

## Cost and benefit of renewable energy in europe

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**Abstract:** Costs and benefits of renewable energy use in electricity generation in the EU are assessed during low oil prices 1998-2002 and high oil prices 2003-2009. The EU statistical data is used. The renewable energy use in the EU was about 21% of the total energy inputs in 2008 and it was growing by 5% annual average during 2003-2008 compared to nearly nil growth of the fossil fuel input. During high and fast increasing oil prices, the correlations between the changes of consumers' electricity prices and the growth of renewable energy use indicates that the large and growing use did not increase the prices but decreased the consumers' electricity prices in several EU countries. An explanation is that the renewable energy enabled input diversification in electricity generation, which has reduced the costs. Consumers' electricity prices are simulated in case these had followed the fossil fuel input costs and compared with the observed prices. It is found that high oil prices invoked substantial efficiency-increase and that the renewable energy input has been net beneficial to the EU citizens even when the periods of low and high fossil fuel prices are taken together.

**Keywords:** *Renewable energy, Electricity prices, Cost-benefit, Feed-in tariffs*

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### 1. Introduction

The European Union (EU) policy aims at a shift in electricity generation away from fossil fuels (coal, oil, gas and nuclear) towards renewable energy resources, which are biomass and waste, hydro-, geothermal-, solar-, and wind power; co-generation heat plants (CHP) is sometimes included (EU, 2005). This shift, however, is not evident because energy policies of the twenty seven EU member countries differ (Blok, 2006) and because renewable energy use for electricity generation is considered costly (Steger et al., 2005; EU, 2008). However, the cost-reducing technological progress (Gross et al, 2008) in combination with increasing oil prices after the year 2003 till 2008 created a competitive edge for renewable energy use in electricity generation called grid parity and global investments in renewable energy expanded from USD 29 billion in 2004 to USD 151 billion in 2008, out of it more than a third in the EU (UNEP, SEFI, New Energy Finance, 2010). Oil prices fluctuate cyclically, they fell down after 2008, and the renewable energy use became costly. A challenge in the EU policymaking is how to foster the shift regarding the oil price cycle.

The EU policy could act anti-cyclic. It could support renewable energy during low oil prices. This support would maintain high investments entailing the cost-reducing technological progress and thereby, anticipate high oil price when no or little support is needed. Such an anticipation policy, however, causes social costs because it drives up electricity prices above the prices that would be based on the lower input prices on international markets. A higher input price also provides social benefits because it invokes efficiency-increase and reduces pollution, especially greenhouse gas emission due to lower combustion of fossil fuels (Sensfuß et al, 2007). A few available cost-benefit studies are inconclusive. For example, a study commissioned by the German government suggests that the German support of renewable energy in 2006, if scaled up to the EU level, would provide net benefit of 9.4 billion euro in the EU, out of it 5 billion euro efficiency increase, 1 billion lower imports and 3.4 billion euro due to lower pollution (Böhme and Dürrschmidt, 2007:29), but another German study, one into a fossil fuel tax in electricity generation, indicates net costs of this policy, albeit the benefits of lower pollution and innovations in energy saving are unaccounted (Walz and Schleich, 2009). Studies in the US suggest that some technical and social benefits of the renewable energy use are often omitted, such as lower thermal, transport

and conversion losses in electricity generation, transmission and use (NREL, 1997; Sawin and Moomaw, 2008), respectively self-reliance and local job creation (Bird et. al., 2008).

## 2. Methodology

The starting point in this paper is that supporting renewable energy during low oil prices to anticipate high oil prices is a costly policy. It is justifiable only if the renewable energy use would be net beneficial during the whole cycle of low and high oil prices, which means when the costs of renewable energy use during low oil prices would be outweighed by the benefits during high oil prices. This paper looks back at the last oil price cycle from the year 1998 when the annual average price was at the lowest point in the last half century to 2008 when the price was at the highest point ([www.inflationdata.com](http://www.inflationdata.com)). Question is if renewable energy in electricity generation in the EU was net beneficial during the price cycle. The price cycle is divided into a period of low oil prices 1998 – 2002 when prices have fluctuated around the price in 2002 and the period of high oil prices 2003 – 2008 when the prices have annually increased. In the calculations, all fossil fuels prices are annual averages in constant (year 2000) FOB prices using the US Energy Information Administration (EIA) data ([www.eia.doe.gov](http://www.eia.doe.gov)). All EU data is based on the EUROSTAT (the EU statistical bureau), which is data on energy and electricity generation and consumption. The consumers' electricity prices are excluding taxes in constant (2005) Euro ([www.statline.eu](http://www.statline.eu)). The assessment covers only the statistically observable prices.

The uses and prices of energy inputs in electricity generation are presented in Section 2. The impact of the renewable energy use on consumers' electricity prices during high fuel prices is discussed in Section 3. The costs and benefits of the renewable energy use in electricity generation are covered Section 4. The conclusions are drafted in Section 5.

## 3. Results

### 3.1. Energy inputs

The question addressed in this section is if renewable energy has substituted fossil fuels. The following data is compiled for the periods 1998 – 2002 (low oil prices) and 2003 – 2008 (high oil prices): the shares of energy inputs in electricity generation in 2008, the average annual volume growth, the annual average international market prices of fossil fuels and the prices of fossil fuel mix in electricity generation (weighed for volume). The prices of nuclear power and renewable energy are not found. Table 1 shows the data.

The energy inputs in electricity generation have changed during the prices cycle 1998-2008 alongside with 2% annual electricity generation growth. During high oil prices, coal and oil inputs decreased, even though the coal price is below the oil price, nuclear somewhat decreased, and the gas use has increased albeit its price follows neatly the oil price. The renewable energy has grown by 5% during the high oil prices compared to 1% in the period of low oil prices. In result, the share of renewable energy in total energy inputs increased from 18% in 1998 (not shown in the table) to 21% in 2008. In addition, the CHP share in energy input increased from nearly nil in 1998 to 11% in 2008. Hydropower and biomass & waste are the largest renewable energy uses, whereas solar- and wind energy uses grow very fast though the volumes were nearly nil in 1998. Renewable energy use has substituted fossil fuels. The substitution cannot be attributed to the public support of renewable energy because the support of fossil fuels in the EU was much larger (EEA, 2004). The renewable energy use in electricity generation has, apparently, advantages during high oil prices.

Table 1 Energy inputs for electricity generation, excluding CHP and geothermal energy

Volume data from Eurosta *), prices data from EIA(**)	Input in total	Average annual volume growth			Average annual prices €/t.o.e.		
		2008	1998-2008	1998-2002	2003-2008	1998-2008	1998-2002
Coal	18%	-0.1%	1%	-1%	85	62	104
Oil	3%	-6%	-3%	-9%	230	161	288
Gas	26%	7%	8%	7%	194	159	223
Nuclear	31%	0.0%	1%	-0.9%	N.A.		
Fossil fuels mix (volume weigh)	79%	1%	2%	0.6%	149	115	177
Biomass & waste	5%	5%	2%	8%	N.A.		
Hydropower	12%	0.3%	-0.1%	0.6%			
Solar	0.2%	61%	47%	73%			
Wind	4%	29%	38%	22%			
Renewable energy	21%	3%	1%	5%			

(\*) No Eurostat data for the biomass & waste use; here assumed 80% of all production is for electricity generation with 15% conversion efficiency. (\*\*). Price converted into €/t.o.e.: Euro/USD with the [www.inflationdata.com](http://www.inflationdata.com) \*42.2 €/GJ \* EIA inputs prices, which are for coal USD/metric ton\*24GJ, for oil USD/b.o.e\*6.1 GJ, for gas USD/1000m<sup>3</sup>feet\*35.5\*39GJ

### 3.2. Consumers' electricity prices

In this section we discuss whether renewable energy growth caused higher consumers' electricity prices in the EU. If renewable energy would be costly compared to fossil fuels, its growing use would drive up consumers' electricity prices, this predicts theory, and this impact on prices would be significant because the renewable energy use has a substantial share in the total energy inputs. To assess this impact, the countries' annual volume growth of renewable energy in electricity consumption is rank correlated with the annual changes of consumers' electricity price. A positive rank correlation of the volume growth with the price change indicates that the renewable energy use causes higher price, and vice versa a negative rank correlation indicates that the use causes lower prices. A rank correlation ( $R^2$ ) 0.8 and higher, or - 0.8 and lower is assumed to indicate a significant impact. The assessment covers the period 2003 - 2008 and within this period the timeframe 2005 – 2008 when the oil prices almost doubled. Table 2 shows: countries' share of the renewable energy use in electricity consumption, energy growth, prices changes and the rank correlations during 2003 - 2008 and 2005 – 2008.

Table 2 Growth of the renewable energy use in gross electricity consumption and changes of the consumers' electricity prices (without taxes). **Bold:** significant negative correlation, *italic:* average consumers electricity prices above the EU average price (2005-2008), *Minus:* net importers of electricity

<i>Eurostat data for the volume and prices</i>	<i>2008(*) Renewable energy use electricity consump.</i>	<i>2003-2008</i>		<i>Correlat. Volume: prices</i>	<i>2005-2008</i>		<i>Correlat. Volume: prices</i>
		<i>Volume growth</i>	<i>Prices</i>		<i>Volume growth</i>	<i>Price</i>	
EU(**)	17%	3%	6%	(0.2)	6%	5%	0.0
<i>Belgium -</i>	5%	19%	1%	0.4	26%	7%	(0.4)
Bulgaria	7%	13%	3%	(0.5)	4%	5%	(0.3)
<i>Czech R. -</i>	5%	8%	2%	0.7	18%	13%	(0.6)
<b>Denmark</b>	29%	10%	-3%	(0.5)	7%	7%	(0.9)
<b>Germany -</b>	15%	16%	1%	(0.4)	17%	1%	(0.8)
Estonia -	2%	53%	5%	0.9	33%	4%	0.8
<i>Ireland</i>	12%	20%	7%	0.4	25%	10%	0.2
<b>Greece</b>	8%	13%	9%	(0.8)	-2%	13%	(0.9)
Spain	21%	8%	4%	0.1	3%	6%	0.7
France -	14%	-2%	-5%	0.1	2%	0%	0.4
<b>Italy -</b>	17%	-1%	19%	(0.1)	2%	5%	(0.9)
<i>Cyprus</i>	N.A.						
Latvia -	41%	4%	11%	0.8	9%	16%	0.8
Lithuania -	5%	14%	5%	0.6	20%	8%	0.5
<i>Luxemb.</i>	4%	7%	-4%	0.5	17%	5%	0.1
Hungary	6%	48%	7%	(0.0)	68%	13%	(0.7)
Malta	N.A.						
<i>Netherland</i>	9%	13%	-3%	0.6	15%	6%	0.5
Austria	62%	0%	5%	0.2	5%	7%	(0.2)
Poland -	4%	14%	1%	0.9	26%	9%	0.8
<i>Portugal</i>	27%	13%	-2%	0.1	8%	-4%	0.2
Romania -	28%	2%	10%	0.8	6%	15%	1.00
Slovenia	29%	-1%	-4%	0.2	4%	2%	0.3
<i>Slovakia</i>	16%	1%	1%	0.6	10%	3%	0.6
<b>Finland</b>	31%	3%	2%	(0.4)	7%	3%	(0.8)
<b>Sweden -</b>	56%	0%	-2%	0.1	8%	5%	(0.9)
<b>Un.King -</b>	6%	14%	0%	0.4	17%	14%	(0.8)

(\*) Renewable energy use is excluding CHP

(\*\*) The EU average price is total EU value of sales divided by the volume of sales.

In the period 2003 - 2008 the significant positive rank correlations between the renewable energy growth and the changes of consumers' electricity prices are found for Estonia, Latvia, Poland and Romania but all these countries hardly use renewable energy, which is largely imported. The high negative correlation is found for Greece that is a large user of renewable energy. The findings in the period of the fast increasing oil prices 2005 – 2008 provide more insight. Next to the significant positive correlations for the countries that hardly use renewable energy, significant negative correlations are found for Denmark, Germany, Greece, Italy, Finland, Sweden and United Kingdom. All these countries except United Kingdom are large users. These significant negative correlations cannot be explained by

cheap domestic and imported hydropower because it has decreased in all EU countries except Bulgaria and Romania. Cheap imports of other renewable energy inputs can be somewhat relevant for Germany, Italy, Sweden and United Kingdom but not for Greece, Denmark and Finland that are net exporters of renewable energy. It could be that the countries in which the significant negative impact is found already experience higher consumers' electricity prices than the EU average, which holds for Germany, Italy and United Kingdom but not for Greece, Denmark, Finland and Sweden.

The growing renewable energy use had low impact on the consumers' electricity prices during 2003-2008 and it has contributed to the lower electricity prices during 2005-2008 (when fossil fuel prices increased very fast) particularly in the countries that are large users of renewable energy. A plausible explanation is that the electricity generators that start with using renewable energy face higher input costs, which are reflected in the higher electricity prices. The generators that use much renewable energy learn to benefit from this input diversification with positive effects on the production costs, which are reflected in the lower consumers' electricity prices

### **3.3. Cost and benefits of renewable energy**

Regarding the positive impact of renewable energy use on the consumers' electricity prices question is whether its use is costly throughout the oil price cycle. Therefore, the observed annual consumers' electricity prices are compared to a hypothetical situation in which electricity prices would have followed the fossil fuel mix prices (see Table 1). The social benefits are in case of lower consumers' electricity prices than if the prices had shadowed the fossil fuel mix prices, and vice versa the social costs are in case of higher consumers' electricity prices than had they shadowed the fossil fuel mix prices.

In the assessment, the year 2002 is taken as the reference because thereafter the oil prices have annually increased and the renewable energy use has grown. Since the electricity prices during 1998 - 2002 are not available for all EU countries it is assumed that they equal to the price of 2002, which is acceptable for this assessment because the annual fossil fuel mix prices fluctuated around the 2002 price. The total social costs and benefits are assessed and the costs and benefits that can be attributed to the renewable energy use, which is based on the additional renewable energy use compared to the reference year 2002. Table 3 shows the energy inputs and outputs in electricity generation, the renewable energy use and its additional use after the reference year, costs of energy outputs and electricity prices, social costs and benefits.

Table 3 Social costs and benefits of renewable energy use in electricity production.

	Reference 2000	Average a year		Year 2008
		1998- 2002	2003- 2008	
Energy inputs and electricity generation in GWh				
Total energy inputs	2,753,671	2,667,958	2,930,344	2,987,611
Renewable energy use	474,417	482,221	550,345	628,069
Additional use compared to 2002	-	7,804	75,928	153,652
Electricity consumption	2,599,739	2,510,120	2,779,549	2,855,561
Price of energy inputs and electricity in €/GWh				
Fossil fuels prices	9,826	9,849	15,207	18,784
Electricity price ('98-'01 equal 2002)	83,019	83,019	102,632	115,033
Index energy input cost	100.0	100.2	155	191
Index electricity price	100.0	100.0	124	139
Social costs and benefits of electricity consumption in €billion				
Had electricity followed fossil fuel price	216	210	358	453
Observed electricity prices	216	208	286	328
Total net social benefit	-	1.88	72	125
Benefit additional renewable energy use	-	0.65	8	18

During low oil prices (1998 – 2002), the consumers' electricity prices closely shadowed the fossil fuel prices, but during high oil prices (2003 – 2008) the consumers' electricity prices were well below the fossil fuel mix prices. The improvements created a net social benefit on average 72 billion euro a year, which is equivalent of 20% efficiency increase. Out of this benefit on average 8 billion euro a year should be attributed to the additional use of renewable energy. Note that in 2008 the total net social benefit has peaked to 152 billion euro, out of it 18 billion euro attributable to the renewable energy use. Throughout the whole oil price cycle 1998 - 2008 the total net benefit attributable to the renewable energy use approached 49 billion euro. When looking back, support of the renewable energy with the incentives of this order of magnitude would be justifiable because it would create cost-neutral renewable energy capacity that would enable to anticipate increase of fossil fuel prices.

#### 4. Conclusions

With reference to the EU policy that aims to shift from fossil fuels to renewable energy in electricity generation, the question is discussed whether it is socially beneficial to support renewable energy during the low oil prices in order to anticipate high oil prices. An answer is given using statistical data for the periods of low oil prices (1998-2002) and high ones (2003-2008). The fossil fuel mix prices in electricity generation have shadowed oil prices though coal at lower prices. During high oil prices 3% of the fossil fuels use is substituted by renewable energy because the latter has grown much faster and within fossil fuels the coal and oil use is substituted by gas. The growing use of renewable energy in the EU did not increase the consumers' electricity prices except in the countries that hardly use it but had a significant calming effect on the prices in the countries that are large user of renewable energy. A plausible explanation of this finding is that the renewable energy diversifies energy inputs and thereby creates opportunities for efficiency increase in inputs allocation. The cost - benefit assessment for the whole oil prices cycle 1998 – 2008 confirms it. The observed electricity prices are compared with the electricity prices had they shadowed the fossil fuel prices and it is assessed whether the additional renewable energy use has caused higher costs or benefits. It is found that 72 billion euro net social benefits are attained in the EU (about 20% efficiency increase). About 11% these net benefits are attributable to the additional

energy use. For the whole oil price cycle 1998 - 2008 the total net benefit attributable to the renewable energy use is estimated at 49 billion euro. The renewable energy, though it is uncompetitive during low oil prices, becomes a viable option during high fossil fuel prices. The policy that anticipates the high prices through incentives for renewable energy has a calming effect on consumers' electricity prices and is socially beneficial.

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