SUSTAINABLE ENERGY ACTION PLAN FOR REDUCTION OF THE EMISSION OF GREENHOUSE GASES IN VALLE CAUDINA AREA

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Abstract
This paper describes and analyzes the overall scenario of greenhouse gases emissions from urban, industrial and agricultural activities in the reference year 2011 of a covenant of 13 small towns located in Valle Caudina area (about 50.000 citizens) and proposes, on the base of the emissions inventory data, strategies to reduces emissions by 20-30%. The work was carried out in the context of *Piani di Azione per l'Energia Sostenibile (PAES)* representing a European movement where local/regional authorities voluntarily commit to increasing energy efficiency and use of renewable energy.

Introduction
The climate changes related to CO_2 emission from combustion of fossil fuels increased more and more in the last 50 years [1]. According to Protocol of Doha, extending the Protocol of Kyoto, the European Union decided 20% (or even more) reduction of CO_2 emission levels of 1990 by 2020. In that context the EU promoted the project *Piani di Azione per l'Energia Sostenibile (PAES)* representing a movement where local/regional authorities voluntarily commit to increasing energy efficiency and use of renewable energy [2-4].
This paper describes and analyzes the overall scenario of greenhouse gases emissions from urban, industrial and agricultural activities in the reference year 2011 of a covenant of 13 small towns located in Valle Caudina area (about 50.000 citizens) and proposes, on the base of the emissions inventory data, strategies to reduces emissions by 20-30%.

Methods
The total population of the 13 small towns located in Valle Caudina area is 57.000 in a surface of 60 Km^2 bordered by two National Parks and crossed by a highway (via Appia) (Figure 1). The inventory of baseline CO_2 emissions was done in the reference year 2011 taking into account also other greenhouse gases as methane, nitrogen oxides etc. which were calculated as CO_2 equivalent and the standard CO_2 emission factor for different fuels. All activities were considered in the inventory including industrial, commercial and agricultural/breeding sector, domestic and

public sector, transports.
Two kind of approaches were used to collect inventory data: top-down and bottom-up approach. The former is based on the direct data collection from primary sources (for example electrical and thermal consumes from energy and fuel providers), the latter is based on a statistical approach through surveys distributed to a suitably selected sample of population.

Figure 1. Location of the 13 towns in Valle Caudina area.

Results

The release of CO_2 is mostly from the burning of fossil fuels, for example burning petrol in cars and lorries, burning gas warming homes and using electricity and was estimated 257.762 t/year in 2011. As a consequence the target amount of CO_2 to be reduced is 51.552 t. In Figure 2 the distribution of CO_2 emission per activity sector estimated on the base of baseline inventory in 2011 is reported.

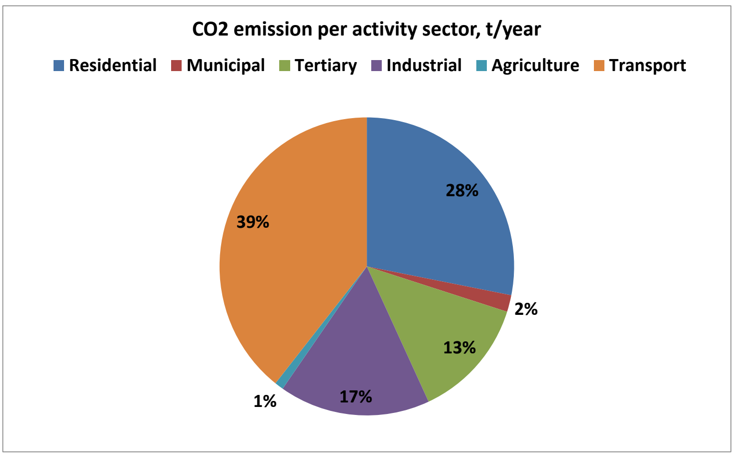

Figure 2. Percentage distribution of CO_2 emission per activity sector in 2011.

Transports and domestic sector account for 2/3 of total emissions whereas a lower fraction is related to the industrial and service sector. The great contribution of transportation sector is due to lack of public transports connecting the small towns which involves an overuse of cars.

CO_2 emission per energy carrier is reported in figure 3 showing the large contribution of electricity followed by methane mainly used for domestic heating, as confirmed by data reported in figure 4, whilst electricity is mostly consumed by both domestic and service sector (figure 5).

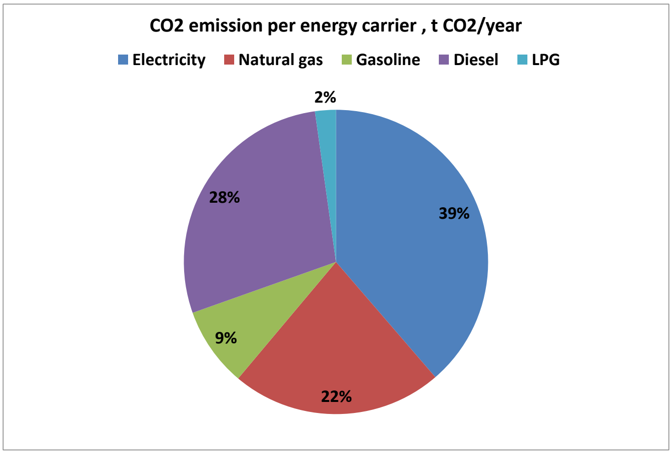

Figure 3. Percentage distribution of CO_2 emission per energy carrier in 2011.

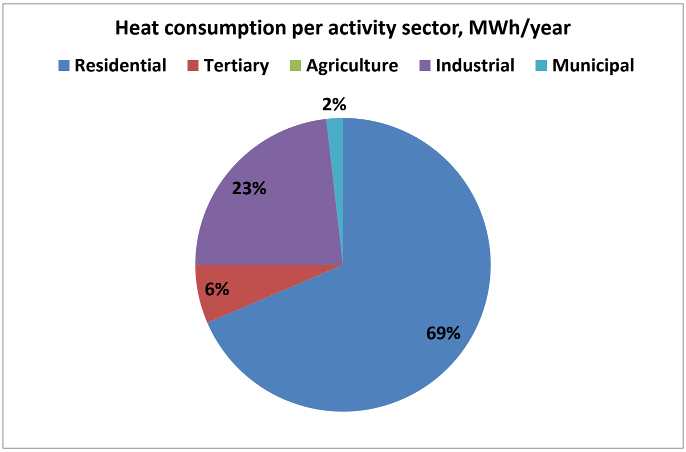

Figure 4. Percentage distribution of heat consumption per activity sector in 2011.

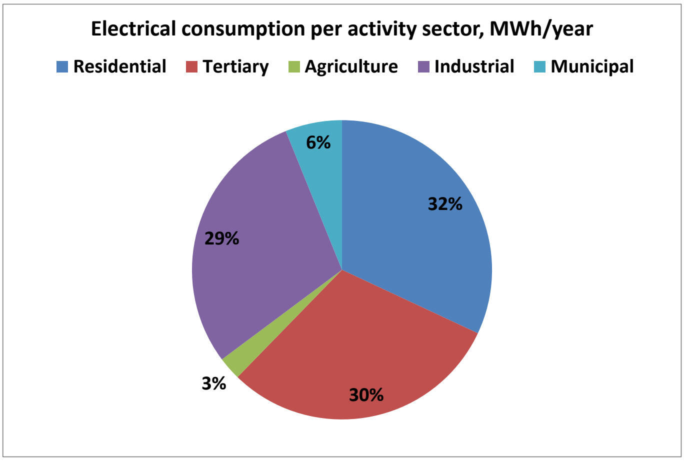

Figure 5. Percentage distribution of electrical consumption per activity sector in 2011.

On the base of these data several strategies to reduce greenhouse gases emissions were proposed based on improving energy efficiency of public and private buildings through thermal insulation, promotion of car sharing and substitution of old and polluting cars, promotion of use of bikes, public education campaign etc.
Nevertheless, in this paper we focus on some proposed actions based on the use of locally produced renewable fuels, substituting fossil fuels, to meet thermal and electric requirements of public or private building.
The first proposal involves the substitution of fossil fuel for biomass consisting in woody waste, properly chipped, from the two national parks surrounding Valle Caudina area to feed boilers to heat schools for 166 days per year (the autumn/winter season) 12h per day taking into account the lower calorific power of biomass compared to natural gas.
In Table 1 the main parameters used for the estimation of the biomass amount to substitute methane and the corresponding amount of CO_2 not released to the atmosphere are reported.

Table 1. Main parameters for the estimation of biomass amount to substitute methane for schools heating and corresponding amount of CO_2 not released to the atmosphere.

Boiler power	Number of schools	Methane for heating	Biomass for methane substitution	CO_2 not released
300 KWh	38	396.968 m^3/year	19.422 q/year	842 t/year

Since local production of biomass (60.000 q/year) largely exceeds that necessary

for schools heating, we planned to use the over production to provide 4000 MWh/year electricity through a steam turbine operating 24 h per day 300 days per year. The equivalent amount of CO_2 not released to the atmosphere is 1.933 ton/year corresponding to about 2.5% of the total target.
According to the second action the garden waste from the 10 plant nurseries of Valle Caudina area are used to produce biogas by anaerobic digestion. The biogas produced is used to produce electrical and thermal energy for nurseries themselves and (the surplus) for the electrical network.

Table 2. Main parameters for the estimation of biogas produced by anaerobic digestion of garden waste and corresponding amount of CO_2 not released to the atmosphere.

Cultivated area	Biomass	Estimated biogas production	CO_2 not released
52 ha	61.3 t/year	45.975m^3	460 t/year

The amount of CO_2 not released to the atmosphere corresponds to about 0.6% of the total target.
Finally, in Table 3 parameters to estimate the amount of CO_2 not released to the atmosphere related to the substitution of methane with livestock manure to produce biogas by anaerobic digestion for thermal and electrical energy are reported.
Calculation are based also on the distribution amount of cows, goats, pigs and poultry in the valley, on values of density and biogas production capacity of the corresponding manure and on data of daily production of manure.

Table 3. Main parameters for the estimation of biogas produced by anaerobic digestion of garden waste and corresponding amount of CO_2 not released to the atmosphere.

Cattle number	Methane for heating	CO_2 not released
117.033	2.005.862 m^3/year	40.245 t/year

This action provides a reduction of the amount of CO_2 not released to the atmosphere as high as 52% of the total target. As a consequence this proposal is one of the most promising to meet requirements of Horizon 2020 included in *PAES*. In addition, it should be taken into account that all actions described involve the reduction of disposal costs.

References

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