Regional coordination of European environmental policies

Carlo Andrea Bollino and Silvia Micheli

Department of Economics, Finance and Statistics, University of Perugia, Italy

Abstract

The European Union (EU) has undoubtedly made a big effort in developing a progressive environmental policy, but many of its own policies are still far from making a difference to climate change. The EU aims to limit its greenhouse gas emissions to 20% below 1990 levels, and to meet a 20% renewables target of total energy supply by 2020 through the 20-20-20 climate and energy package. Each EU region must take complementary and coordinated actions to green themselves, by implementing their own national plan. The aim of our paper is to analyze the problem of coordination among policy makers that undermine the achievement of the 20-20-20 targets. Governments in EU regions use a large variety of support instruments to face the climate and energy package. Evidently, every region would want to spur new activities, new investment, more employment in its own territory, by using an appropriate mix of local taxation and subsidies, in conjunction with other command and control instruments. However, EU regions have the incentive to free-ride, or to impose as few costs as possible on their home economy while enjoying the benefits created at the other countries' cost. So, there are formidable problems of opportunistic behavior and inefficient outcomes. Through a model of Nordhaus (2009) that we have adapted to the European context, we study the costs of reaching EU energy and environmental targets where there is limited participation by member States. From our calculation, we show that limiting participation produce inefficiencies by rising the costs for the participating countries to the agreement.

1. Introduction

The concentration of greenhouse gases (GHG) in the atmosphere was at 438 parts per million (ppm) of CO_2 equivalent in 2008, that is almost twice the pre-Industrial Revolution level (IEA, 2010). Such an increase is mainly caused by fossil fuel combustion for energy purposes in the power, industry, building and transport sectors (Stern, 2007). In the Reference Scenario, which gives economic and environmental assessments of a world in which the economy continues on its current course without polluting emission reductions policies, fossil fuel use is projected to grow, and the dirtiest fuel, i.e. coal, is expanding its share to face rising energy demand driven by emerging countries such as China and India.

The global response to climate change started with the so called Rio Earth Summit in 1992: governments realized the need to work together for an environmental and sustainable economic development. The Summit was a first move towards an environmental policy at global level, by setting the emission reduction targets for developed countries and establishing a framework of wider reduction for the future from a sustainable development point of view. Its weak point was that the Summit promised a lot at little cost, since it was an agreement without stringent measures (Helm, 2008). The Summit has been followed by several discussions with the purpose of finding optimal shared environmental policy for facing climate change.

Afterwards, the Kyoto Protocol, an international agreement adopted in Kyoto on December 1997, has committed (instead of encouraging) 37 industrialized countries and the European Union (EU) to reduce GHG emissions through national measures. The EU has undoubtedly made a big effort in developing a progressive environmental policy, but many of its own policies are still far from making a difference to climate change. Following the ratification of the Kyoto Protocol in 2002, the EU committed itself to reduce emissions to 8% below 1990 levels by 2008-2012, allowing different national emissions target within the EU accounting for different income levels, country sizes and environmental attitudes (Borghesi, 2010).

The current policy action toward green Europe is the so-called 20-20-20 Climate and Energy Package. The EU aims to limit its 2020 greenhouse gas emissions to 20% below 1990 levels and to meet a 20% renewables target of total energy supply by 2020. The Package includes a 20% energy efficiency target and a biofuel target of 10% by 2020 (Hepburn et al., 2006). To meet these targets, governments in EU countries use a large variety of support instruments. The first part of the paper is then devoted to a critical review of the main international agreements to reduce climate change and their implementation in the EU environmental policy. The search for a consensus among EU governments is tricky since energy policies advocated by EU members differ (Nordhaus W.D., 2006).

The second part of the paper evaluates the range of strategies implemented in different EU countries to tackle climate change. The primary objective of these strategies is to increase the use of renewable energy in order to enjoy the environmental benefits and for energy security reasons (Held et al., 2006). The analysis reviews the EU climate-change package and the main policy instruments contained in it. We categorize policy instruments through the most frequently used typology, i.e. price-oriented or quantity-oriented (Dinica, 2006). Some of them are claimed to be more market friendly than others, while other schemes are claimed to be more efficient in promoting the development of renewable energy (Meyer, 2003). Currently, there is no general agreement on the effectiveness of each scheme. By analyzing the different schemes that have been used in EU Member States in order to achieve the 20-20-20 targets, the research takes into account the extent of financial support given by each EU member region by considering some exogenous factors, as the availability and distribution of renewable resources, and the institutional context. The strategies planned by governments imply different costs that might be prohibitive if other countries are not making comparable efforts.

Finally, the research highlights the problem of coordination among policy makers that undermine the achievement of the 20-20-20 Climate and Energy Package targets, using a theoretic model of Nordhaus (2009). It is well-known that EU countries should take complementary and coordinated actions to green themselves, by implementing their own national plan (Böhringer et al., 2009). Every country would want to spur new activities, new investment, more employment in its own territory, by using an appropriate mix of local taxation and subsidies, in conjunction with other command and control instruments. However, EU countries have the incentive to free-ride, or to impose as few costs as possible on their home economy while enjoying the benefits created at the other countries' cost (Barrett, 1994). So, the research highlight the formidable problems of opportunistic behavior and inefficient outcomes.

2. Energy and Environmental Policies

According to the projections of the Reference Scenario, which gives economic and environmental assessments of a world in which the economy continues on its current course without polluting emission reductions policies, energy demand should increase by 1.5% per year between 2007 and 2030 and fossil fuels remain the main sources of energy. They represent three quarters of global energy consumption during the same projection period and the dirtiest fuel, i.e. coal, is expanding its share to face the raising in energy consumption mainly driven by developing countries, such as China and India. Actually, non-OECD countries are the main drivers in the increase of energy demand as a result of their economic and population growth.

Renewable energies, including hydroelectric, geothermal, biomass, solar energy and wind energy, grow at a fast pace relative to electricity production, but their share in energy consumption is still low.

Country	Solids	Oil	Gas	Nuclear	Hydro	Biomass	Other
United States	23.7	38.9	23.0	9.3	0.9	3.5	0.7
EU-27 **	18.3	36.4	23,9	13.4	1.5	5.4	1.1
Japan	22.3	44.8	16.2	13.4	1.2	1.4	0.7
Russia	15.2	19.7	54.4	6.3	2.3	1.0	1.2
China *	65.6	18.2	3.1	0.8	2.1	9.9	0.2
India	40.8	23.7	5.6	0.7	1.8	27.2	0.3
Korea	25.3	42.5	14.0	16.8	0.1	1.2	0.0
Brazil	5.8	39.3	7.5	1.4	13.7	30.7	1.7
Canada	11.2	35.1	29.3	9.0	11.8	4.3	- 0.7
Mexico	4.9	56.9	27.4	1.5	1.3	4.5	3.5
Others	13.5	39.6	25.7	1.6	2.4	16.5	0.8
World	**26.5**	**34.0**	**20.9**	**5.9**	**2.2**	**9.8**	**0.7**

Table 1. Gross energy consumption by country (share, %). Source: Eurostat

Almost 18% of total electricity in 2007 was generated by renewable energy and, according to the Reference Scenario, it is supposed to rise to 22% in 2030. Actually energy production from renewables is more expensive than fossil fuel based technologies, and the reasons for such disadvantages are several. Methods used by economic engineering to evaluate cost-accounting of energy technology projects are outdated; as a consequence, renewable technology projects seems more expensive (Awerback, 2003). Moreover, it has to be taken into account that production costs of energy from fossil fuels do not internalize both the environmental and human health externalities. An higher penetration of renewable resources in the energy mix would lead to both environmental and economic benefits, as a reduction of polluting emissions and a mitigation of energy import dependency.

The concentration of greenhouse gases (GHG) in the atmosphere was at 438 parts per million (ppm) of CO_2 equivalent in 2008, that is almost twice the pre-Industrial Revolution level (IEA, 2009). Mostly of the world emissions originate from China and United States, which together produce about 12.1 Gt CO2 that is 41% of world CO2 emissions. The relation between GHG emissions and economic growth may be well understood through the Kaya identity, which express the CO2 emissions of the energy sector in terms of GDP, energy intensity of the output, and carbon intensity of energy consumption (Stern, 2007):

$$\text{Carbon Dioxide Emissions} = \text{population} \cdot \text{per capita GDP} \cdot \text{energy intensity} \cdot \text{carbon intensity}$$

From this identity it is clear that the increase in world GDP tends to increase global emissions, unless the increase in income does not stimulate a reduction in carbon intensity or total energy (Nakicenovic et al., 2006).

The contribution to global warming by countries is controversial. The United States represent the second largest CO_2 emitter. On the one hand, the high share of CO_2 emissions is related to the share of GDP that is the largest in the world. On the other hand, the United States generates at around 20% of global CO_2 emissions while the population is only 5% of the total world population. China produces 22% of world polluting emissions but it accounts for 20% of the population of the world (Kawase et al., 2006).

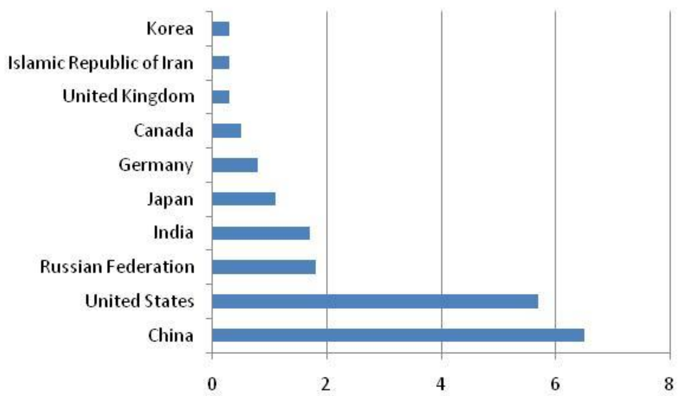

Figure 1. Top 10 emitting countries in 2008 (Gt CO_2). Source: IEA, 2010.

The sectors that contribute more on CO_2 emissions are transport and electricity and heat generation, that together account for two-thirds of global emissions in 2008 (IEA, 2010). The former represents 22% of CO_2 emissions in 2008 worldwide, and the World Energy Outlook 2009 projections reveal that the share is estimated to grow to 45% by 2030. Actually, the level of passengers travel is growing according to the population growth, and only the EU is encouraging fuel economy (as a response to the high fuel price as well) through voluntary agreement with manufacturers. Electricity and heat generation constitute the largest polluting sectors in 2008, by making a 41% contribution to the world CO_2 emissions in 2008, relying on carbon fuel, especially in developing countries such as China and India.

We deem imperative that a global response to face climate change is needed at the European level. The EU energy portfolio relies strongly on fossil fuels, and it has important consequences both in terms of "importing" CO_2 emissions and for energy security reasons.

Origin	2000	2001	2002	2003	2004	2005	2006	2007	Share 2007(%)
Russia	112.4	136.8	154.7	170.8	188.9	188.0	189.6	185.3	33.9
Norway	115.9	108.1	103.1	106.4	108.6	97.5	89.1	84.3	15.5
Libya	45.5	43.8	39.1	45.9	49.9	50.6	53.1	55.5	10.2
Saudi Arabia	65.1	57.5	53.1	61.5	64.5	60.7	51.1	39.4	7.2
Other, Middle East	54.7	48.2	43.2	27.8	28.5	29.9	32.5	34.4	6.3
Iran	33.5	31.4	25.9	34.7	35.9	35.3	36.3	34.1	6.3
Kazahkhstan	9.9	9.1	13.4	15.9	22.2	26.4	26.8	18.3	3.4
Nigeria	22.4	25.7	18.4	23.2	14.9	18.6	20.2	15.5	2.8
Other Origin	58.2	62.3	64.2	56.6	56.6	66.2	65.9	78.1	14.4
Total Imports	519.8	522.9	515.3	542.9	570.2	573.4	564.7	545.1	100

Table 3. Crude oil imports in the EU27 (in Mio tonnes). Source: Eurostat (2009)

Origin	2000	2001	2002	2003	2004	2005	2006	2007	Share 2007(%)
Russia	4539709	4421515	4554744	4895252	4951044	4952879	4937711	4685365	40.8
Norway	1985231	2136379	2601569	2699473	2801723	2671779	2844237	3061751	16.7
Algeria	2203075	1957181	2132477	2158803	2042137	2256826	2132236	1943976	16.9
Nigeria	172020	216120	217882	335929	410260	436319	563905	588317	5.1
Libya	33442	33216	25536	30390	47809	209499	321150	383615	3.3
Qatar	12443	27463	87952	80414	160170	195713	232721	275496	2.4
Egypt						202419	327394	221305	1.9
Trinidad and Tobago	36334	24498	19120	1365		29673	163233	104917	0.9
Other Origin	112810	199256	125425	100023	313245	409387	227147	213995	12.0
Total Imports	9095064	9015628	9764705	10301649	10726388	11364494	11749734	11478737	100

Table 4. Gas imports in the EU27 (in TJ). Source: Eurostat (2009)

	2000	2001	2002	2003	2004	2005	2006	2007	Share 2007 (%)
Total EU-27	151575	173041	171629	180360	196062	197043	213809	214358	100
Russia	14976	20875	23033	26545	40382	48304	55544	56117	26.2
South Africa	40177	49273	53961	56932	54190	51698	53080	46121	21.5
Australia	28600	29450	29337	31004	30838	27013	27147	29069	13.6
Colombia	23132	22633	21398	22908	24224	24147	26068	29018	13.5
United States	20447	20119	14082	12619	15416	15673	17370	20833	9.7
Indonesia	9097	10254	11540	13004	13980	14704	21092	17594	8.2
Other	15146	20437	18278	17348	17032	15504	13508	15606	7.3

Table 5. Coal imports in the EU27 (in Kilotonnes). Sources: Eurostat (2009)

The global response to climate change started with the so called Rio Earth Summit in 1992: governments realized the need to work together for an environmental and sustainable economic development. The Summit was a first move towards an environmental policy at global level, by setting the emission reduction targets for developed countries and establishing a framework of wider reduction for the future from a sustainable development point of view. Its weak point was that the Summit promised a lot at little costs, since it was an agreement without stringent measures (Helm, 2008). The Summit has been followed by several discussions with the purpose of finding optimal shared environmental policy for facing climate change.

Afterwards, the Kyoto Protocol, an international agreement adopted in Kyoto on December 1997, has committed (instead of encouraging) 37 industrialized countries and the European Union (EU) to reduce a basket of six greenhouse gases. The Kyoto Protocol entered into force in February by committing contracting parties as a group to achieve an overall reduction in polluting emissions of 5% in the period 2008-12 with respect to 1990 levels(IEA, 2010). The Protocol has helped sensitize public awareness of problems related to climate change. Despite the Protocol has detailed commitment for each country member in terms of GHG reductions, it is limited in its potential to climate change mitigation since not all major emitters as United States were included in reduction commitments. In March 2001, the United States explicitly declared their non-participation in the Kyoto Protocol, because of the too high potential compliance costs and the domestic voters' low willingness to pay (Böhringer and Vogt, 2004).

	1990	**2008**	**% change 90-08**	**Kyoto Target**
Kyoto Parties with targets	**8 858.3**	**7 980.1**	**-9.2%**	**-4.7%**
North America	432.3	550.9	27.4%	
Canada	432.3	550.9	27.4%	-6%
Europe	3 153.6	3 222.9	2.2%	
Austria	56.5	69.3	22.7%	-13%
Belgium	107.9	111.0	2.8%	-7.5%
Denmark	50.4	48.4	-4.0%	-21%
Finland	54.4	56.6	4.0%	0%
France	352.3	368.2	4.5%	0%
Germany	950.4	803.9	-15.4%	-21%
Greece	70.1	93.4	33.2%	+25%
Iceland	1.9	2.2	17.0%	+10%
Ireland	29.8	43.8	46.7%	+13%
Italy	397.4	430.1	8.2%	-6.5%
Luxembourg	10.5	10.4	-0.6%	-28%
Netherlands	155.8	177.9	14.1%	-6%
Norway	28.3	37.6	33.0%	+1%
Portugal	39.3	52.4	33.5%	+27%
Spain	205.8	317.6	54.3%	+15%
Sweden	52.8	45.9	-13.0%	+4%
Switzerland	40.7	43.7	7.4%	-8%
United Kingdom	549.3	510.6	-7.0%	-12.5%
Pacific	1 346.6	1 582.0	17.5%	
Australia	260.1	397.5	52.9%	+8%
Japan	1 064.4	1 151.1	8.2%	-6%
New Zealand	22.0	33.3	51.5%	0%
Economic in Transition	3 852.9	2 624.3	-31.9%	-6%
Other Countries (non-participating)	**11 566.6**	**20 368.2**	**76.1%**	
United States	4 868.7	5 595.9	14.9%	-7%
China	2 244.4	6 550.5	191.9%	
Latin America	869.5	1 476.5	69.8%	none
Africa	545.6	889.9	63.1%	none
Middle East	592.5	1 492.3	151.8%	none
Non-OECD Europe	106.1	92.2	-13.1%	none
Asia (excl. China)	1 510.1	3 521.1	133.4%	none
WORLD	**20 964.8**	**29 381.4**	**40.1%**	

Table 6. World CO_2 emissions from fuel combustion and Kyoto targets. Source: IEA, 2010.

The European Community has taken part in the Kyoto Protocol through a positive measure. Between 2008 and 2012, countries that were already European Union (EU) members, have to cut 8% off GHG emissions. Countries that have joined EU later undertake to cut emissions for the same amount, apart from Poland and Hungary (6%). Kyoto Protocol suggests tools of action: strengthening of national policies to reduce emissions, as improvement of energy efficiency, promotion of sustainable forms of agriculture, development of renewable energies etc.; cooperation with other contracting parties, as exchange of experience and information, coordination of national policies through the right to emit.

During the period 1990-2007 the European Commission has recorded emission reductions as follows: 7% in the energy sector; 11% in the industrial process; 11% in agriculture (reduced use of mineral fertilizers); 39% in the waste sector.

The EU results should be interpreted not only in the light of Kyoto and all following agreements. The emission reductions are likely to be attributed to two factors as well: the global economic and financial crisis that has reduced industrial production, and the new member States entered in the European Union that have decreased on average the EU level of emissions because of their less productive economies.

2.1 The European climate and energy package

Actually, the European environmental and energy policy is represented by the so-called "20-20-20 Climate and Energy Package", through which the EU is showing to be ready to assume the global leadership to face climate change, tackle the challenges of energy security, making Europe a model of sustainable development for the 21st Century. The EU aims to achieve by 2020:

- a commitment to reduce by at least 20% greenhouse gas emissions compared to 1990 levels by 2020, and the goal of reducing emissions by 30% by 2020 if other developed countries make comparable efforts;

- a binding target for the EU of 20% of energy from renewable sources by 2020, including a target for biofuels.

The 20-20-20 Package, introduced in 2008 through the Communication (COM(2008)30), answers to the call made by the European Parliament about real measures for the transition toward a sustainable development. The Package includes a number of important policy proposals closely interlinked:

- a revised directive on the EU Emission Trading System (EU ETS);

- a proposal on the allocation of efforts by member states in order to reduce GHG emissions in sectors not covered by the EU ETS (as transport, building, services, small industrial plants, agriculture and food sectors);

- a directive on the promotion of renewable energy to achieve the goals of GHG emission reductions.

The EU ETS scheme has been a pioneering instrument prior to the 20-20-20 Climate and Energy Package. It is a market instrument that has been already implanted in the US quite successfully, and it has been introduced in Europe in 2003 in order to find market solutions to encourage firms cutting GHG emissions. The Cap and Trade system set a maximum amount of emissions per period (2005-07 and 2008-12) per country. Then, each country establishes a national emission scheme and it allocates to firms the emission allowances which could be traded between the companies covered by the scheme. Once the emission permits are allocated, firms can trade them within the EU according to their criteria of economic efficiency. In the first and second ETS trading periods (2005-2012), mostly of the EU permits are allocated for free.

The importance of the EU ETS scheme is that it has been able to create a market and an artificial price for a public good as clean air. Thus, firms covered by the EU ETS have to face costs when emitting CO_2 emissions: on the one hand, a firm that needs for its activity more permits than those at its disposal faces the cost of purchasing them. On the other hand, opportunity costs arise because permits could be sold in case of non-production. The 20-20-20 Climate and Energy Package has modified the Emission Trading Scheme through the Directive 2009/29/EC and it will enter into force from 2013 to 2020, in order to overcome the application problems that rose during the first few years of its application. The first problem is related to the EU allocation mechanism that have been used so far. Emission permits have been allocated for free, the allocation could be done on the basis of historic emissions, that is grandfathering. This mechanism may create vicious circle since it does not spur adoption of new technologies with a low environmental impact. Moreover, it favors large firms that at the first stage receive many permits to preserve their activity level over the small firms.

Another problem is related to the inconsistencies between the emission permits and the National Allocation Plan: governments have created too many emission permits to protect the welfare of the firms operating in the country who wanted to receive as more permits as possible.

Finally, the large and persistent fluctuations of the market price have created havoc in the market and uncertainty on the goodness of the environmental policy.

In this direction, a research carried out by Hesmondhalgh et al. (2009) shows how different factors may influence CO2 prices, as it is shown in the following table.

Factor	**Effect on CO_2 prices**
Higher than expected economic growth	*Upward* - increased demand for allowances
Coal prices fall relative to gas prices	*Upward* - increased demand for allowances
International agreement on abatement post-2012	*Upward* — EU will tighten cap on emissions
Failure to meet renewables and/or energy efficiency targets	*Upward* — increased demand for allowances
Overall fuel prices	*Uncertain* — lower prices may increase energy demand but will mitigate effect of fuel price differentials and vice versa for higher prices
Economic downturn	*Downward* — reduced demand for allowances
Coal prices rise relative to gas prices	*Downward* — reduced demand for allowances

Table 7. Potential influences on CO_2 prices. Source: Hesmondhalgh et al. (2009)

The main elements of the reformed Emission trading Scheme are:

- a new emission cap set at 20% below with respect to the 2005 levels by 2020;
- the use of credits from the Clean Development Mechanisms and Joint Implementation is limited to 50% of the overall EU emission reductions in the period 2008-2020;

- inclusion of new sector as aviation and aluminium sector;
- firms operating in the electricity sector are obliged to acquire 88% of emissions allocated to each installation through the auction mechanism; 10% of permits is redistributed from countries with higher per capita income to the one with lower per capita income and the remaining 2% is given to member States that successfully reached the 20% GHG reduction target in 2005 (i.e. the East European Countries).

The adoption of the auction mechanism in the EU ETS means a better distributional effect compared to grandfathering, because government entries generated by auctioning may be used both to reduce distortionary taxes and to promote research and development (R&D) activities in clean technologies.

The Directive on renewable energies to reach the target of 20% on energy consumption by 2020 shares the burden between Member States. In particular, 50% of this effort has to be shared equally between Member States, while the other 50% is modulated according to GDP per capita. Moreover, the objectives are modified to take into account a proportion of the efforts already made by Member States which have increased the share of renewable energy fuels in recent years.

The promotion in the European Union of the electricity production based on renewable energy sources takes place in an energy market that is more and more competitive, since 1996 when the Council of Ministers reached an agreement on the Directive specifying the rules for electricity liberalization in EU.

On the basis of the experience from electricity liberalization around the world, the goal of the European Union is to achieve higher efficiency and lower consumption prices by introducing conditions of intensified commercial competition, but it is quite hard for firms that produce energy from renewable resources to compete within the energy industry that produce energy mainly from fossil fuel.

Governments in EU countries use a large variety of instruments to stimulate the adoption of renewable energies; there are different schemes implemented by the European Union in order to use renewable energies and make them competitive on the energy market (Espey, 2001). The fundamental distinction that can be made among the European support mechanisms is between direct and indirect policy instruments. Basically, direct instruments stimulate the installation of energy from renewable resources immediately, while indirect policy measures focus on improving long-term framework conditions. There exist also voluntary approaches; this type of strategy is based on the consumers' willingness to pay premium rates for renewable energy, like donation projects and share-holder programs. The important classification criteria are whether policy instruments are price-oriented or quantity-oriented. With the regulatory price-driven strategies, financial support is given by investment subsidies, soft loans or tax credits. Economic support is also given as a fixed regulated feed-in tariff (FIT) or a fixed premium that governments or utilities are legally obliged to pay for renewable energy produced by eligible firms. Among the price-oriented policy, the most used within the European members is the Feed-in Tariff. The Feed-in Tariff is a price-driven incentive in which the supplier or grid operators are obliged to buy electricity produced from renewable sources at a higher price compared to the price they pay for energy from fossil fuel. The criticisms made to the feed-in tariff scheme underline that a system of fixed price level is not compatible with a free market. Moreover, these favorable tariffs generally do not decrease with the improvements of the efficiency of the technologies that produce green energy (Fouquet and Johannson, 2008). A particular kind of feed-in tariff model used in Spain consist in a fixed premium, in addition to the market price for electricity, given to the producers relying on renewable energy sources. Also in this case, premiums should be adjusted in accordance with the performance of the different technologies.

With regard to the regulatory quantity-driven strategies, the desired level of energy generated from renewable resources or market penetration is defined by governments. The most important are the tender system and the tradable certificate system. In the tender system, calls for tender for defined amounts of capacity are made at regular interval, and the contract is given to the provider that offer the lowest price. The winners of the tenders are getting a fixed price per kWh for the period of the contract and the contract offers winner several favorable investment conditions; this system is in a sense quite close to the feed-in tariff model. In the tradable certificate system, firms that produce energy are obliged to supply or purchase a certain percentage of electricity from renewable resources. Then, at the date of settlement, they have to submit the required number of certificates to demonstrate compliance. The firms involved in the tradable certificate system can obtain certificate from their own renewable electricity generation; they may as well purchase renewable electricity and associated certificates from another generator, or they can purchase certificates that have been traded independently of the power itself.

		Direct		**Indirect**
		Price-driven	**Quantity-driven**	
Regulatory	Investment focussed	- Investment incentives	Tendering system	Environmental taxes
		- Tax incentives		
	Generation based	- Feed-in tariffs	Tendering system and Quota obligation based on TGCs	
		-Rate-based incentives		
Voluntary	Investment focussed	- Shareholder programmes		Voluntary agreements
		- Contribution programmes		
	Generation based	- Green tariffs		

Table 8. Classification of promotion strategies. Source: Held et al., 2006.

The economic incentives for renewable resources differ among the EU members. In Germany, the main electricity support scheme is represented by a price-driven incentive, the feed-in tariff. The main features of the German support mechanism are stated in the Renewable Energy Source Act of 2000. The Act establishes that the feed-in tariffs are not dependent on the market price of energy but are defined in the law and that the feed-in tariff are different for wind, biomass, photovoltaic etc. Moreover, the feed-in tariffs are decreased over the years in order to take into account the technological learning curves (Petrakis et al., 1997).

The United Kingdom was the first European country to pursue liberalization in the electricity market by the end of 1998. In UK, energy from renewable resources is supported by quantitative-driven strategies. Over the last decades, the scheme adopted by UK was the tender system, but, since 1999, the system in use is a quota obligation system with Tradable Green Certificates. The obligation (based in tradable green certificate) target increases during years, and electricity companies that do not comply with the obligation have to pay-out penalties.

In Denmark the support schemes are mainly related to the wind power sector. To implement renewable resources, the strategy adopted is price-driven, that is a premium feed-in tariff for on-shore wind, and fixed feed-in tariffs for the other renewable resources.

In France, the strategy adopted is mainly price-oriented; the electricity support schemes are feed-in tariffs plus tenders for large projects.

Italy has not a significance experience in producing energy from renewable resources with the exception of large hydro. Several factors obstruct the development of renewables in Italy, as administrative constraints and high connection costs. During the 1990s, the energy sector in Italy was entirely restructured in order to introduce competition, as set by the EU Directive 96/02/EC (Lorenzoni, 2003). The promotion of electricity produced from renewables has taken place through support schemes as the quota obligation system and feed-in tariff. Concerning wind energy, in 2002 the Italian government abandoned the feed-in-tariff, introducing the quota obligation system with tradable green certificates. Under this certificate system, electricity producers and importers are obliged to source an increasing proportion of their energy from renewable resources. Green certificates are used to fulfill this obligation. Italy has adopted a ministerial measure that balances supply and demand in order to tame speculative fluctuations on the value of green certificates.

The recent literature argues that EU ETS mechanism and the promotion of renewable energies may lead to different results (Carraro et al., 2006). While the EU ETS could be interpreted in the light of the "polluter pays principle", which requires the cost of pollution to be borne by those who cause it, the implementation of renewable energies aims at eliminating GHG emissions (Borghesi, 2010). Keeping constant the supply of emission permits, the implementation of renewables may lead to a decrease in emission permits' demand and thus their price without generating a significant GHG emissions reduction. Assuming that to be true, the two instruments should be substitutes instead of complements, unless government reduce the supply of permits on the long run. Government involvement is essential to spur the use of renewable energies, since the EU energy consumption is still heavily based on fossil fuels.

The main advantage of renewable sources with respect to fossil fuels is that they contribute to mitigate climate change. The liberalization of the electricity market may appear as a partial response to climate change since it allows consumers to purchase cleaner electricity directly from suppliers. Anyway, most consumers are not willing to pay higher prices for green electricity since they are burdened with higher prices to preserve a public good (i.e. clean air) which everyone benefits from. Consequently, the proportion of renewable sources in the energy portfolio is low, unless there are governments subsidies (Carraro and Siniscalco, 2003).

Actually, subsidies are needed because fossil fuel prices do not fully internalize environmental damages to society. In fact, polluting emissions create a damage to society; without a price system, firms face a suboptimal opportunity cost for pollution and this leads to a wrong amount of pollution (Grimaud and Rougé, 2008). Since the right level of pollution will not emerge in a spontaneous way, government must increase pollution cost by raising a tax, in order to reduce pollution generation. If the tax is at the optimal level, it is called a Pigouvian tax. The optimal amount of pollution is the amount that minimizes total costs from producing one more unit of pollution and total damages from pollution. Thus, the condition that marginal cost (or marginal saving) equals to marginal damage leads to the generation of the right amount of emissions. This is the main idea of the Pigouvian tax: "A Pigouvian fee is a fee paid by the polluter per unit of pollution exactly equal to the aggregate marginal damage caused by the pollution when evaluated at the efficient level of pollution. The fee is generally paid to the government" (Kolstad, 2000). Note that the Pigouvian tax is also equal to the marginal cost from pollution generation at the optimal level of pollution. The difficulty for the government to levy a Pigouvian fee is that there are reasons why it is not feasible. First of all, it is not easy to quantify marginal damage. The number of activities and the number of people affected by pollution are so great that it is quite hard to came up with monetary estimation of damage from pollution. Moreover, the optimal tax level on polluting emissions is not equal to the marginal net damage that the polluting activity generates initially, but to the damage it would cause if the level of the activity had been adjusted to its optimal level (Baumol and Oates, 1971). If we are not at the optimum, the Pigouvian tax will be neither the marginal cost of pollution nor the marginal damage from pollution.

Basically we can say that in a perfect environment, like an economy in which there is perfect information and no constraints on the government tax policy, the Pigouvian tax is only necessary to achieve efficiency. If there are other distortions in the economy or limitation for the social planner, then other taxes and subsidies are needed to achieve efficiency (Sandmo, 1976).

Incentive systems are needed to stimulate technical change so that renewable energies lower future production costs. The reasons often put forward are the learning by doing effects from the production of energy from renewable resources on the cost of future production. The main idea is that a critical mass of production has to be reached first, and then costs will be reduced thanks to research and development activities (Fundenberg and Tirole, 1983).

The reasons related to the implementation of renewable energy does not lie only in the mitigation of climate change. There are also political reasons related to the energy security issue. Nowadays, energy security does not mean anymore protecting existing energy supplies. The political instability of the Organization of the Petroleum Exporting Countries (OPEC) countries has a strong impact on the global energy markets by leading to supply shortage in importing countries, as the recent conflict in Libya has shown.

The implication of energy policy measures are thoughtful: economic efficiency and political interests may conflict in climate change policies, especially when there are costs imposed in the future (Helm, 2008).

3. The model

Within the bounds of the 20-20-20 Climate and Energy Package, each Member State should work to support competition in energy markets and harmonize shared rules at European level. From the Package it is clear that Member States could take different mechanisms to reduce GHG emissions and implement renewable energies in the portfolio energy mix. Most countries have chosen the feed-in tariff scheme, while the minority has implemented green certificates. Assessment that results both on the effectiveness and costs of different mechanisms are quite controversial (Dinica, 2006). The availability and quality of renewable energies differ among countries: two countries may offer the same support scheme but they face heterogeneous quality of the energy resource. It translate in different production costs incurred by renewable energies that lead to misleading evaluations of the support instruments. Moreover, support mechanisms are implemented in different economic context which can then bring dissimilar results.

During the last three years the estimated costs to reach the 20/20/20 target have been reduced: in 2007, before the economic and financial crisis started, costs to reach the Climate and Energy Package goals were estimated at around 70 billion euro; nowadays, by taking into account the economic recession, costs estimates have lowered to 48 billion euro (i.e. 0.32% of EU GDP in 2020). The lower costs are due to several factors, including the reduction of world energy consumption due to economic and financial crisis and the rising in oil prices.

In the forecast costs of climate change will probably vary upward according to the economic recovery, which should also serve as a stimulus to the global energy investment, essential to develop technologies with low environmental impact and increase energy efficiency.

The implementation of less high carbon technologies, such as wind and solar energies furthers the time horizon of the target to 2020. The costs related to the 20-20-20 Climate and Energy Package have to be mainly supported by customers and taxpayers, and such costs are higher if not all Member States make comparable efforts (Böhringer et al. 2009). There exists the incentive to free-ride by EU regions, or to impose as few costs as possible on their home economy while enjoying the benefits created at the other countries' cost, as demonstrated by a fair chunk of literature (Helm, 2008; Kemfert, 2003; Haas et al., 2004).

An interesting research made by Nordhaus (2009) analyzes, at global level, the impact of non participation on the costs of slowing global warming. He assesses the economic impact that arises when some countries do not take part in the agreement to mitigate climate change through a functional form for the cost function that allows to estimate nonparticipation costs. In particular, the author assumes that a subset of countries will reduce CO_2 emissions according to the Kyoto Protocol and the rest does not undertake any emission reductions. By varying the number of participating countries to the agreement, the cost of participation varies. The approach of Nordhaus is based on the of CO_2 abatement cost function. In the case of 100% participation, the cost function is:

(1) $C_t = Y_t \alpha_y e_t^{\beta}$;

where C_t is the average cost, Y_t is the total output of CO_2 emissions, e_t is the emission reduction rate, α is a fixed cost parameter and β is a fixed parameter. The author defines as σ_t the share of worldwide emissions for a fraction of countries that takes part in the climate agreement. The emission reduction rate e_t is equal zero for the non participating countries, while is equal e_t^P for the participants.

By taking into account that some countries do not join the agreement, the abatement cost of participation C_t^P is:

$$C_t = C_t^P = Y_t^P \alpha_t (e_t^P)^{\beta}.$$

The overall emission reduction rate is:

$$e_t = e_t^P \sigma_t,$$

and the output of participating countries is:

$$Y_t^P = Y_t \sigma_t.$$

By substituting the equations above in the participation function (1), Nordhaus gets:

$$C(t) = Y_t \sigma_t \alpha_t \left[\frac{e_t}{\sigma_t} \right]^{\beta}$$, that is

(2) $C(t) = Y_t \alpha_t e_t^{\beta} \sigma_t^{1-\beta}$.

Equation (2) is the participation cost function that shows how the non participation affects the costs.

By comparing this equation with the cost of abatement of CO2 with 100% participation, it turns out that the incomplete participation rises abatement costs by a penalty factor $\sigma_t^{1-\beta}$.

The inefficiency produced by non participation is an exponential function of the parameter $(\beta - 1)$, that is the convexity of the marginal cost of abatement. If marginal costs are constant, then $(\beta - 1)$ equals zero and the cost-penalty factor is zero as well. Otherwise, if marginal costs rises with emission abatement (as it is shown by most empirical studies), then the parameter $(\beta - 1) > 0$ and non-participation is costly.

Nordhaus estimates the cost of nonparticipation by dividing the world into two groups of countries, i.e. participants and nonparticipants, in the manner of the Kyoto Protocol. Participants have a carbon price while nonparticipants face a zero price for carbon emissions.

We do a similar analysis framed inside the European context that is EU's 27 Member States (EU27), and the climate change agreement is the 20-20-20 Climate and Energy Package. We divide the EU in two groups, the old and the new member States (EU 15 and EU 12). Such division reflects both the contribution to CO_2 emissions and the economic trend that is very low for EU12 countries compared to the old member States. As Nordhaus' study, we take the parameter value $(\beta - 1) = 1.8$ for the estimates below; that value is sustained also by other models (Holtsmark and Mæstad, 2002; Nordhaus, 1991).

The following examples illustrate how participation affects costs to pursue the climate change policy goals. Table 9 lists the EU27 member States as ranked by 2007 energy CO_2 emissions (Eurostat, 2009). The top four countries generate 53% of total EU emissions, and by including the old member states, i.e. EU15 countries, one gets 82% of emissions.

		Emissions		
Rank	**Country**	**Millions of tons of carbon**	**Share of EU-27 (%)**	**Cumulative share of EU-27 total (%)**
EU15				
1	Germany	876	19.5	19.5
2	United Kingdom	585	13.0	32.5
3	Italy	493	10.9	43.4
4	France	424	9.4	52.8
5	Spain	404	9.0	61.8
6	Netherlands	235	5.2	67.0
7	Belgium	149	3.3	70.3
8	Greece	127	2.8	73.1
9	Austria	76	1.7	74.8
10	Finland	69	1.5	76.3
11	Portugal	67	1.4	77.7
12	Sweden	61	1.3	79
13	Denmark	59	1.3	80.3
14	Ireland	51	1.1	81.4
15	Luxembourg	13	0.3	81.7
EU12				
1	Poland	330	7.3	89
2	Czech Republic	131	2.9	91.9
3	Romania	112	2.5	94.4
4	Bulgaria	60	1.3	95.7
5	Hungary	58	1.3	97.0
6	Slovakia	38	0.8	97.8
7	Estonia	20	0.4	98.2
8	Slovenia	17	0.3	98.5
9	Lithuania	16	0.3	98.8
10	Cyprus	10	0.2	99.0
11	Latvia	9	0.2	99.2
12	Malta	5	0.1	99.3

Table 9. EU27 Member States by share of global CO2 emissions, 2007. Source: Eurostat (2009)

We assume that the exponent parameter is $(\beta - 1) = 1.8$ and then we calculate the cost penalty that arises from incomplete participation to Climate and Energy Package. Using equations (1) and (2) that are respectively the cost function with 100% participation and the cost of incomplete participation, we calculate the ratio of the cost of achieving a policy with partial participation with respect to the cost with EU27 participation. Table 10 illustrates the results of the calculations.

Participants	EU participation rate (% of EU27 emissions)	Associated cost penalty (% of cost of EU27 participation)
Big 4 only (EU15)	53	213
Big 7 only (EU 15)	70	90
EU 15 (old member States)	82	25

Table 10. Estimates of the penalty from limiting participation in EU 20-20-20 Climate and Energy Package. Source: Eurostat (2009), Nordhaus (2009).

Table 10 shows that limiting participation to the four big emitters that are Germany, United Kingdom, Italy and France would cover about half of EU emissions (precisely 53%). The cost penalty factor associated to this partial participation would be 3.14 (that is $0.53^{-1.8}$), which means that achieving the EU 20-20-20 goals would cost around four times as much (213%) if the Energy Package were limited to these member States. By including all the EU15 old member States would cover 82% of emissions and this would lead to a cost penalty of 25%.

From these calculations, it is quite straightforward that limiting participation produce inefficiencies by rising the costs for the participating countries. The reason for high cost penalty from partial participation is related to the convexity of the marginal cost function expressed by the exponential parameter $(\beta - 1)$ that is higher than zero. It means that at the very beginning there are substantial reductions of CO_2 at quite low cost, but the marginal cost of additional reductions rises as the reduction rate rises. This convexity implies that significant EU emission reductions could be achieved at a low cost if all EU 27 member States participate to the 20-20-20 Climate and Energy Package.

The reasoning above is quite intuitive: if many countries do not participate in a treaty, the cost penalty is high, because the emission reduction target hardly could be achieved. As Nordhaus says: "..there are low-hanging fruits all around the world, but a regimen that limits participation to the high-income countries passes up the low-hanging fruit in the developing world".

We think that European Member States must then take coordinated actions to reach the 20-20-20 goals by implementing national policies at national level. Clearly, EU12 has to put a minor effort in the agreement: they emit less as a consequence of their macroeconomic context, but in the long run they have to de-couple economic growth and CO2 emissions.

4. Conclusions

The European Union (EU) has undoubtedly made a big effort in developing a progressive environmental policy, but many of its own policies are still far from making a difference to climate change. The policy into action to "green" Europe is the so-called 20-20-20 climate and energy package. The 20-20-20 Package, introduced in 2008 through the Communication (COM(2008)30), answers to the call made by the European Parliament about real measures for the transition toward a sustainable development. The Package includes a number of important policy proposals closely interlinked, that are: a revised directive on the EU Emission Trading System (EU ETS); a proposal on the allocation of efforts by member states in order to reduce GHG emissions in sectors not covered by the EU ETS (as transport, building, services, small industrial plants, agriculture and food sectors); a directive on the promotion of renewable energy to achieve the goals of GHG emission reductions.

So far, a large strand of literature on climate change states that we need several economic policy instruments to correct for existing types of market failures, for instance, an environmental tax on carbon emissions and a research subsidy for research and development (R&D) spillovers in the renewable energy sector (Cremer and Gahvari, 2002). Policy instruments implemented to these aims are generally classified as price-oriented or quantity-oriented. Some of them are claimed to be more market conform than others, while other schemes are claimed to be more efficient in promoting the development of renewable energy (Meyer, 2003). Currently, there is no general agreement on the effectiveness of each scheme. Evidently, every region would want to spur new activities, new investment, more employment in its own territory, by using an appropriate mix of local taxation and subsidies, in conjunction with other command and control instruments. However, EU regions have the incentive to free-ride, or to impose as few costs as possible on their home economy while enjoying the benefits created at the other countries' cost. So, there are formidable problems of opportunistic behavior and inefficient outcomes.

We have examined the economic impacts that arise when some countries do not participate in the 20-20-20 Climate and Energy Package, through a model of Nordhaus (2009) that we have adapted to the European context. We study the costs of reaching EU energy and environmental targets where there is limited participation. From our calculation, we show that limiting participation produce inefficiencies by rising the costs for the participating countries to the agreement. The reasoning is quite intuitive: if many countries do not participate in a treaty, the cost penalty is high, because the emission reduction target hardly could be achieved.

To conclude, the 20-20-20 Climate and Energy Package requires simultaneous and coordinated action. Both politically and institutionally the EU Member States (EU15) are quite heterogeneous, and the old member States have a bigger responsibility in attempting to de-couple economic growth and CO_2 emissions since EU15 are the big emitters. Unless cooperation is sustained by institutions which can punish free-riding, every region will earn even higher profits by free-riding on the virtuous behavior of the remaining cooperators.

References

Awerbach S., 2003. Does renewables cost more? Shifting the grounds of debate. *Presentation at the Sonderborg on Renewable Energy – Renewable Energy in the market: New Opportunities,* Sondenborg, Denmark, September 2003

Barrett S., 1994. Self-Enforcing International Environmental Agreements. *Oxford Economic Papers, Special Issue on Environmental Economics*, Vol.46, pp.878-894

Baumol William J., Oates Wallace E., 1971. The Use of Standard and Prices for Protection of the Environment, *The Swedish Journal of Economics*, Vol.73, No.1, pp. 42-54

Borghesi S., 2010. The European Emission Trading Scheme and Renewable Energy Policies: Credible Targets for Incredible Results? *Nota di Lavoro 141.2010, Fondazione Eni Enrico Mattei*

Böhringer C., 2009. Strategic partitioning of emission allowances under the EU Emission Trading Scheme. *Resource and energy economics*, Vol.31, No.3. pp. 182-197

Böhringer C., Löschel A., Moslener U., Rutherford T., 2009. EU climate policy up to 2020: An economic impact assessment. *Energy Economics*, Vol.31, pp.295-305

Böhringer C., Vogt C., 2004. The Dismantling of a Breakthrough: the Kyoto Protocol – Just Symbolic Policy. *European Journal of Political Economy*, vol.20, no.3, pp.597-617

Carraro C., Eychmans J., Finus M., 2006. Optimal transfers and participation decisions in international environmental agreements. *The Review of International Organization*, Vol.1, pp.379-396

Carraro C., Siniscalco D., 1993. Strategies for the International Protection of the Environment. *Journal of Public Economics*, Vol.52, pp.309-321

Cremew H., Gahvari F., 2002. Imperfect Observability of Emissions and Second-best Emission and Output Taxes, *Journal of Public Economics*, Vol. 85, no. 3, pp. 385-407.

Dinica V., 2006. Support systems for the diffusion of renewable energy technologies – an investor perspective. *Energy Policy*, Vol.34, pp.461-480

Espey S., 2001. Renewables portfolio standard: a means for trade with electricity from renewable energy sources?, *Energy Policy*, Vol. 29, pp. 557-566

Eurostat – European Commission, 2009. Europe in figure. Eurostat yearbook 2009. *Eurostat Statistical Books*, Luxembourg.

Fouquete D., Johannson T., 2008. European renewable energy policy at crossroads—Focus on electricity support mechanisms. *Energy Policy*, Vol.36, No.11, pp. 4079-4092

Fundenberg D., Tirole J., 1983. Learning-by-Doing and Market Performance, *The Bell Journal of Economics*, Vol 14, No. 2, pp. 522-530.

Grimaud A., Rougé L., 2008. Environment, directed technical change and economic policy. *Environmental and Resource Economics*, Vol.41, No.4, pp. 439-463.

Haas, R.; Eichhammer, W.; Huber, C.; Langniss, O.; Lorenzoni, A.; Madlener, R.; Menanteau, P.; Morthorst, P.-E.; Martins, A.; Oniszk, A., 2004. *How to promote renewable energy systems successfully and effectively*. *Energy Policy*, Vol.32, No.6, pp.833-839

Held A., Haas R., Ragwitz M., 2006. On the success of policy strategies for the promotion of electricity from renewable energy sources in the EU. *Energy & Environment*, Vol. 17, No. 6, pp. 849-868

Helm D., 2008. Climate-change policy: why has so little been achieved? Oxford Review of Economic Policy, vol.24, no.2, pp.221-238

Hepburn C., Grubb M., Neuhoff K., Matthes F., Tse M., 2006. Auctioning of EU ETS phase II allowances: how and why? *Climate Policy*, Vol.6, pp.137-160

Hesmondhalgh S., Browun T., Robinson D., 2009. EU Climate and Energy Policy to 2030 and the Implications for Carbon Capture and Storage. The Battle Group, 2009

Holtsmark B., Mæstad O., 2002. Emission trading under the Kyoto Protocol—effects on fossil fuel markets under alternative regimes. *Energy Policy*, Vol.30, No.2, pp. 207-218.

Kawase R., Matsuoka Y., Fujino J., 2006. Decomposition analysis of CO_2 emission in long-term climate stabilization scenarios. *Energy Policy*, Vol.35, No.15, pp.2113-2122

Kemfert C., 2004. Climate coalitions and international trade: assessment of cooperation incentives by issue linkage. *Energy Policy,* Vol.32, No.4, pp.455-465

Kolstad Charles D., 2000. Environmental Economics, *Oxford University Press*, ISBN -19-511954-1.

IEA, 2010. CO2 emissions from fossil fuel combustion - Highlights. International Energy Agency, Paris, 2010 edition

Lorenzini A., 2003. The Ialian Green Certificates market between uncertainty and opportunities, Energy Policy, Vol.31, pp. 33-42.

Morthorst P.E. (2008). Wind Energy – the Facts. The Economics of Wind Power, World Wind Energy Association

Nakicenovic N., Kolp P., Riahi K., Kainuma M., Hanaoka T., 2006. Assessment of emissions scenario revisited. *Environmental Economics and Policy Studies*, vol. 7, no. 3, pp. 137-173

Nordhaus W.D., 1991. The cost of slowing climate change: a survey. *The Energy Journal*, Vol.12, No.1, pp.37-66

Nordhaus W.D., 2006. After Kyoto: Alternative Mechanisms to Control Global Warming. *The American Economic Review*, Vol.96, No.2, pp.31-34

Nordhaus W.D., 2009. The impact of Treaty nonparticipation on the Costs of Slowing Global Warming. *The Energy Journal*, Vol.30, Special Issue No.2, pp.39-52

Petrakis Emmanuel, Rasmusen Eric, Roy Santanu, 1997. The Learning Curve in a Competitive Industry, *The RAND Journal of Economics*, Vol.28, No.2, pp. 248-268.

Sandmo A., 1976. Direct versus Indirect Pigovian Taxation, *European Economic Review*, Vol.7, pp. 337-349

Stern N., 2007. The Economics of Climate Change: The Stern Review. Cambridge University Press