Expectations towards reality:
how renewable sources can help Europe to meet its Kyoto target

by

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1. Premises

Many actions have been launched to implement the new Framework Program, accounting for a global financing of Euro 95 billion (1997-2010). The Framework Program for action in the Energy Sector (1998-2000) is trying to meet the following three main targets:

- security of energy supplies
- competitiveness
- environmental protection

year	**Energy Production** (Mtoe)	**TPES/GDP** (toe/1.000US$'90)	**TPES** (Mtoe)
1967	337,62	0,221	755,60
1970	408,12	0,254	1015,07
1977	519,42	0,235	1164,14
1980	584,31	0,227	1217,90
1987	735,37	0,209	1280,64
1990	711,08	0,197	1328,36
1997	766,97	0,189	1421,18

Table 1. *Indicators for the 15 EU countries.*

As it is clear from the above illustrated Table, the production of energy in the EU 15 is increasing and it is more than doubled in the last forty years. This is to accomplish the augmenting in energy demand for the increase in income, goods consumption and technology depending on electricity. The Total Primary Energy Sources has increased as well to almost the double. The decreasing in energy intensity is instead especially given by the change in the sector composition of economy and advancements in technology which justify a higher efficiency.

In the renewable energy sources sector the European Community has prepared the White Paper (EC 1997) to lay down a strategy and action plan for the future. The White Paper follows on from the discussion stimulated by the Green Paper (EC 1996) published by the Commission in November 1996. In the Green Paper it was stated that the potentials of renewable energy sources in the European Countries are unevenly and insufficiently exploited. Overcoming the barriers, especially from the financial point of view that hinder their dissemination, will allow to take the advantages that these sources offer, since technology has already reached high standards. The main aim is to reach 12% in 2010 as the penetration rate of renewable energy sources in the European Union that means to double the actual (1997) 6% rate of penetration. Renewable sources may help in:

- reducing the dependence on imports
- increasing security of supplies
- reducing CO_2 emissions
- creation of new jobs.

The European Commission points then to encourage each Member State to accomplish the aforementioned goals by developing and enlarging their national industry potentials. The percentage varies from country to country: for instance in Sweden renewables have already the 28% of share, but they can still contribute to a general improvement.

Global estimates aims further to:

- the creation of 500 to 900 000 jobs;
- an annual saving of fuel costs of Euro 3 billion from 2010;
- the reduction of fuel imports by 17.4%;
- the reduction of CO_2 emissions by 402 million tons a year by 2010.

To define the objectives in this prospective under the equity rule, each Member State must have an annual upper limit for its emissions (since they start from different levels) which must meet the same value per person in the year 2050. From a scenario analysis presented by the Earth Friends in UNFCC 1998 (in Molocchi A. 1998), the sustainability path for the European Union tends to reach 6.57 tons CO_2 per person in 2010 (Germany: 9.07; Italy: 5.58) and the uniform value to be reached in 2050 is 1.70. Factors that differentiate the limits are both the population forecasted for each country and the initial reference emissions levels. Renewables (indicated as REN from now on in the paper) are strictly linked to the global emissions and thus to the Kyoto target that for Europe is –8% in GHGs emissions in the year 2010. Costs and benefits of the 12% penetration of REN will be explored along with the feasibility of the Kyoto target.

2. Sectors and energy sources

In our research 4 sectors are considered: ENERGY (from now on indicated as ENE), INDUSTRY (as IND), TRANSPORT (as TRA), OTHER SECTORS (as OTH). Domestic sector, agriculture, services are included in OTH. The choice of the sectors is reasonable and it is further justified from the availability of the data, whose unique sources has been IEA, OECD and EC (IEA 2000, OECD 1999, and EC 2000). Together with data on TPES (Total Primary Energy Sources) and TFC (Total Final Consumption) data on CO_2 emissions and costs both for tons of emissions and kWh produced by different sources are examined to complete the framework of this research. The aim is to examine whether the 12% of penetration for REN into the energy market have the premises to be reached in the year 2010, thus to evaluate its feasibility taking the steps from the actual energy scenario. Feasibility is intended to test how the diffusion of REN will affect costs, emissions amounts and global energy distribution.

The time series of the final consumption for energy in the different sectors clearly indicates that industry had a great amount of energy consumed in the seventies before the first oil shock and it was mostly due to the German industry (106.9 Mtoe were just from Germany in 1973). Between 1973 and 1990, industry has decreased consistently, transport is highly increased and will keep on

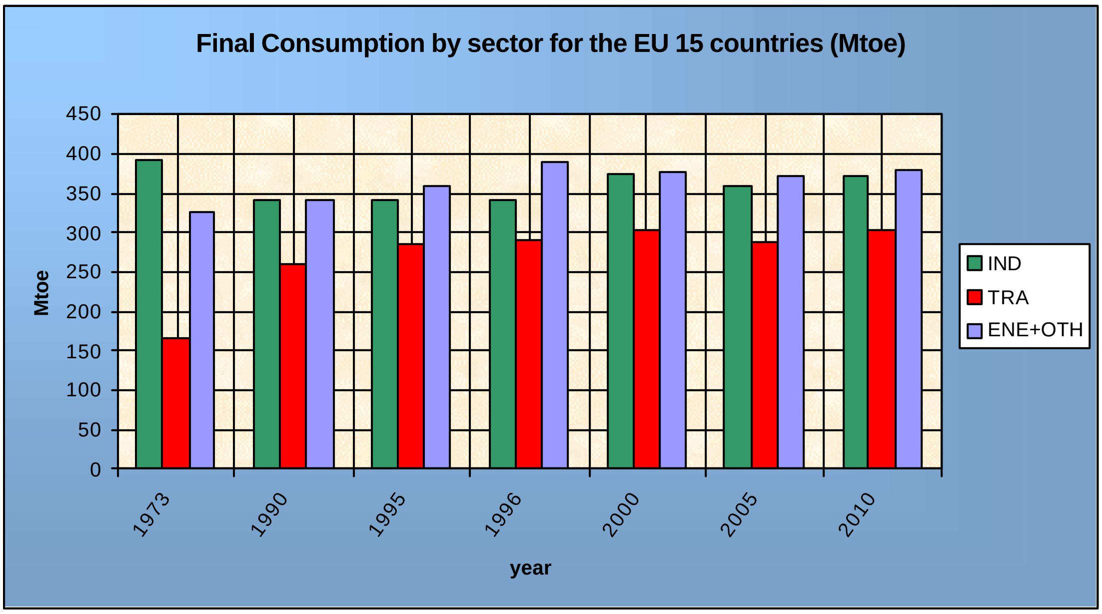


Fig. 1. Final consumption for the EU15.

increasing even if at a lower rate, while the OTH including services and domestic will represent the most of the final demand for consumption in the next years.

Germany, then UK, France and Italy, give the most relevant contribution to energy demand. The gap between Germany and the other bigger countries is more relevant in the IND.

The energy sources considered differentiate in conventional and renewable. The official IEA data aggregate solar with wind, given separate data just for geothermal and hydro, since biomass as well is calculated together with waste combustion and combined cycles. Conventional fossil sources are coal, oil and gas, while REN include biomass, solar, wind, hydro and geothermal. The shares for each source resulting from our aggregation of IEA data over sectors and countries are presented as follows:

SHARES - 1997	*Industry*	*Transport*	*Other Sectors*	*Energy*
Coal	0,127		0,032	0,283
Oil	0,515	1,000	0,428	0,113
Gas	0,358		0,540	0,132
Comb. Renew & Wastes				0,068
Nuclear				0,351
Hydro				0,040
Geothermal				0,0042
Solar/Wind/Other				0,00233
Peat				0,0054

Table 2. *Fuel shares for the EU 15.*

In the IND half of the energy comes from oil, with the other half dominated by gas which is more and more going forward. In the TRA the whole share is attributed to oil and derivatives. The OTH depends more on gas, still heavily on oil but almost anymore on coal. The ENE is instead the crucial sector for the study since in this sector REN plays a relevant role. Most used is nuclear, then coal followed by gas and close by oil. The renewable source on which the energy market counts more is biomass and wastes incineration.

Given these data sets and keeping as fundamental year the 1997, the dynamic model will try to investigate how different scenarios in REN penetration could fit the Kyoto target in lowering in emissions and whether the costs and benefits analysis could give positive results.

3. Methodology

To analyze these issues we have chosen to use the I-think software. It permits to perform a dynamic system analysis picturing different scenarios.

3.A. Model Structure

The I-think method includes three different levels of analysis:

- Level 1, GLOBAL: model macrostructure and parameter definition, range definition in which variables could vary. GRAPHICAL AND LOGICAL: interrelations between variables and definition (storage, flows, converters, interrelationships).

The four sectors are identified (IND, ENE, TRA, OTH) and linked in a fifth box “All sectors”. Two more boxes recall data and simulation for renewables and costs in terms of emissions and REN implementation. The definition of variables and parameters which initiate and follow the simulation process are made through I-think definition devices: slider or graphics (Figs. 2, 3, 4) which associate a value for each of the fourteen years between 1997 and 2010. For each sector here is defined: growth rate (slider), intensity-INT (graphic), oil share (graphic). For IND, OTH and ENE the coal share is added (graphic). Finally, for the ENE only, we use discount rate (slider), delta between cost to produce a kWh with a renewable source and a reference price for fossil fuels (5 sliders, one for each REN source), CO2 costs (slider), share REN (graphic). As far as the fuel shares are concerned, substitution between gas and oil, renewable sources and coal are hypothesized: this means that, according to a scenario, if the gas and renewable shares grow in the years the oil and coal shares decreases.

Fig. 2 *- Growth rate regulator*

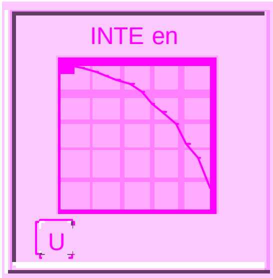


Fig. 3 *- Energy intensity regulator*

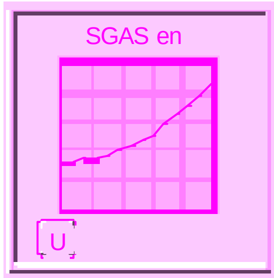


Fig. 4*- Fuel share regulator*

- Level 2, GRAPHICAL AND LOGICAL: interrelations between variables and their definition (storage, flows, converters, interrelationships).

Energy consumption (ENE) is derived multiplying the activity level (ACTIVITY) by energy intensity (INTENSITY). The single fuel consumption (COAL, OIL, GAS, REN) is the product of the total energy consumption (ENE) by the single fuel shares (SHCOAL, SHOIL, SHGAS, SHREN). Finally, CO_2 emissions are derived multiplying the single fuel consumption by the CO_2 coefficients (COEFCOAL, COEFOIL, COEFGAS). The activity level is synthesized by traditional indicators: added value, for ENE, IND and OTH; passenger-km and ton-km, for TRA.

- Level 3, ANALYTICAL: list of equations of the whole model divided by sector.

To implement a linear dynamic system model it is necessary to settle variables and to impose equations that state the existing relationships between them.

3.B. Scenarios definition

The model outlines trajectories from 2000 to 2010 for level of activity, energy intensity and fuel shares performing simulation over three key forces: growth, efficiency, fuel mix. Before describing the different scenarios as studied, it is then necessary to explain which are the fundamental assumptions, which have made possible to investigate the problem modeling in a quite simple way.

A first assumption concerns the total absorption of renewable energy sources by the Electricity sector (ENE), since the share of REN in the other sectors is sensitively irrelevant. However, even if we had considered some absorption of REN by the other sectors, this would have only had distributive effects and would have not changed the basic results of our analysis. In the TRA all the shares are considered as oil share, even if gas increasing as fuel in TRA is considered in the fuel share forecasting.

For ENE we consider that the TPES is formed by TFC and losses both for electricity processes (input-output) and for other reasons. Thus the variable to investigate is a derivative electricity (ELEDRV) as the difference between TPES globally intended and the energy contribution of electricity in IND, TRA and OTH.

BAU – Business As Usual Scenario

The Business As Usual (BAU) scenario is built on the hypothesis that each sector will develop at the same rate it has developed between 1990 and 1997. So Activity and Intensity for each sector will grow and decrease respectively between 1997 and 2010 according to the same trend of the period 1990-97. As expected, activity is everywhere higher while intensity decreases in each sector due to the increase in energy efficiency (energy savings, technology improvement). The growth rate is as well defined as the average value calculated between 1997 and 1990 referred to the year 1990. The BAU scenario plays a key role in the modeling process, since the other scenarios are built considering changes in respect to the BAU assumptions.

Activity (H or L)

The ACTIVITY variable is a storage variable since its values during simulation are continuously up-to-date by the annual growth rate effect. Activity multiplied by Intensity gives the global TPES of each sector. We consider a Higher Growth Perspective (H) and a Lower Growth Perspective (L) compared with the BAU level according to the following table:

	IND	TRA	OTH	ENE
Higher Growth	+20%	+30%	+40%	+40%
Lower Growth	-40%	-30%	-40%	-40%

Both the scenarios take into account that industry is not expected to get radical changes while the more dynamic sectors will be transport, services and energy, given the fact that markets are continuously changing especially in these sectors and that evolution is very fast. The H and L scenarios cover a realistic range of possibilities although statistics are better oriented towards an increase in growth rate.

Efficiency (B or H)

INTENSITY is defined for each sector by a graph where the final predicted level of efficiency in the year 2010 is gradually reached. Efficiency is not supposed to decrease so the lower limit is the BAU case (B). Stronger increases in efficiency considered in the Higher Efficiency (H) scenario make the INTENSITY decrease slower in the next future and faster approaching the year 2010. We suppose that market develops at a higher level of efficiency than in the BAU scenario, according to the following decreasing percentage for each sector:

	IND	TRA	OTH	ENE
Higher efficiency	-13%	-20%	-13%	-13%

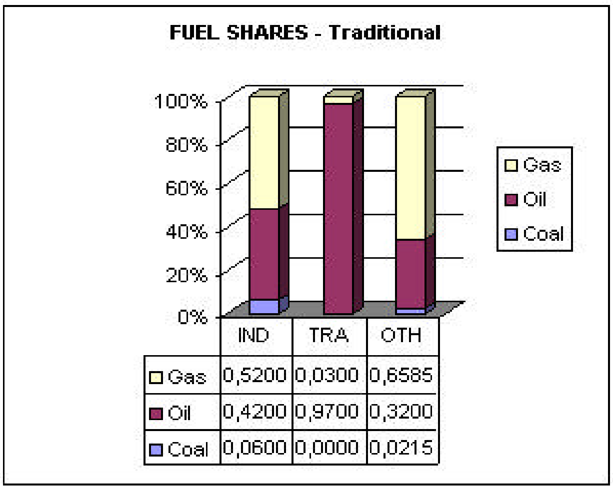
In other words, compared with the BAU scenario, the Higher Efficiency scenario assumes an additional decrease in energy intensity equal to 1% per year, except for the transport sector (about 1.5% per year).

Fuel Shares (T or I)

The fuel share plays a fundamental role. Hypotheses on fuel shares follows two different directions: traditional (T) and innovative (I).

As said before the greatest assumptions for fuel shares are to consider just oil, gas and coal for ENE, IND and OTH, only oil for TRA (although gas role is recognized and evaluated in the scenarios hypotheses), REN totally concentrated in the electricity sector. Solar and wind were aggregated in the IEA data: we have though separated the values, keeping the criterion valid for the scenarios as well, attributing a ratio of 1/3 to solar and 2/3 to wind, leaving aside the so called "other" which should be mainly represented by tidal energy.

For IND, TRA and OTH the Innovative scenario compared to the Traditional mainly gives more importance to gas as fossil fuel: in the Innovative scenario coal almost disappears in IND while gas strongly increase. TRA is considered innovative when at least a 6% of the fuel will be represented by gas. In OTH the 70% in 2010 is supposed to be provided by gas while coal will be reduced to 1,6%.



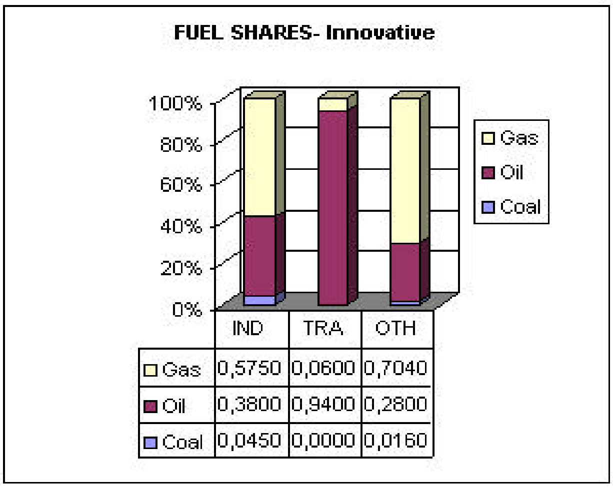


***Fig. 5**. Fuel shares in IND, TRA, OTH according to the 2 different scenarios.*

In ENE coal and oil will decrease, of course more heavily in the Innovative scenario, giving opportunities to the REN with higher potentials of diffusion to increase, that means solar, wind, biomass and wastes combustion, geothermal. Innovative Scenario computes a share of 15% for biomass and wastes incineration in the year 2010 and 0,6% for solar, which, considering the low peak power usually installed is a relevant part.

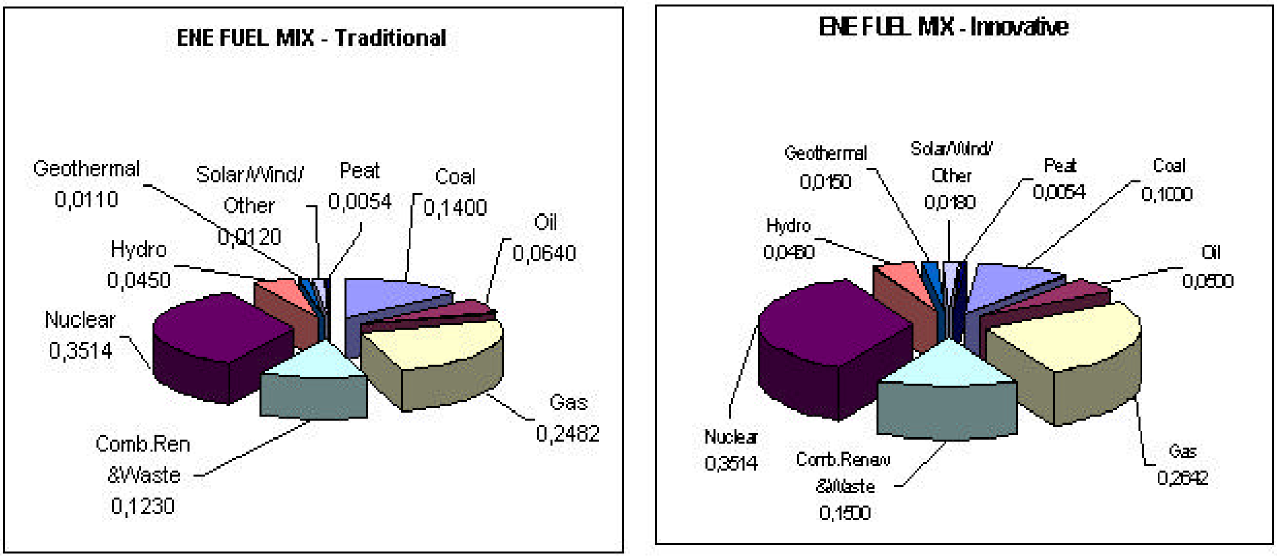


Fig. 6. *Fuel mix in ENE, including REN.*

So defined the possible scenarios to be built will combine the following perspectives:

GROWTH	EFFICIENCY	FUEL SHARE	
High	Higher	Innovative	HHI
Low	Higher	Innovative	LHI
High	BAU	Innovative	HBI
Low	BAU	Innovative	LBI
High	Higher	Traditional	HHT
Low	Higher	Traditional	LHT
High	BAU	Traditional	HBT
Low	BAU	Traditional	LBT

Costs (Low or High)

Once the trajectories are outlined after simulation, the second phase of the research occurs. The amount of CO_2 emissions generated in each scenario is multiplied by the CO_2 cost to reach the total costs of emissions avoided with the use of REN. This sum is to compare with the higher impact in operating costs that REN have. Comparison between costs from fossil fuels and REN is carried out by the cost to produce a kWh, taking a Reference price as representative for all the fossil fuels. To achieve a wider range of results, two different scenarios are defined for the costs, high and low. The values brought into the model are as follows (source IEA 1997[1]):

	Cost (Euro[2] /kWh)		**Extra Cost (Euro/kWh)**	
	Low	**High**	**Low**	**High**
Biomass	0,045	0,133	0,019	0,088
Hydro	0,035	0,069	0,009	0,024
Geothermal	0,036	0,17	0,01	0,125
Solar	0,196	0,424	0,17	0,379
Wind	0,042	0,067	0,016	0,022
Reference price fossil fuel	0,026	0,045	-	-

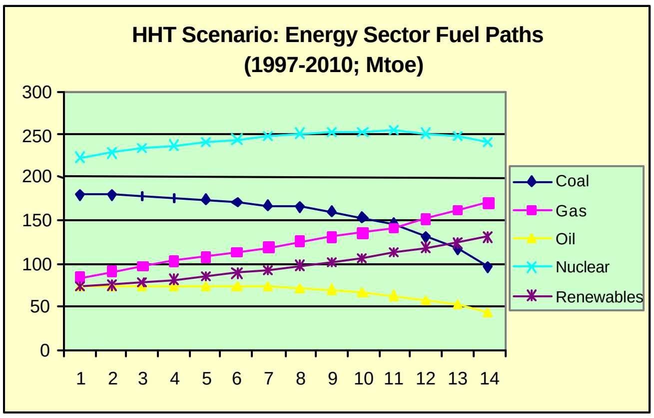
Table 3. *Costs and Extra Costs per kWh*

The model analyzes the difference between costs for REN and reference price: hypotheses assumed are introduced in the Global level of the model as the growth, efficiency, fuel shares. Both total costs from REN and CO2 emissions monetary savings are defined as Net Present Value (NPV). Finally, the difference between savings and costs is calculated.

4. Results

4.A. Fuel mix composition

The fuel mix path for the Energy sector is showed, for the Traditional and Innovative in the Figures 7 and 8.



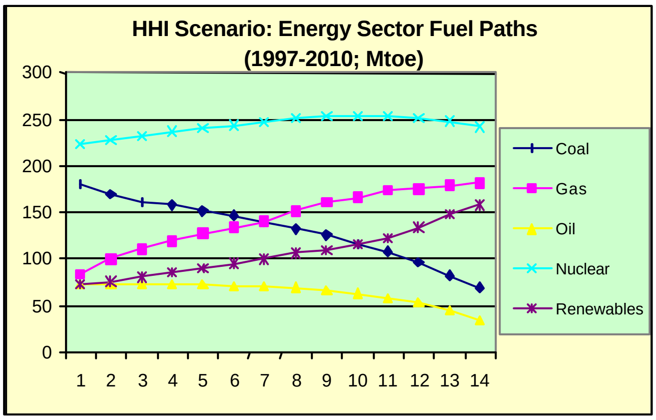


Fig. 7 and 8. *Fuel paths in the Energy sector.*

[1] More recent data are those provided in a nice Australian survey (Commonwealth of Australia 1999). However, they are not far from those provided in the IEA 1997.
[2] It is assumed 1 Euro = 1 USD

It can be seen that both the scenarios, which assume same growth in the activity level (High) and same energy intensity path (Higher Efficiency), are characterized by strong expansion of REN and gas, decline of coal and oil, stability of nuclear. Since activity level and energy intensity are assumed to be the same in both the scenarios, differences in the amount of each fuel used depend only on the fuel mix assumptions (Traditional and Innovative). A closer representation of REN development is given, for the period 1997-2010, in Figures 9 and 10.

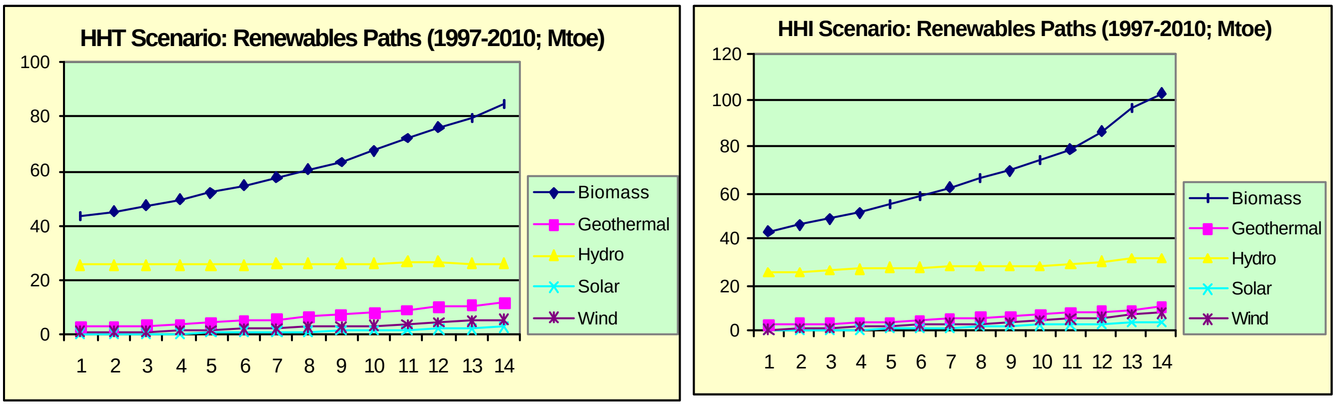


Fig. 9 and Fig. 10. *REN paths.*

Both the scenarios are characterized by the strong expansion in biomass, geothermal and, to some extent, wind and solar, while hydro does not grow. It must be noticed that the expansion of biomass seems to be larger than it occurs for other sources because of its higher starting point. Nevertheless, in relative terms, geothermal, solar and wind grow more than biomass. However, the initial structure of REN strongly affects future developments and it is assumed that the initially limited economies of scale play a key role.

The picture of the fuel mix composition for the entire economy is given in Fig. 11 and 12.

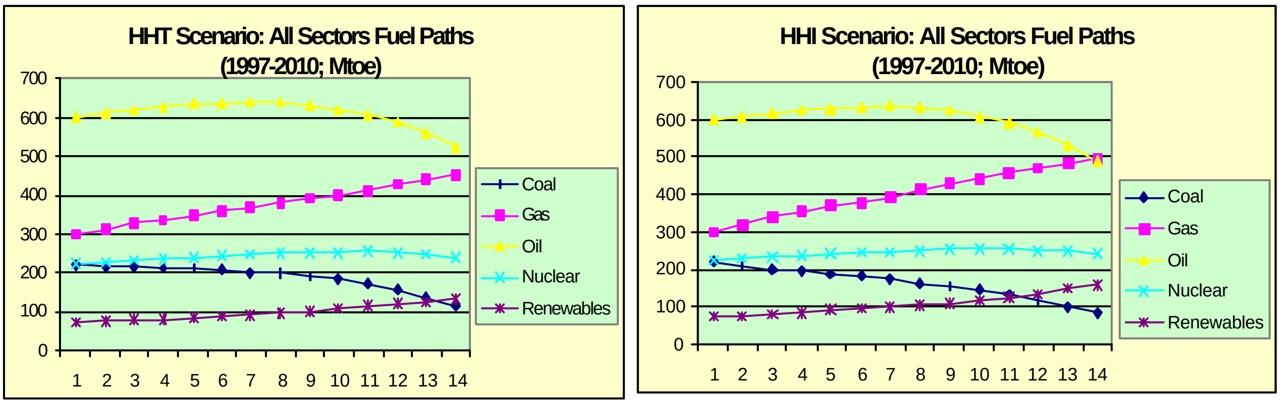


Fig. 11 and 12. *Fuel paths for the entire economy.*

In both the scenarios, oil is characterized by an initial increase, while coal declines since the beginning. Nuclear is nearly stable while gas and REN increase since the beginning. However, such an increase in the oil use is not confirmed in relative terms, as it can be seen by Fig. 13 and 14 which focus on the fuel share paths.

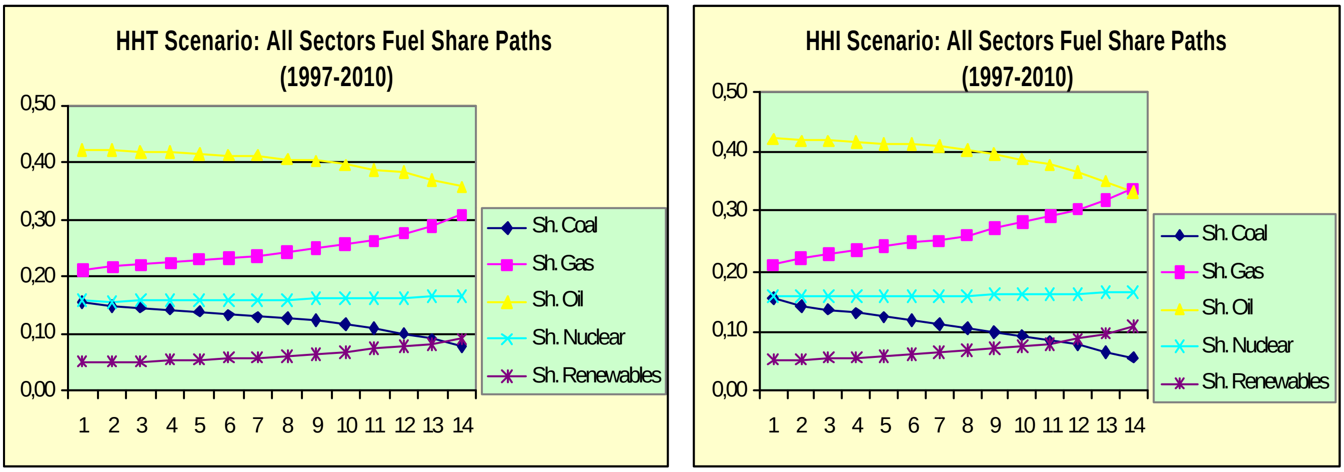


Fig. 13 and 14. *Fuel share paths for the entire economy.*

In the innovative scenario the REN share is approximately doubled, coal is halved, the gas share reaches the oil share while nuclear keeps constant. The traditional share is affected by less strong changes so that oil e.g. stays as main fuel while the REN share does not double even if its increase is remarkable.

4.B. CO_2 emissions trajectories

The amount of CO2 emissions generated in each scenario in 2010 is summarized in Fig. 15.

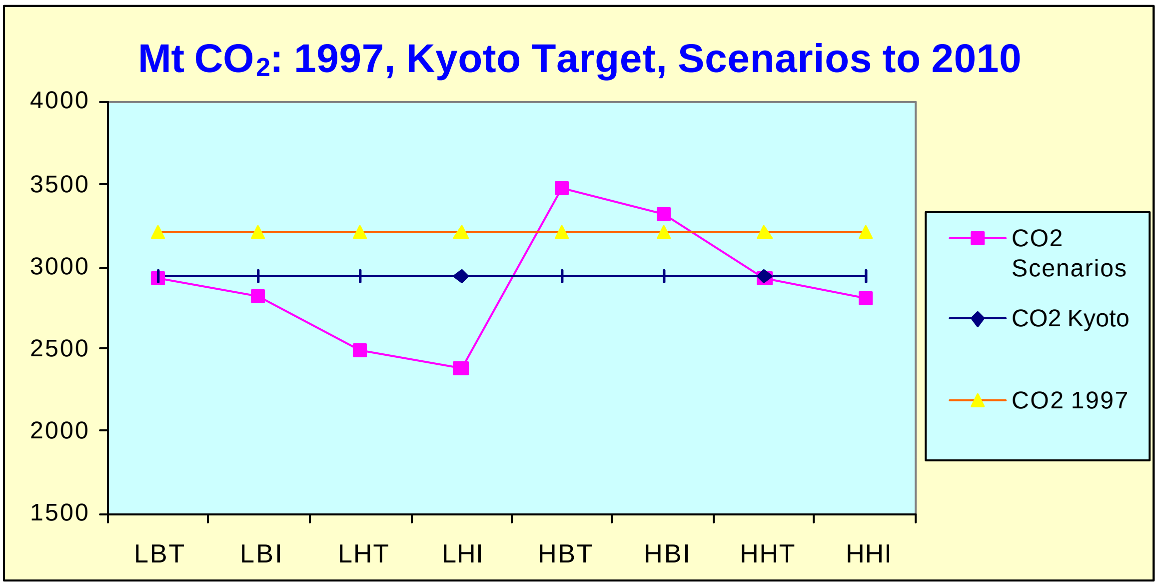


Fig 15. *CO2 emissions: scenarios, 1997 value and Kyoto target.*

A part from the HBT and HBI scenarios, all the scenarios give rise to substantial reductions in CO_2 emissions and allow to meet the Kyoto target. In particular, in case of low economic growth, the target is reached also when energy intensity does not decrease more than in the past (B scenarios) and/or when the REN increase is not very strong (T scenario). On the contrary, when a high activity level is implemented, a very strong decrease in energy intensity is necessary in order to meet the Kyoto target. This means that a very strong improvement in energy efficiency is required if the activity level has not to decrease and that energy intensity can be regarded as a key factor. Nonetheless, the fuel mix plays a very important role because the target can be met only if gas and REN expand: in fact, if a traditional scenario (T) is assumed for the fuel mix, in coincidence with high growth of the activity level and high efficiency, the target is just met. In other words, both H (for energy intensity) and T and I (for the fuel mix) scenarios are necessary but not sufficient conditions to meet the Kyoto target. In the absence of conditions given in T or I, H scenario for energy intensity is unable to lead to the target, and viceversa. Thus, energy intensity and fuel mix can just be regarded as two blades of scissors, the second blade being made of a substantial expansion in renewable energy. The paths of CO_2 emissions are showed in Fig. 16. It can be seen that the combination of low growth in the activity level and high efficiency (LHT and LHI) allow to meet the target well before the deadline, while in the LBI and HHI scenarios the target is met approximately a year before 2010. Finally, in the LBT and HHT cases, it is just in 2010 that the Kyoto target is reached. It is interesting to see that the high efficiency paths (e.g. HHI and HHT) are characterized by a quite high slope (negative) in the final period, as an effect of the assumption of increasing gains in energy efficiency. On the contrary, in the scenarios HBT and HBI such gains are not present and the trajectories are flatter that the symmetrical HHT and HHI scenarios. As a consequence then, they do not reach the target.

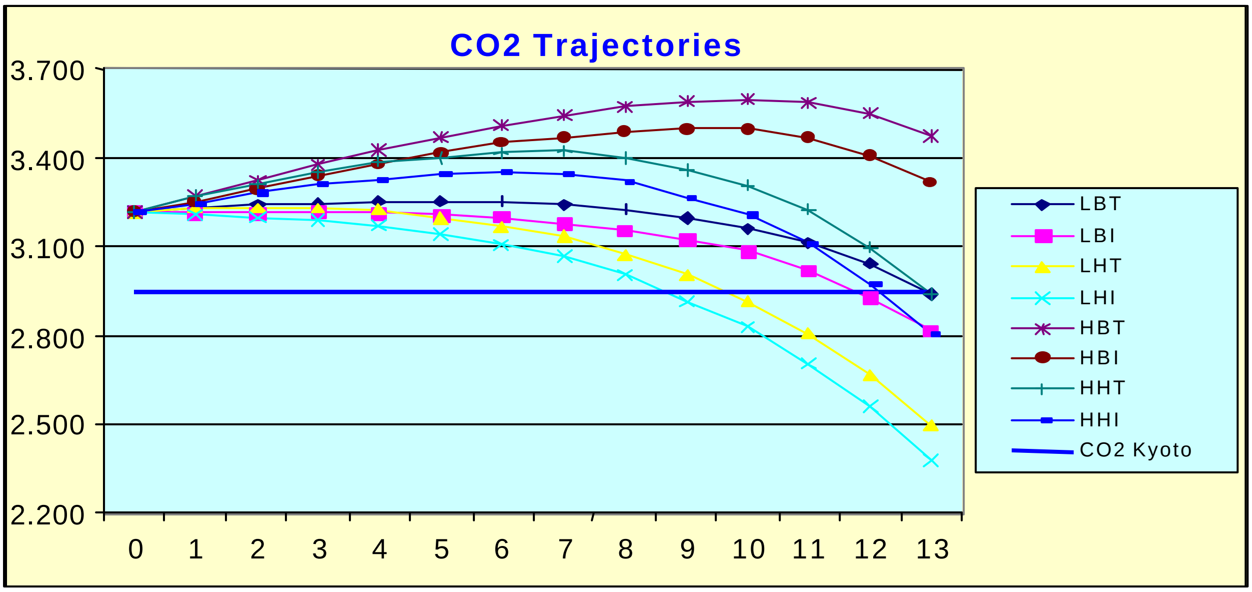


Fig 16. *CO2 emissions trajectories.*

4.C. Economics

The expansion of REN gives rise to substantial reductions in CO_2 emissions and contributes to meet the Kyoto target, in those scenarios in which it is met. In particular, given the assumption that REN substitute half oil and half coal, the following CO_2 emissions saving paths arise (Fig. 17).

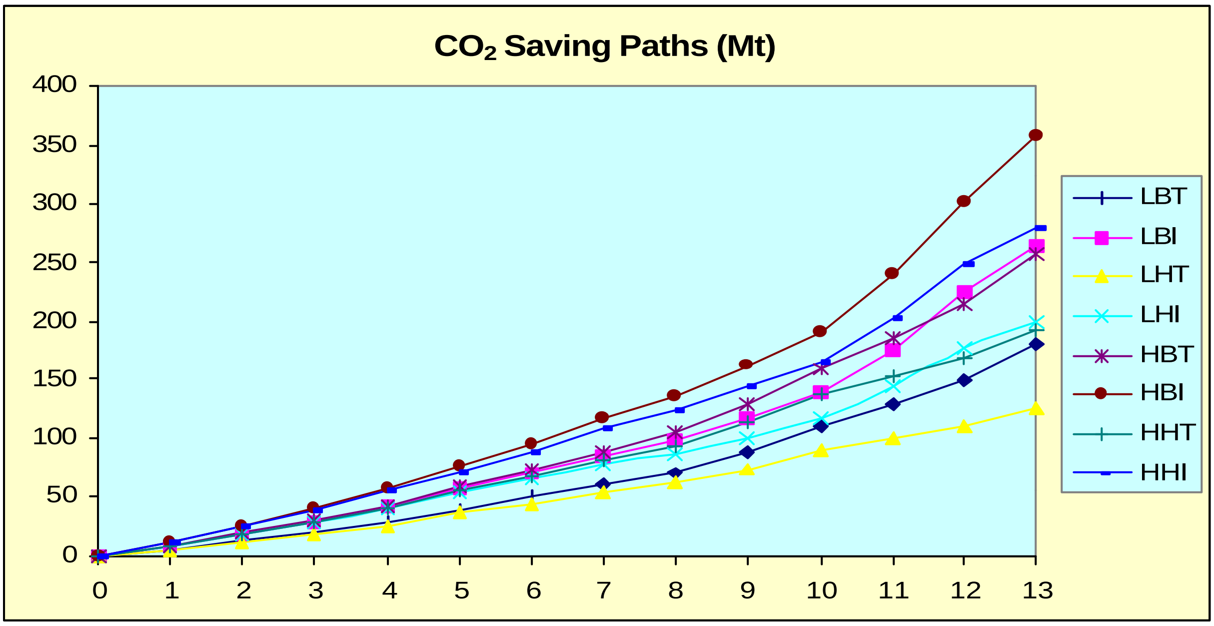


Fig 17. *CO_2 emissions avoided due to REN expansion.*

Maximum and minimum savings originate, respectively, from HBI and LHT scenarios. In fact, HBI generates large consumption of energy, due to the high activity growth and the business as usual energy intensity. On the other hand, in LHT, the low activity level and the high efficiency imply lower energy consumption and, thus, lower CO_2 emissions saving. It is possible to see that, *ceteris paribus*, the Innovative scenario always generates larger CO_2 emissions savings than the Traditional one (HHI>HHT; HBI>HBT; LHI>LHT; LBI>LBT). These remarks imply that the amount of savings in CO_2 emissions has not to be used as an indicator of the desirability of a scenario since high CO_2 emissions savings are not only related to the Innovative scenario but also to low efficiency. Such reductions in CO_2 emissions imply some extra costs related to the fact that REN are more expensive than coal or oil. There are several estimates of the REN costs, as well as of ton CO_2. Due to such variability, we implemented some exercises using different hypotheses on REN and CO_2 costs. In particular, we assumed a price of 40 Euro/ton CO_2, while for REN we based the first two exercises on data showed in Table 3. Here, it is very important to stress that these exercises must not be considered as definite answers about the convenience of REN. Such a theme is beyond the aim of this paper and it would imply the consideration of other issues such as other kinds of externality avoided by REN, the impact on the labor market, the technology effects related to REN development, and so on. Rather, our exercises must be taken as a simple “what if” reasoning whose aim is to generate some information about an important topic such as the development of REN.

The paths of REN extra costs (NPV) in the case of high extra costs are showed in Fig. 18, while in Fig. 19 the differences between CO_2 monetary saving and high extra costs NPVs are represented (discount rate=5%). While the results emerging from this exercise are absolutely negative for REN, the assumption of low REN extra costs generates rather different results, keeping constant the cost of a ton CO_2 (Fig. 20).

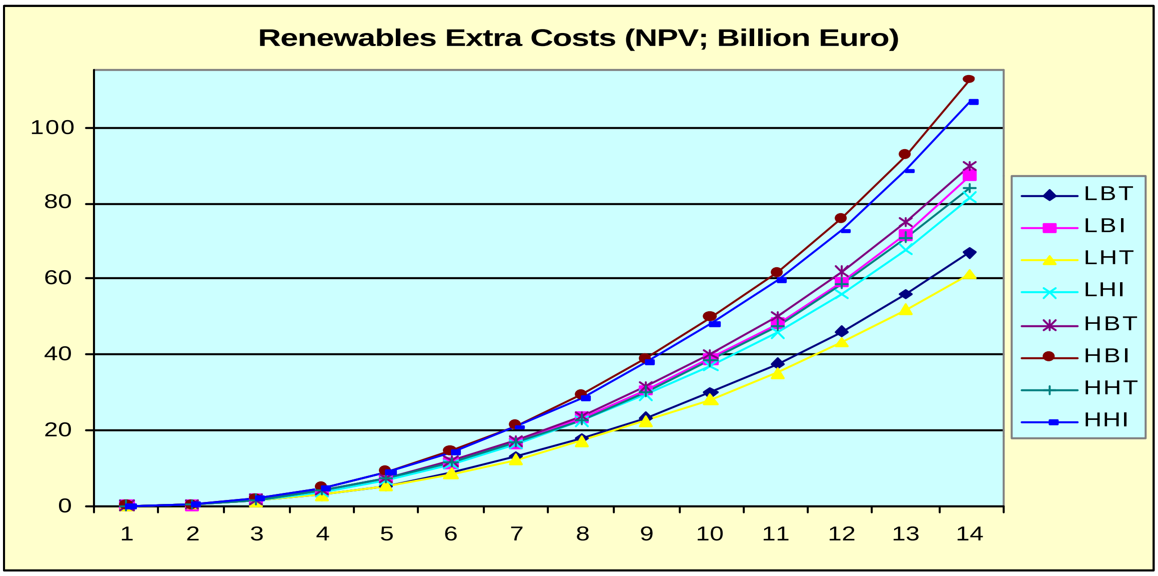


Fig 18. *NPV of extra costs due to REN expansion.*

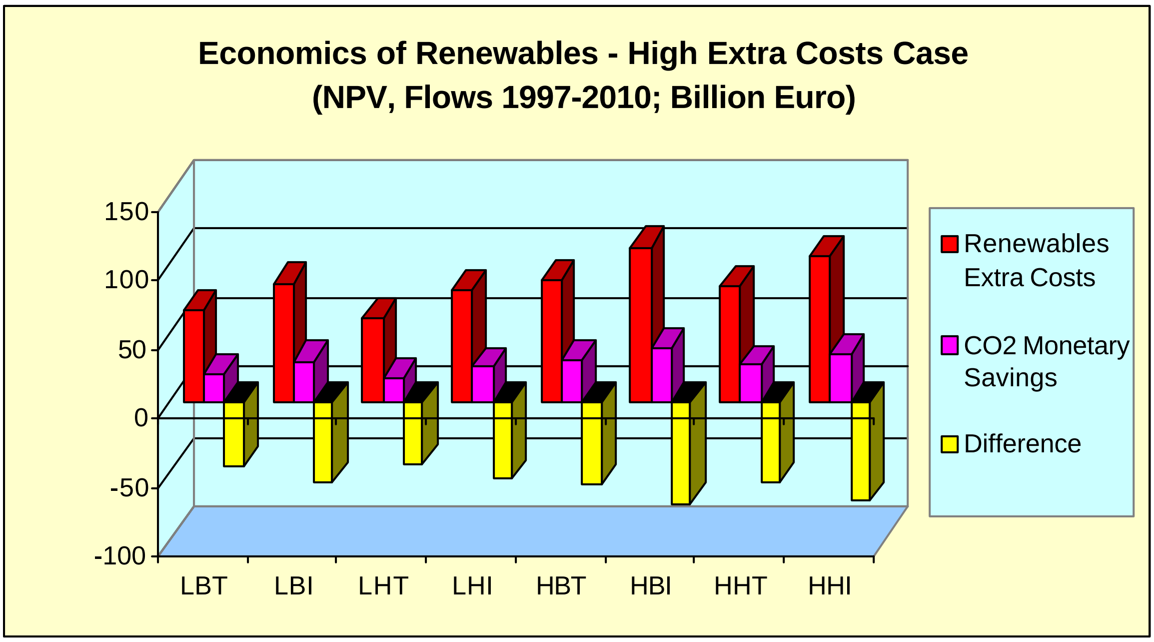


Fig 19. *Economics of REN (high extra costs case).*

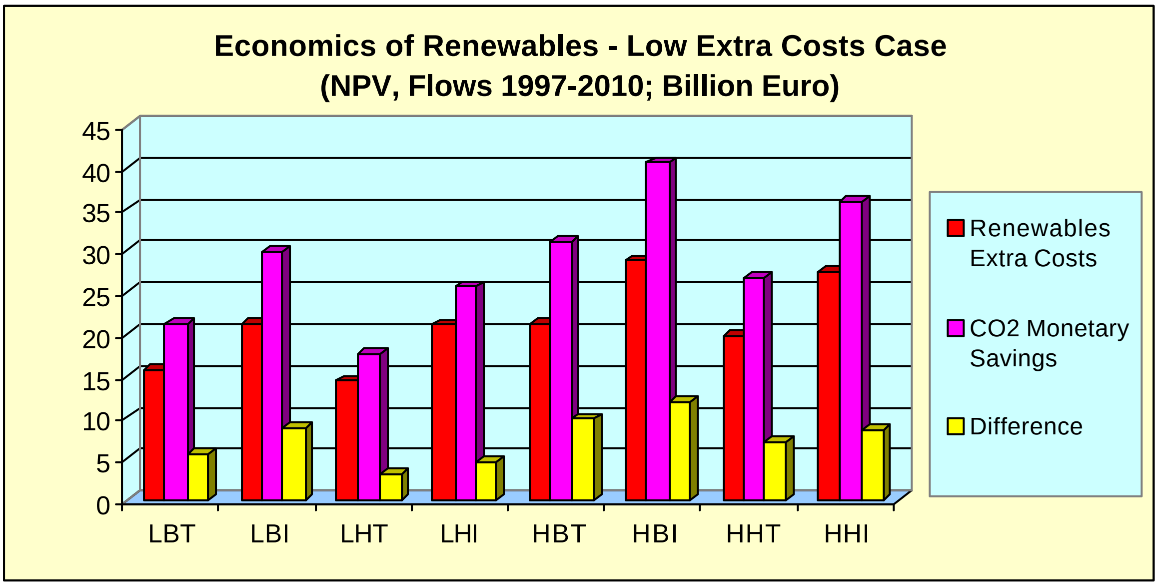


Fig 20. *Economics of REN (low extra costs case).*

It is possible to see that, in this second case, renewable extra costs are lower than CO_2 monetary savings so that the difference is positive. Naturally, this result depends strongly on the assumption made about CO_2 cost: a value lower than 40 Euro/ton CO_2 would lead again to a negative result. However, in general it can be said that, given our scenarios, the possibility of a positive result cannot be excluded.

4.D. Further investigations

In order to obtain a clearer understanding of the economic aspects, a further investigation has been implemented for a selected scenario (HHI). HHI is characterized by a REN expansion that is very strong and close to the EU doubling target. Moreover, due to the combination of high growth and high efficiency, it generates medium energy consumption and, as a consequence, medium savings in CO_2 emissions. For this reason, it can be regarded as a sort of medium representative scenario.

The first exercise considers the high extra costs case, but now it is assumed that renewable substitute only coal, and not coal and oil. This generates higher savings in CO_2 emissions. The results of this simulation are showed in Fig. 21.

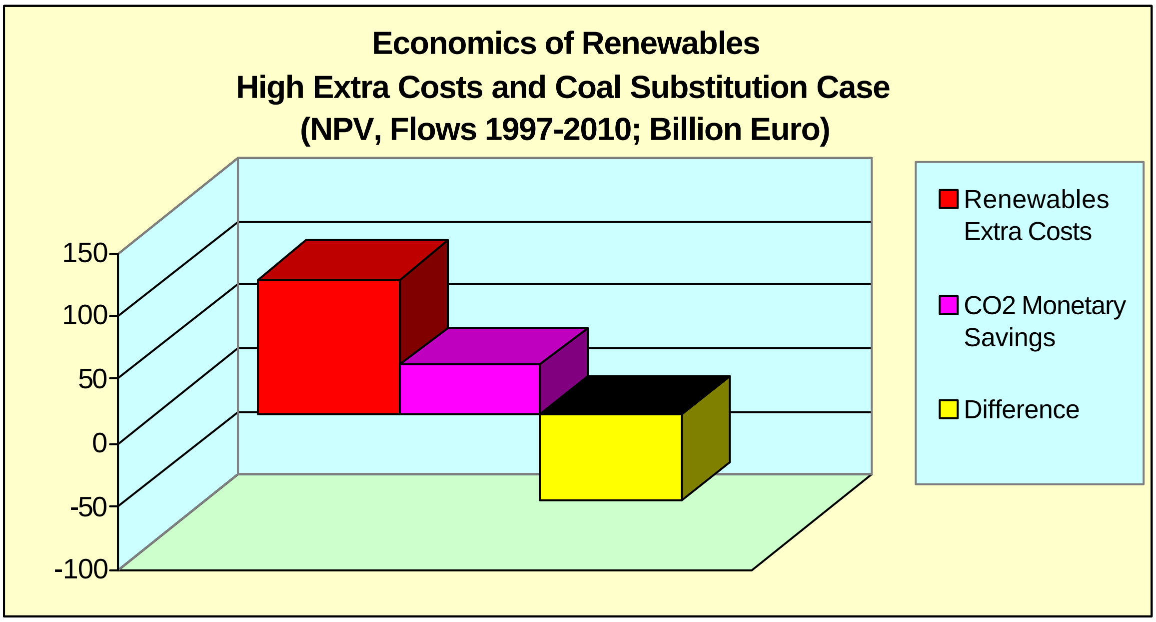


Fig 21. *Economics of REN (high extra costs and coal substitution case).*

It is possible to see that a negative difference still arises, even if slightly lower that the one emerging in case of joint substitution of coal and oil (-67 vs. - 71 billion Euro). Such a difference disappears and parity is reached if we assume a cost of CO_2 equal to around 106 Euro. In the second exercise, we took into consideration the low extra costs case and assumed that, again, REN substitute only coal (Fig. 22).

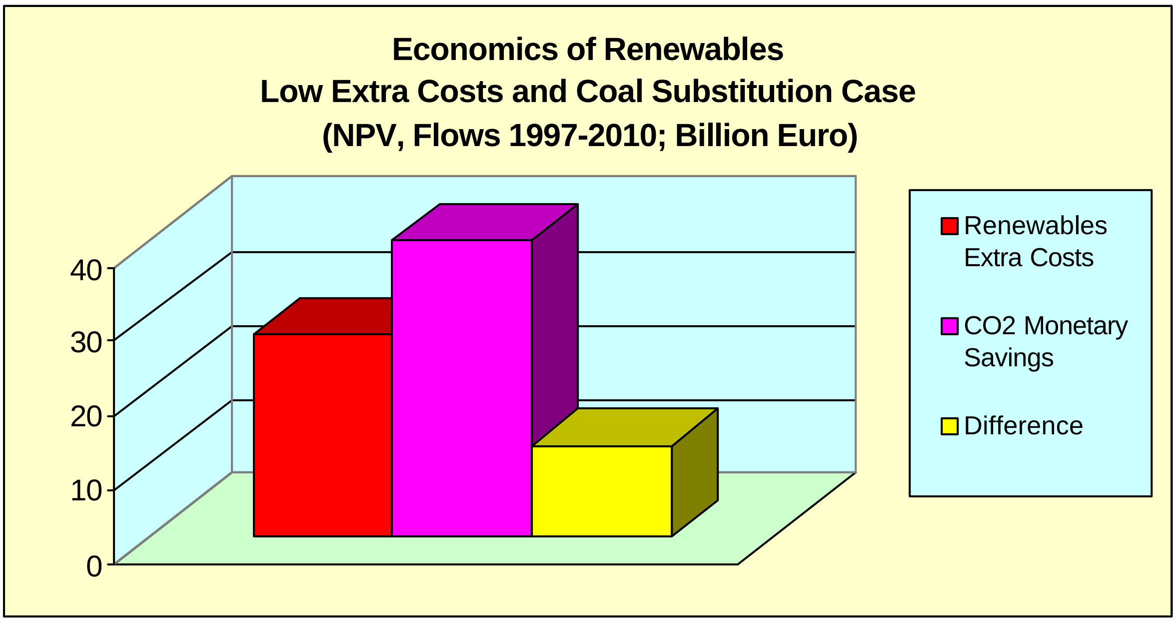


Fig 22. *Economics of REN (high extra costs and coal substitution case).*

As expected, we obtain a positive result, but slightly higher than the oil and coal substitution case (12 vs. 8.4 billion Euro). The difference is eliminated if the CO_2 cost decreases to around 26

Euro/ton. Finally, in the last exercise we have abandoned the hypothesis of REN costs that are constant over the whole period, and assumed that, due to learning and economies of scale associated to production expansion, they decrease as 2010 is being approached. In particular, since there is uncertainty about values, we assume high extra costs as starting point and low extra costs as the value in the final period. As far as CO_2 emissions are concerned we assumed, as in the other exercises, a cost of 40 Euro/ton. Finally, it is assumed that REN replace partly coal (3/4) and partly oil (1/4). The results are showed in Fig. 23.

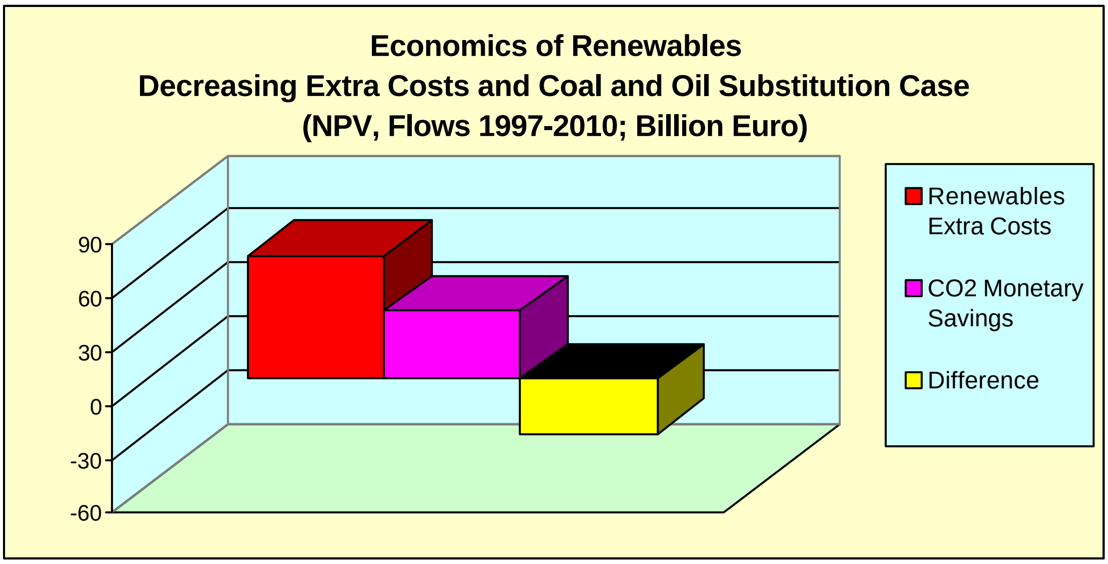


Fig 23. *Economics of REN (decreasing extra costs, coal and oil substitution case).*

The difference between extra costs and CO_2 emission monetary savings is negative (-31 billion Euro) and in order to disappear the CO_2 cost must rise up to 72 Euro/ton. Certainly, many other exercises are conceivable but here what seems to be important is a general indication about the economics of REN and the exercises carried out provide a good insight for this aim.

5. Conclusions

The scenario analysis so far implemented is summarized in Table 4. It shows that while the assumption of high extra costs always implies negative economics, even in the case that REN replace only coal, when low extra costs are assumed there is room for a positive result. The "medium" hypothesis of decreasing extra costs does not generate a positive result. In all cases, a part from the uncertainty related to the dimension of extra costs, the result strongly depends on the CO_2 emissions cost assumption. Nevertheless, it must be noticed that if the hypothesis of a very strong decrease in the CO_2 cost is excluded, there exists the possibility of positive economics for REN.

Scenario	REN Extra Costs	CO_2 Cost	REN Substitute:	Difference: Monetary CO_2 Savings - REN Extracosts	Parity if CO_2 Cost is:
All scenarios	High	40 Euro/ton	½ Coal + ½ Oil	Negative	-
All scenario	Low	40 Euro/ton	½ Coal + ½ Oil	Positive	-
HHI	High	40 Euro/ton	Only Coal	Negative	106 Euro/ton
HHI	Low	40 Euro/ton	Only Coal	Positive	26 Euro/ton
HHI	Decreasing	40 Euro/ton	¾ Coal + ¼ Oil	Negative	72 Euro/ton

Table 4. *Exercises synthesis.*

Again, it must be stressed that our analysis is just a first exploration of an issue characterised by a high degree of complexity. A complete analysis of the effects of a strong development of renewables within EU should take into account how such a development affects the labour market, technology breakthroughs, other kinds of externalities, and the energy industry. This is beyond the purpose of this paper. Moreover, a higher degree of disaggregation on renewables, as well as the consideration of the very low CO_2 emissions associated to the renewables cycles, would be very useful. However, when the issue of renewables development is explored in a simplified, but rigorous way, what we see is that renewables can play a key role in helping Europe to meet its Kyoto target and that this does not always imply negative economics. A very decreasing trend in the price of CO_2 emissions can deny such a conclusion but, on the other hand, the consideration of other kind of externalities avoided by renewables can reinforce it. In simple words, EU expectations are that renewables can economically help it to meet its Kyoto target: there is a high probability that reality confirms such expectations.

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