Environmental Effects of the Sicilian Energy Policy

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Abstract

The increasing of CO_2 discharge, resulting from energy power production, as well as the growing energy consumption in developed and developing countries make relevant the current role of renewable sources in a regional policy context, to support the energy supplying and conservation strategies.
Suitable political strategies and action measures are needed to establish a sustainable energy system. The local planning, at regional level, has to be addressed to promote the Renewable Energy Technologies (RET), aimed at reaching the control of environmental impacts by transport, buildings, land use, and sectors of domestic, services and industrial end-use.
The aim of this paper is to assess the status of the energy planning sector in Sicily and the relative measures to match the Kyoto Protocol (KP) targets, incorporating the specific costs of the saved energy through the RET, and of the relative avoided emissions of CO_{2eq} into the planning process.

Keywords: Renewable sources; energy planning; greenhouse gases; Kyoto Protocol.

Introduction

Sustainable patterns should be identified for the sector of the energy power generation. The saving of primary energy from fossil fuels and the promotion of renewable sources are two of the most relevant paths to follow in order to match the climate protection goal fixed by the Kyoto Protocol in 1997 (the reduction of the greenhouse emissions by 6.5% below 1990 levels over the commitment period 2008-2012) (Hennicke, 2004).
This requires suitable political strategies and programmes to establish a sustainable energy system, as well as action measures not only at national scale, but also at regional one. (Watanabe, 1995). Local authorities are called to play a remarkable role in carrying out environmentally oriented strategies to manage energy resources efficiently and to address the life quality towards the sustainability (Beccali *et al*., 2003). The local action, at regional level, has to be addressed to promote the Renewable Energy Technologies (RET) aimed at reaching the control of environmental impacts by transport, buildings, land use, and sectors of domestic, services and industrial end-use (Sayigh, 1995).

In particular, energy planning has to be oriented to the introduction of sustainable technologies in the energy power generation aimed at: i) the energy saving; ii) the efficient improvement of energy systems; iii) and the reduction of CO_2 emissions through the spread of the RET.
This paper assesses the status of the energy planning sector in Sicily and the relative measures to match the Kyoto Protocol (KP) targets, incorporating the specific costs of the saved energy through the RET, and of the relative avoided emissions of CO_{2eq} into the planning process.

The promotion of the renewable energy sources in the Sicilian context

CO_2 represents the most relevant greenhouse gas, since it represents the 80% of the total emissions of gases taken into account by Kyoto Protocol (K.P.). In particular, energy sector is the main sources of CO_{2eq} releases (Table 1).
Guidelines and action paths have been defined to comply with the targets fixed in KP at regional level. In particular, the actions included in the Draft of the Regional Energy Master Plan (REMP) (Draft of Regional Energy Master Plan, 2004) are described together with the targets of the Regional Operative Programme (ROP), which allocates the public financing resources to the RET.
The set of sustainable targets specified in the ROP essentially aims to integrate energy policy with environmental strategies, so that the conversion of energy systems towards clean technologies could match the national objective of renewable sources promotion.
It involves the following goals of climate protection and air emissions reduction:
- saving of fossil fuels and substitution of them with renewable sources in the energy power generation, like solar, wind and biomass power;
- efficient energy use;
- cogeneration.

In particular, the 1.17th strategy of the ROP about "to diversify the energy production" aims to encourage the renewable sources use for the energy power generation in Sicily, in order to reduce the primary energy consumption and the GHG emissions, according to the *Italian White Paper on renewable energy sources* (European Commission, 2000).
Such strategy is addressed to achieve the following objectives (Sicilian Government, 2003):
- A sustainable system of the energy distribution, which could allow to improve the life quality of urban areas and the performance of the production system;
- The generation of energy power from renewable sources, acting on the firms system, by means of specific financial aids.

In detail the Sicilian Government makes provision for the following financial investments:
- wind farms with a nominal power of 200 MW;
- biomass plants with a power of 60 MW;
- photovoltaic panels with a total power of 5 MW;

No financial objectives are fixed about solar thermal collectors and geothermal layers. Therefore, we focus on the specified renewable energy targets.
In particular, public financing is supplied for the above targets achievement, as a complement of private investments. Table 2 shows a detailed list of available public resources and private capital, for a total financing of € 85,010,000, shared by wind, photovoltaic and biomass technologies.

Environmental releases calculation

For estimating the efficiency of the actions enclosed in the Sicilian ROP we assess the saving of primary energy and the avoided emissions of CO_{2eq}, deriving from the achievement of the Programme targets. In other terms, it is significant to evaluate whether the reduction of CO_{2eq} emissions could fulfil the KP target within 2010, that is 10.6E+09 $kgCO_{2eq}$ below 1990 levels. For this purpose, the Sicilian CO_{2eq} emissions in 1990 are compared with the following scenarios:
- the avoided CO_{2eq} emissions, which should derive from the accomplishment of the ROP targets, Scenario 1;

- the avoided CO_{2eq} emissions, which should derive from the financed actions of REMP, Scenario 2.

The status in 2000 is assumed for the calculation of environmental releases in the assessed scenarios (GRTN, 2002). The energy power generation and the relative CO_2 emissions essentially depends on the thermal plants, which are mostly characterized by the use of oil (Table 3).

In detail, in both the two compared scenarios we have assessed the following items:

- Energy power produced by the RET.
- Avoided CO_{2eq} emissions, replacing the thermo-electric production by the RET, during their life cycle.
- Specific costs of the saved energy [€/GJ] and of the avoided CO_{2eq} emissions [€/10^3kgCO_{2eq}], by means of the RET.

Table 4 shows the emission factors of CO_{2eq}, which are estimated for the thermoelectric energy power in Sicily, and for the RET construction. The emission factor of the thermoelectric energy power is derived for a giga-joule of energy power generated in the specified geographical context (Beccali M. *et al*, 2003) and is calculated as it follows:

$$e_j = \frac{m_{CO_2eq}}{P_j} \tag{1}$$

where:

- e_j is the emission factor of CO_{2eq} [10^3kg/ GJ];
- m_{CO2eq} represents the amount of CO_{2eq} released in the specified year [10^3kg/year];
- P_j is the energy power production in the specified year [GJ/year].

In each scenario the calculation of the CO_{2eq} emission factor is extended to the construction and operation stages of the power plants (ANPA, 2000).

In particular, with regard to the renewable energy plants, air emissions are assumed null during the operation time. The CO_{2eq} balance is assumed null for the biomass, since in combustion it returns the CO_{2eq}, which was been absorbed during its growth. That implies a combustion without greenhouse effect. The CO_{2eq} emission factors are calculated referring to existing plants and the following life times have been fixed:

- 20 years for photovoltaic panels (Nomura *et al*., 2001; Kato *et al*., 2001);
- 20 years for wind farms (Schleisner, 2000; Lenzen *et al*., 2002);
- 25 years for biomass plants (Heller *et al*., 2003).

In detail, each of them is estimated as the CO_{2eq} emissions from the plant construction to the energy power production in the overall life cycle (Jungmeier *et al*., 1998). Then, such emission factors are compared with average values provided by environmental databases (i.e. I-LCA 2000, Boustead Model).

Tables 5 and 6 show the saving of thermo-electric energy power and the consequent avoided CO_2 emissions through the use of the renewable energy sources, respectively, according both the two compared scenarios. The rate of fulfilment of the climate goal of KP is just 4.12% by the ROP (Scenario 1) and 1.19% by the REMP financed actions (Scenario 2), as Table 7 shows.

Assessment of the costs of the saved energy and avoided emissions costs

On the basis of the required investment and of the available financing resources, it is relevant to estimate the cost of such benefits. In detail, we assess costs of the saved energy in €/GJ and

of the avoided CO_{2eq} emissions in €/10^3kg. (Table 8) shows the allocation of the cost of the saved energy among the RET to introduce in the energy power generation.

Conclusions

On one hand, energy use is one of the most relevant indicators of the socio-economic development of a country and the fulfilment of an expected energy demand, over a period, is the basis of energy planning. On the other hand, the energy planning sector has to take into account not only social, economic, and political aspects, but also environmental issues. In fact, as a consequence of the growing interest in the environmental effects of CO_{2eq} emissions from primary energy consumption, the K.P. involved the integration of the environmental considerations into the energy planning sector. In response to such requirements, planning policies must be supported to promote the use of renewable energy sources.

This paper focuses on the Sicilian policy planning in the energy power generation, which is essentially characterized by the use of oil in thermal plants. The efficacy of the ROP strategies and the already financed REMP actions has been estimated, with respect to the KP target on the CO_2eq reduction. Besides, taking into account the available financing resources, it is possible to estimate the specific costs of the saved energy and of the avoided CO_{2eq} emissions involved by the RET.

It can be noted that the regional planning targets do not allow to match the reduction of the greenhouse emissions by 6.5% below 1990 levels within 2010. Therefore, results of the assessment show that energy policy should aim at increasing the production of RET at regional scale, since Sicily presents a high potential for energy resources exploitation. For this purpose, an energy planning path should include specific strategies and interventions, able to fit, in the best way, the sectorial demand and supply, taking into account the dimension of environmental protection and the needed costs to accomplish such strategies.

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Tables:

Table 1. Emissions of GHG from the energy use sector in Sicily in 1990 and 2000

Sector	**Sicily [10^9kg CO_{2eq}] 1990**	**Sicily [10^9kg CO_{2eq}]**
ENERGY USE:	39.6	39.9
Energy industries:	21.0	21.9
- thermal plant	13.3	13.9
- oil refinement	6.1	6.2
- other	1.6	1.8
Manufacturing industry and building	6.5	4.5
Transport	6.6	7.9
Civil sector	1.7	1.7
Agriculture	0.6	0.6
Other sources	3.2	3.3

Table 2. Public resources and private financing for RET

Technology	**Public 10^6 €**	**Private 10^6 €**	**%**
Wind	36.67	37.60	43
Biomass	29.17	30.00	34
Solar photovoltaic	19.17	19.72	23
Total	85.01	87.32	100

Table 3. Energy power production in Sicily in 2000

Technology	**Energy power generation at 2000 [GJ/year]**

Hydro	2,900,160
Thermoelectric by oil	88,180,200
Wind/ Photovoltaic	360
Total	91,080,720

Table 4. CO_{2eq} emission factor

CO_2eq emissions	**Thermoelectric [10^3kgCO_{2eq}/GJ]**	**Photovoltaic [10^3kgCO_{2eq}/GJ]**	**Wind [10^3kgCO_{2eq}/GJ]**	**Biomass [10^3kgCO_{2eq}/GJ]**
Construction step	0,008	0,015	0,003	0,0018
Operation step	0,158			

Table 5. Saved energy by the RET, according the targets of the two assessed scenarios

RES	**Scenario 1**		**Scenario 2**	
	Yearly energy saving [GJ/y]	**Life cycle energy saving [GJ]**	**Yearly energy saving [GJ/y]**	**Life cycle energy saving [GJ]**
Photovoltaic panels	28,404	7.10E+05	5,68E+04	1,42E+06
Wind farms	1,152,000	2.88E+07	7,08E+05	1,77E+07
Biomass	1,589,414	3.97E+07	3,31E+04	8,28E+05
Total	**2,77E+06**	**6,92E+07**	**7,98E+05**	**2,00E+07**

Table 6. avoided emissions, according the targets of the two assessed scenarios

RES	**Scenario 1**		**Scenario 2**	
	Yearly avoided emission [10^3kg/y]	**Life cycle avoided emission [10^3kg]**	**Yearly avoided emission [10^3kg/y]**	**Life cycle avoided emission [10^3kg]**
Photovoltaic panels	4,5E+03	1,01E+05	8,95E+03	2,02E+05
Wind farms	1,8E+05	4,46E+06	1,12E+05	2,74E+06
Biomass	2,5E+05	6,19E+06	5,22E+03	1,29E+05
Total	**4,4E+05**	**1,07E+07**	**1,26E+05**	**3,07E+06**

Table 7. Fulfilment rate of KP goal

RES	**Scenario 1**	**Scenario 2**
Photovoltaic panels	0.05%	0.08%
Wind farms	1.72%	1.05%
Biomass	2.35%	0.05%
Total	4.12%	1.19%

Table 8. Cost allocation of the saved energy and avoided CO_{2eq} emissions

Technology	**Scenario 1**		**Scenario 2**	
	Cost of the saved energy [€/GJ]	**Cost of the avoided CO_{2eq} [€/(10^3kg CO_{2eq})]**	**Cost of the saved energy [€/GJ]**	**Cost of the avoided CO_{2eq} [€/(10^3kg CO_{2eq})]**
Photovoltaic panels	27.00	189.35	41.77	292.96
Wind farms	1.27	8.23	1.20	7.78
Biomass plants	0.73	4.71	2.01	12.87