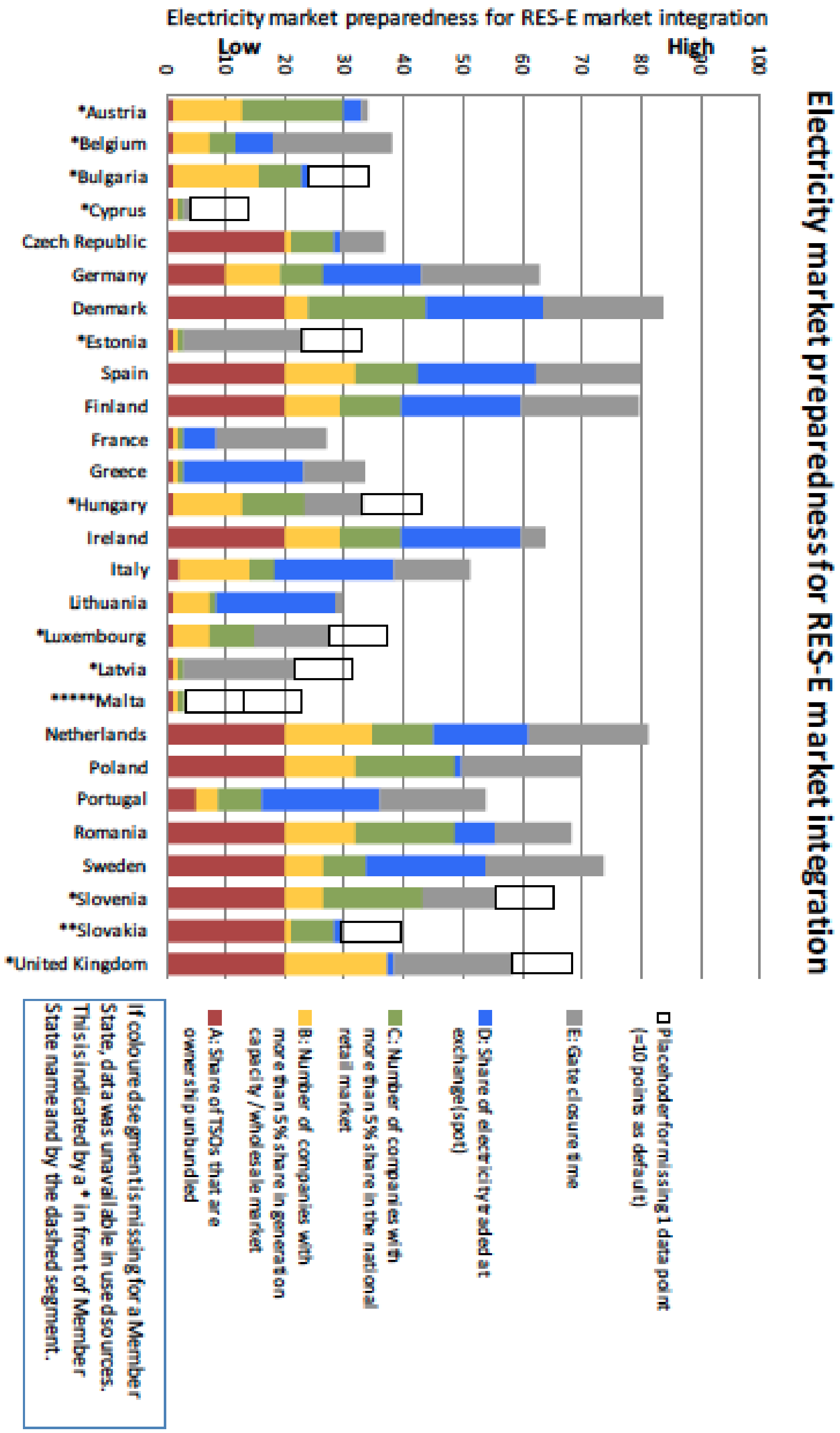


Figure 4: Electricity Market preparedness for RES-E market integration,
Steinhilber et al.,2011

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3. Efficiency and cost efficiency

In ideal theoretical situations, price-based and quantity-based approaches are seen as comparable methods for achieving RES-E targets (Menanteau et al., 2003), but as shown in section 3, stimulation of sustainable technical change and risk plays role while assessing cost-efficiency. There are different definitions of cost- efficiency (Rio and Cerda, 2013), for our analysis we are using inputs/outputs comparison (see details in section 4).

Table 4 represent an overview of the relevant literature assessing efficiency of different support schemes. As expected price based models are overall more efficient when it comes to the early stage of the investment and installed capacity. FIP is proven more efficient then TGC in reaching objectives and acknowledging externalities. Additionally, TGC seem to be efficient in case of large projects.

However, the interaction of policy design, electricity price, and electricity production cost is a more important determinant of RES-E development than policy itself (Jenner et al., 2012).

Table 4: Relevant literature on cost-efficiency

Efficiency	Aspect	E/S	Country	Author
FIT>TGC FIT<TGC	Total cost in long run (2020) Initial cost (until 2014)	S	IE	Hubera et al., 2006
FIT>TGC	Installed capacity Stimulation of technical change	E	UK, DE, FR	Menanteau et al., 2003
FIP>TGC	Reaching objectives: climate change, competitiveness, energy security	R	EU-27	Fouquet and Johansson, 2008
FIT>TGC	Cost Deployement	R	UK, DE	Butler and Neuhoff, 2008
FIT>TGC FIT<TGC	Early investment Larger projects	R	DK, FI, EE, NO, SE	Boomsma et al., 2012

4. Methodology

The methodology used to analyze the efficiency of the different support schemes is described in this section. The methodology is based on a cost efficiency frontier, which is created for every observed year and it determines the most cost-efficient use of resources. It means that inputs (support) iare compared with outputs (RES- E production) with aim to maximize output with minimum input. How the border is created and what decomposition is applied is described hereunder.

It is assumed that governments are using N resources (in our application support to the renewable electricity production) described by a nonnegative input quantity vector xt = (xt 1,..., xt N), in order to produce nonnegative output (in our case renewable electricity) quantity vector yt = (yt 1,...,yt M) in time period *t = 1,...,T.* The price for unit of input is defined as a strictly positive output vector wt = (wt 1,..., wt N).

*The input isoquants Isoq L(y) = {x: x □ _L(y), □x □ _L(y), □ _□ _1} describe the sets of input vectors capable of producing each output vector y but which, when radially contracted, became incapable of producing output vector y (*Kumbhakar and Lovell, 2000).

The input isoquant Isoq L(y) guarantees that in order to produce given output we are using minimal input. The shortest distance of the observation to the input isoquant is represented by distance function defined as $D_i(y,x)=\max\{\theta: x/\theta \in IL(y)\}$ (Shephard (1953).

Cost distance function $c(y,w)=\min_x\{w^T x: D_i(y,x) \leq 1$, shows a minimum cost that is required in order to produce given amount of output and given amount of input prices.

The methodology used to determine the various effects included in an efficiency analyses is based on decomposition of the Konus input price index proposed by Grifell-Tatjé and Lovell, 2013. The method is the following:

$$\frac{w^{1T}x^1}{w^{0T}x^0} = \frac{c^1(y^1,w^1)}{c^1(y^1,w^0)} \times \left[\frac{w^{1T}\,x^1/c^1(y^1,w^1)}{w^{0T}x^0/c^1(y^1,w^0)}\right].$$

$$= \frac{c^1(y^1,w^1)}{c^1(y^1,w^0)} \times \left[\frac{w^{1T}\,x^1/c^1(y^1,w^1)}{w^{0T}x^0/c^1(y^0,w^0)}\;\frac{c^1(y^1,w^0)}{c^1(y^0,w^0)}\right].$$

$$= \frac{c^1(y^1,w^1)}{c^1(y^1,w^0)} \times \left[\frac{w^{1T}\,x^1/c^1(y^1,w^1)}{w^{0T}x^0/c^0(y^0,w^0)} \times \frac{c^1(y^0,w^0)}{c^0(y^0,w^0)} \times \frac{c^1(y^1,w^0)}{c^1(y^0,w^0)}\right]$$

= Input price effect x quantity effect

= Input price effect x productivity effect x activity effect

= Input price effect x cost efficiency effect x technology effect x activity effect

Where, productivity effect = cost efficiency effect x technology effect

w^0 … input price in period 0
w^1 … input price in period 1
x^0 … input in amount period 0
x^1 … input amount in period 1
c (y , w)… cost distance function

As price of support is assumed to be a harmonised indicator of consumer price for electricity [1] (HICP). This indicator is produced by EUROSTAT in order to measure changes over time in household's electricity prices. Knowing the total costs of support, we calculated amount using following formula:

wx = C where w = (1+ HICP) and x = C/w.

[1] Source: http://epp.eurostat.ec.europa.eu/portal/page/portal/hicp/introduction, EUROSTAT, 2014

Where:

x1 … amount of support, in euro
TC … total costs for support, in euro
HICP … inflation represented by harmonized indicator of consumer price for electricity

Table 5: Interpretation of the effects

Cost efficiency effect	< 1	Cost efficiency improves
	= 1	remains
	> 1	decreases
Technology change effect	< 1	Technical progress
	= 1	stagnation
	> 1	regression
Activity effect	< 1	Output quantitates decline
	= 1	remain unchanged
	> 1	increase

Cost efficiency effect indicates improvement in cost efficiency over observed time period. In case that country pays more than other countries, but produces the same amount of renewable electricity, the support scheme is less efficient. Technology effect explains which countries are able to produce more with the same amount of support. And activity effect takes into consideration the cost that occurs due to more installations.

We can also express the cost difference decomposition in function of the previous (ratio) number index approach. In this way, a percentage is translated in value that is, cost variation. Of course, the impact depends of the importance (amount) of the subsidy as illustrated in the expressions below.

Price effect : $[c^1(y^1,w^1) - c^1(y^1,w^o)] = c^1(y^1,w^o)\{[c^1(y^1,w^1)/c^1(y^1,w^o)] - 1\}$

Quantity effect: $\{[w^{1T}x^1 - c^1(y^1,w^1)] - [w^{oT}x^o - c^1(y^1,w^o)]\}$

$$= c^1(y^1,w^1)\{[w^{1T}x^1/c^1(y^1,w^1)] - 1\} - c^1(y^1,w^o)\{[w^{oT}x^o/c^1(y^1,w^o)] - 1\}$$

Quantity effect decomposition

$$[w^{1T}x^1 - c^1(y^1,w^1)] - [w^{oT}x^o - c^1(y^1,w^o)] =$$

$$[w^{1T}x^1 - c^1(y^1,w^1)] - [w^{oT}x^o - c^1(y^o,w^o)] \qquad \text{productivity effect}$$

$$+ [c^1(y^1,w^o) - c^1(y^o,w^o)]. \qquad \text{activity effect}$$

Productivity effect: $[w^{1T}x^1 - c^1(y^1,w^1)] - [w^{oT}x^o - c^1(y^o,w^o)]$

$$= c^1(y^1,w^1)\{[w^{1T}x^1/c^1(y^1,w^1)] - 1\} - c^1(y^o,w^o)\{[w^{oT}x^o/c^1(y^o,w^o)] - 1\}$$

Activity effect: $[c^1(y^1,w^o) - c^1(y^o,w^o)] = c^1(y^o,w^o)\{[c^1(y^1,w^o)/c^1(y^o,w^o)] - 1\}$

The productivity effect decomposition

$$[c^1(y^o,w^o) - c^o(y^o,w^o)] = c^o(y^o,w^o)\{[c^1(y^o,w^o)/c^o(y^o,w^o)] - 1\}$$

Technology effect

$$[w^{1T}x^1 - c^1(y^1,w^1)] - [w^{oT}x^o - c^o(y^o,w^o)]$$

$$= c^1(y^1,w^1)\{[w^{1T}x^1/c^1(y^1,w^1)] - 1\} - c^o(y^o,w^o)\{[w^{oT}x^o/c^o(y^o,w^o)] - 1\}$$

Cost efficiency effect

And then we further decompose the index into price effect that occurs due to the price changes and quantity effect.

$$w^{1T}x^1 - w^{0T}x^0 = [c^1(y^1,w^1) - c^1(y^1,w^0)] \qquad \text{price effect}$$
$$+ \{[w^{1T}x^1 - c^1(y^1,w^1)] - [w^{0T}x^0 - c^1(y^1,w^0)]\} \qquad \text{quantity effect}$$

The quantity effect can be further decomposed into cost efficiency, technology and activity effect.

$$[w^{1T}x^1 - c^1(y^1,w^1)] - [w^{0T}x^0 - c^1(y^1,w^0)] =$$
$$[w^{1T}x^1 - c^1(y^1,w^1)] - [w^{0T}x^0 - c^0(y^0,w^0)] \qquad \text{cost efficiency}$$
$$\text{effect} + [c^1(y^0,w^0) - c^0(y^0,w^0)] \qquad \text{technology effect}$$
$$+ [c^1(y^1,w^0) - c^1(y^0,w^0)] \qquad \text{activity effect}$$

Grifell-Tatjé and Lovell, 2013

5. Data

We are investigating the efficiency of the support schemes that were introduced in relation to the 2009/28/EC Directive on promotion of renewable energy sources, thus the observed period starts in 2009 and goes until 2012, which is the most recent year for which data are available.

Collected dataset covers 26 EU Member States and one EU-27 representative, which make the total of 108 observations. Each observation is determined by one input, price of input and three outputs and is focused on households.

Outputs are defined by actual amount of renewable electricity produced. This amount has been further divided into three parts depending on the technology used. The most of the support has been dedicated to the wind power plants, or photovoltaic. Therefor electricity produced by these technologies is considered to create two main outputs y1, y2. The rest of the renewable electricity produced by other technologies (such as small hydro, tide, ocean, waves etc.) is summed under third output y3, other. All three outputs are in form of primary energy production, in GWh. In case of y1 and y2, values are quantified by EUROSTAT.

Not in all Member States the expenditures are oriented towards all types of RES electricity production. Some countries allocated all resources to only 1 type of renewable electricity production. This might lead to a small distortion of the technological frontier.

In order to quantify the third output y3, a top down approach has been applied. From the total gross electricity production (GWh) and share of renewable electricity (%), the total production of renewable electricity (GWh) has been calculated. The *y3 others* is been result of subtraction of the amounts of electricity produced by wind and photovoltaic from the total amount of renewable electricity.

The data set has been carefully put together in order to allow for the best representation of the costs and resulting outputs. Nevertheless due to the complex matter there are a big amount of macro-economic and MS inherent characteristics that cannot always be completely accounted for. The discussion below describes the process followed in order to create the data set and indicates the refinements.

As every source of information the data has strong points and weaker points. In order to perform the analysis correctly we need to understand the strong and weak points of the available data. Therefore we will briefly discuss the data below:

5.1 Strong points of data

- The expenditures used account for the MS registered expenditures for the 3 main support schemes (FIT,FIP, QOUTA) specifically for electricity production. Since this analysis will focus on the optimal policy regarding the 3 main support schemes this is powerful and valuable data.
- The dataset covers 2009 – 2012, initial three years of the Energy and Climate package, thus it focuses on early years of the support mechanism implementation.

- The information regarding production of RES is detailed information provided by EUROSTAT. This is trustworthy and complete information.
- The renewable electricity production is split up in 3 main categories on which support schemes mainly focus. The most universal (available and supported all over the continent) RES electricity production are wind and PV and are therefore isolated from the other RES production, showing that policies are mainly orientated towards wind and PV. This can be concluded from the Figure 3.
- In order to account for inflation and cost differences in different countries, the expenditures made are price and inflation corrected. This is a strong tool that makes the comparison between the different EU member countries more realistic. However this is not expected to have significant impact on the cost-efficiency.

5.2 Assumptions

- The expenditure data does not take into account other expenditures such as for example subsidies, tax reductions etc. Other support schemes such as subsidies might also impact total RES production but are not included in the current data. Because the “secondary” support schemes as for example subsidies have only a minor influence on the RES production the margin of error is limited.
- By comparing total expenditures in 1 year and total RES production of that year there is assumed that in the time period considered that previous investments/costs do not really lead to higher renewable electricity production in the considered year. Because the expenditure focuses on the specific support schemes, which are only in place a limited time before the start of the observation years, this is a correct assumption. We are not considering other support schemes such as subsidies who can generate long term renewable electricity production after an investment in only 1 year (*we need to verify how FIT, FIP & QUOTA work and whether all expenditures need to be made every year again*)

5.3 Data set characteristics

The data set contains the expenditures on FIT,FIP and QUOTA for most member states. The observations for the following member states have not been considered in the analysis for the reasons as detailed below:

Member states with several years of 0 investment in RES-E are:

- Malta
- Greece
- Lithuania

Observations with 0 investment in 1 year:

- Portugal 2012

6. Results

In this section we are presenting very preliminary results of the analysis.

The model used holds prices constant and thus we only observe the

AVERAGE OF THREE PERIODS – EASIER TO COMMENT

TECHNOLOGY

year	Quantity effect 2009/2010	Quantity effect 2010/2011	Quantity effect 2011/2012
AT	1,24	0,88	1,07
DK	0,90	1,25	1,60
EE	2,99	1,29	1,82
FI	0,94	1,35	2,24
FR	1,31	1,83	1,20
DE	1,43	1,50	0,97
HU	1,27	0,87	1,59
IE	2,54	0,61	0,78
IT	1,40	2,05	0,77
LZ	0,89	2,13	1,58
LU	1,22	1,24	1,38
NL	1,07	0,99	1,12
PL	1,28	1,11	1,23
PT	1,37	0,70	0,00
SE	1,12	0,92	0,98
SK	9,82	4,63	0,53
UK	2,26	1,01	0,39
EU	0,94	1,34	0,48
Average	**2,16**	**1,97**	**1,04**

Looking at the average cost efficiency for years 2009 until 2012 we observe that countries that have high involvement in renewable electricity have harder time to increase RET deployment in cost efficient manner. On the other hand that just started supporting renewables as a reaction to the Directive and thus have a lot of available potential, tend to perform more cost efficient as indicated in Table 6.

Table 6: Cost efficiency average improvement 2009 – 2012

SLO	0,58	Cost efficiency improves
IT	0,62	
UK	0,67	

SE	0,76	
AT	0,77	
PL	0,77	
HU	0,85	
NL	0,85	
PT	0,88	
FR	0,91	
EU - 26	0,92	
FI	1,00	Cost efficiency remains
IE	1,00	
DE	1,01	Cost efficiency decreases
SK	1,04	
LT	1,20	
EE	1,30	
LU	1,31	
DK	1,31	

Table 3 has been used as a base for the analysis of differences between feed in tariff, premium and quota. For each mechanism average value has been computed and presented in Figures 5-7. We examine evolution between two time periods. The values reflect on annual changes 2009/2010, 2010/2011 and 2011/2012.

Generally, over observed period cost efficiency improves. Between 2009 and 2010 we observe negative technology effect and positive cost efficiency effect. It can mean that countries that are behind with technology, used examples of best practices from countries with higher deployment of RES. Countries, with already high level of RET implemented did not show significant improvement.

In periods 2010/2011 and 2011/2012 more efficient countries improved in technology while less efficient countries improved their cost efficiency. As can be seen in Table 8.

Activity improved significantly in a first time period observed, later it seem rather constant. However more recent data need to be used in order to confirm this.

As expected, the most cost efficient is quota mechanism for all observed periods. Feed in tariff and premium show similar patterns in cost-efficiency, even though premium show low cost efficiency in 2010/2011. This is mainly caused by developments on Danish market that will be further discussed.

Technology effect has the same shape for all three support mechanisms. The best technology improvements trigger premium mechanism. Activity effect shows that premium leads to slow and constant development. FIT and quota follow the same developments, first we see increase and in 2010/2011, significant decrease is observed.

Figure 5: Cost efficiency, FIT, FIP, quota, average

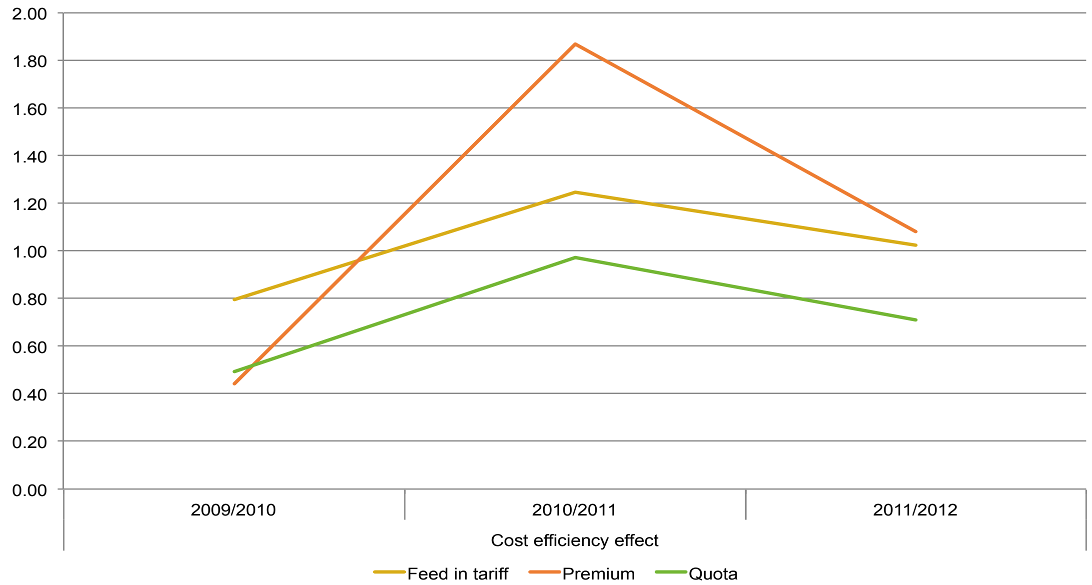

Figure 6: Technology effect, FIT, FIP, quota, average

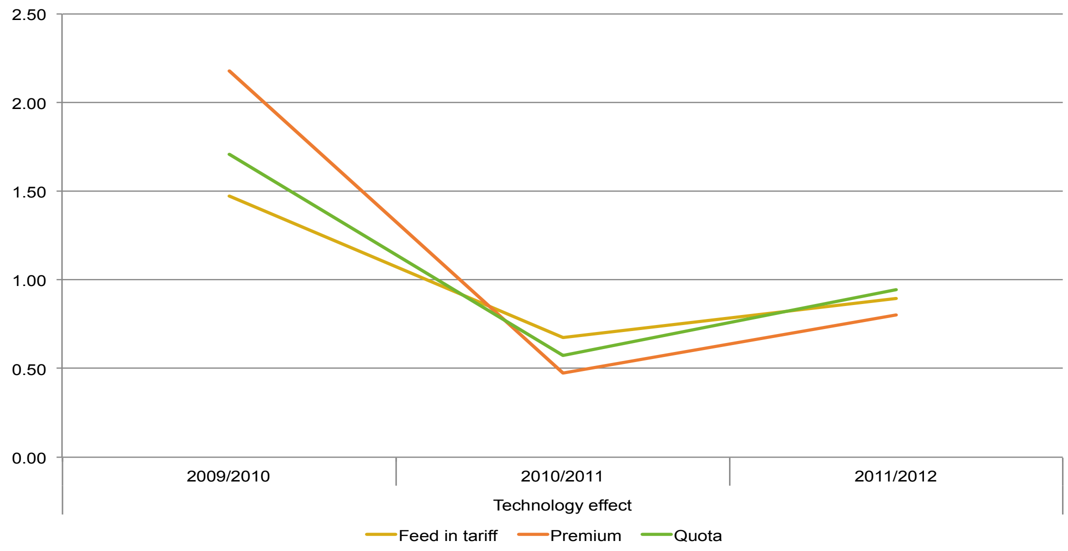

Figure 7: Activity effect, FIT, FIP, quota, average

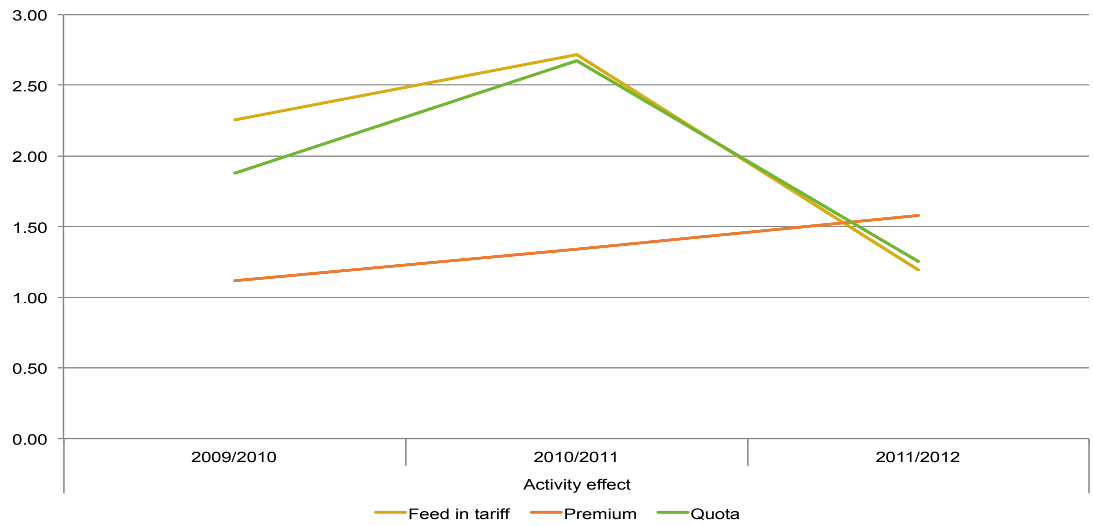

Table 7: FIT, FIP, Quota, average

		Feed in tariff	Premium	Quota
Cost efficiency effect	2009/2010	0,80	0,44	0,49
	2010/2011	1,25	1,87	0,97
	2011/2012	1,02	1,08	0,71
Technology effect	2009/2010	1,47	2,18	1,71
	2010/2011	0,67	0,47	0,57
	2011/2012	0,90	0,80	0,95

Activity effect	2009/2010	2,26	1,12	1,88
	2010/2011	2,71	1,34	2,67
	2011/2012	1,19	1,58	1,25

Table 8: Cost efficiency, technology and activity effect, 2009-2012

year	Cost effect 09/10	Cost effect 10/11	Cost effect 11/12	Technology effect 09/10	Technology effect 10/11	Technology effect 11/12	Activity effect 09/10	Activity effect 10/11	Activity effect 11/12
AT	0,64	0,84	0,77	1,32	0,72	0,81	09/10	10/11	11/12
DK	0,29	2,48	1,31	2,53	0,41	0,83	1,24	1,23	1,47
EE	1,15	2,03	1,30	1,92	0,50	1,24	1,35	1,27	1,13
FI	1,00	1,00	1,00	0,83	1,16	1,77	1,13	1,17	1,27
FR	0,43	0,96	0,91	1,36	0,72	0,72	2,26	2,65	1,84
DE	0,82	1,16	1,01	1,05	0,78	0,72	1,68	1,66	1,33
HU	0,48	1,50	0,85	1,85	0,51	1,12	1,44	1,14	1,67
IE	1,00	1,00	1,00	2,67	0,39	0,85	0,95	1,55	0,92
IT	0,51	0,51	0,62	1,09	0,76	0,71	2,51	5,30	1,74
LZ	0,43	2,17	1,20	1,66	0,53	1,21	1,25	1,86	1,09
LU	1,18	1,58	1,31	1,03	0,78	0,72	1,00	1,00	1,47
NL	0,59	1,26	0,85	1,83	0,54	0,78	0,99	1,45	1,69
PL	0,50	1,26	0,77	1,81	0,51	1,17	1,43	1,75	1,36
PT	0,69	1,06	0,88	1,60	0,57	0,00	1,24	1,15	0,00
SE	0,54	1,13	0,76	1,62	0,54	1,13	1,27	1,51	1,13
SK	0,95	0,40	1,04	0,94	0,77	0,71	11,05	14,93	0,71
UK	0,43	0,99	0,67	2,31	0,48	0,77	2,31	2,13	0,77
EU	0,76	0,94	0,92	1,12	0,76	0,72	1,12	1,88	0,72
AVE	**0,69**	**1,24**	**0,95**	**1,58**	**0,63**	**0,89**	**1,98**	**2,51**	**1,22**

7. Conclusion

8. Limitations of the study

Technology frontier based on observations for all countries when the conditions in all different countries can vary a lot. In the current analysis there is no way to account for these differences per country. We can just keep them into account when analysing the results.