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Toward a more sustainable electricity production in Corsica island: medium and long terms scenarios

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Highlights

- Review and analysis of forecasts existing for the future of electricity generation and consumption of Corsica island
- Formulation of consumption and production scenarios for medium (2030) and long (2050) terms horizons
- Environmental and energy assessments of a total renewable energy mix

Abstract

Corsica island is subject to lots of constraints in respect of electricity supply and management. Nevertheless, the island displays of significant renewable sources. The eventuality of a sustainable mix may be worth considered. The contribution of this paper aims to review the existing electricity consumption and generation scenarios developed for Corsica island and a comparison between the forecasts of different periods have been conducted. Then a presentation of possible future paths of the electricity sector is made. Two demands based on a demographic growth rate equals to 0.4% yearly between 2040 and 2050 are investigated. The differences come from: the electrical vehicles fleet and the impact of the energy saving actions concerning the reduce of final electricity consumption, with increase rates varying between 0.5% and 0.1% per year reaching 3011 GWh for the first demand and 2749 GWh for the second. On the other hand, three ways of electricity production are considered, including various penetration rates of renewable energy sources and the cessation of thermal power plants. The current evolutions are implemented for one projection and the part of renewable generation meets 45% for 2050. One appraises the ability of a 90% renewable electricity production in 2050 considering faster deployments, the addition of storage systems and the preservation of the connections with Italia and Sardinia island anyway. The last one, follows the local government objectives and ensures the electricity provision keeping non-renewable appliances as back-up system.

Keywords: renewable electricity, energy transition, non-interconnected zone

List of abbreviations

Symbol	Description
ADEME	French environmental and energy management agency
DREAL	Corsican regional direction of environment, construction and housing
EDF SEI	Electricity of France – Insular energy system
EE	Electric energy
ES	Energy simplicity
EU	European Union
EV	Electric vehicle
INSEE	French national institute of statistics and economics studies
LPG	Liquefied petroleum gas
MDE	Energy consumption management
NIZ	Non-interconnected zone
PE	Energy framework
PPE	Multi-year energy planning
PyPSA	Python for power system analysis
RE	Renewable energy
RES	Renewable energy sources
SACOI	Sardinia – Corsica - Italia
SARCO	Sardinia - Corsica
SRCAE	Climate, air and energy regional outline
TRNSYS	Transient system simulation tool
TIMES	The integrated MARKAL-EFOM1 system

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1 Introduction

Climate change and its various consequences compel territories to orient their electricity production to a more sustainable way [1]. So that, public politics set Energy plans in order to define the principal policy directions [2]. Generally speaking, the small territories as islands can be especially affected [3]. Among the 670 000 discovered islands, 11 000 are inhabited [4] and they hold specific features in term of demography, geography, politics and energy management. In this context, insular territories because of their remoteness, have non or weakly connected electricity grid. Moreover, the energy dependency of those areas, usually exceeds 60% [5], engendering polluting and expensive cost of electricity supply [6] in comparison to interconnected mainland. Consequently, energy transition and carbon neutrality lead to several issues such as the maintain of grid stability while maximizing the renewable generation and avoiding power outages [7]. According to [8], illustrated by the case of Hawaii, an optimal energy transition implies a flexible and autonomous energy supply. Different energy management, of worldwide insular territories have been conducted from the beginning of the 21st century. The program “Renewable energy solutions of islands - Renewislands” launched at the beginning of the 2000^s, intended to promote energy system including renewable energy (RE) supplies and hydrogen chains [9]. Several Canary and Greek islands were selected for those studies. The main results allow to develop a software for sizing hybrid power plant rested on economic, environmental and technical features. Power model “REMIX” is used in [12] for the progression of energy supply to a 100% sustainable in the Canary Islands. A dynamic analysis of one island (Gran Canaria) of the archipelago has been conducted in [13] and developed in Matlab environment with TRNSYS. They concluded that optimal system is mostly determined by financial aspects. Mimica et al. [14], have developed the “Smart Island” tool, that is dedicated to detail energy plan based on the minimization of the investment cost while meeting the load demand. Krk and Vis islands located near Croatia have been selected. For decarbonation of eight EU islands, “REACT-DECARB” platform [15] assess different techno-economic scenarios toward a complete energy self-sufficiency and compare economic results to the current market. French islands are considered as the non-interconnected zones (NIZ) [20]. They bring ten territories, splitting in different groups: Corsica island, overseas departments, regions (Guadeloupe, Reunion island and Mayotte) and communities (Saint-Pierre-et-Miquelon, Wallis and Futuna), Ponant Islands (Sein, Molène, Ouessant and Chaussey islands). Even if their electrical supervision has similar aspects as NIZ, New Caledonia and French Polynesia, due to their particular governments, are not considered as NIZ. In [21], Notton has presented the current energetic situations of those areas and he also points out the challenges for islands to reach energy transition. It is compatible with the two main objectives set by the relative law of energetic transition for green growth, adopted the 18th of August 2015. The first aimed to expand the percentage of RE to 50% into the energy mix in 2020. However, none of the NIZ have reached this threshold as noticed in [22] a more recent article written by Notton et al. The second one established the energy independence of the French NIZ on the horizon 2030, except for Corsica island that has been defined for 2050. The paths toward the energy transition have already been examined for some of these territories. For Reunion island in [23], the authors have proposed a review of the current and future energetic situation and they also provide some possibilities for energy self-sufficiency. In [24], Selosse et al. has studied different possibilities enabling the electricity autonomy of the Reunion island in 2030. The works are based on an energy model entitled TIMES-Reunion. Bénard-Sora and Praene [25] have treated of the interdependence between policy objectives and energy transition for the case of Reunion island. Contrary to Reunion island, papers treating energy transition in Corsica island or presenting energy scenarios to reach the objective of energy sovereignty in 2050 do not exist. Only public reports or the annual publication of the energy provider are available. So that, this paper reports the current energy situation of the island and focuses on the electricity field. After that, the existing scenarios for consumption and production found in the literature are reviewed and compared to the present facts in order to assess their truth. The last part of the paper proposes the description of scenarios formulated for electricity sector of Corsica island according to the current situation, the policy objectives and the sustainable potentials.

2 Energy situation

Corsica island well-known as “L’île de Beauté” is a French territory situated in the Mediterranean Sea. It stretches on 183km long and 83km wide, with a total area about 8 722 km².

In 2018, 581 ktoe (kilo tons of oil equivalent) corresponding to 6,76 TWh, that represents 86.1% of the total primary energy consumption depended on external supplies [39]. Thus, RE sector (electric and thermal) represents only 13.9%. According to Corsican energy balance of 2020, final energy consumption can be divided as follow: 39.9% of oil-products are dedicated to the transport sector, while the heating consumption represents 7.8% encompassing mainly liquefied petroleum gas (LPG) and heating oil. Electricity demand corresponds to 33% of the final energy. Because of its partial connected grid, the cost production of electricity is way more expensive than the one of France continental due to the provision of an important amount of fossil fuels. Moreover, the electricity production remains more and more pollutant, so that the yearly carbon dioxide emissions of the electricity generation for Corsica and France mainland from 2018 to 2022. The intensity of the island’s mix is in average 5 times more important than the French one.

The electricity generation capacity of the island has not increased from 1996 to 2005 because of the lack of decisions taken since 1987 as noticed in the first chapter of the Energy Framework of Corsica [40] and as illustrated in (Figure 1). (Figure 2). presents the evolution of the electricity generation from 2015 to 2021. In 2021, the total installed capacity bordered 944 MW including SARCO and SACOI links. The system has two thermal power stations: Vazzino that is composed of seven diesel

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generators with an individual capacity of 18.9 MW and a 20 MW combustion turbine generator. Lucciana power plant, owns seven diesel generators of 16 MW and four turbines, so a total capacity equal to 105 MW. After that, the direct current SACOI has an importation capacity fixed at 50 MW, while the alternative current SARCO link corresponds to 100 MW. Concerning the renewable energy portion, large hydraulic represents a total of 200 MW divided into four valleys and eight constructions. The solar power plants stand for the second renewable source and it is more than 2000 solar facilities totaled. Approximately 81 plants have a unit power higher than 100 kW and the more numerous ones are the small and residential photovoltaic solar installations with a range of power included between 1kW and 3 kW. The island also holds two wind farms for a total of 18 MW on the western north, even so, one site is in re powering, thus only one is still functioning. Then, there are two biogas units located in Borgo with an installed capacity of 2.3 MW.

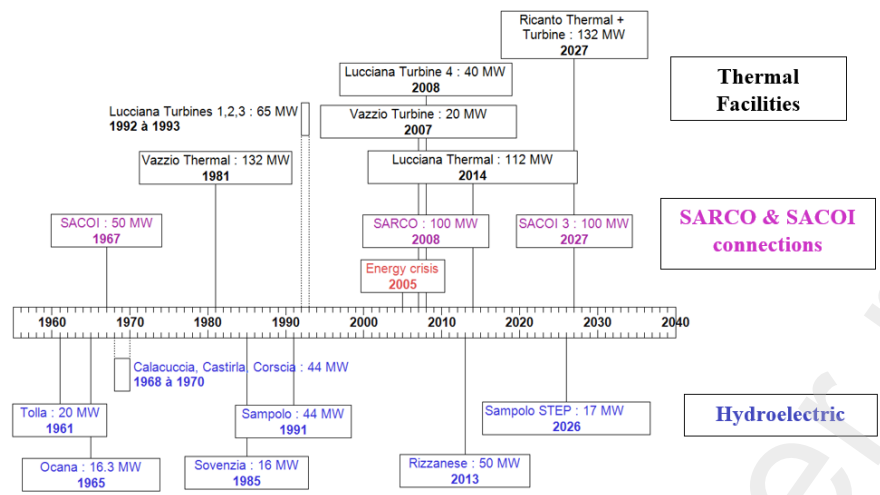


Figure 1 Timeline of electric energy power plants

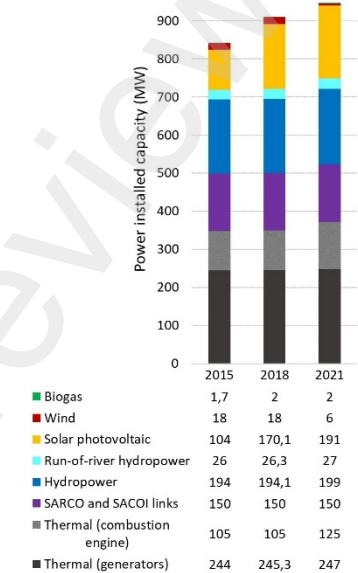


Figure 2. Total installed capacity

Ricanto will have the same process as Vazzio, means around 110 MW divided into 7 generators of 16 MW and a combustion turbine of 20 MW. The power unit can be supplied with three fuels: natural gas, light fuel oil and liquid biomass. According to EDF, the Ricanto will be exploited for approximately 30 years and the decree of the 30th of June 2023 has ruled for a liquid biomass provision coming from rapeseed oil [41]. Another electrical reinforcement project has been implemented; it is the increase of the capacity of the direct current link SACOI to 400 MW and the substation to 100 MW. The completion of the construction was initially forecast for 2024, but because of the administrative authorization period, it has been expanded to 2028. The high-voltage transmission network of Corsica is composed of 758 km of high voltage electric lines, a high voltage direct current link (SACOI) crossing the island and 33 substations with 5 ones to injection only and 28 are transformers substations. (Figure 3). sums up the existing electrical network and the different electricity appliances.

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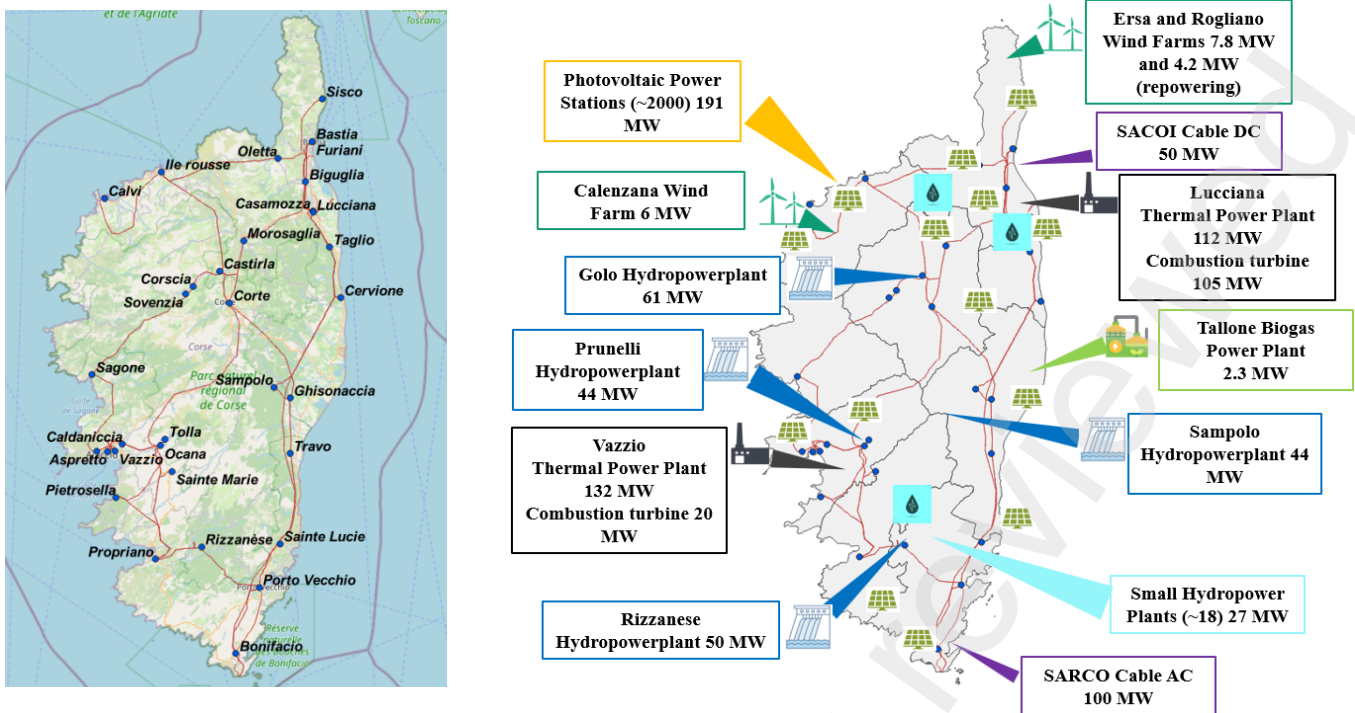


Figure 3. (a) Map of the high voltage electrical network of Corsica; (b) Map of the electricity power plants installed in 2021

3

4 Review and analyze of the electricity scenarios for 2020-2023 and 2030-2050

The assembly of Corsica has adopted in 2005 the "Energy framework 2005-2025" (PE in French) [40] further to the crisis incident occurring during the winter. The electricity demand improved due to the important cold spell this year and the total electricity generation did not evolved as well. As a result, in the wake of the several blackouts, four projects had been engaged: the reinforcement of the SARCO cable, the commissioning of a turbine generator and the construction of a new hydraulic dam. In order to guarantee energetic objective, the assembly has proposed a "Tripod system for energy" as a reliable solution for the horizon 2015, with this configuration: 30% of renewable electricity production (mainly rested on the hydroelectric schemes), 30% coming from importations by SARCO and SACOI and the remaining 30% are insured by the thermal power plants. Otherwise, assessments for the period 2015-2025 have been introduced according to the data recorded for the year 2004.

After that, in 2013, the "Climate, Air, Energy regional plan of Corsica" (SRCAE in French) [42] was published. The first part relates an energetic review and the second presents prospective scenarios. Three situations have been suggested for different horizons: 2020, 2030 and 2050. They are entitled respectively "Trend", "Grenelle" and "Break" previsions. Concerning the consumption projections, they are principally based on the energy demand management (MDE in French) with similar demographic trends. The "Trend" scenario aims to point out the priority actions to lead and also evaluates the results of the different measures adopted before 2008 in the previous report. The "Grenelle" one focuses on the respect of the national targets set during the "Grenelle environment forum" [43]. To finish, the "Break" option proposes a vision of the energy autonomy in 2050.

Considering the orientations expressing by the SRCAE, the assembly of Corsica has adopted in 2015 the "Multi-year energy plan" [39] covering two time intervals 2016-2018 and 2019-2023. The uploaded version has been published in 2021 and it extends the horizon to 2028. In regard of the perspectives introduced for renewable deployments, only the development of the solar facilities matches with the ambition. Thus, new objectives have been put forward for 2028. The expected part of renewable electricity production is 62%.

The French environmental and energy management agency (ADEME) conducted from 2014, a batch of studies named "Toward the energy self-sufficiency in non-interconnected areas" [44]. The final reports have been published in 2020. The scope of the works is 2050 for Corsica as agreed with the Energy autonomy goal. Five production scenarios are built and sorted out in two classes. First group suits with the non-constraint forecasts implying that there is not objective to deploy sustainable power plants. It has been applied for "Trend" (1), "Thermal advantage" (2) and "Technological advantage" (3) scenarios. "Trend" denotes the reference and thus the optimum energy mix production adapted to fit with the current situation. The "Thermal advantage" favors the conventional electricity productions. And the "Technological advantage" allows to an easier access to contemporary

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technologies. Otherwise, the second class integrates the constraint scenarios with the definition of a total renewable electricity production without taking into account the importations from Italy and Sardinia. It owns the “All green lights” (4) and the “Toward the energetic self-sufficiency” (5) projections.

Each year, the insular energy provider EDF SEI publishes a yearly generation adequacy report [45] [37] on the electricity supply and demand balance providing current installed capacity, consumption data and prospective progressions. The horizon of the study generally depends of the year of the publication. The newest version (2022) [37], two scenarios have been developed the “Azur” and the “Emeraude”. Both, cover five years period from 2021 to 2026. The foremost differences between them are: the energy demand management part amounting to 75% for “Azur” where it is 100% for “Emeraude”. Then the part of intermittent energy capacities differs from 350 MW to 452 MW.

In order to develop consumption conjectures, all reports consider demographic growth. Generally, the hypothesis are fixed by the INSEE considerations. Nevertheless, they are usually reviewed yearly and thus predictions values may vary. The evolution of the population exploited by the SRCAE proceeded from the 2007 INSEE scenario whereas the growths found in ADEME report followed the 2017 INSEE scenario. Seeing as electricity demand mainly depends on this feature, if the previsions do not match with the reality, consumption forecasts risk to be under or over evaluated. As shown in (Figure 4)., the electricity consumption predicted by all the SRCAE frameworks has been under evaluated given that the population increase was under judged. The differences between the current consumption and the “Break” prevision is around 45% and 15% for the “Trend” for 2019 (the year 2019 has been taken as reference because of the Covid-19 crisis in 2020, that prompted a stop of the traditional way of life). Depending of the previous results, it may be expected that trends in the SRCAE will not be in keeping with the situation in 2050. Concerning the forecasts of the Energy framework, they have been over estimated, perhaps it is owing to the fact that the politic choices seek to prevent power outages. Overall the ones proposed by the ADEME report, the difference is taking in consideration the part of the personal electric vehicles (EV). ADEME (5) envisions a more important electricity consumption because it is assumed that all the personal car fleet will be converted into EV and the electricity will be produced in a greener and cleaner manner.

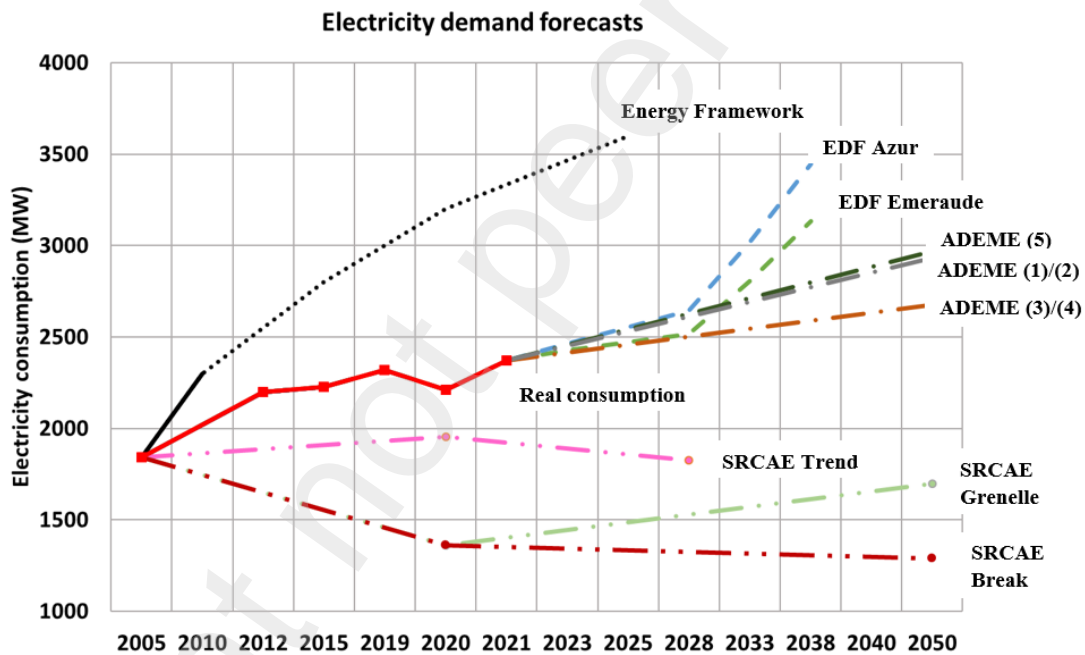


Figure 4: Consumption forecasts of the different scenarios

About the renewable electricity productions, none of the SRCAE corresponds to the current capacities except for the hydraulic sector. The schemes predicted the installation of new wind farms achieving 36 MW, being six times more than the ongoing ones. So that, it will make sense that capacities for 2050 will not fit in with the future waited for 2050. Relating to the Multi-year energy plan, the solar photovoltaic has known a faster development unlike the solar thermodynamic and wind turbine farms. It may emphasize a promising prospect for the solar sector. According to that, ADEME scenarios get into position that solar will cover the major part of the electricity supply. Dams and hydroelectric generators are already exploited at their maximum. Even so, wind sector has to progress in a more significant way to fit with the forecasts. (Figure 5). illustrates the different situations described.

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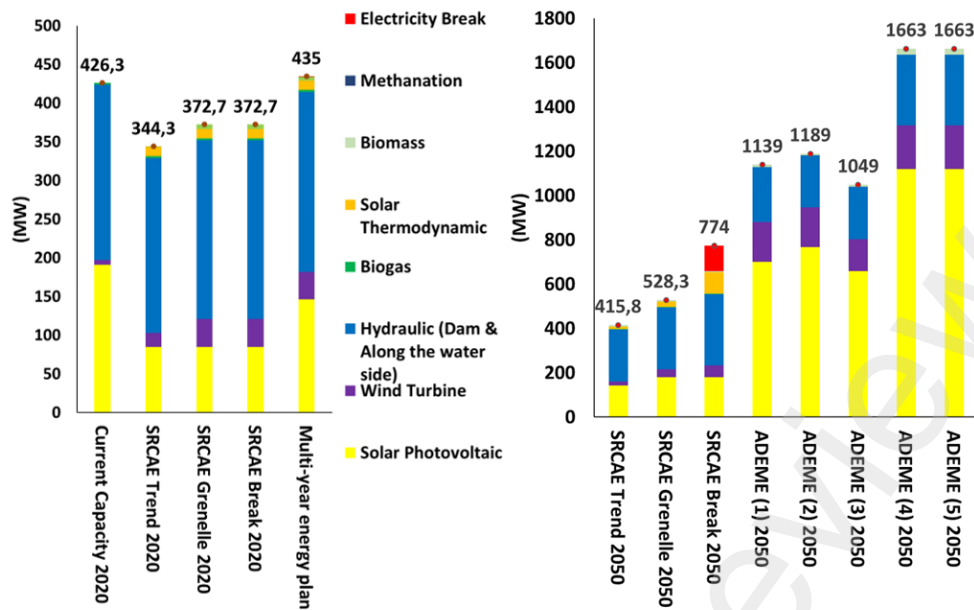


Figure 5: Renewable capacities for 2020 and 2050 of the different projections

5 Modelling of the electricity demand and generation

5.1 Electricity consumption

Based on the existing forecasts and their relevance, medium and long terms scenarios have been generated for the electricity sector given that the lack of data on the various uses of energy. The open database available on EDF SEI website provides the total electricity production with an hourly time step and the annual consumption by sectors (residential, tertiary and industrial). According to various “Generation adequacy” reports (2017 and 2022), the total losses on the grid correspond to 12.3% [45] for 2017 and 13.4% [37] for 2022. To ensure those values remain steady, the losses have been calculated for other years. The high mean is equal 13% and will represent the reference percentage, considered constant.

The demographic growth is the same for both scenarios. With the year 2019 taken as reference, the following rates have been selected to estimate the population:

- +0.7% per year from 2019 to 2030
- +0.5% per year from 2035 to 2040
- +0.4% per year from 2045 to 2050

The first scenario is entitled “Trend” and considers the current evolution of MDE actions implemented. Regarding the transport sector, EV fleet is based on the electric mobility scheme drawn up by the Multi-year energy plan. In this case, consumption will grow of 0.4% yearly until 2030 and of 0.5% between 2030 and 2050.

The second scenario is an “Energy simplicity” (ES) forecast. A strengthening of MDE actions and the establishment of measures in readiness of the energetic simplicity are assumed. The scenario takes into account the “Simplicity plan” published in 2022 by the current national government. The growth rates are 0.25% from 2019 to 2030 and 0.1% until 2050. In this point of view, the EV fleet offers a better development with the possibility to convert the total personal cars into EV. An abstract of the two projections is given in (Figure 6).

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	2030		2050	
	Trend	ES	Trend	ES
Electricity consumption without EV fleet (GWh)	2321	2090	2370	1845
% of EV fleet	20%	50%	50%	100%
Total electricity consumption (GWh)	2423	2385	2665	2432
Energy supply to the grid (GWh)	2738	2694	3011	2749

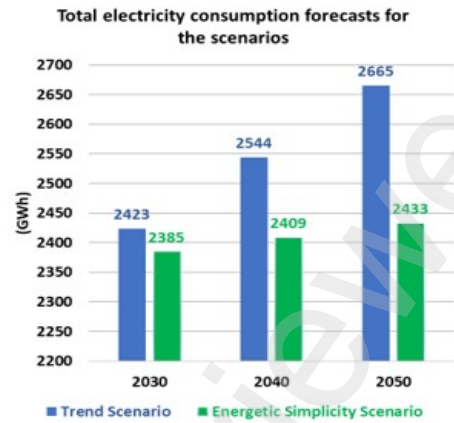


Figure 6: Features of the electric energy consumptions scenarios

In order to reckon the consumption of the 28 transformer substations, a top-down approach has been applied. Thus, the following assumptions are contemplated:

- A town is connected to a single substation
- The total consumption of the subsidiary station corresponds to the sum of the consumption of the attached municipalities

On the basis of the distribution network influence map recounted in [44] and thanks to Geoportail software [46] providing the geographical mesh networks. The 360 towns or villages are assigned to the substations. Consequently, the weight of each substation can be evaluated compared to the island general demand and it is supposed that this rate will not vary over the time and until 2050. The ratios are applied to the values for 2030 and 2050 to find the electricity consumption at the different substations. (Figure 7), presents the different level of consumption per substation.

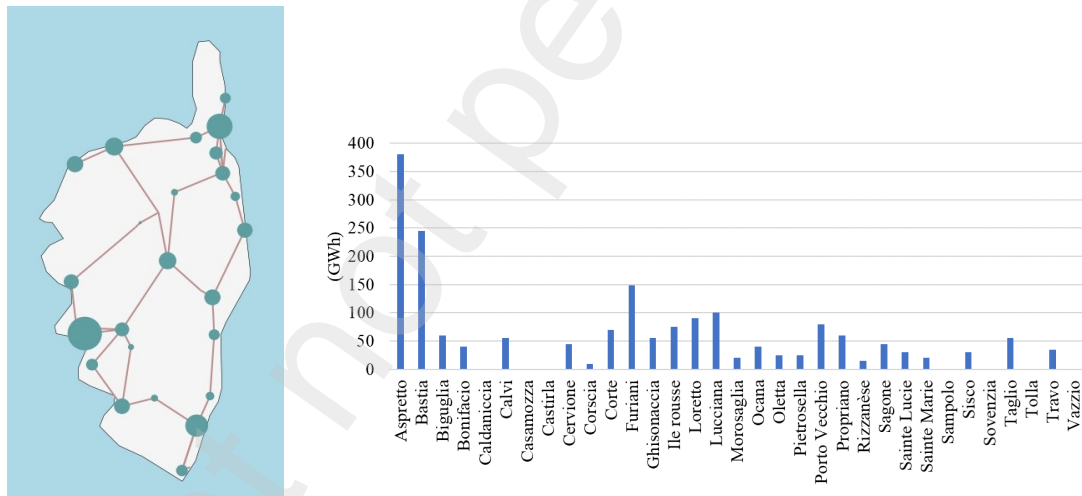


Figure 7: Map and modelling of the electricity demand per substation and its weight

5.2 Electricity generation: assessments of the energy mix and carbon emissions

The “Trend” scenario provides objectives about renewable electricity production. It corresponds to the future of the current electricity sector, following the present evolutions. The two thermal appliances (Lucciana and Ricanto) will keep working until 2050. The cables are also stored considering the SACOI link increase for 2050. Concerning the wind production, assuming the same progression of the past 6 years, only the repowering of the existing plants is expected until 2050. The solar photovoltaic sector meets same evolution as the one occurring from 2015 to 2020. The deployments are expected to reach 580 MW in 2050. The solar thermal is the only new renewable energy developed from 2030 and the hydraulic (dam and run of the river) conserves the same capacity for 2030 and 2050.

After that, the “Electric energy security” (EE Security) forecast is contemplated. The main goal here corresponds to the Multi-year energy plan one: guarantee the energetic security of Corsica island in order to avoid the episodes of black-out. As a result, it aims to develop all the production sectors (renewable, thermal and electricity links), in accordance with the national political

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decisions [39]. Therefore, it is assumed the development of RES, in line with their acceptability. Then with the commissioning of the Ricanto appliance, in 2027, the generators will be functional until 2050 and it can be fueled with liquid biomass as mentioned previously. Lucciana power plant stays operational till 2030. The two power stations allow to guarantee a backup for electricity demand and the maximum hours of operation is set to 3500h. SARCO and SACOI interconnections are kept. The medium-term scenario aims for a doubling of wind farms in 2030 and an evolution of solar fixtures equals to +205%. Thus, the solar farms reach 849 MW and the wind turbines installed capacity is 60 MW. There will be also new run of the river facilities and hydroelectricity schemes.

The last one considered a “100% Renewable electricity mix” (Renew EE) within the acceleration of the deployment of all renewable sectors, allowing the maximum utilization of the local sustainable potentials. Considering that the setting-up of off-shore wind farms is assumed for 2040, it can be imagined that either Ricanto power plant will be supplied with liquid biomass until 2030 or the limit of electricity transfer by SARCO and SACOI links will be applied in 2050. Nonetheless, the Ricanto power plant must be interrupted imperatively in 2050. So that, two options are considered for medium horizon (2030):

- Preservation of Ricanto power generation and limitation of SARCO and SACOI discharge at 50% from 2030
- Cessation of Ricanto power generation and limitation of SARCO and SACOI discharge at 50% from 2050

With a total electricity production ensured by renewable energy, the addition of storage systems will be probably necessary in order to mitigate the intermittency of the resources and to enable a virtual balance between importation and exportation through cables.

The last part of the subsection suggests some assessments on the production mix and the total carbon dioxide equivalent emissions of the electricity generation. To estimate the total solar production, the yearly average sun hours with maximal operation that is 1327h [44] [48]. Regarding the others renewable sectors, the extrapolations are inspired from regional outlines [49], [50]. The electricity supplying from the interconnections and the combustion engines are limited by a maximum hours of operation and their energy efficiency [37]. The reference values for the CO₂ emissions for each sector come from [39] based on the open data “Base Carbone” [51], [52] and [53] for hydropower and electricity connections. To obtain the results of the previous years, the yearly electricity production per sector provided by EDF SEI Open Data [54] is considered. The carbon dioxide equivalent emissions for the year 2021 is equal to 546 g CO_{2eq}/kWh and for 2022 it corresponds to 488 g CO_{2eq}/kWh.

(Figure 8). highlights the main characteristics of the different scenarios. As a reminder, the part of green energy represents 30% in average [55]. If the “Trend” scenario is contemplated, it will not be able to respond to both demands but only to the “EE Security” one. The part of renewable electricity output increases to less than 50% in 2050, and one-third of the energy generation still depends on thermal scheme. Otherwise for the “EE Security” scheme, its mix estimations face up all consumption with an excess of production, however it is also planned several investments in numerous infrastructures. The economic analysis and the cost of the total system may impact. The electric power production is covered by 60% with renewable sources while the carbon emissions lower to 232.84 g CO_{2eq}/kWh. Finally, the third projection of a total electricity production provided by local sources, the “Renew EE” spotlights that renewable electricity may ensure 90% of the electricity demands even if there is not a great decrease of the consumption. Then the emissions rate meets with the PPE objective with a reduction of 80% of the equivalent emissions. Nevertheless, the availability of those sources will be impacted with climatic changes and the addition of medium and long terms storage systems is necessary to overcome the intermittency behavior.

Scenario	<i>Trend</i>	<i>EE Security</i>	<i>Renew EE (1)</i>	<i>Renew EE (2)</i>
Total capacity installed 2030 [MW]	1158.3	1323	1550	1438
Production mix 2030 [GWh]	2698.48	3012.48	2823	2677
Generation from renewable sources	39%	46%	71%	75%
Relative emission [gCO_{2eq}/kWh]	403.6	368.09	216.88	162.72
Total capacity installed 2050 [MW]	1354.3	1520	1775	1775
Production mix 2050 [GWh]	2994	3068.5	3091.82	3091.82
Generation from renewable sources	45%	63%	89%	89%
Relative emission [g CO_{2eq}/kWh]	368.97	232.84	93.41	93.41

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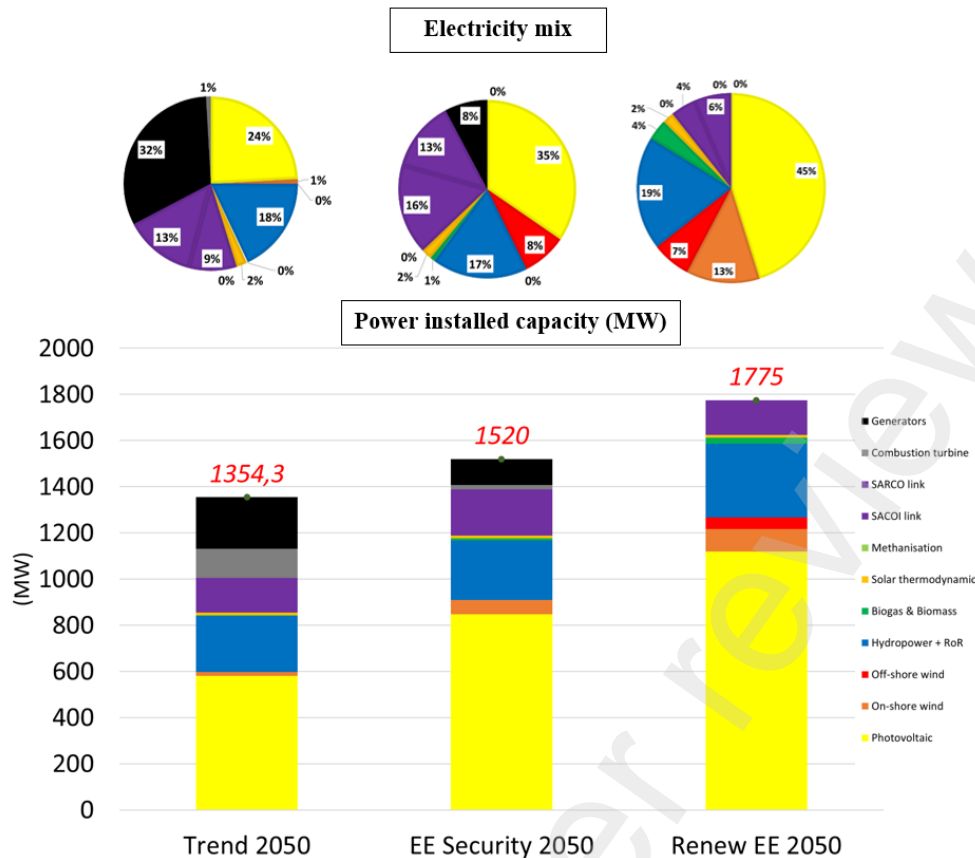


Figure 8: Main results and total installed capacity bar graph and energy mix pie of each scenario for 2050

6 Conclusion

Energy transition and carbon neutrality for islands imply many challenges and not only the technical aspects. Several works relied on public policies, local sources possibilities and economic advantages, hypothesize patterns toward energy autonomy in isolated territories. The existing research studies about the energy transition in Corsica island are few. Only public reports proposed by either the energy provider EDF SEI, the French national agency ADEME and the local government are currently founded. The work relates firstly a general presentation of the island and its current status. Then comparisons between the extant prospective medium and long terms scenarios and the present energy situation are underlined.

These contributions allow to develop new forecasts to mapping the future of electric energy. Two consumption possibilities are investigated and then a top-down approach is used, to recover the electricity demand at each substation. Then the possibilities of different electricity supply by renewable, interconnections or thermal plants are modelling. By combining policy frameworks and an intensive development of RES, the eventuality of a low carbon electricity sector and energy transition is conceivable.

The scenarios will be implemented in a high-voltage electrical network system framing under Python Power for Power System Analysis tool (PyPSA) [56]. The predicible future works are: the techno-economic feasibility of the grid, the needed expansion of electrical infrastructure in instance the high-voltage line capacity expansion or storages required. This preliminary study will serve as a first assessment toward the progression of the electricity sector of Corsica island and perhaps a greener production.

7 Acknowledgements

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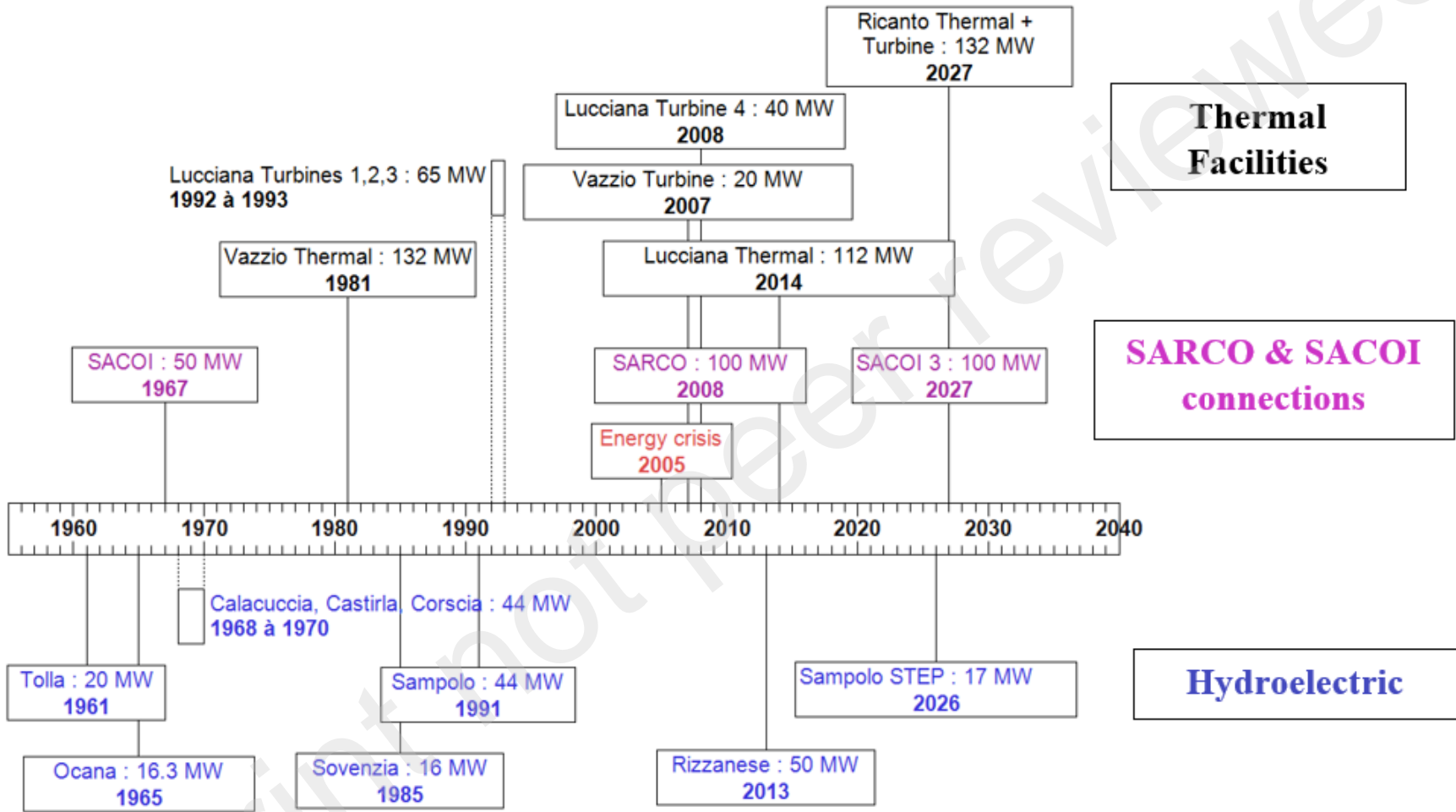
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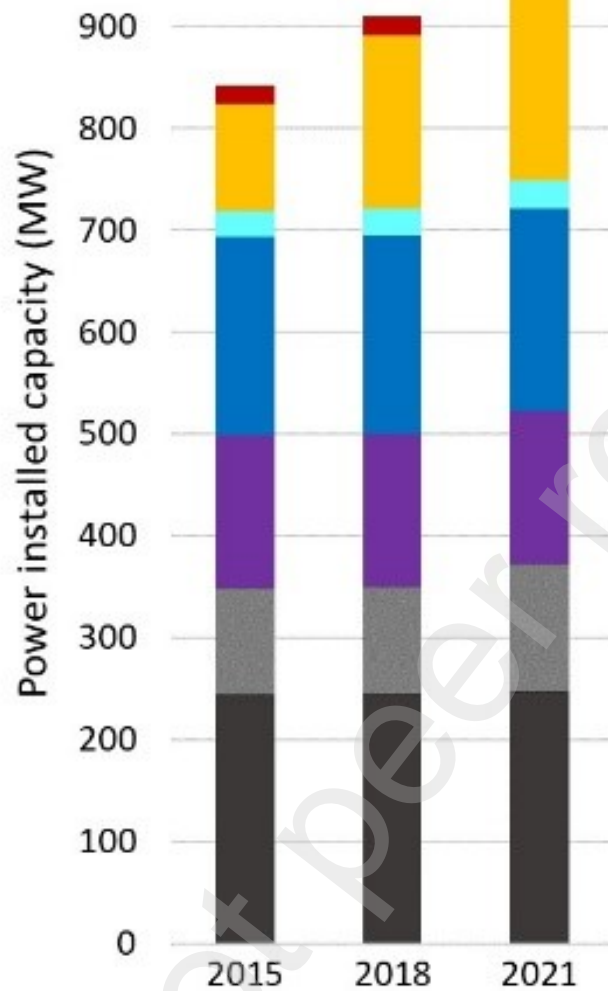
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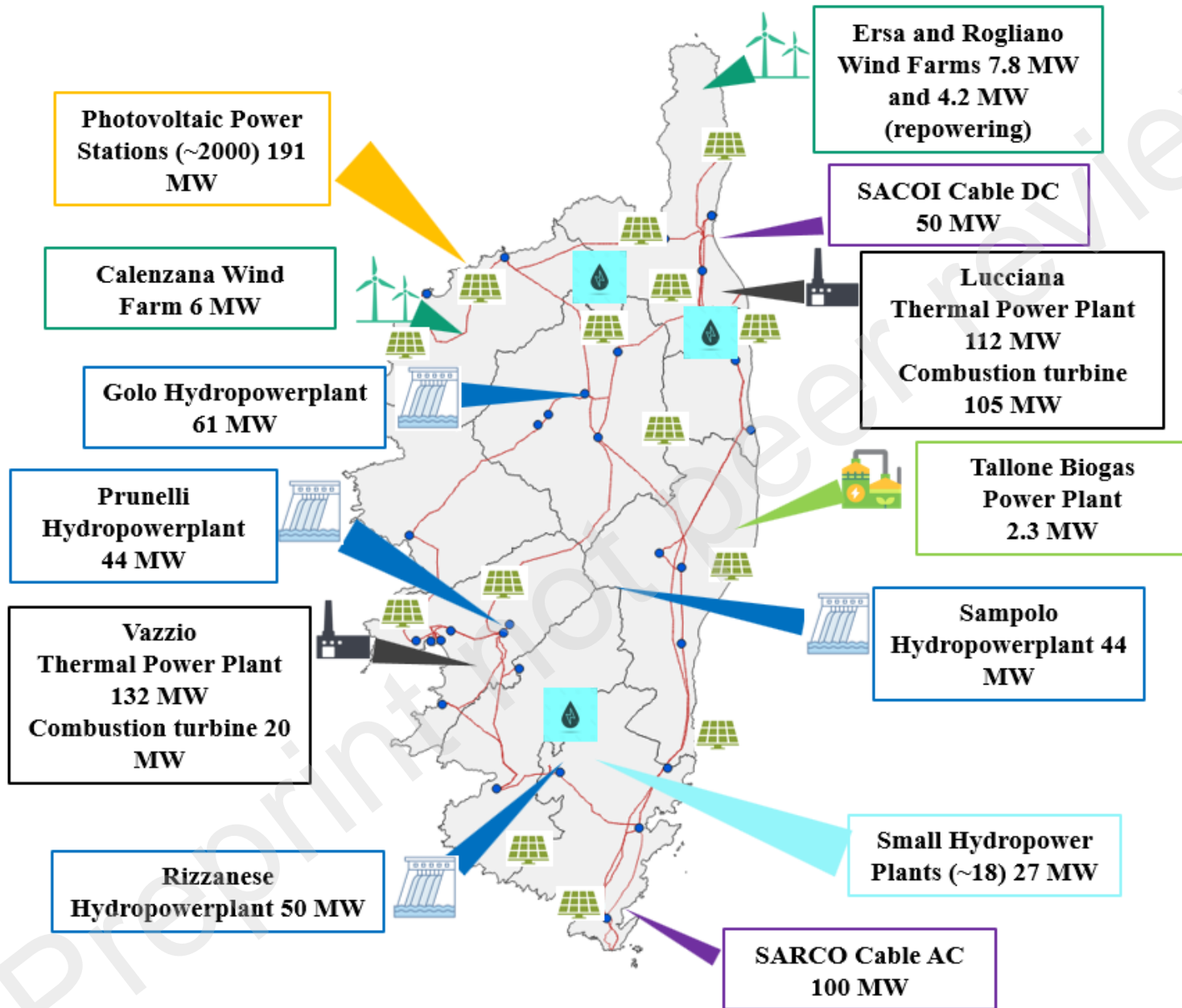


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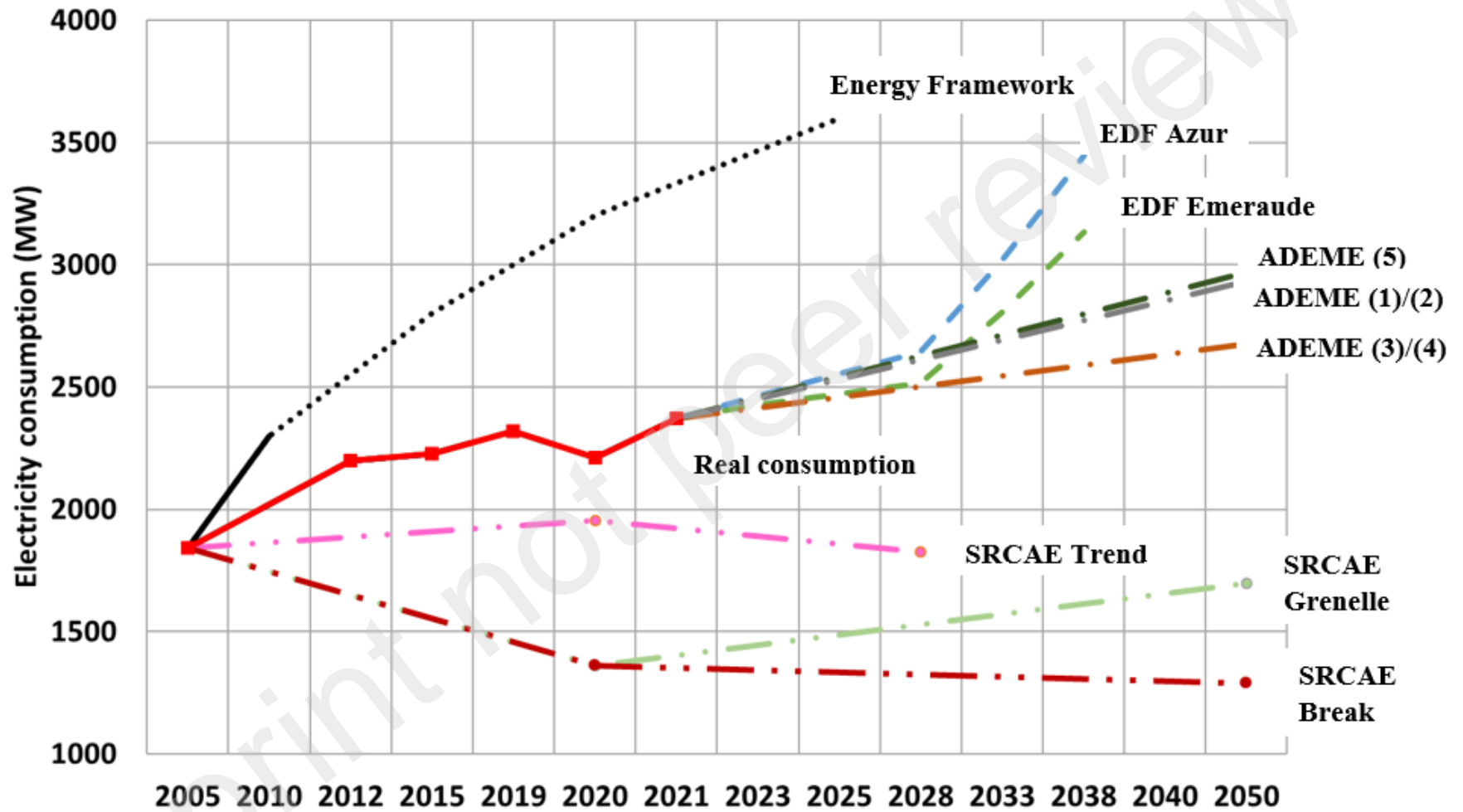


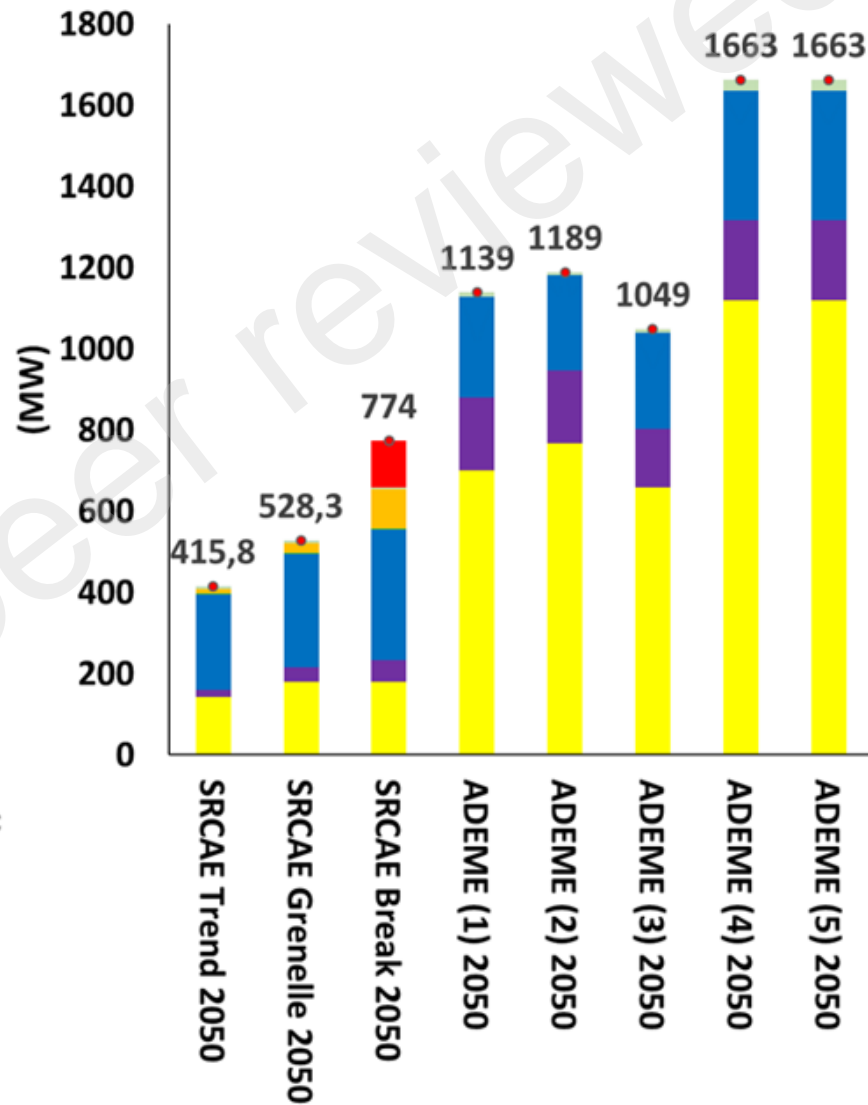
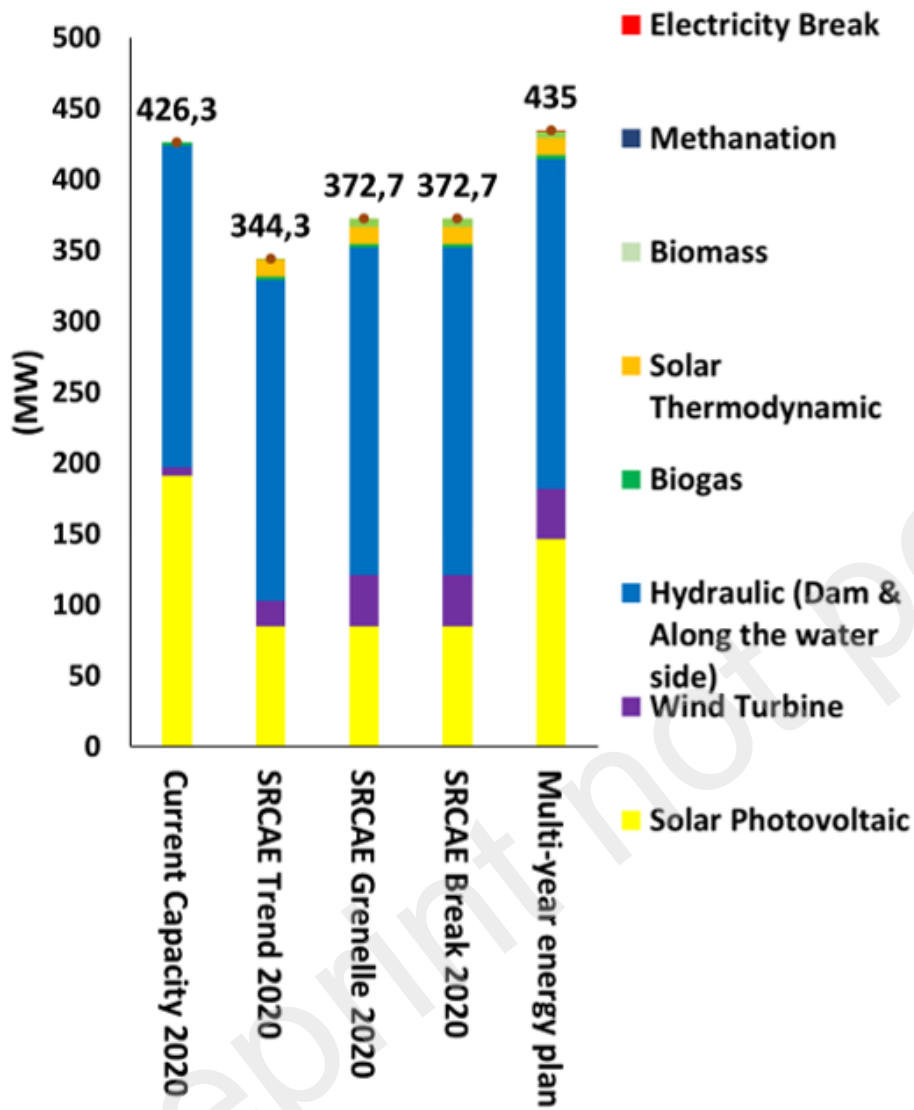
	2015	2018	2021
Biogas	1,7	2	2
Wind	18	18	6
Solar photovoltaic	104	170,1	191
Run-of-river hydropower	26	26,3	27
Hydropower	194	194,1	199
SARCO and SACOI links	150	150	150
Thermal (combustion engine)	105	105	125
Thermal (generators)	244	245,3	247



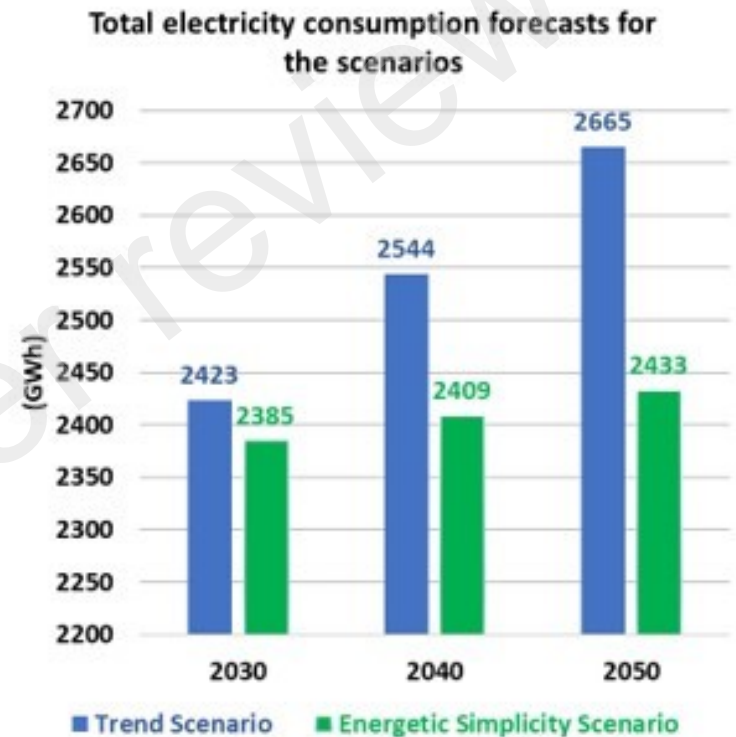


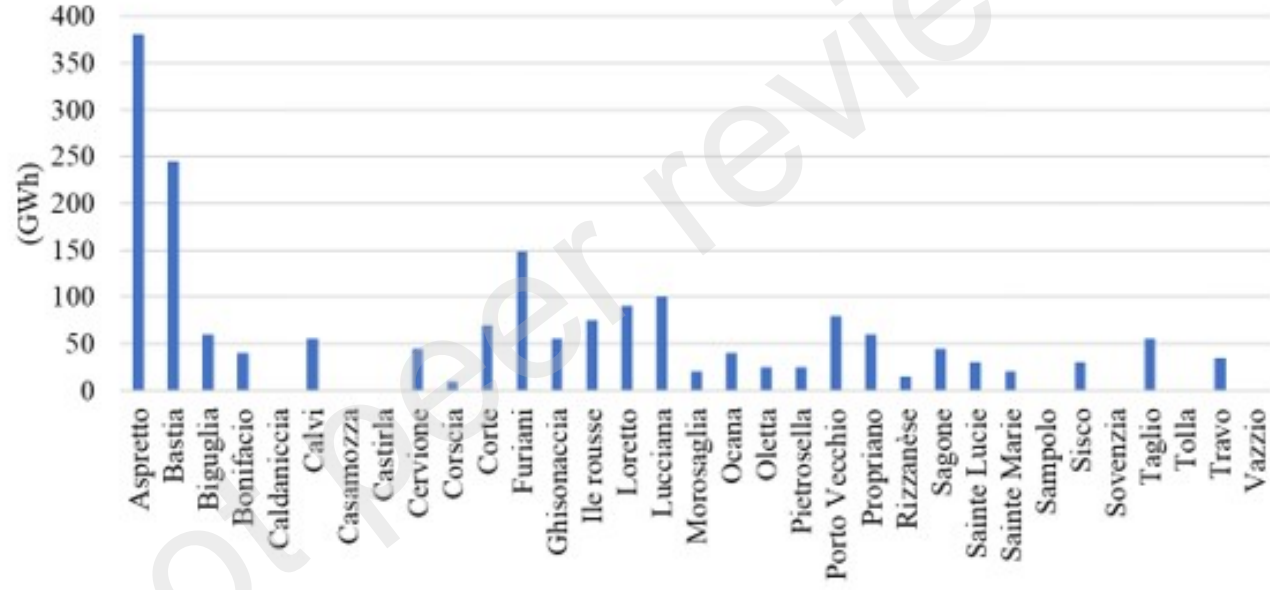
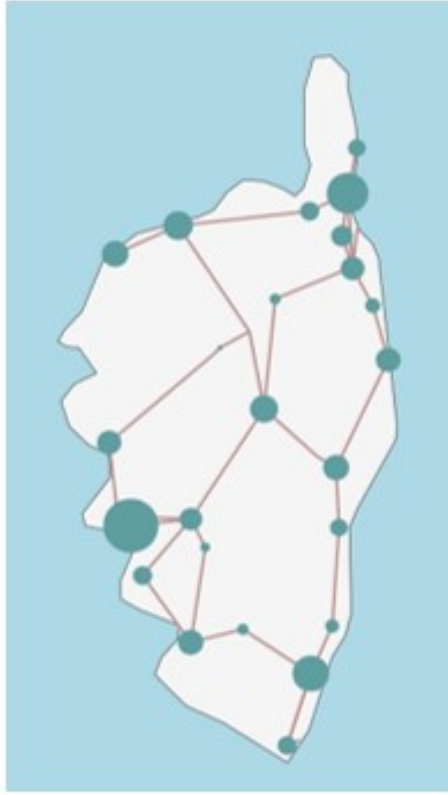
Electricity demand forecasts





	2030		2050	
	Trend	ES	Trend	ES
Electricity consumption without EV fleet (GWh)	2321	2090	2370	1845
% of EV fleet	20%	50%	50%	100%
Total electricity consumption (GWh)	2423	2385	2665	2432
Energy supply to the grid (GWh)	2738	2694	3011	2749

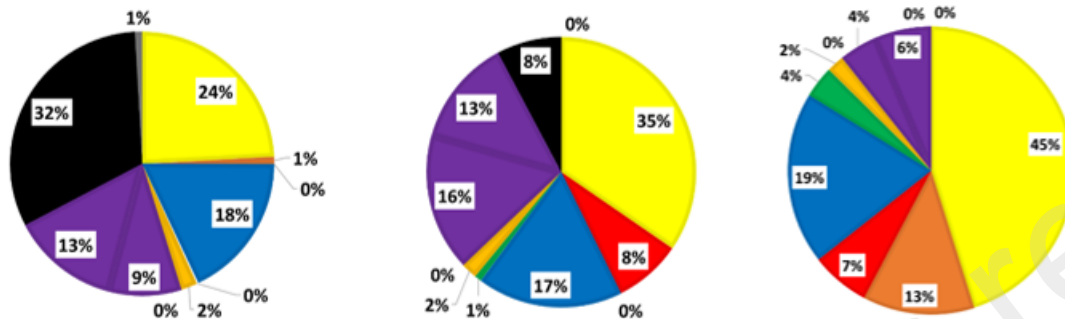




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Scenario	Trend	EE Security	Renew EE (1)	Renew EE (2)
Total capacity installed 2030 [MW]	1158.3	1323	1550	1438
Production mix 2030 [GWh]	2698.48	3012.48	2823	2677
Generation from renewable sources	39%	46%	71%	75%
Relative emission [gCO _{2eq} /kWh]	403.6	368.09	216.88	162.72
Total capacity installed 2050 [MW]	1354.3	1520	1775	1775
Production mix 2050 [GWh]	2994	3068.5	3091.82	3091.82
Generation from renewable sources	45%	63%	89%	89%
Relative emission [g CO _{2eq} /kWh]	368.97	232.84	93.41	93.41

Electricity mix



Power installed capacity (MW)

