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Designing high-share 50% and 100% renewable energy scenarios for Ragusa by sustainable energy toolkit application

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ABSTRACT

Increasing renewable energy production and integrating it into the current energy systems may lead to conditional solutions linked to the context of applications as well as regulatory and techno-socioeconomic issues. The PRISMI Plus toolkit is a powerful tool that can be improved to entail rural areas and energy islands for effective planning of the various renewable energy system scenarios associated with urban contexts. The target Flagship Case Study is Ragusa, a Municipality located in Southern Italy, analyzed with the EnergyPLAN software. The simulation and validation were carried out by the HOMER software. The input dataset was created jointly in collaboration with the Municipality, the updated Sustainable Energy Action Plan was inserted into the PRISMI Plus toolkit, and three transition scenarios based on different renewable energy uses were considered within the post-processing stage. For the baseline scenario, no green energy is considered and the whole electricity consumption is taken into account. In scenarios two and three, 50% and 100% renewable energy shares are secured through optimal investment in Photovoltaic (PV) panels, Wind Turbines (WT), and Battery Energy Storage (BES) technologies. From an economic point of view, it was concluded that the best scenario is the second one thanks to the increased technical capacity of the investment ratio compared with the two other scenarios, showing an energy price reduction of up to 10 %.

Introduction

Feasibility studies for renewable energy deployment based on different algorithms and different simulators are to determine energy potential and balances [1] together with resilience in the digitalization of systems [2].

In 2014, the European Union decided to provide a new strategy based on Renewable Energy Sources (RES) to reduce 40 % of CO_2 emissions targeting 2030 [3]. This analysis of new energy sources requires technical and economic investigations of the region's potential. Bigerna et al. showed that energy prices will be reduced by 14 % in 2030 [4].

Designing and combining hybrid renewable energy systems, according to the potential and needs of the region in question, from technical and economic viewpoints are crucial in these periods due to the global warming phenomena [5]. Therefore, estimating the least number of solar panels, according to the region's potential, can reduce the level of investment. This estimation is based on performing multi-objective optimization aiming to reach the best possible combination of solar energy systems (addressed in Sohani et al.) to achieve a net zero energy goal for future perspectives [6].

On the other hand, a combination of solar energy integrated with energy conversion systems (such as electrolyzers and batteries) to target pollution reduction has been designed by applying various renewable sources considering the potential and needs of the regions [7]. Although the use of multi-source energy for producing heating load, cooling load, electricity, and hydrogen may not be economical at first glance, such systems can maintain energy balance during peak and off-peak demand [8].

Connecting hybrid renewable systems and solar panels to the power grid (in line with environmental guidelines) to reduce CO_2 emissions has drawn the attention of different countries due to climate change [9]. In the continent of Europe, there are several islands where the energy prices are high, so, the electricity grid is not sustainable. Groppi et al. showed that the RES is playing an important role in Mediterranean

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Nomenclature

BES	Battery energy storage
CEEP	Critical excess electricity production
EV	Electric vehicles
GHG	Greenhouse gas
HP	Heat pump
IRR	Internal interest rate
NPV	Net present value
O&M	Operation and maintenance
OPEX	Operating expense
PES	Primary energy supply
RES	Renewable energy source
STC	Solar thermal collector
WT	Wind turbine

islands [10]. Research on the share of solar panels, wind turbines, and biofuels in these islands was done by simulating different configurations via the EnergyPLAN [11] and HOMER software [12], and the economic analysis of these systems via the MATLAB software showed that the cost of electricity production was reduced but caused network instability [13,14].

The research by Deason [15] shows that in multiple scenarios where cost was evaluated based on the amount of energy used, the increase in renewable energy use by up to 100 %, increased the investment cost by around 42 % to 102 %, but the cost of each kW of energy-reduced generated electricity up to 62 %. Also, the study by Ndwali et al. [16] (where a solar power plant was connected to the power grid) showed that electricity generation can be optimized and the use of local power capacity can increase up to 64 %. The latter effect increased the efficiency of clean energy generation systems and thereby reduced CO_2 emission by around 30 %. techno-economic and various algorithms have been made to optimize and increase the efficiency of utilizing wind energy for electricity generation studies were obtained from Nigeria that could aid renewable energy policy for the development of wind power in this area [17,18]. The most important ones are: 1) finding the best angle of solar panels according to the change of sunlight and 2) increasing the efficiency of solar panels. Research in this area shows that by increasing the efficiency of solar panels, solar beams can increase the efficiency of solar panels by up to 30 % by guiding the reflection [19,20].

The thermo-economic investigation of photovoltaic systems has attracted researchers insomuch that investments in such projects have been doubled in recent years [21], for instance, the study of renewable energy systems, design, operation, and maintenance for photovoltaic during the project life are important criteria indicators to analyze in the investment and construction of solar power plants [22]. The photovoltaic power forecast is another factor that should be examined for the techno-economic feasibility of the project [23]. On the other hand, economic analyses such as internal interest rates (IRR) and the return period of capital cost are usually carried out after technical assessment. For this purpose, technical experts evaluate several scenarios to compare proposed energy systems in terms of energy and cost [24]. Furthermore, the inclusion of advanced resource assessment tools enhances the robustness of renewable energy potential for solar, wind, and other carbon–neutral sources like wave energy [25,26].

Planning for the European climate change agreement has been carried out in the field of expansion and investment in renewable energy. In this regard, research by Nikolaev and Konidari has indicated that the percentage of renewable energy expansion in Bulgaria has increased by 16 % in 2020. This research used the LEAP tool model (an essential method for discerning the time development of scenarios and detecting the most suitable one) and selected three scenarios as a goal for 2030. This study aimed to determine the most possible Bulgarian renewable energy policy on the international energy policy [27].

The importance of creating a proper plan to employ renewable energy resources for the next 15 years has also been the focus of Asian countries, such as South Korea and Iran, which have examined the costs of energy production and the number of pollutants for 2030 [28,29]. For example, in the research by Saheli et al. [30] three ports of Iran are considered for the effect of the solar-wave energy production of the Caspian Sea on the price of energy composition in Iran. For this purpose, they provided six scenarios to expand renewable energy resources in the south of the Caspian Sea. The results showed that if the use of renewable energy is met 100 % by 2030, then the energy costs will be reduced by $220 million per year, and CO_2 production will be dropped by 2.43 million tons per year [30].

Usually, renewable systems are selected for areas that operate independently of the network (such as small villages, islands, and forests) or far from the power grid [31–33]. Choosing equipment and the best combination of energy generation systems are very important to reduce the costs of the network [34]. Hence, several studies have designed and examined solar, wind, and fuel-driven energy systems to meet the electrical and thermal requirements set by global agreements through various case studies, especially in European countries such as Italy and Spain [35,36]. They used hybrid renewable systems and optimized their electricity-generating systems to fulfill commitments associated with mitigating climate change [37]. In this regard, Hoseinzadeh et al. investigated multiple case studies having hybrid energy flexibility systems for the decarbonization of some islands in Spain [38] and Sicily in Italy [39]. Items that have improved simulation results in various research using the EnergyPLAN software and HOMER software are the use of sensitivity analysis in data analysis and results [40,41]. This sensitivity analysis can indicate the performance of the intended systems and equipment used under different conditions and energy consumption in the region for peak hours and non-peak hours. On the other hand, sensitivity analysis can determine the amount of deficit or surplus of energy and subsequently determine the amount of income and profit of the project [42]. The EnergyPLAN and HOMER software help engineers to develop and navigate the complexities of designing techno-economics which combine traditional and renewable generation sources [43] as well as conventional and innovative technologies [44].

This research is intended to plan the optimal energy transition of Ragusa by examining the investment scenarios of renewable energy resources in Italy and their integration within the energy system in terms of economic, environmental, and technical impacts. Three scenarios are considered to meet the electrical, thermal, and transportation needs of the city of Ragusa in Italy with 0 %, 50 %, and 100 % renewable energy shares. Indeed, the research investigates the advantages brought by sector coupling solutions through the synergic operation of technologies such as Heat Pumps (HPs) and Electric Vehicles (EVs) along with renewable generators (i.e., photovoltaic panels and wind turbines) to optimally exploit their non-dispatchable production. The scenarios are simulated by EnergyPLAN and the results have been compared and validated by the HOMER software. The basis of simulations derived from meteorological data is on the prediction of production in 2030. This research could be placed as a renewable energy policy for similar areas of Italy and other European countries with the same climate.

Methods and scenarios

This research aims to investigate the PRISMI Plus approach that has been used for Ragusa to compare the feasibility of using various renewable energy systems according to the graphical abstract; Baseline scenario, 50 % renewable energy scenario, and 100 % renewable energy scenario while considering low carbon production while using PVs, WTs, Solar Thermal collectors (STCs), EVs, HPs, and Battery Energy Storage (BES) simultaneously.

In this research, a specific framework method for devising future energy scenarios is studied for Ragusa as a case study by using the

PRISMI PLUS methodology. This methodology consists of the following phases: the first step is the need for energy to be provided by the Ragusa regional municipality with real data related to the consumption of energy for the electricity generating system, heating system, and transportation service. In the second step, the mapping of the locally available RES such as solar and wind data is carried out to assess the RES potential. To perform this step, the web tool "Renewables.ninja" [45] is used. The hourly distribution data (throughout the year) of solar photovoltaic power, wind power, heating demand, and air temperature were extracted from the aforementioned website for Ragusa. In the third step, the appropriate green technologies such as PVs, WTs, STCs, EVs, HPs, and BES are considered for the Ragusa Municipality to check how feasibly they can be employed in this location. For this purpose, the following scenarios are defined for the techno-economic analysis in this case study while the analysis is performed utilizing the EnergyPLAN software.

The RES development is investigated with three scenarios. The case study has a short overview of present demands, accessible energy resources, and energy technologies. The last (i.e., fourth) step of the project in the PRISMI PLUS procedure is the split of schemes. The development of the structure for the energy system in Ragusa city has been investigated through the three following schemes:

- First Scenario: This scheme is a baseline scenario as it only deals with the existing state of the city and no added investment and establishment are taken into account. In this scheme, the data for power use of the area provided by Ragusa Municipality is considered for which no RES technology is being employed.
- Second Scenario: During this scheme, incomplete electrification (50 % of the complete use) of transport and heating has been considered by the installation of Electric Vehicles (that are enabled only for smart charging) and Heat Pumps. It should be noted that the Vehicle-To-Grid (V2G) is not allowed in this case.
- Third Scenario: During this scheme, which administers complete electrification, all the total energy consumption for heating and transport is analyzed by installing Electric Vehicles and Heat Pumps. In this scenario, the V2G option has been considered as a viable option. Also, the costs of PV, WT, and BES are analyzed assuming to reach a 100 % RES share.

The scenarios have been identified in collaboration with the Municipality and their objective in the short and long term (respectively the second and third scenarios) considering, at the same time, the viability of some of the proposed solutions such as the V2G option that has not been considered viable in the short/medium term (second scenario) while it has been considered viable for the long-term (i.e. third scenario).

As previously described, the scenarios are simulated by EnergyPLAN and the results have been compared and validated by the HOMER software to investigate and analyse the performance of each scenario and identify the optimal future energy strategy.

Case study, design and methodology

Ragusa is located in southern Italy and is known as a Municipality on the island of Sicily in the capital of the province of Ragusa. It is located between two deep valleys "Cava San Leonardo and Cava Santa Domenica" on a wide limestone hill. Regarding its location and its electricity supply, the overall size of the interconnection to the national power grid has been assumed to be 26.55 MW. The estimation has been done considering the maximum (peak) load of electricity that is provided by Ragusa as a case study which is considered 22.13 MW; this value has then been oversized by a factor of 1.2 to receive the aforementioned value of 26.55 MW.

According to first-hand information from the municipality, the opportunities for local energy production are limited, so this city is strongly dependent on electricity imports. In this regard, only a few PV panels and wind turbines could be installed in the city with an overall yearly production of 79.4 GWh/y and 18.46 GWh/y, respectively. Ragusa is also a popular tourist attraction during summer, thereby resulting in highly seasonal loads. As can be seen from Table 1, the values of energy consumption and energy vector are informed for each sector provided by Ragusa Municipality.

Regarding the sector of heating, no information has been provided for HPs, so in the mixing system, the baseline scenario does not consider this technology. Knowing the following RES mapping such as solar and wind capabilities for the last ten years in Ragusa using the web tool "*Renewables.ninja*" [45] it can be claimed that the solar potential is extremely usable and commodious, with yearly solar irradiation of 1,900 kWh/m^2.

Fig. 1 shows the average hourly electricity demand in scenarios 2 and 3 to grasp the effect of the increasing demand for electrification. To evaluate this, a shift from currently used technologies towards sustainable ones has been assumed as per the previously described scenarios. Particularly, this shift has been done assuming a specific consumption for traditional vehicles of 1.5 km/kWh vs consumption of EVs (both dump charge and smart charge) equal to 5 km/kWh. The same method has been adopted to evaluate the final consumption for traditional heating systems (i.e. boilers) with an efficiency of 0.85 and HPs with a COP of 3. The power of installed PVs and WTs is evaluated to see whether it reaches the objective RES share. Also, the Critical Excess Electricity Production (CEEP) reduces to decrease the need for curtailment as much as possible.

Fig. B1 depicts the hourly solar radiation profile, and Fig. B2 shows the capacity factor of PV panels in an hourly period used in Ragusa, from which both raw data time series are retrieved. Also, to have a better evaluation and simulation of the energy system, photovoltaic (PV) and WT technical specifications are shown in Table 2a shows the capacity of PV and WT installed in Ragusa and the input data for all the simulated scenarios. In both scenarios 2 and 3, EVs are considered to be enabled only for smart charging, no Vehicle-To-Grid (V2G) is allowed. Further considerations will be elaborated based on the year 2030. The installed PV capacity for the 3 scenarios are: (S1: 50650, S2: 157700, and 383000) [kW$_p$], and the installed WT capacity for the 3 scenarios are: (S1: 7096, S2: 23585, and 127000) [kW$_p$] while Fig. 1 shows the electricity demand variation between the scenarios due to the increasing electrification of demands.

The municipality of Ragusa provided all yearly data needed for calculations. However, since the hourly electricity distribution of Ragusa was not given, the reference hourly profile given by the software was employed. According to assumptions of scenarios, the total electricity consumption of Ragusa for scenarios 1, 2, and 3 are 527.59 GWh/y, 611 GWh/y, and 698.91 GWh/y, respectively.

Table 1
Consumption details of Ragusa.

Consumption	Energy vector	Value (MWh/y)
Heating	Diesel	15,270
	Coal	0
	Biomass	25,658
	GPL	39,294
	Oil	16,414
	Natural gas	98,077
	Solar thermal	1364
Transport	Gasoline	120,793
	Diesel	274,412
	GPL	20,214
	Biofuel	16,615
Industry and other fuel consumption	Oil	106,872
	Natural gas	50,570

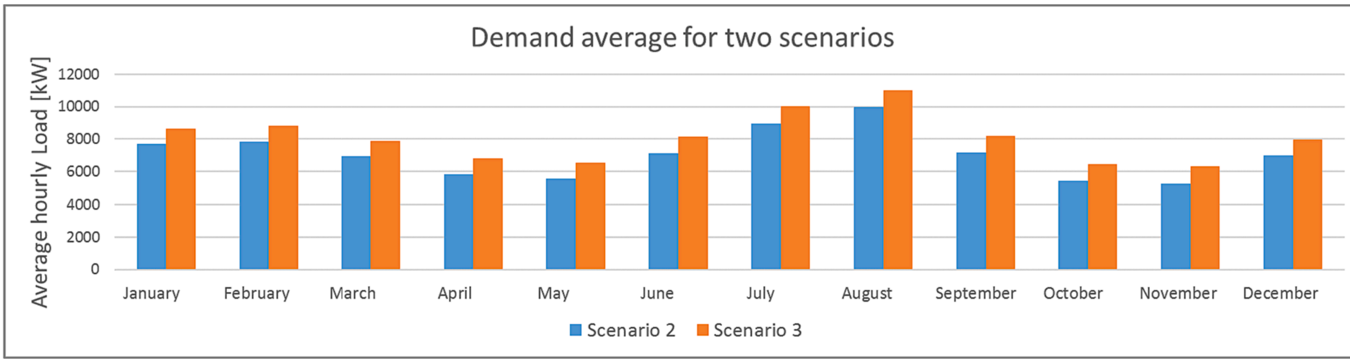

Fig. 1. Average monthly load demand for Ragusa municipality in 2030 for scenarios 2 and 3.

Table 2a
PV and wind turbine specifications.

Component	Name	Size	Unit	Capital (€)	Replacement (€)	O&M (€/year)
PV	Generic flat plate PV	1	kW	1070	1000	10
Storage	Generic 1kWh Lead Acid	1	strings	300	300	10
Wind turbine	Generic 1 kW	1	#	990	900	31.68
System converter	System Converter	1	kW	300	300	0

Results of modeling

The HOMER software is a simulator for the economic and technical feasibility of renewable resources. This software can introduce the best and most efficient system technically and economically according to the given input and output data, including the area's meteorological data, the hourly consumption of electricity, as well as financial input information. These results include the output power of each equipment and the estimation of the initial investment costs to show the current cost and the net cost of energy per kW. The reason for the use of HOMER

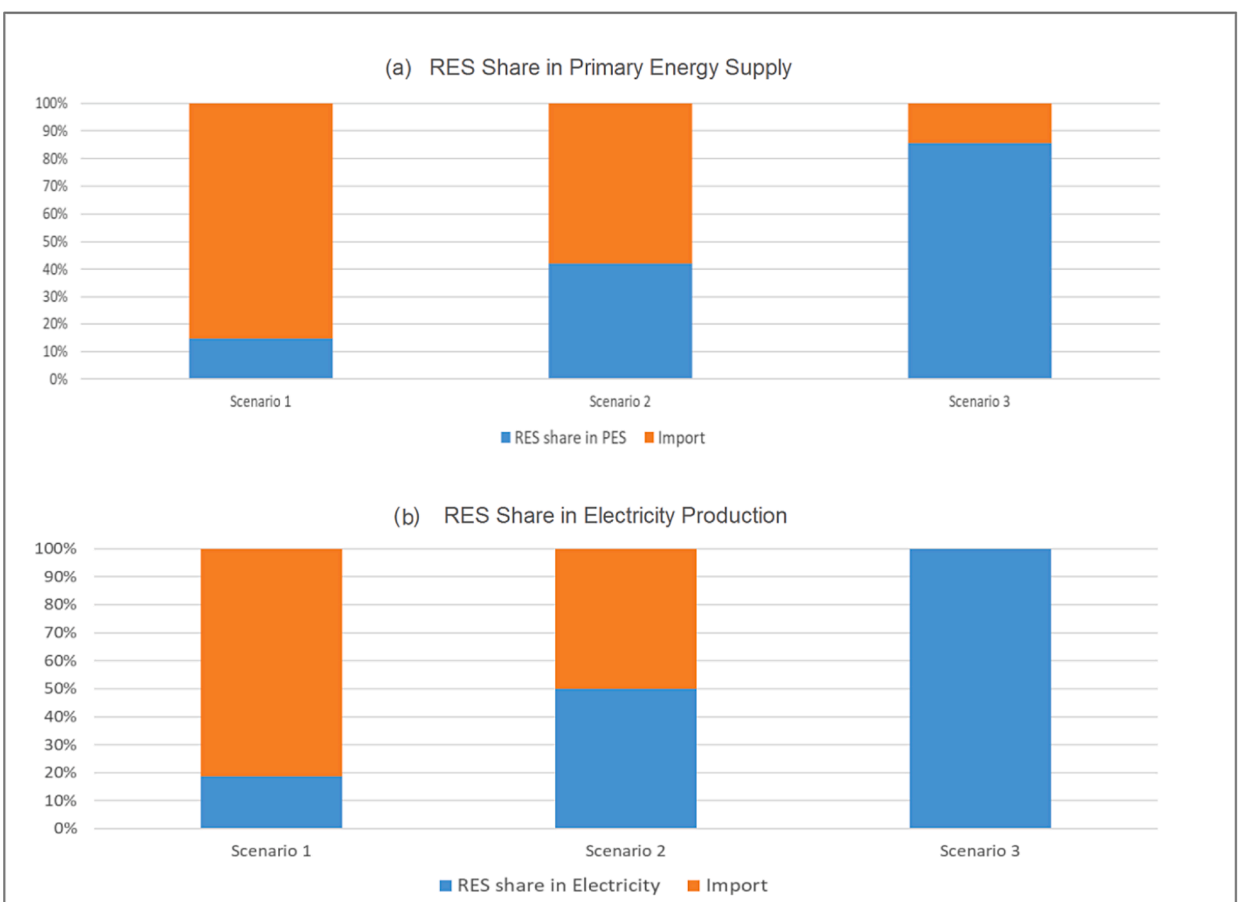

Fig. 2. (a) Investigation of RES in different scenarios for energy supply, (b) Investigation RES share in different scenarios for electricity production.

software is that it simultaneously performs economic and technical analysis and provides the results with the ability to add sensitivity analysis and make a validation with the results of EnergyPLAN.

Energy modeling and analysis

In this section, the technical modeling is simulated, and the results of the combination of RES shares in energy supply and electricity production are investigated to make a careful comparison of each scenario.

For each scenario investigated in EnergyPlan, the combination of RES deployed is presented and the Results of modeling – energy generation from RES are as follows: Scenario 1: (79,42 GWh/year for PV production, 18.46 GWh/year for WT production), Scenario 2: (247.28 GWh/year for PV production, 61.35 GWh/year for WT production) and Scenario 3: (600.56 GWh/year for PV production, 330.34 GWh/year for WT production). In HOMER each scenario is calculated as follows: Scenario 1: (79,59 GWh/year for PV production, 5.025 GWh/year for WT production), Scenario 2: (232.25 GWh/year for PV production, 32.05 GWh/year for WT production) and Scenario 3: (564.05 GWh/year for PV production, 172.61 GWh/year for WT production).

As it can be seen from Fig. 2a, the RES share for different scenarios is investigated based on the primary energy supply (PES). Fig. 2b shows the RES share for different scenarios of the electricity supply based on the amounts of energy generation. As it can be compared to the percentages of the RES share, a great diversification has been seen in RES shares in electricity supply.

Validation of modeling

In this section, the combination of solar and wind energy systems as RES are presented that can be compared and validated with each other. In both Figs. 3a and 3b, the PV and WT systems' average values for output power in each month of the year are shown for all scenarios (1, 2, and 3) separately. As can be seen, first, the results are extracted by EnergyPLAN which is shown in Fig. 3a, and then by following the same scenarios, all the results have been extracted by the HOMER software which can be seen in Fig. 3b. By comparing the results of Figs. 3a and 3b,

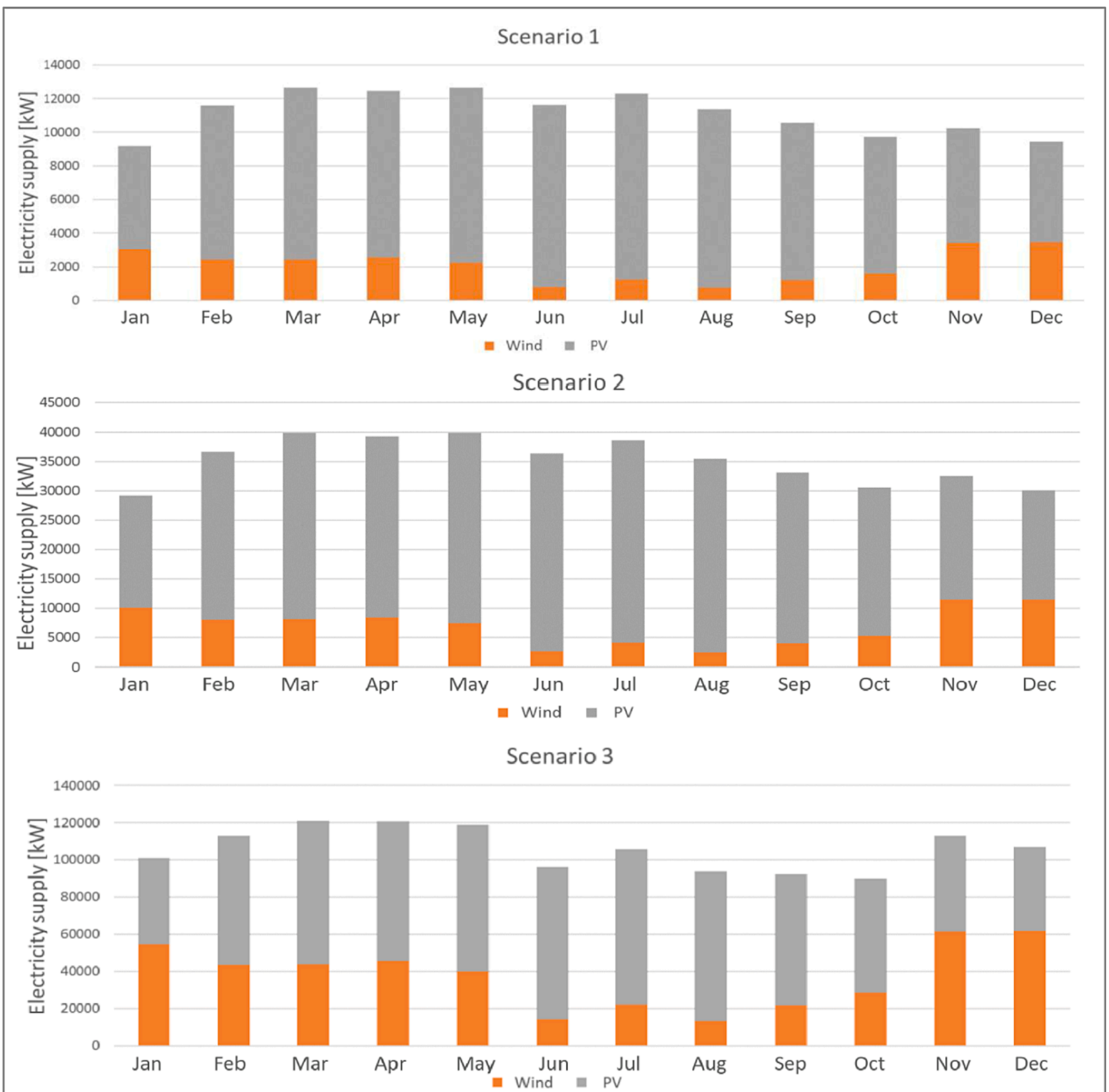

Fig. 3a. Average PV and WT systems' output power values for scenarios (1, 2, and 3) by EnergyPlan.

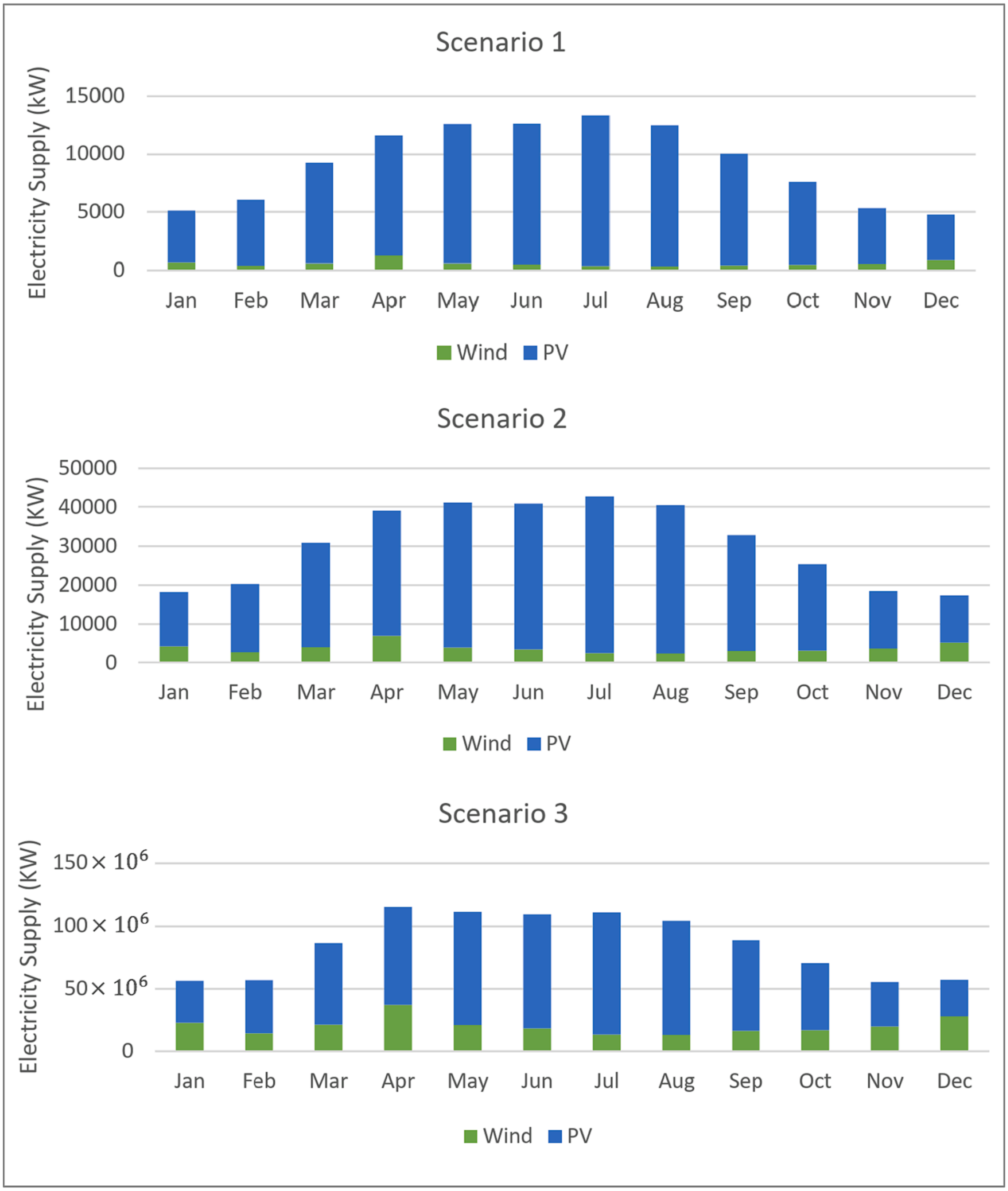

Fig. 3b. Average PV and WT systems' output power values for scenarios (1, 2, and 3) by HOMER.

it can be proved that the accuracy of the results for each scenario is reasonable and good enough to be validated by each other.

Scenario 3 leads to a high value of CEEP equal to 75.39 GWh/y (i.e., 10 % of the total consumption of electricity). Such a percentage value is considered high, indeed, the reference value of 5 % is usually what a modeler should aim for. To avoid stability issues, the CEEP should be reduced by curtailment, thus wasting renewable electricity and leading to a renewable, usable, energy production equal to 298.2 GWh/y from Wind Turbines and 557.28 GWh/y from PV plants.

Specifications and economic information details of photovoltaic production and panel and wind turbine production and equipment in the HOMER software for three scenarios designed in Tables C1 and C2, respectively. All scenarios of the simulation were carried out by HOMER Cycle charging for the dispatch strategies. These tables show the energy production of PV and WT after careful checking. It can be seen that the numbers in the HOMER software are close to that of the EnergyPLAN software, indicating the accuracy of the simulation of both software.

In the results of the wind turbine, the reason for the difference in result is the Hub Height in the HOMER software for the wind turbine is less than the EnergyPLAN.

A comparison of the results obtained from the two software is shown in Fig. 4, as it is clear that the two software are highly accurate in the calculation and estimation of energy production from the photovoltaic panels [46]. The results are close to each other. The discrepancy in the results is due to the selection of different elements in the selection of radiation angle and the amount of clearness coefficient of the atmosphere.

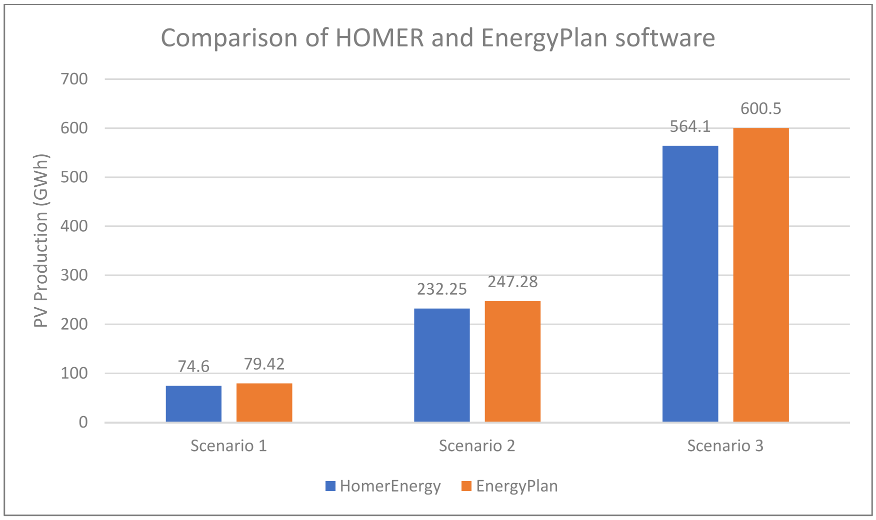

Fig. 4. Comparison of the accuracy between the two software (i.e., EnergyPlan and HOMER).

Socio-Economic and environmental analysis

Input data for all three scenarios, regarding the prices of the PV and WT technology, are presented as Initial inputs for techno-economic analysis for PV [kEUR/kW]: (143.87 Investment, 1 % operation and maintenance (O&M), 35 Lifetime) and for WT [kEUR/kW] are 133.12 Investment, 3.2 % operation and maintenance (O&M), 27 Lifetime.

The economic results of the three scenarios are shown in Table 3, simulated by HOMER software. As can be seen, the results showed that the capital expense (CAPEX) in scenario 2 has increased by 62 % compared to scenario 1. Also, 2nd Scenario has the lowest annual operating expense (OPEX). Hence, when selecting the second scenario as an optimum setting, the results show that the cost of energy will be increased by about 10 % when the levelized cost of energy in this scenario is 0.813 EUR per kWh.

The rapid development of RES over the past 10 years has driven the prices of installed PV and WT systems to fall drastically. This trend is continued, but even more interesting is the share of downstream jobs, such as engineering and installation as well as (O&M).

According to Fig. 5a, discrimination between downstream and upstream job situations is being performed. Emphasis is put on the majority of jobs that are downstream and local for the region where the solar technology is implemented. This is mainly related to the investigated case study, as it can create a new economic regional opportunity through energy technologies.

The implementation of WT and PV systems will create new jobs in the municipality of Ragusa in Italy, such as for installation, management, and maintenance of these systems, as well as administrative tasks. For the next 25-year period, it is worth noting that O&M jobs will have a stable situation for installation jobs and engineering that are occurring during the repowering period.

Since the use of fossil fuels currently employed for electricity generation is partially substituted, the GHG emissions are to a great extent reduced. For the environmental analysis, it can be seen that the Reduction of Greenhouse Gas (GHG) emissions is investigated in Fig. 5b for all scenarios.

Table 3
Economic results for all scenarios.

	Scenario 1	Scenario 2	Scenario 3
Net Present Cost	€311M	€338M	€716M
Capital Expense	€148M	€239M	€572M
Operating Expense	€8.28M	€5.04M	€7.37M
Levelized Cost Of Energy (Per kWh)	€0.749	€0.813	€1.73

Conclusions

This study used a different scenario approach in RES modeling to investigate future energy system scenarios for the Ragusa Municipality. The HOMER and EnergyPLAN models were employed as the simulation tools due to their ease of use and performance. A pre-processing tool, the PRISMI Wind Power calculator, was also used to facilitate the PRISMI PLUS toolkit for future energy strategy development. The methodology includes the construction of an input dataset acquiring what is available in the Sustainable Energy Action Plan and collaboration with the Municipality, the run of the simulation, and the visualization of the results with the relevant discussion for assessing the techno-economic feasibility of the solutions and potential financial impacts. All energy scenarios focused on diversifying the production of renewable energy sources to meet energy needs at different percentages. The study also showed that 2nd scenario has the highest performance from an economic point of view due to its high technical capacity for the consumption of electricity which led to energy prices being reduced by 10 %. Furthermore, the study discusses the implications of grid stability in the Ragusa Municipality and the surrounding areas, including the following points:

- Examination of ways to prevent reliance on renewables curtailment by the proper integration of the installed RES capacity;
- Providing support and potential incentives for the installation and upgrading of infrastructure for electric vehicles and grid flexibility;
- Analysis of the feasibility of using vehicle-to-grid services for added grid flexibility and demand response;
- Although the capital cost in scenario 2 rises to 60 % in compression to scenario 1, the cost of energy (COE) increased by 10 %; it means that the financial efficiency of 2nd scenario is much better than the other two scenarios according to CAPEX as 239 M€ and OPEX as 239 M€.
- The cost of energy is increased in 3rd scenario in comparison to other scenarios because of the greater penetration of the WT compared to the photovoltaic panel in providing the required power according to its net present cost 716 M€, so it means that it isn't financially feasible to use WT in comparison to photovoltaics.
- Examination of ways to diversify the energy mix in the region and stabilize energy supply.

Future implications and suggestions

The presented scenarios show interesting hints of what can be

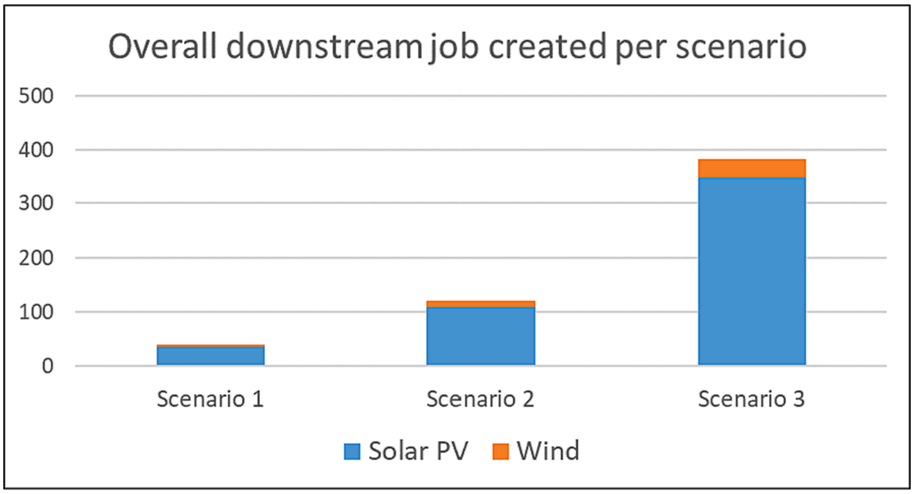

Fig. 5a. Overall downstream job positions creation per scenario for Ragusa Municipality.

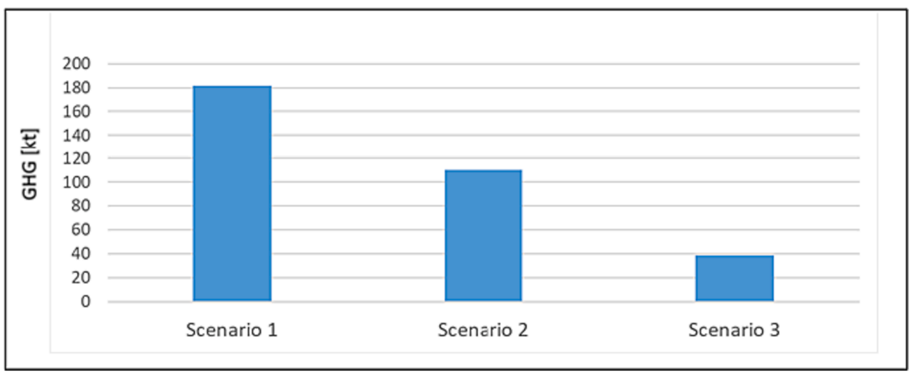

Fig. 5b. Comparison of GHG emissions for all scenarios as compared to the base year GHG emissions.

achieved with Energy Planning strategies developed by the PRISMI PLUS projects applicable for the Ragusa municipality but also for other locations/situations. The results obtained in this study show that Ragusa has a good solar and wind energy potential. Thus, the future energy strategy of Ragusa could be revolved around the following ideas:

- Conceptualization of a thorough implementable plan for the integration of PV systems in the residential and public buildings' rooftops.
- Identifying a location for the installation of Wind farms.
- Introduction of a special provision in new building permits for the aforementioned integration.
- Supporting the installation of and upgrading of the required infrastructure (physical and digital) for the introduction of EVs to provide flexible services to the grid.
- Public awareness, informative campaigns, and promotion of events for the adoption of energy efficiency measures.
- The use of Solar Thermal Collectors, Wind Turbines, HPs, as well as Electric Vehicles.
- A detailed qualitative and quantitative analysis for the integration of other RESs that would differentiate the energy mix of the region thus stabilizing the energy supply and reducing the need for energy storage systems.
- The flexibility provider, such as HPs and EVs, is indeed a need for most energy systems.

Indeed, Ragusa as a middle-sized city, and also a tourist location, represents a perfect case study since it owns features of most cities as well as a seasonal trend in energy demands similar to most tourist destinations. Thus, these results are replicable and scalable.

CRediT authorship contribution statement

Siamak Hoseinzadeh: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Daniele Groppi:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Benedetto Nastasi:** Writing – review & editing, Visualization, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Daniele Bruschi:** Writing – review & editing, Visualization, Software. **Davide Astiaso Garcia:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.seta.2024.103645.

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