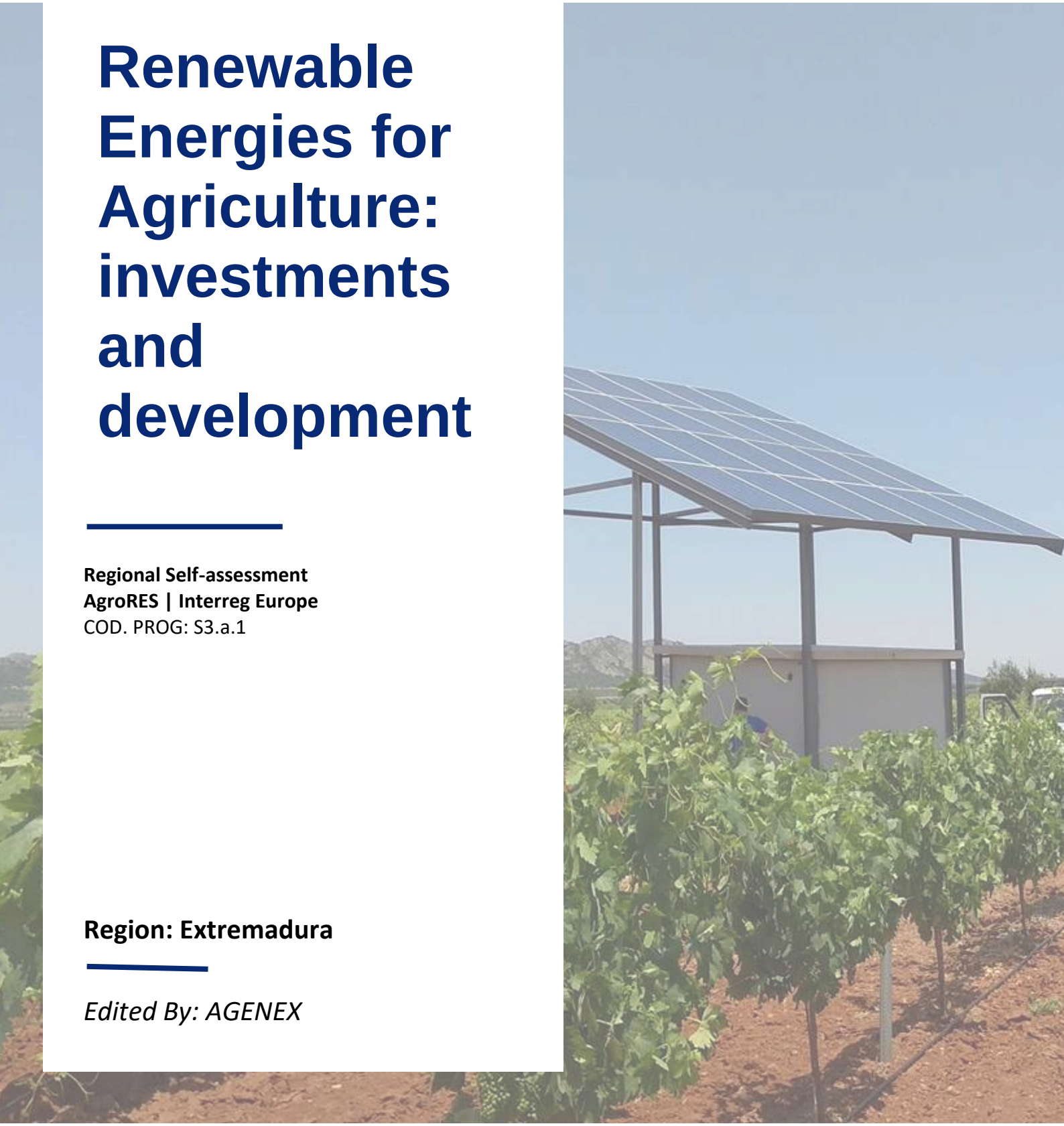
Renewable Energies for Agriculture: investments and development



Regional Self-assessment
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INDEX

Executive Summary

The agricultural and agro-industrial industries are key sectors in the Extremadura economy. In 2019, they contributed to the regional economy with 11.7% of the Gross Added Value and 13.3% of the occupation of employed workers. These indexes are much higher than the national average, indicating a high degree of specialization in both sectors. Agri-food is the second sector that generates the most Greenhouse Gas (GHG) emissions in the Spanish territory, only behind transport. By fields, agricultural activity accounts for around 80% of emissions and the rest is attributed to agribusiness.

The purpose of this report is to seek the feasibility of implementing the different types of renewable energy in the agricultural and agro-industrial sectors in the different environments of Extremadura.

The results show that the region has a variety and quantity of natural resources that favour the introduction of renewable energy solutions in the market. The renewable installed power and production capacity make the region an energy exporter, thus demonstrating the technical-economic viability of these technical solutions. The adoption of energy efficiency solutions in the production processes of agribusiness in Extremadura will make it possible to enhance competitiveness.

Likewise, the policy of incentives for renewables is improving its mechanisms for grants and increasing in successive calls the budget availability, the technologies that can be subsidized and the potential beneficiaries.

Within the agricultural sector, crop farms, due to their zero-thermal demand, would benefit from the installation of photovoltaic solar energy; livestock farms would also improve their energy efficiency by also installing thermal technologies. In the agro-industrial sector, due to their size and process equipment, they can also access medium temperature solutions for steam generation and even for cogeneration applications. In all cases, the grouping of companies would favour the generation of economies of scale, improving the profitability of the investment. The union of companies with complementary seasonality would also improve the viability of the investment.

It is concluded that there is an enormous potential for improvement in the efficiency of the productive processes of Extremadura's agribusinesses through investment in renewable energy generation facilities.

I. *Regional socio-economic framework*

Extremadura is located in southwestern Europe and the Iberian Peninsula. It limits to the north with Castilla-León, to the south with Andalusia, to the east with Castilla-La Mancha and to the west with Portugal. Its capital is the city of Mérida.

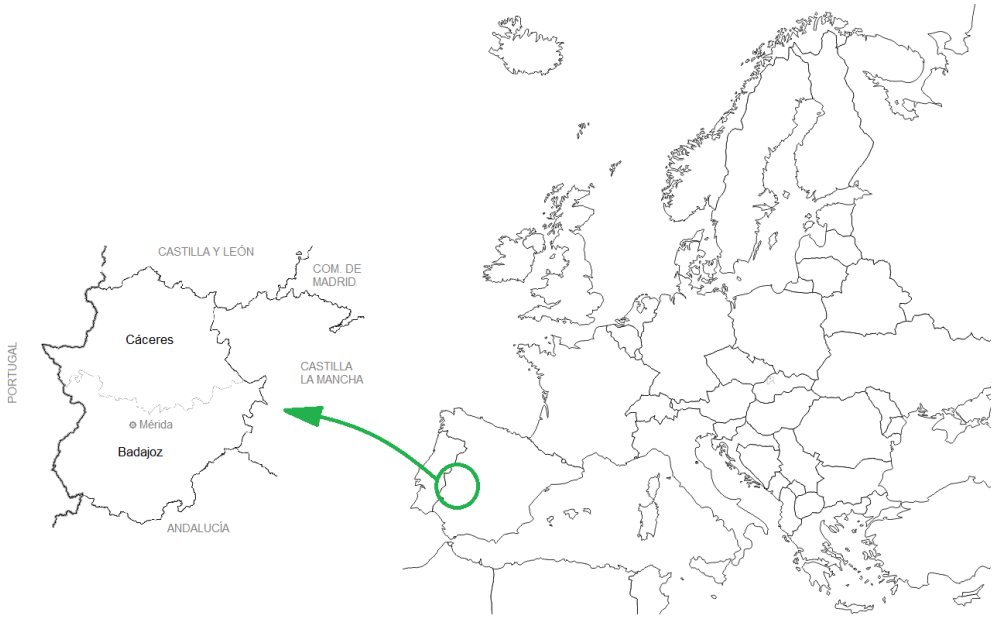


Figure 1. Situation of Extremadura in Europe.

It has a total area of 41,635 km2, which represents 8.2% of the total area of Spain. According to Eurostat, this region has 1,065,424 inhabitants, which results in a population density of 25.6 inhabitants / km2. The territory is divided into two provinces: Caceres in the north, with 392,931 inhabitants, and Badajoz in the south, with 672,493. There are 388 municipalities.

The most important economic activity in this region is related to the primary sector, both agriculture and food, due to the industrial characteristics of the region. It represents around 8% of the regional Gross Domestic Product, well above the national average.

A. Regional environmental context.

Extremadura is a region especially rich in natural resources with the possibility of exploiting them for their classic uses: food, agricultural and industrial production, etc.; as well as for the production and storage of energy from renewable sources.

<u>Agricultural, livestock and forestry resources.</u>

Extremadura leads the national tomato production with 2,122 million kg, which represents 68% of the Spanish total and 8.04% of the world, planting up to 24,000 hectares last year. In this sense, other products such as paprika, olives and olive oil, etc. can be highlighted.

This region is also positioned as the leading producer of Iberian pork, with 1.7 million pigs registered in Extremadura. The enormous availability of meadows makes it possible to have up to 150,000 breeding mothers.

Special mention should be made of beekeeping, which constitutes a significant economic engine in underprivileged regions of Extremadura, such as Hurdes, Sierra de Gata, Villuercas-Ibores and Siberia. The region has a population of 517,017 hives, being the second Spanish autonomous community, behind Andalusia

Regarding Extremadura agroforestry sector, according to the latest National Forest Inventory, Extremadura region is the first in the Spanish ranking in a wooded area and occupies the fourth position in a forest area with 2,727,858 ha. The exploitation of forest resources in 2014 involved the extraction of 870,937 m3 of wood and 203,876 tons of firewood produced.

The meadow is the most representative agroforestry system in Extremadura. The region has approximately 1.3 million hectares, which represents a third of the total area of the Extremadura territory. 16% of the world's cork oak surface is in Extremadura, which allows it to produce 11.6% of the world's cork. At the state level, Extremadura contributes more than 38% of the national cork production.

Water resources.

Water resources are also abundant in Extremadura. The region has 14,219 hm3 of dammed water. It has 41 dams, eight in the Guadiana river basin and 33 in the Tagus basin.

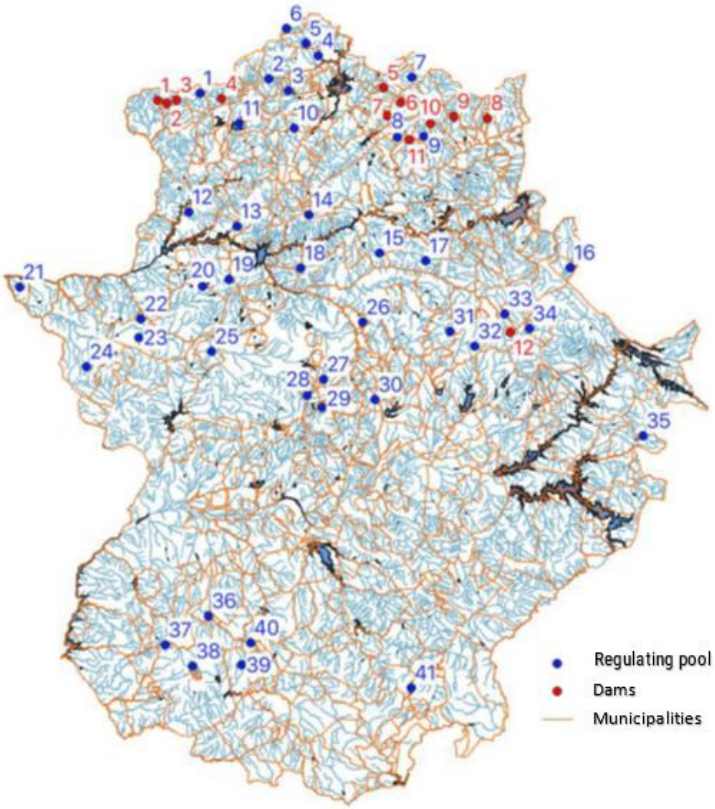


Figure 2 Location of dams and reservoirs in Extremadura. Junta de Extremadura.

Solar resource.

Extremadura receives between 4.8 and 5.1 kWh / m2 · day of average global irradiance throughout the year. This amount of solar resource places Extremadura as the second Spanish region in installed solar thermal power (849 MW), behind Andalusia, and the third in photovoltaic (1,585 MW), behind Andalusia and Castilla-La Mancha.

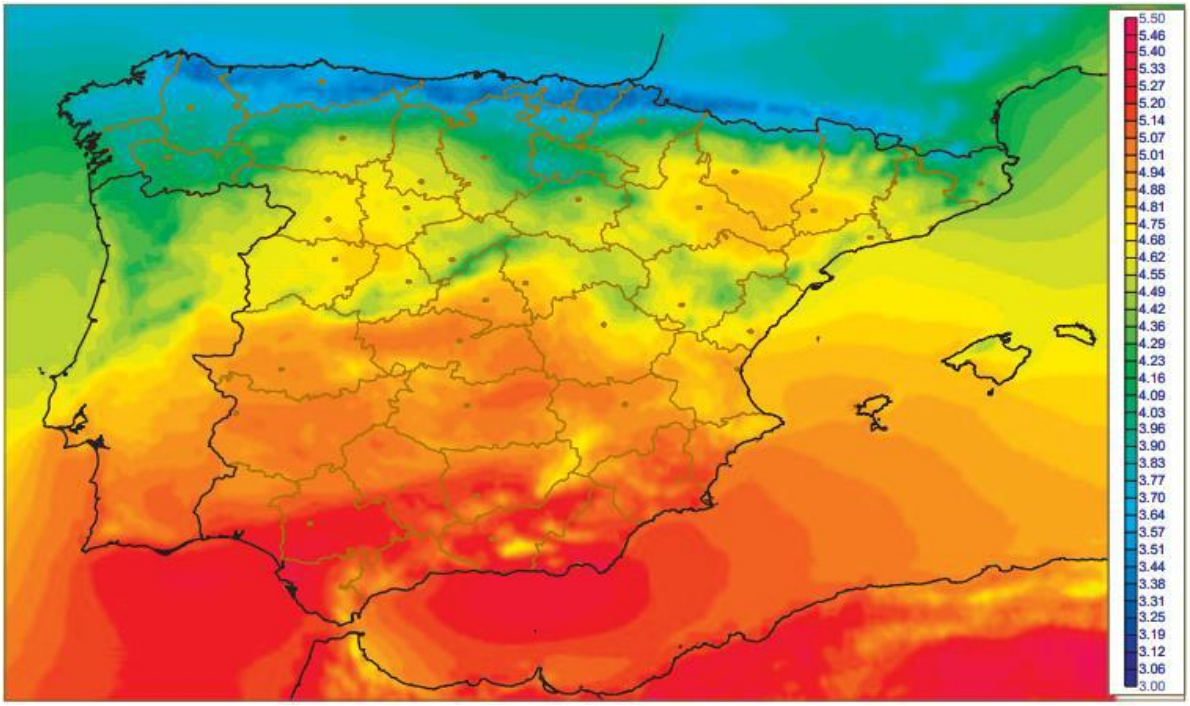


Figure 3: Map of global mean irradiance (1983-2005 series) in kWh / m2 · day. Source: State Meteorological Agency.

Wind resources.

Extremadura has 17% of the usable territory for the exploitation of the wind resource at an altitude of 80 m with the technology currently available. The Spanish average is 23.4%, so this resource is not so present in Extremadura.

Greenhouse Gas Emissions Balance.

Currently, there are five sectors present in the region subject to the administrative control of emissions derived from their activity according to Law 1/2005. The sectors are combustion, steel, cement, glass and ceramics. As a subsector within combustion is the tomato agroindustry, to which six of the ten most polluting industries in the region belong.

Extremadura pollution accounted for 0.24% of the national total, above Ceuta, Melilla and La Rioja, all of them with less extension and inhabitants than Extremadura. This makes Extremadura enjoy the best air quality in the entire national territory.

B. Regional industrial context.

Agriculture, industry and construction, and services constitute the economic sectors of the economy.

The following table indicates the number of workers in each sector and the average number of workers per company, as well as the number of Extremadura companies that dedicate their activity to each of the economic sectors.

Economic sector.	Number of workers				Number of Companies		
	Badajoz	Caceres	Average workers per company	Total Workers	Badajoz	Caceres	Total Companies
Agricultural	23.871	10.284	4,6	34.155	4.295	3.148	7.443
Industry	17.169	9.384	10,3	26.553	1.700	939	2.639
Construction	9.479	7.545	5,1	17.024	1.966	1.409	3.375
Services	97.305	56.027	8,2	153.332	12.011	7.279	19.290
Total	147.824	83.240	7,2	231.064	19.972	12.775	31.747

Table 1: Number of workers and companies by economic sector and province. Source: IEEX.

As in the rest of Spain, 66.36% of employed workers belong to companies in the service sector. This sector is also the most crowded, with 58.92% of registered companies. The primary sector, for its part, encompasses 22.74% of companies with 14.78% of workers. Finally, the secondary sector remains at 18.34% of the total number of companies, but the percentage of workers rises to 18.86%.

Regional GDP maintains an upward trend during the last two decades. From 2008 to 2014 it suffered a slight decline due to the global economic crisis. Since 2015, it is growing at a rate similar to the period before the aforementioned crisis. In these two decades, the average contribution of Extremadura to the national GDP is 1.65%, with minimums of 1.62% and maximums of 1.69%. By provinces, Badajoz has contributed an average of 62.1% of regional GDP in the last 20 years, while Caceres averaged the remaining 37.9%. This region has the lowest GDP per capita in Spain, being 68.9% taking the Spanish index as 100%.

Agricultural and agribusiness activity have an important weight in the economy of Extremadura. Compared with the country, the region shows the highest degree of specialization in the field of activity “Agriculture, livestock, forestry and fishing” both from the perspective of the value of its production and of employment. The agricultural sector contributes 9.0% of the GVA of Extremadura and 10.3% of employment.

On the other hand, an important specialization of the manufacturing industry in the agri-food field is also observed for Extremadura. These agro-industrial activities contribute 40.9% of industrial GVA and 41.8% of employment.

In this way, agribusiness constitutes a strategic activity for the Extremadura economy due to its productive specialization, the quality of the food produced and the type of settlement. The contribution of the farming operations and agro-industrial activities to the Extremadura economy accounted for 11.7% of GVA and 13.3% of employment. Agribusiness constitutes the first branch of the manufacturing industry, generating around 40.9% of the value of production and 41.8% of industrial employment.

Regarding the analysis of these distributions, it can be said that the location coincides with certain spatial axes: primarily in Las Vegas del Guadiana, from Badajoz to Villanueva de la Serena, which accounts for most of the food industry; the Ruta de la Plata south, from Mérida to Jerez de los Caballeros; the northern irrigation corridor, between Navalmoral and Coria, articulated by Plasencia; and Cáceres, which appears relatively isolated.

The main centres of agricultural activity are found in the municipalities of the Guadiana riverbank in the Serena region (Santa Amalia, Villanueva de la Serena and Don Benito), as well as in the areas near Badajoz. The activity carried out in the city of Almendralejo (Tierra de Barros) also stands out.

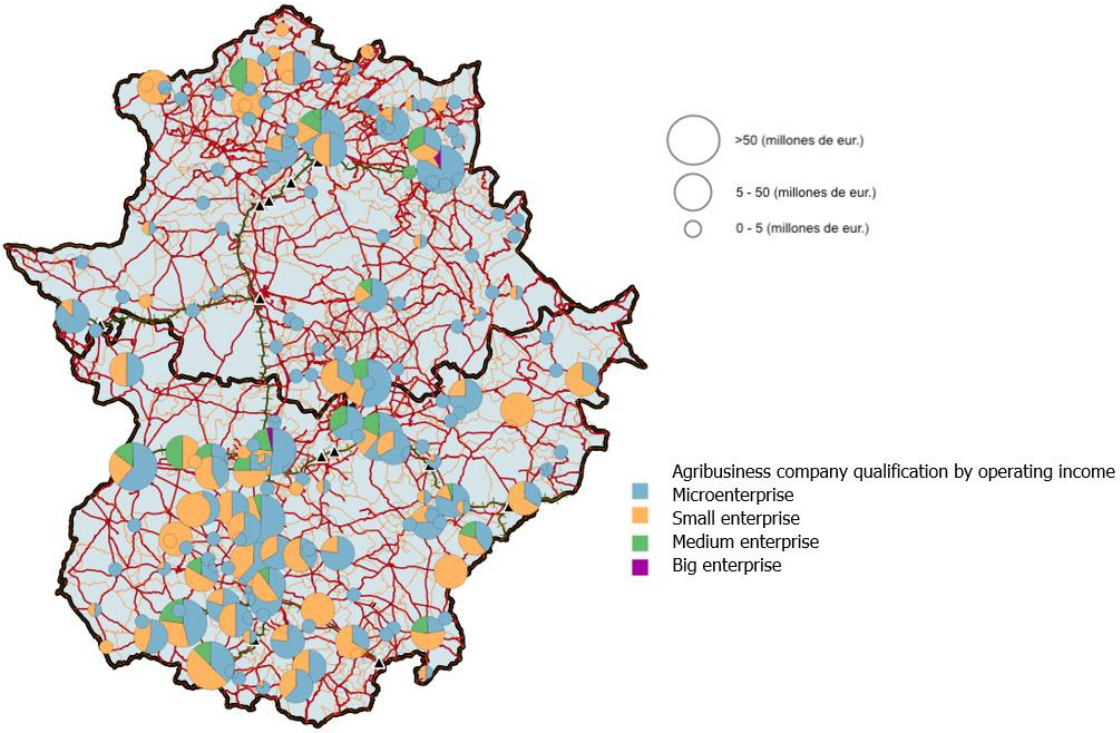


Figure 4: Turnover volume of agro-industrial companies for the year 2019 at the municipal level.

C. Regional energy context

The total installed power in Extremadura amounts to 6,484 MW. The proportion of installed power by technology is balanced in four large blocks: hydro (2,278 MW), nuclear (2,017 MW), photovoltaic solar (1,585 MW) and thermoelectric solar (849 MW), which account for 98.56% of the power installed. The rest is divided between wind technology (39 MW), renewable thermal technology (electric biomass and biogas) (36 MW) and cogeneration (18 MW).

Despite this in the Extremadura energy mix, 77.58% of the energy produced in 2019 was due to nuclear technology. It should be borne in mind that the Almaraz Nuclear Power Plant is located in Extremadura, in service since 1983, and the most powerful in Spain. It has two reactors, whose total power amounts to 2,017 MW. In 2019, it registered an electrical energy production of 16,315 GWh. Renewable generation ranked second with 22.14% of electricity production.

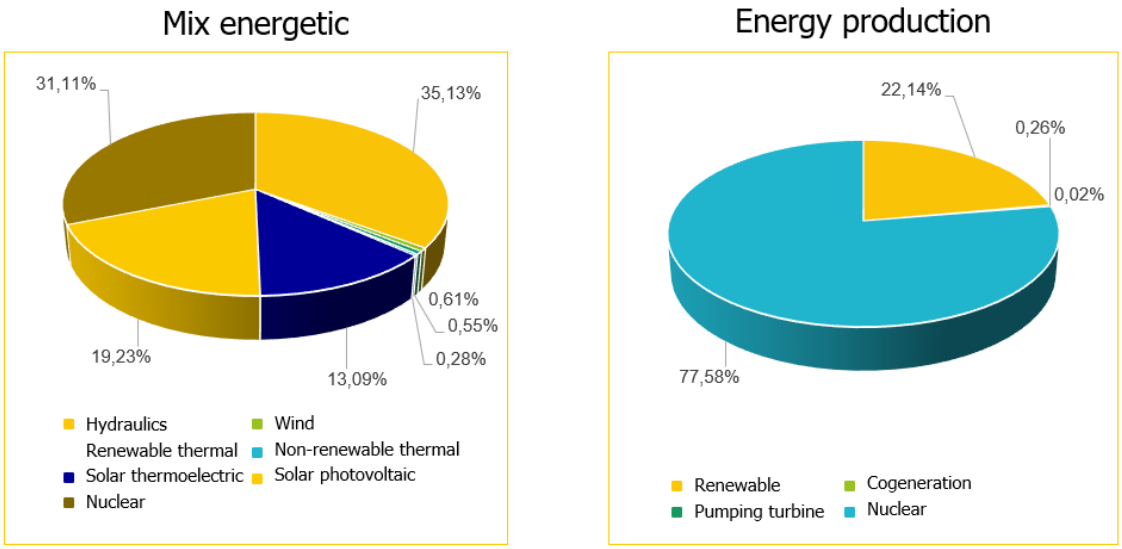


Figure 5: Distribution of installed power by technologies (left) and distribution of electricity production (right) in 2019. REE.

Energy demand

However, on the consumer side, this analysis can be expanded in addition to electricity consumption to fuel consumption (oil-bearing and biofuels) and thermal energy consumption, using natural gas and from renewable generation.

Extremadura households constitute the most important electricity consumer sector in the region with 37.57% of the total, being almost three times higher than the next (iron and steel industry and foundry) with 13.34%. They are followed by commerce and services (12.21%), Administration and other public services (10.78%), the food, beverage and tobacco industry (5.90%) and the primary sector (3.99%). Among these seven chapters of the CNAE (National Classification of Economic Activities) they account for 83.79% of electricity consumption in Extremadura.

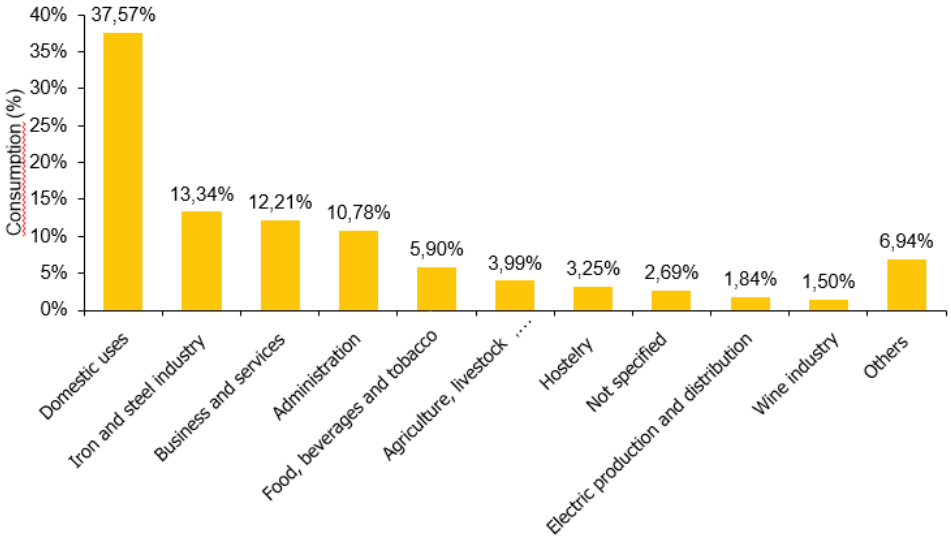


Figure 6: Electricity consumption by CNAE sectors in Extremadura. Ministry for the Ecological Transition and the Demographic Challenge.

In Extremadura, 1,066,541 tons of petroleum products and biofuels are consumed. Diesel is predominant with 79.43% of the total consumed and destined mainly to the transport sector. It is followed by gasoline with 9.14%, Liquefied Petroleum Gas (LPG) with 6.00% and biodiesel, with 4.59%, related to transport, but also to the residential and industrial sector.

Regarding the consumption of Natural Gas for energy uses, for the year 2018, 2,948,857.59 MWh were consumed in Extremadura referred to Higher Calorific Value (HCV). The agri-food sector is the most important, with 19.24% of consumption. Other industrial sectors have somewhat lower percentages of consumption, the primary sector being the fifth in importance with 10.20% of consumption.

Thermal uses of renewable energies consume 85,655 tons of oil equivalent (toe). Biomass constitutes 96.75% of this production, followed by solar thermal energy with a weight of 3.22% and with a residual presence of geothermal energy. Once again, the domestic sector has the highest share of consumption (88.68%). The industrial sector accounts for 9.87% of consumption, the services sector 1.23%, with the minimum for agriculture (0.22%) and transport.

Energy consumption

Referring to the field of "Agriculture, livestock, forestry, hunting and fishing", it constitutes 3.99% of the demand for electricity in Extremadura with 180,015.20 MWh in 2018. It has 8,594 clients.

In the agricultural subsector, energy consumption occurs mainly in the irrigation system, since the rest of the consumer elements are usually tractor vehicles and other machinery, which are outside the scope of this report.

In general, the greatest energy demand for irrigation will occur at the time of least availability of water resources, that is, in summer. In a particular way, energy consumption also depends on the seasonality of the crop.

Energy demand in hothouses depends on the relationship between outdoor climatic conditions and the environmental needs of indoor crops. In this situation, air conditioning systems are necessarily assuming that they are the main energy demand of this type of farm.

Energy demand in the livestock subsector is closely linked to maintaining adequate indoor environmental conditions for animal welfare. These conditions contribute enormously to achieving the productive objectives of the farm. Consequently, the demand will be of a thermal nature for cooling, heating and domestic hot water (DHW). Regarding electricity demand, it will mainly be due to lighting and consumption of certain machines for dispensing feed, filling of water troughs, movement of fans, etc. and power outlets.

Referring to the field of "Food, beverages and tobacco", it reaches 5.90% of Extremadura electricity consumption with 1,667 customers and 266,290.25 MWh consumed in 2018. There is no data recorded at the regional level for thermal consumption.

The main activities of the agro-industrial sector that can be found in Extremadura are grouped into the following three blocks.

- Plants for the processing, transformation and packaging of fruit and vegetable products, olive oil and the wine industry.
- Industry of processing and manufacturing of products of animal origin (meat, dairy and cheese, canning, etc.).
- Agricultural product drying industry (tobacco).

The horticultural plants present an eminently electrical consumption, with 86% of the total energy. This industry presents a seasonality in the summer months (May-August) coinciding with the fruit and vegetable harvest season.

The oil mills present a production process with electrical requirements, for the movement of electric motors and supply to other auxiliary equipment, and thermal for the process of extraction and separation of the paste (grinding). In proportion, both energy purposes represent the same proportion close to 50%.

The main energy consumption of the wine industry is of an electrical nature, reaching around 90% of the total and destined to the operation of the electrical equipment of the industry. The remaining 10%, of a thermal nature, is used for heating applications, DHW, washing of containers and tanks.

The meat industry, understood as one where the complete process is carried out, consisting of slaughterhouse, cutting, cold storage, drying room, and ageing cellar; require electrical and thermal energy.

For certain operations (scalding and dehairing) steam is required. Conservation operations are carried out in cold storage and their consumption depends on the storage time until dispatch. The drying phase is common for both sausages and hams and requires thermo-hygrometric conditions.

The dairy industry requires a higher proportion of thermal energy for its process than that of electrical energy.

The drying of agricultural products requires the generation of thermal energy to cause a loss of water in the plant that leads it to produce the physical-biochemical changes in the most appropriate way to achieve a high-quality product.

The tobacco curing process can be carried out using four techniques: in the air, in the fire, in the sun and an artificial atmosphere. This last process requires the generation of hot air from a boiler and lasts approximately one week. The fuel for this boiler can be of fossil origin (diesel) or renewable (biomass). It can also get hot air from renewable energy sources. The seasonality of this industry coincides with the harvest in late summer.

II. Evolution of renewable energies in agriculture and rural communities.

Thermal solar energy.

Extremadura's land surface is one of the areas in Spain with the highest incident solar radiation throughout the year. As a consequence of this, any location in the region is feasible to implement this technology to satisfy the demand of the agricultural and agro-industrial sectors.

Focusing on the study for the agricultural sector, it can divide into two subsectors: agriculture and livestock. The demand for thermal energy is residual or null for crop farms, so its implementation in this subsector is not of interest.

Livestock farms (cattle, pigs, sheep, goats, poultry and fish farms) have a demand for thermal energy for heating and DHW applications. In this sense, low-temperature solar thermal is completely viable both by location and by type of energy demand. The union of different industries would improve the profitability of the investment, accessing economies of scale in production. Although they are not complimentary due to the demand for heating, the union will reduce the infrastructure cost.

Concerning the agro-industrial sector, both low-temperature applications (90-150ºC) and medium temperature applications for thermal purposes would be interesting for supply to the production process. The size of certain agri-food industries in the region and their proximity (concentration in the Don Benito area, for example) increases the viability of their implementation.

The generation of electrical energy from steam production is profitable and feasible in large solar thermal plants that, due to the economies of scale and the technology implemented, reduce the unit costs of electricity production. Therefore, neither the medium nor the high temperature is applicable for the sectors under study.

Photovoltaic Solar Energy

The adaptability of this technology makes it viable in both small companies and large industries. Both agricultural and livestock farms have a demand for electrical energy that adapts to the photovoltaic generation profile.

For agro-industrial, it is especially viable due to the energy intensity of electricity in its production process. Even though it will have to be supplemented with energy demand from the electricity grid, the reduction in costs is evident. In addition, the current regulatory framework contemplates the shared ownership of these facilities, which will further favour the profitability of the investment. In this sense, it will be more feasible to unite agro-industrial industries instead of agricultural and livestock farms, due to the geographic dispersion of the latter. Agribusiness has significant seasonality, so it would be possible to unite companies with work campaigns in summer (tomato and other vegetables) with olive-growing industries, with winter campaigns.

Biomass energy

The usable agricultural and livestock farms by-products are firewood, wood chips and other forest residues, and their derivatives in the form of pellets. On the part of the agroindustry, the slurry from pig farms, sludge derived from the production of olive oil, olive pits, fruit peels, etc.

On the one hand, concerning the thermal applications of biomass, for the agricultural subsector, it would not be able or useful due to the low thermal needs of its operation. For the livestock subsector, on its part, its election would be acceptable, especially for thermal purposes related to heating. Electrical applications could be interesting; though, this requires large-scale installations that differ from the small size of this type of installation in the region. However, at this point the option of energy cooperatives is interesting. Although these industries share seasonality due to heating needs, their union allows them to access larger investments to make cogeneration and/or electricity generation viable.

On the other hand, the agribusiness does not find limitations in the thermal application of biomass as boilers and to feed drying kiln, blanchers, autoclaves, ovens, etc. For electricity generation, the size of the industry and the possibility of an alliance with other nearby ones should be taken into account. This is a limiting factor since transportation would generate huge thermal losses that limit profitability. For large Extremadura agri-food companies, even cogeneration would be viable, since they would also take advantage of the electrical energy produced.

Biogas energy

The energy potential of agro-industrial waste from wine, olive oil or tomato production is low compared to forest biomass. Its main advantage resides in the possibility of carrying out circular economy activities that value this waste, thus improving the economic potential of its treatment.

Thermal applications are, accordingly, whose will have the greatest application in the livestock subsector, not finding their place in agriculture due to the lack of thermal needs. Agroindustry, on its part, could benefit enormously from this technology. As with biomass, for cogeneration and the isolated generation of electrical energy, equipment of greater power is necessary and, consequently, it will only be accessible for large agribusiness or the union of several smaller farms.

Small-scale wind energy

Its implementation is interesting in agricultural and livestock farms with electricity demand (electrical outlets, pumping and irrigation systems, etc.). Currently, the unit cost of electricity generation from wind is below that of photovoltaic, making it highly profitable. Nevertheless, its applicability is limited by the lack of continuity of production. To improve its feasibility of implementation, it would be necessary to have a sufficient and efficient energy storage system.

Hybridization with photovoltaics is especially interesting due to its supplementation for small companies. In this way, photovoltaics can provide a base generation (more or less predictable throughout the year) that is increased by wind generation.

For agro-industrial companies with huge electricity demand, it is interesting both isolated and hybridized with photovoltaics. The space needs for their implantation are a disadvantage in agricultural operations since the cultivation area would be occupied by the absence of buildings on which to install them. In livestock farms, where there are buildings, the associated infrastructure for their implementation on the roof could pose a problem. This would increase investment costs, reducing its economic viability.

In general, this technology is highly influenced by location. The potential for electricity generation is highest in the northern area of Caceres but, the concentration of companies is very low and even nil.

III. *Local policies and actions to achieve the main goals of the European strategy*

Extremadura's policies to promote renewable energies in the industrial sector have resulted in two programs that seek their development. The normative bases of each of them were published in the following Decrees:

DECREE 115/2015, May 19th, which establishes the regulatory bases for the granting scheme for actions in renewable energies in Extremadura and approves the first call, modified by DECREE 309/2015, firstly, and later by Decree 169/2016.

DECREE 110/2018, July 17th, which establishes the regulatory bases for the system of granting subsidies for actions in renewable energies in Extremadura.

Both grants are part of the measures to promote renewable energies in favour of a sustainable development model and reduce greenhouse gas emissions. The amount of the grants awarded was co-financed at 80% by the Operational Program of the European Regional Development Fund (ERDF) 2014-2020, within the OT-4 Supporting the shift towards a low-carbon economy. Due to this, Decree 115/2015 focused on two investment priorities: companies, particularly SMEs, buildings and public infrastructures.

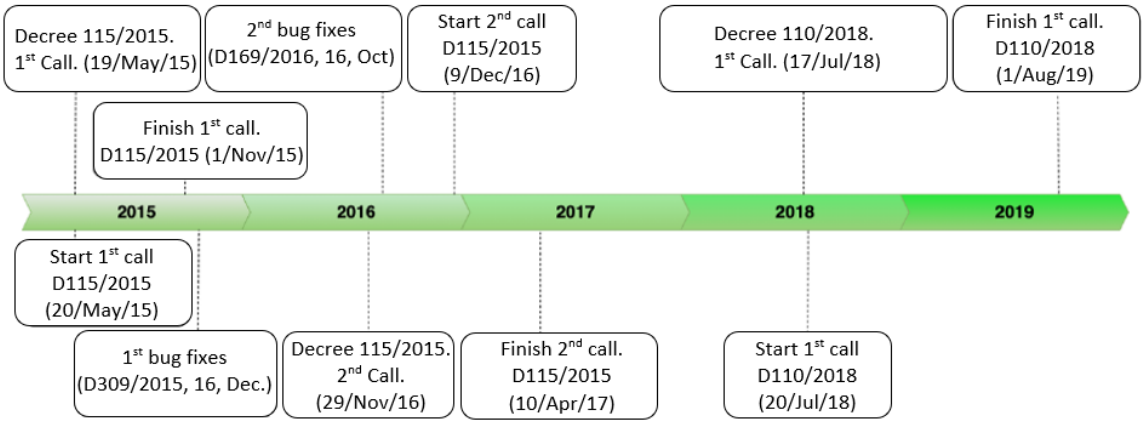


Figure 7: Timeline of events related to grants for renewables energies in Extremadura.

The simplification of the processing of these grants and reasons of legal certainty led to the approval of new regulatory bases set out in Decree 110/2018, July 17th. The modifications had to do with the entities plausible to acquire the status of beneficiaries, with the eligible facilities and with the eligible costs. In the first place, non-profit associations (such as communities of owners) were incorporated, and the type of beneficiary company was specified. Second, the medium temperature solar thermal installation for industrial applications was incorporated. Finally, another limit was established for the eligible actions and the intensity of the grant.

In both cases, these subsidies were divided into three lines of grants according to the legal person of the beneficiaries, as indicated in the next image. Lines 1 and 2 were financed by ERDF under specific objective 4.3.2 “Increase the use of renewable energies for electricity production and thermal uses in buildings and public infrastructures, in particular by improving small-scale generation in points close to

consumption”; line 3 being financed under specific objective 4.2.2. "Promotion of the use of renewable energies by companies, in particular, SMEs".

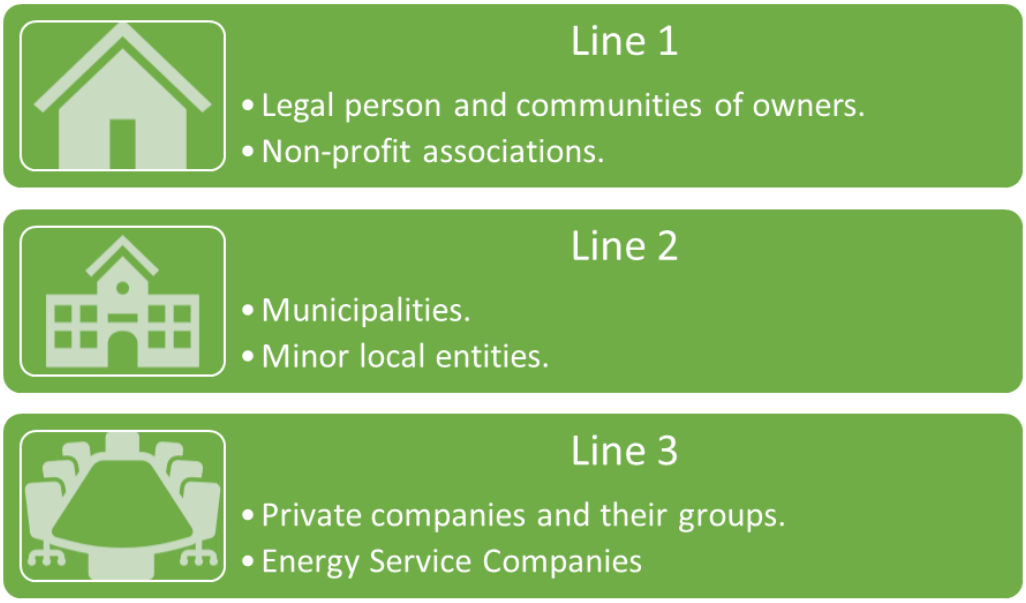


Figure 8: Lines of grants according to the legal person of the beneficiaries

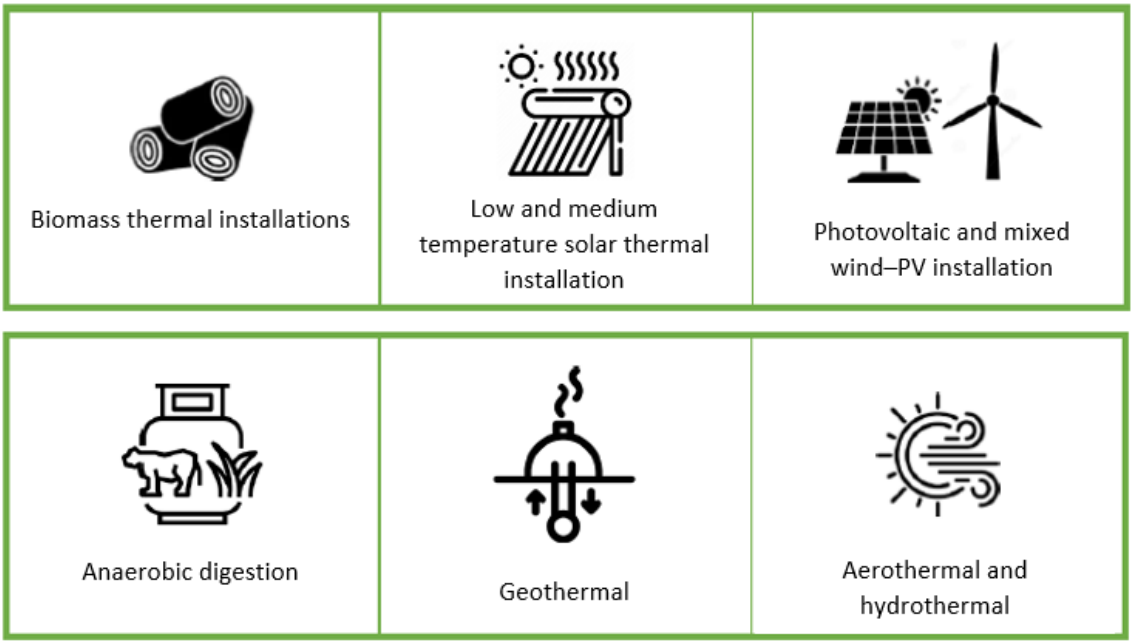


Figure 9: Actions eligible for grants for renewable energies in Extremadura

The following table shows the planned spending plan in each call for aid, broken down by grant lines.

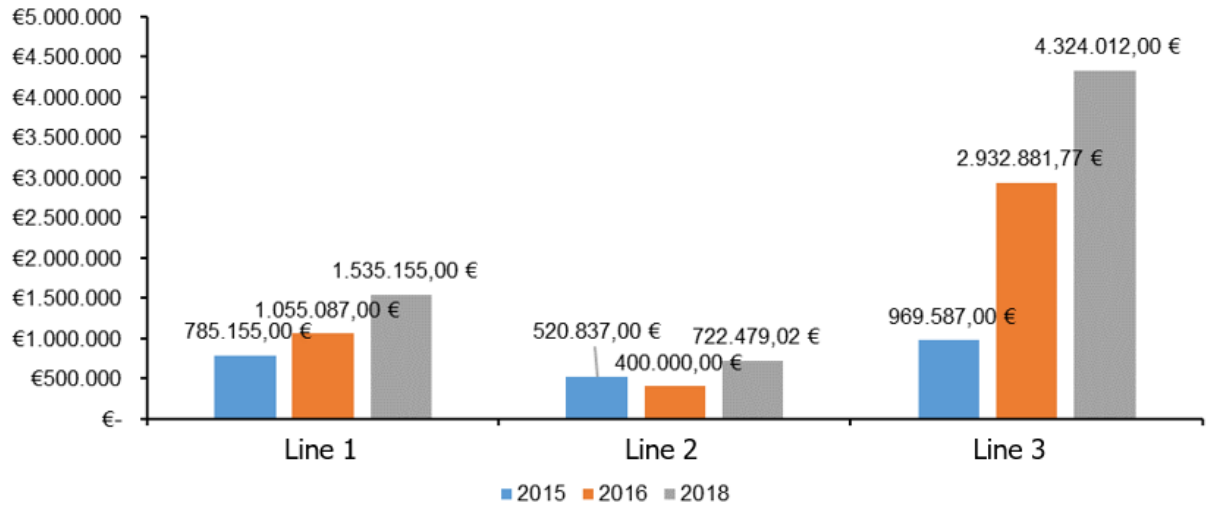
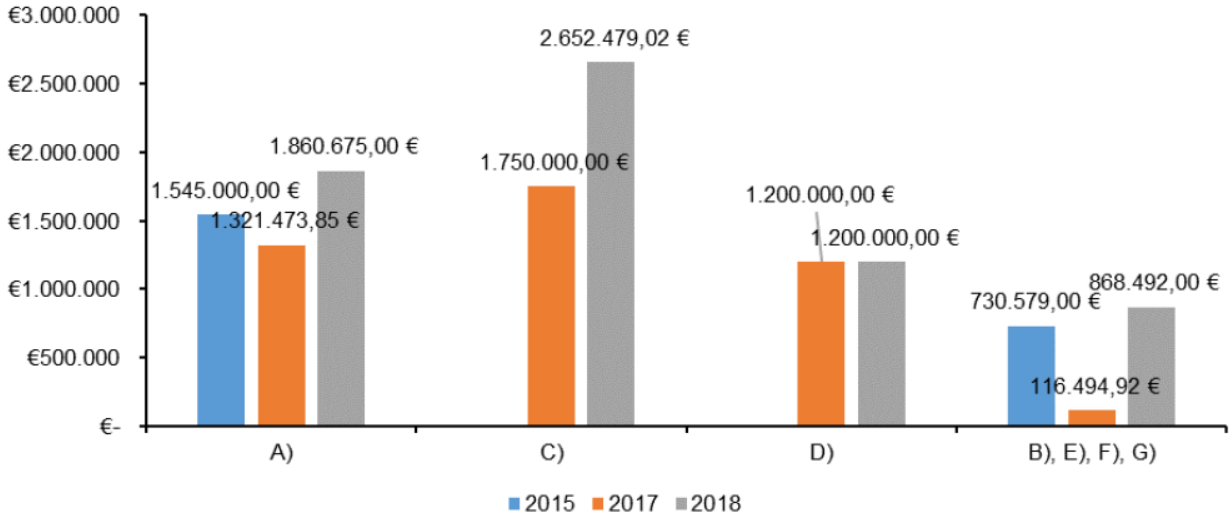


Figure 10: Spending plan per call according to the incentive line.

Figure 11 shows this same spending plan for each call broken down by technology.



Note: A) Biomass; C) Photovoltaic; D) Biogas; B), E), F), G) Other renewable energies. In the 2015 call, categories C) and D) were included in "Other renewable energies".

Figure 11: Spending plan per call according to technology.

2015 call.

In the first call for grants under Decree 115/2015, two categories were used: Biomass and Other renewable energies. The relationship between the available budget according to the expenditure plan, the amount gave for grants and the budget executed for each call is shown in Figure 11.

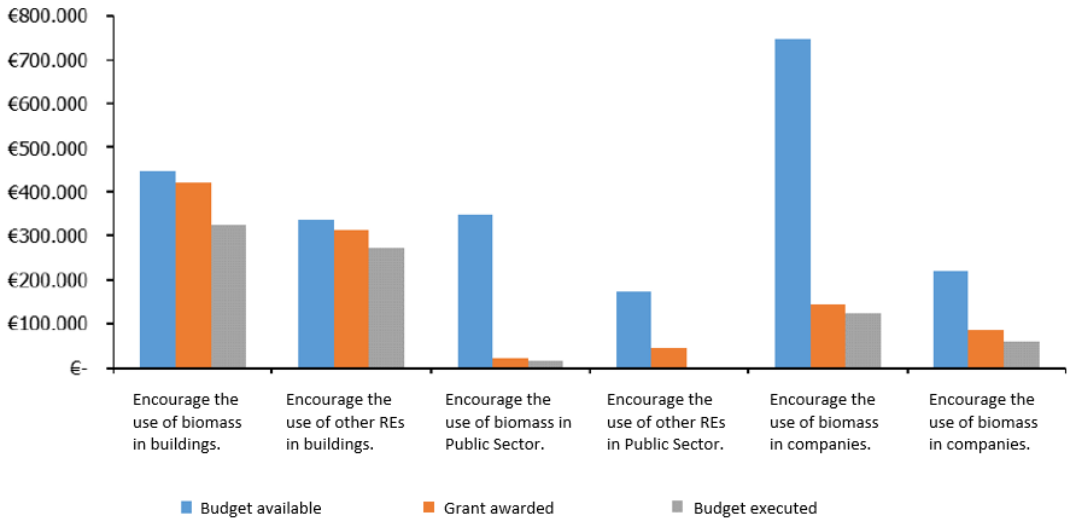
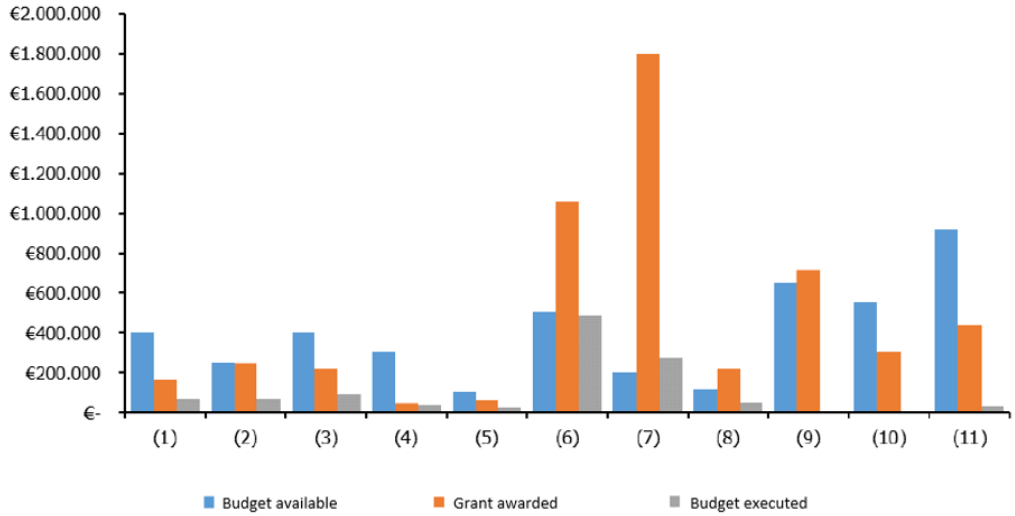


Figure 12: Budget breakdown for the 2015 call.

2016 call.

In the second call for grants under Decree 115/2015, the categories were divided into: Biomass, Biogas, Photovoltaic and Other renewable energies. The relationship between the available budget according to the expenditure project, the amount awarded for grants and the budget executed for each call is shown in Figure 12.



Note: (1) PV to grid in Building; (2) Isolated PV in Building; (3) Biomass in Building; (4) PV to grid in Public Infrastructures; (5) Isolated PV in Public Infrastructures; (6) PV to grid in Companies; (7) Isolated PV in Companies; (8) Other RES in Companies; (9) Biogas (grid cogeneration) in Companies; (10) Biogas (isolated cogeneration) in Companies; (11) Biomass in Companies.

Figure 13: Budget breakdown for the 2016 call.

2018 call.

In the first call for grants under Decree 110/2018, the categories established were: Biomass, Photovoltaic and Other renewable energies. As of the date of this report, the relationship between the available budget according to the expenditure project, the amount awarded for grants and the budget executed for each call cannot be established since the call is still in process.

IV. Risks and opportunities to encourage renewable energy in agriculture.

Impact, benefits and identified barriers.

The impact of the 2015 call influenced the installation of 965.3 kW of aerothermal energy, 33.3 kW of geothermal energy, more than 280 m2 of low temperature solar thermal collection surface and more than 8.9 MW of biomass. In the 2016 call, it was possible to install 5.2 MW of biomass boilers, 1.8 MWp of photovoltaic, 315.8 kW of aerothermal energy, 117 m2 of low temperature solar thermal collection surface. The impact of the 2018 call cannot be measured as, of the date of this report, the procedure is still active.

The main benefits are the mobilization of the budget motivated by incentives for different sectors in society. This has had a positive impact on the modernization and start-up of new facilities with renewable technologies.

As main barriers, the following can be listed:

- The need to develop administrative and technical documentation that justifies the necessity for the grant and the viability of the action limits the possibility of participating, making the contribution of specialized companies necessary.

- There is a time lag of several months since the beneficiary makes the investment to implement the action and, after technical justification, receives the amount of the grants. This implies a need for capital that discourages participation.

- The implementation period is insufficient for certain ambitious actions, as shown in the files relating to biogas.

- The need to repeat the complete inquiry procedure when there is a change in the investment executed greatly delays the process of paying the grant.

Consecutively, the general SWOT analysis about the implementation of renewable energies in the agricultural and agro-industrial sectors in Extremadura is presented.

A. SWOT analysis.

Strengths

- Great energy demand to accomplish agro-industrial processes.
- There is a diversity of renewable energy sources in the region with sufficient energy potential.
- Demonstrated experience in design, assembly, commissioning, and maintenance of facilities.
- There are European requirements to favour the implementation of renewables energies to reduce GHG emissions.
- Job creation in the sector and multiplier effect on other sectors.

Weaknesses

- Difficulties in accessing credit for renewable energy projects are partly due to uncertainty efficiency.
- Complicated administrative processes for grid-connected renewable energy systems.
- Lack of information by the population regarding the energy services business.
- Impossibility of disconnecting from the grid and single supply by renewable energies, due to lack of manageability.

Opportunities

- The GHG emission reduction policy creates opportunities for the development of new infrastructures.
- Incentive lines for R&D in new technologies to generate energy.
- Energy efficiency opportunities in the sectors, aimed at the maximum energy use in the process.
- Possibility of developing new technologies: Hydrogen.
- Support to the electrical system through distributed generation.
- Charge for saving emissions in the CO2 market.

Threats

- Dependence on regulations affects the future profitability of the facility.
- Possible financial crises limit the possibility of credit/incentives.
- The possible need for new measures to reduce the costs of the system could affect the financial situation, in particular renewable facilities owners.
- Lack of skilled labour to implement and operate new technologies (e.g., medium temperature solar thermal).

V. Conclusions

Extremadura is a region especially rich in natural resources with the possibility of exploiting them both for their classic uses: food, agricultural and industrial production, etc.; and for the production and storage of energy from renewable sources.

The Extremadura region leads the national tomato production and stands out in other products such as paprika, table olives and olive oil, etc. It is the leading producer of Iberian pork meat mainly due to the more than three million hectares of non-urban land. It is the first in the Spanish ranking in the wooded area and occupies the fourth position in the forest area with 2,727,858 ha. The meadow is the most representative agroforestry system with almost a third of the surface of Extremadura. The territory is crossed by the water basins of the Guadiana and Tagus rivers and, in addition, there are 41 dams throughout the territory, which represent 14,219 hm3 of dammed water with much of the largest artificial lake in Europe. Extremadura receives between 4.8 and 5.1 kWh / m2 · day of average global irradiance throughout the year, which places it as the second Spanish region in installed solar thermal power (849 MW) and the third in photovoltaic (1,585 MW). The region has 17% of the usable territory for the exploitation of the wind resource at an altitude of 80 m with the technology currently available and planned to reach 660 MW of installed power of this technology by the year 2030.

Extremadura is characterized by being a region with a solid concentration of small and medium-sized companies. The primary sector includes 22.74% of the companies with 14.78% of the workers and the secondary sector remains at 18.34% of the total of the companies, but the percentage of workers amounts to 18.86%. This region has the lowest GDP per capita in Spain, being 68.9% taking the Spanish index as 100%. Agricultural activity and agro-industrial are strategic for the Extremadura economy due to its productive specialization: the agricultural sector contributes 9.0% of Extremadura's GVA and 10.3% of employment and the manufacturing industry in the agri-food field contribute 40.9 % of industrial GVA and 41.8% of employment, above the average of the Spanish regions. Concerning the irrigated areas as a result of the “Plan Badajoz”, most of the agricultural and agro-industrial activity are concentrated, coinciding with two axes: horizontal, which follows Las Vegas del Guadiana, and vertical, which follows the Ruta de la Plata, in addition to the Navalmoral and Coria area.

The agro-industrial sector ranks 5th in electricity consumption and first in natural gas, while the agricultural sector ranks 6th in electricity consumption and 5th in natural gas. The energy consumption profile of the agricultural sector is principally electrical, without account the use it in transport. However, the consumption of the agro-industrial sector converges both thermal and electricity demand. The main thermal demands have to do with heating and cooling, although the need for water vapour also stands out.

The measures to promote the implementation of renewable energies in Extremadura are in charge of the Operational Program of the European Regional Development Fund (ERDF) 2014-2020, within the OT-4 Supporting the shift towards a low-carbon economy. Since 2015, three calls have been executed.

The main barrier to encourage renewable energies in Extremadura's agricultural and agro-industrial sector is the inconvenience of not replacing existing facilities, that is, these are not yet another alternative in the analysis of the feasibility of replacing a power generation facility. These are generation facilities that require supplementary generating equipment (or supplies) to guarantee to satisfy 100% of the energy demand at any moment. The hybridization between renewable energies or

conventional energies will determine the investment and operating costs and the amount of energy of renewable origin produced and, consequently, that of non-renewable origin., determining the economic viability of the technical solution.

The environmental, energy and economic impact in the sector is evident after the review of renewable energy Good Practices, either through exclusively private capital or with public participation. The results in operating certify the viability, with consumption reduction rates and increased efficiency that guarantee it.

It is detected that investment in renewable energy production solutions finds difficulties in accessing capital that block the deployment of these technologies due to multiple interrelated factors. In addition to the uncertainty in terms of regulatory evolution and the lack of standardization of projects, is added the climatological dependence and the manageability of the energy produced. This has an impact on the level of trust perceived by potential funders, having a negative influence on the financial instruments and mechanisms available.

The feasibility analysis revealed that there is a lack of information in the consumer about the provision of energy services. This distances the agricultural consumer from the implementation of renewable energy technologies to improve the energy efficiency in their process, which, in the case of agribusiness, has energy-intensive phases. The adoption of these renewable solutions by the sector was perfectly viable since it fits the energy demand profile, type of energy demanded and location. One solution to the problem of introducing new renewable energy sources in these sectors could be the size of the industry. The Extremadura business fabric, and specifically the agricultural and agro-industrial sector, is composed of SMEs. This can pose a difficulty in the availability of funds (or access to financing). Developing energy communities can be a viable solution and also has enormous potential due to the proximity between agricultural and livestock farms and agro-industrial facilities, incurring a lower cost per unit of energy and minimizing the impact on the environment.

The participation of Extremadura companies for the execution and development of the promotion of renewable energy in the agricultural and agro-industrial sectors are perfectly viable and necessary. In conjunction with the regional government, the business possibilities would go through awareness-raising actions in energy and economic matters of the benefits reported by the incorporation of these technologies. Once society assimilates the possibilities and the economic dimension of the ecological transition, Extremadura will need companies located in the region for the necessary technological deployment it requires. Given the importance of these sectors in the regional economy, proximity to the agricultural/agro-industrial user constitutes a notable competitive advantage for companies in the region concerning national or international competitors.

The establishment of renewable technologies, most of which are modular and scalable, will have an incentive and multiplier effect in other related sectors (manufacturers, engineering, installers and maintenance, etc.). Increasing the scope of the impact can include an increase in specialized labour, which will have a positive impact on the occupancy rate in the region.

One of the objectives should be to hybridize technologies to satisfy the demand of this sector. In this sense, it is therefore of particular interest the union of farms with both complementary and supplementary demand profiles. In the first case, it will increase the profitability of the investment by maximising its use throughout the year. In the second case, it will allow access to economies of scale

that make the investment profitable following the installed capacity. For large industries, to go towards energy accumulation using hydrogen would be interesting. Regarding the by-products derived from the operation of certain industries (of animal origin), undertaking circular economy strategies would be recommendable. Waste from certain industries can be useful to others as input to their energy process.