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Feasibility of Small Wind Turbine via Net Metering in Greek Islands

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Abstract: The evaluation of a small 3kW wind turbine through the net metering scheme is studied in this article. 14 near to sea locations in Greece examined with the help of the RetScreen expert software. The simulations based on electrical, financial and environmental criteria. Siros with average wind speed of 6.93 m/s is the most attractive area while Iraklion is the least attractive location. According to the results the simulated project is already economically sound and a small wind turbine in the Greek islands will become a progressively an even more financially source of electricity in Greece. Finally, yet importantly is the fact that the use of small wind turbines has as a result that significant amount of Greenhouse gases do not reradiate into the topical atmosphere.

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1. Introduction

Net metering in electricity section is a method of trading electricity from renewable energy sources. This method offers to customers' future credit when they have an energy system which based on renewable energy sources. Of course there are rules according to how long and in which way someone can take the advantages of this credit. In Greece the net metering system has operated from 2014 in consistence with Law 3583/2014 while from 2006 the Greek government has announced and the "virtual net metering" a billing plan which allows a customer to credit energy from one meter to another (Law 3468/2006) [1, 2]. In Greece the net metering scheme permits many renewable energy sources such as photovoltaic panels, small wind power turbines, biomass, biogas, small hydroelectric power plants and combined heat and power systems. The Greek net metering program foresees that the electricity produced by a renewable energy power plant is offset with self-consumed energy in an annual base. If there is surplus this energy is fed into the grid without remuneration. Now very soon there will be two new categories:

- Installations with wind turbines up to 60 kW after bids for the category of small wind turbines.
- Installations with small wind turbines up to 2-3 kW for self-generation and self-consumption, in homes and businesses, according to the decentralized production scheme of net metering and virtual net metering, as well as related facilities from energy communities.

The second category which will have a really small bureaucracy has interesting for many consumers especially in the "windy" Greek islands. The purpose of this article is to evaluate both the financial and the environmental analysis of a small 3 kW wind turbine in 14 island areas. All the simulations realized using the RetScreen Expert clean energy management software system version 6.0 [3-6].

2. Case study

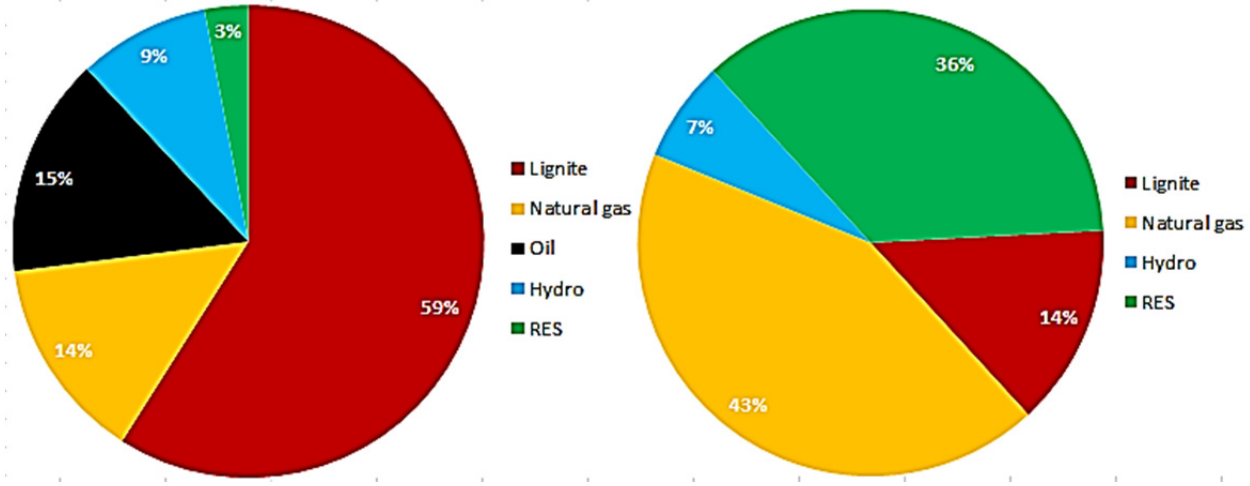
The power transmission grid in Greece divided in the 2 part, the first is main-land national grid and the second is a mixed of thousands small networks in the Greek islands. The electricity cost in these small networks is really high and based in autonomous power stations with natural gas as a fuel. In these islands owing to the fact that there is a very good wind resource the use of small wind turbine through the net metering program it seems attractive [7].

The electricity production in Greece today based mainly in Natural gas (with contribution more than 43%) and in renewable energy sources with significant reduction in the use of lignite. In 2005 the lignite covered more than 59% of the electricity production; the oil contribution was approximately 14% while Renewable Energy Sources (RES) and Hydro energy together offered less than 12% [8, 9]. During the 2020 lignite is the fuel for only of the 14% for energy production but RES production contributes to the national grid more than 36% (Figure 1).

Without doubt the potential for wind energy in Greece is really high. Figure 2 shows the cumulative installed capacity and the Electricity production (according to Eurobserver) during the years 2009-2019 in Greece [10]. During 2020, the installed capacity of wind power in Greece exceeded the 4,000 MW, reached 4,114 MW and

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meets approximately the 12% of electricity demands in country.



a) b)

Fig. 1. The electricity production in Greece for every fuel a) in 2005, b) in 2020.

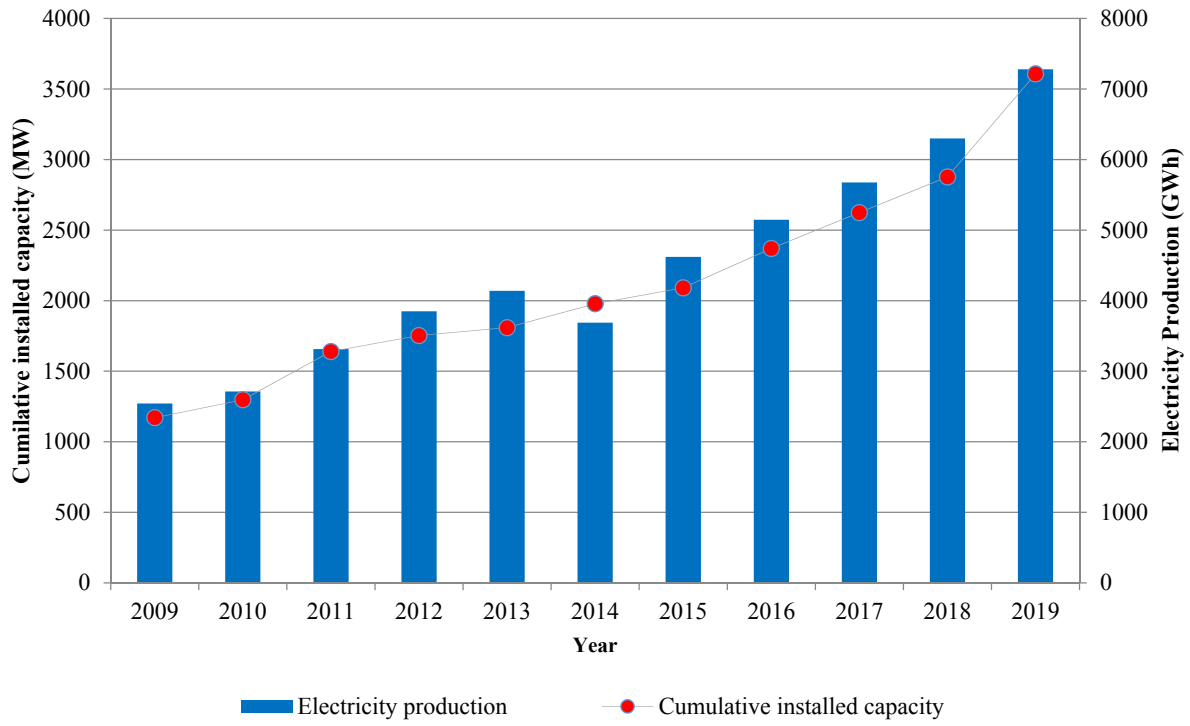


Fig. 2. The wind power installed capacity and the electricity production during the years 2009 - 2019 in Greece.

Is really a matter of peculiar interest that all this energy is installed onshore because in Greece there are not offshore wind turbines!

In this article based on the long-term official data from Technical Chamber of Greece (Table 1) a small 3 kW wind turbine was evaluated in 14 cities (Fig. 3) near to the sea with good wind potential [11]. These areas include 13 cities in Greek islands (Iraklion, Ierapetra, Kithira, Limnos, Milos, Mitilini, Naxos, Paros, Rhodes, Samos, Skiros, Siros, Chios) and 1 city which belong to the main-land (Methoni).

The project presumes a small 3 kW wind turbine at each of the 14 locations to simulate with the help of the RetScreen expert software, the electricity production, the Capacity Factor (CF), the financial viability and the Greenhouse gases (GHG) emission reduction due to the use of the wind turbine. The selected wind turbine is a 3 kW model from ReDriven Power Inc..

RetScreen is easy handle software based on a well-known Microsoft Excel and can be used in order to evaluate the viability of renewable energy projects. In order to calculate the energy production in each area the necessary energy model and the characteristics of the

selected wind turbine model illustrated in Figure 4. The project lifetime has been considered to be 25 years.

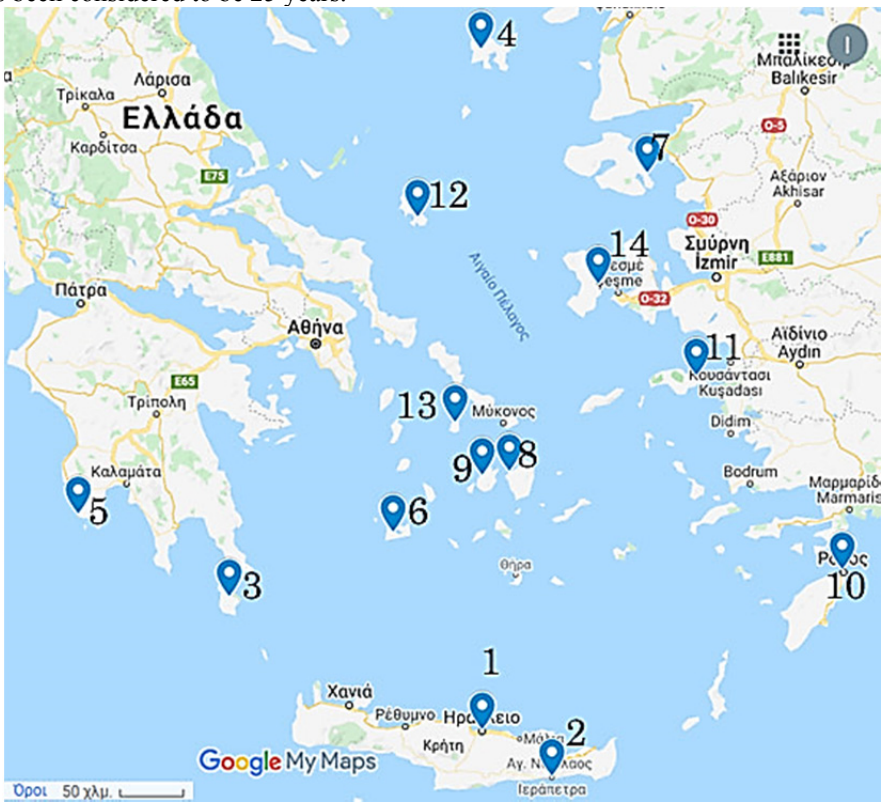


Fig. 3. The 14 simulated areas**: 1.** Iraklion**, 2.** Ierapetra**, 3.** Kithira**, 4.** Limnos**, 5.** Methoni**, 6.** Milos**, 7.** Mitilini**, 8.** Naxos**, 9.** Paros**, 10.** Rhodes**, 11.** Samos**, 12.** Skiros**, 13.** Siros**, 14.** Chios**.**

Table 1. Long-term mean values of wind speed for the 14 simulated area.

	Location													
Month	**Iraklion**	**Ierapetra**	**Kithira**	**Limnos**	**Methoni**	**Milos**	**Mitilini**	**Naxos**	**Paros**	**Rhodes**	**Samos**	**Skiros**	**Siros**	**Chios**
1	4.8	4.7	7.1	5.8	5.5	7.9	5.5	7.9	7.5	3.9	6.0	6.8	8.1	5.2
2	5.1	4.9	6.8	6.3	5.7	8.0	5.8	8.1	7.5	4.4	6.2	6.9	8.1	5.9
3	4.7	4.6	6.8	5.7	5.5	7.1	5.1	7.6	6.5	4.4	5.5	6.2	7.6	4.8
4	4.1	4.0	5.7	4.2	5.3	5.7	4.3	5.9	5.4	4.5	4.3	4.9	5.8	3.4
5	3.2	3.7	5.0	3.9	4.8	4.4	3.5	4.9	4.5	4.3	4.2	4	5.4	3.1
6	3.5	4.4	4.4	3.7	5	4.1	3.8	5.0	4.0	5.2	4.7	4.2	4.9	3.5
7	4.6	6.4	4.4	4.4	5.1	5.7	4.9	6.6	5.2	6.0	7.0	4.8	7.0	5.2
8	4.6	6.0	4.5	4.8	4.9	5.9	4.7	6.9	4.9	5.8	6.6	5.1	7.2	5.2
9	4.0	5.1	5	4.4	4.6	5.9	4.4	7.0	4.9	4.9	5.7	5.1	6.5	4.4
10	3.8	4.4	6.3	5.3	4.5	6.3	4.3	7.4	5.5	3.4	5.1	6.0	7.5	4.3
11	4.2	3.9	5.8	5.3	5.1	6.3	4.7	6.7	6.3	3.1	5.5	5.6	7.2	4.5
12	4.8	4.6	6.8	5.7	5.5	7.4	5.6	7.5	6.8	3.8	6.0	6.4	7.8	4.8
Average	**4.28**	**4.73**	**5.72**	**4.96**	**5.13**	**6.23**	**4.72**	**6.79**	**5.75**	**4.48**	**5.57**	**5.50**	**6.93**	**4.53**

Energy model includes six subsections: Resource Assessment, Wind turbine, Power and energy curves, Losses, Summary and Other information. Resource assessment comprises all the data associated to wind potential. Wind turbine contains all the related parameters of the selected wind turbine. Power and energy curves subsection depicts the corresponding power curve value of the selected wind turbine. Losses subsection includes the availability of the wind turbine and three types of losses, array losses, airfoil losses and miscellaneous losses. Summary section gives the initial and O&M costs, the electricity export rate and the RetScreen calculates the

capacity factor and the electricity exported to the grid [12].

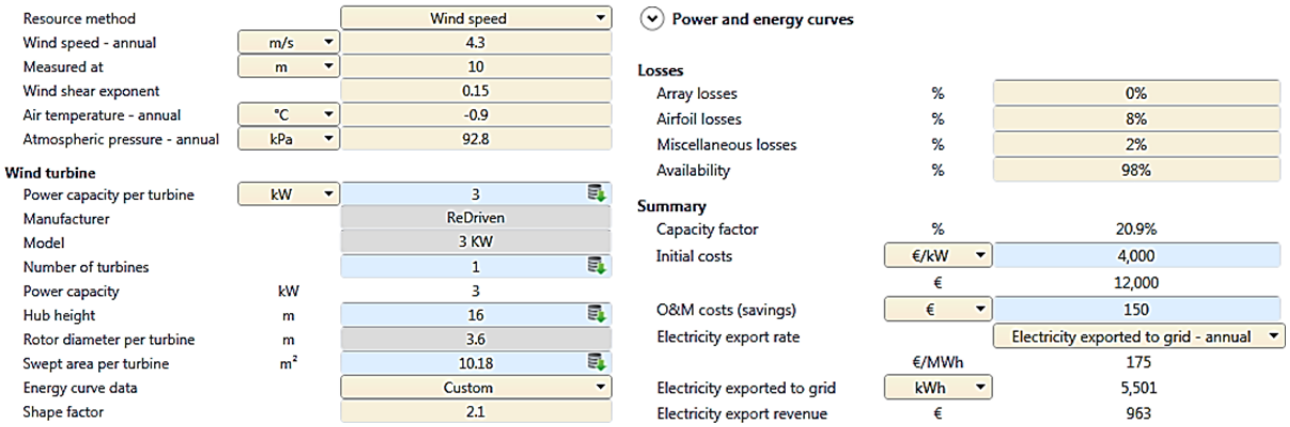


Fig. 4. Energy model and the technical characteristics of the selected wind turbine model.

3. Results and discussion

According to the estimations of RetScreen the electricity derived from the wind turbine and the CF for each of the 14 locations are given in Figure 5. According to fig. 5 the maximum energy production and CF take place in Siros with values 11883 kWh and 45.2% correspondingly, while the minimum yield occurs in Iraklion with values 5519 kWh and 21% respectively.

Based on the costs which depicted in fig. 4 (Initial cost 12,000€, O&M costs 150€ per year and electricity price for the produced energy to grid equal to 175€/MWh) from financial point of view Siros has the maximum IRR (Internal Rate of Return) on equity and the minimum payback time and as presumable result Iraklion with the lowest wind capacity provides the minimum IRR on equity and the maximum payback time. Figure 6 shows the IRR and the payback time for each area correspondingly. In all cases both the inflation ratio and deb ratio was 0%. Based on the fact that the lifetime of a project is 25 years the investment is attractive in each of the investigated area.

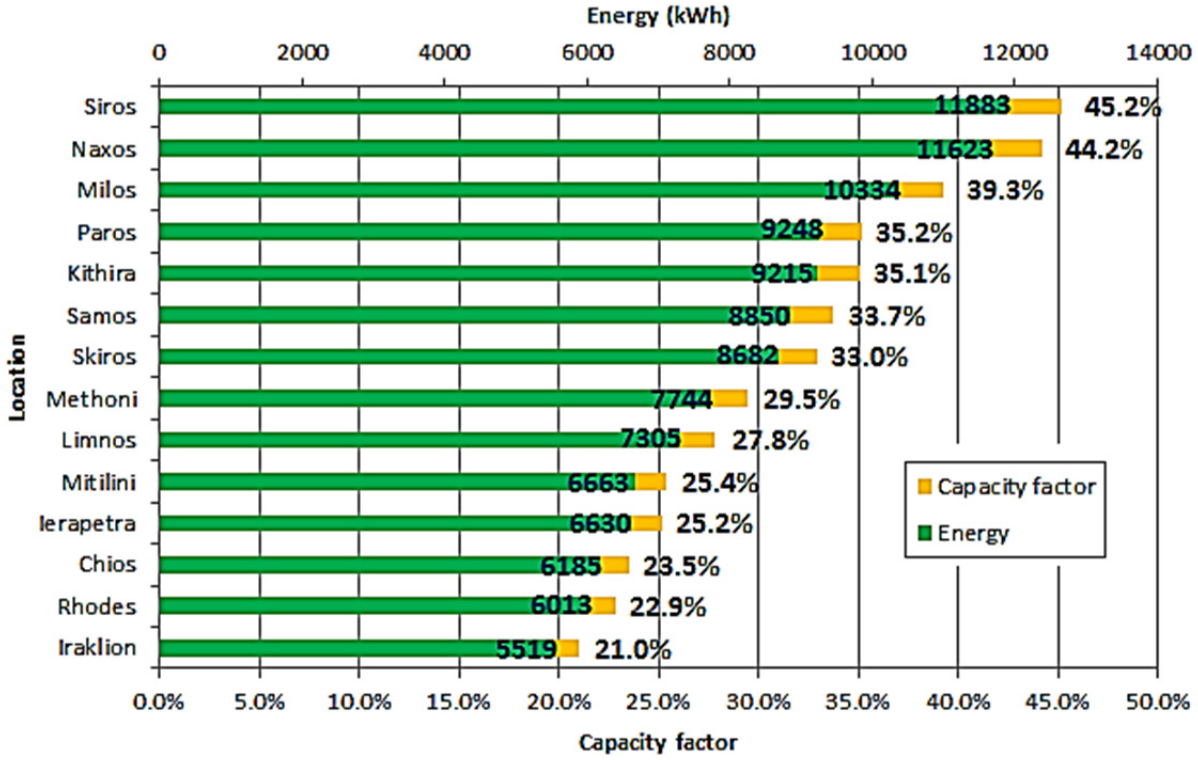


Fig. 5. Yearly energy production and the capacity factor for the 14 simulated areas in Greece.

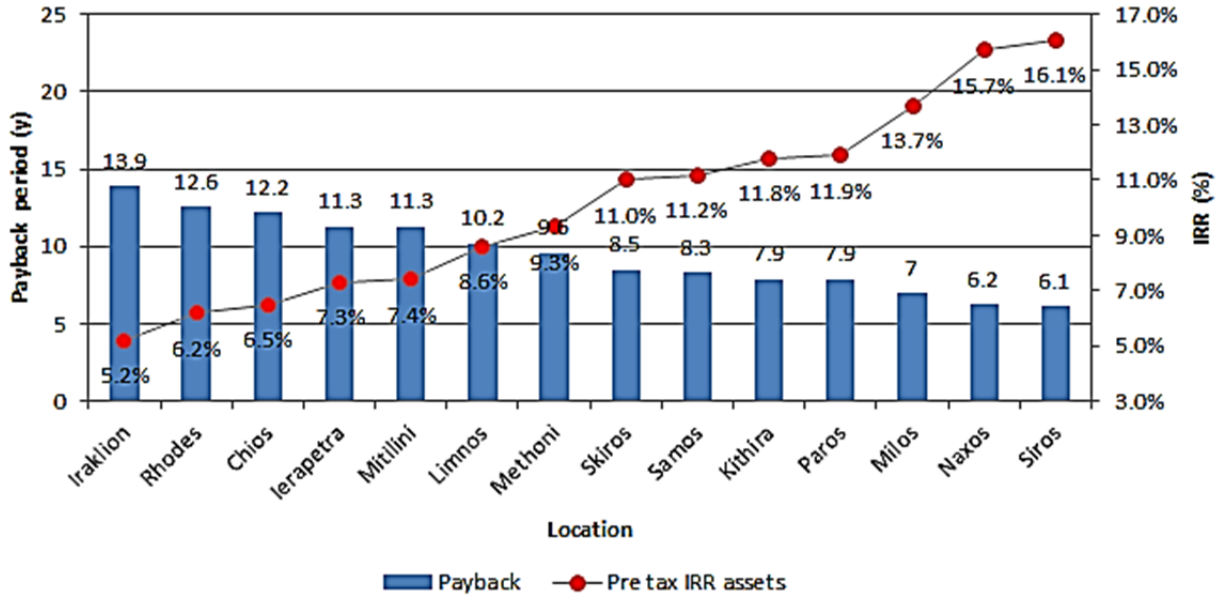


Fig. 6. Internal return rate for the 14 simulated areas in Greece.

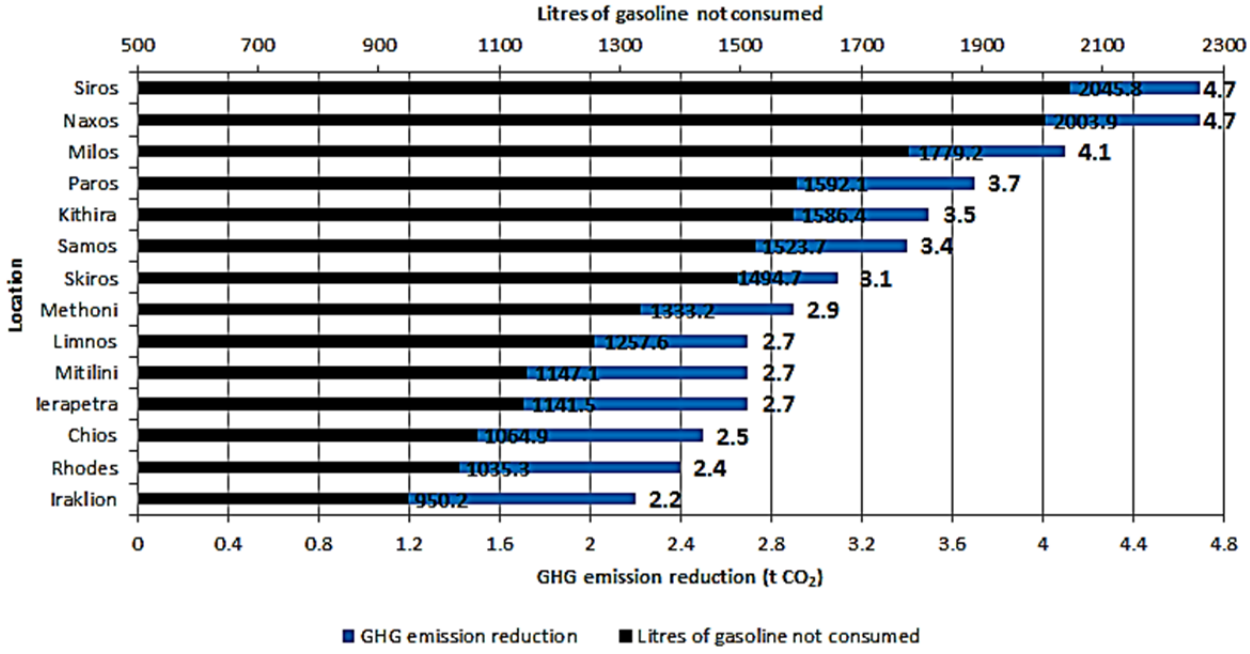


Fig. 7. Greenhouse gases reduction and the equivalent in litres of gasoline do not consumed owing to the use of the simulated wind turbine project for the 14 different locations.

The use of a small wind turbine instead of conventional fuels such as lignite, natural gas or diesel offers significant benefits in the reduction of the emitted GHG. Based on the fact that today natural gas is the most common fuel in Greece in order to produce electricity the GHG reduction based on the comparison between natural gas and wind turbine energy. The emission worksheet is used for this purpose. For GHG emission factor equal to 0.401 tCO2/MWh, the algorithm of the RetScreen calculates the total annual reduction of GHG emissions for each of the 14 areas. The maximum GHG emissions reductions of 4.7 t per year were estimated in Siros and Naxos while the lowest reduction was occurred for Iraklion with values 2.2 t per year. Figure 7 shows both the GHG reduction and the equivalent in litres of gasoline that not consumed for each simulated area.

4. Conclusion

Greece as a country with very long coastline and numerous islands Greece has high wind energy potential. This work based on real long-term wind speed data presented a study for evaluation of an installation of a

small wind turbine in 14 different areas. The average annual wind speed in these areas fluctuates from 4.28 – 6.93 m/s. The electricity production varies between 5519 and 11883 kWh/year while the Capacity Factor varies between 21 and 45.2%. The internal rate of return diverges from 5.2 up to 16.1% while the payback time fluctuates from 6.1 up to 13.9 years. From an environmental point of view the use of a small wind turbine instead of natural gas minimize the Greenhouse gases emission at least of 2.2 t CO_2 every year. Bearing in mind the fact that the price of natural gas is steady rising is obvious that the financial benefits will be even more attractive during the next years.

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