Country Report – Portugal

Stakeholder and Driver Analysis on Energy Efficiency in Agriculture

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1. Introduction

1.1.AGREE

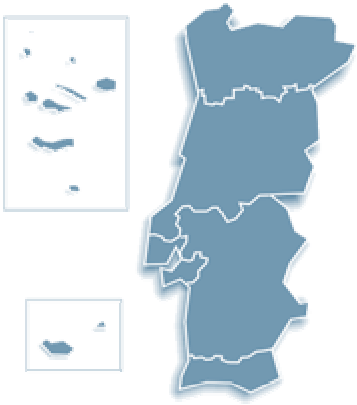
Until recently energy efficiency in agriculture has received little attention. Nevertheless, energy consumption in agriculture is considerable, especially when indirect energy use is taken into account. AGREE has the objective of showing the potential of short term energy efficiency gains and the promise of a long term potential. Environmental effects of savings on direct and indirect energy use in agriculture are integrally considered, as energy use efficiency also implies reduction of greenhouse gas emissions.

According with EU (2009) Portugal is in the group of EU countries most vulnerable in terms of negative impacts of climate change. It is expected a reduction yield due to several effects, such as the increased climatic variability, average temperature increase, reduction of rainfall and higher concentration in the winter period and higher occurrence of extreme events (floods, droughts and heat waves). Some national policy measures already take these aspects in consideration, which led, for example to the construction of new irrigation infrastructures and the improvement of existing ones, the encouragement to farmers to use soil conservation practices, among others.

The objective of this report is to analyse the drivers and introduce the stakeholders which have impact on energy efficiency in the Portuguese agriculture. For that a general characterization of the Portuguese agriculture sector is presented followed by the analyses of drivers and stakeholders.

1.1.Agriculture in Portugal

In order to have a broad perspective of the agricultural sector in Portugal some general statistics are presented. With a total surface area around 92 thousand square kilometres Portugal has a population of 10.6 million persons out of which around 5.5 million are active. This information refers to the year 2010 and is available from the Portuguese National Statistics Institute (INE).



- Total surface area - 92 212 km^2
- Population - 10 637 346
- Working population - 5 580 700

Figure 1 Map of Portugal (www.ine.pt)

According to the Office of Strategy and Studies, Ministry of Economy and Employment, in 2011 Portuguese gross national product was estimated in 170 928 Millions of Euros, unemployment rate

was 12.7% and inflation rate 3.7%. However, the macroeconic trend is negative, namely GNP and unemployment, with an expected recession of at least 3% and an unemployment rate of more than 15 % for 2012.

The development of the relative contribution of agriculture for the national Gross Domestic Product (GDP) is presented in the Table 1. Total agricultural sector is referred to as the "Agro-Forestry complex". Agriculture is responsible for 2% of national GDP_{cf}, and represents approximately 10% of total employment. However, in some regions this value is higher showing their importance and specialization in the agricultural sector. It's the case of the High Alentejo region, where the sector represents 7% of the regional GDP.

Table 1 – The importance of the Agro-Forestry complex in the GDP (%) (GPP, 2012)

	2000	2005	2006	2007	2008	2009	2010[P]	2011[E]
Base prices								
Agriculture	2.5	1.9	2.0	1.7	1.6	1.6	1.6	1.4
Food, Drinking and Tobacco industries	2.1	2.1	2.1	1.9	2.0	2.1	2.1	2.2
Forestry	0.8	0.5	0.5	0.5	0.4	0.4	0.4	0.4
Forestry industries	1.2	1.7	1.7	1.7	1.5	1.3	1.3	1.4
Agro-Forestry Complex	7.5	6.2	6.2	5.7	5.5	5.5	5.5	5.4
Production costs								
Agriculture	2.7	2.3	2.3	2.1	2.2	2.0	na	na
Agro-Forest Complex	7.7	6.6	6.5	6.2	6.0	5.8	na	na

[P] – preliminary data; [E] – estimative; na – information not available

The Agro-Forestry complex includes agro-food sector (agriculture, food, drinking and tobacco industries) and the forestry sector (forestry and related industries) being responsible for approximately 6% of GDP and 15% of employment. In 2009 the contribution of the employment in the agriculture sector for the total employment was 10.7% of the active population. The partial productivity of the agriculture work was less than 1/3 of the all economy. This was explained by several factors, such as the small dimension of farms, frequently complementing other activities and income sources. Also, manpower in agriculture is in general older people and/or with low academic habilitations. Analyzing only the medium and large size farms the scenario changes and the productivity is identical to that of other economic sectors. In fact, it is clear that the productivity levels are higher in large farms, which are able to accomplish technological improvements and some changes in the production structure showing the capacity for innovation and adaptation (GPP, 2012).

Portugal imports around 80% of total primary energy (76.7% in 2010), mainly fossil energy. This dependency is decreasing since 2005 due to the contribution of the renewable energies. The external dependency and the expected increase in energy prices are important factors to the portuguese economy in general and in particular for the agricultural sector. Total energy consumption in the Portuguese agricultural sector is presented in Table 2.

The energy consumption is divided into three main subgroups: natural gas and heat, electricity and tractor fuel. In the last years, in spite of the higher Gross Value Added (GVA) the consumption of final energy in agriculture is decreasing as a result of the improvements in the efficiency of using this resource (Figure 2).

Table 2 - Total energy consumption Portuguese agriculture (in toe)

	1999	2004	2009	2010
Natural gas, heat	3 183	12 396	6 375	5 888
Electricity	59 942	84 386	80 384	83 010
Tractor fuel	246 082	320 106	260 615	254 889

Source: www.dgeg.pt

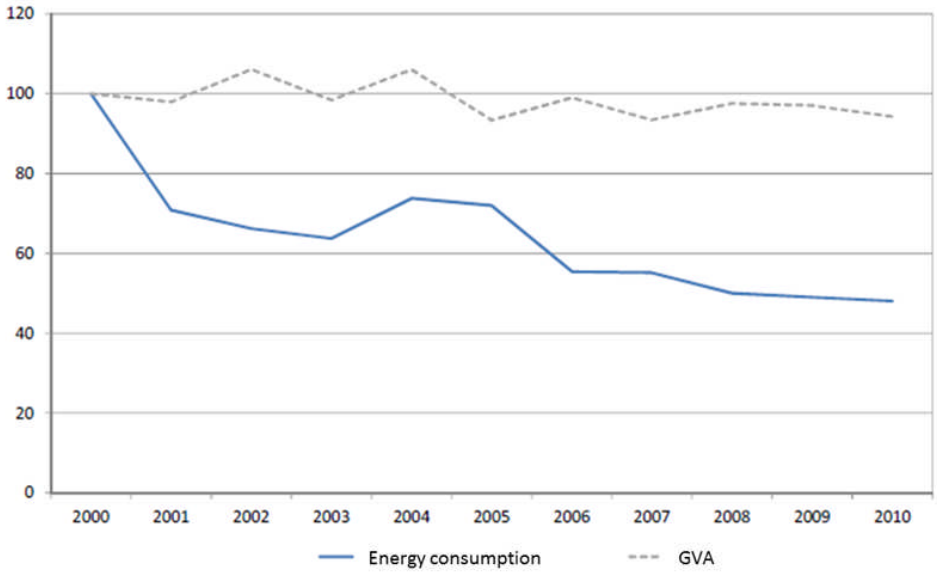


Figure 2 Evolution of Final Energy Consumption and GVA of Portuguese Agriculture Sector between 2000 and 2009 (GPP, 2012)

2. Driver Analysis

This projects deals with the energy use and energy efficiency in the agriculture sector. Energy is a variable cost that we believe has potential to decrease, contributing to the increase of farm profit margin and to the reduction of environmental negative impacts through the use of innovative technologies. However, energy use efficiency in agriculture is a complex issue, due to the high amount of affecting factors that deserves proper attention in order to identify and improve the knowledge of the various interactions. At farm level, energy use and savings are influenced by several drivers or factors, such as political, social, economic, technological and environmental. In this point an analysis of the drivers for the Portuguese case is presented, divided in four main topics: agricultural sector trends, environmental, technological and policy aspects.

2.1. Agricultural sector trends

In this section we analyze the development of the agriculture sector considering demographic, social, economic and land use aspects.

According to the Office of Planning and Policies - GPP (2012) the area occupied with agriculture and forestry is around 70% of the national territory. In the last decade there was a decline of 35.8 % in family members working in agriculture. Nevertheless, 7.5 % of the Portuguese resident population are still families working in agriculture, and in some northern and central sub-regions of the country, the percentage can go up to 40.9%. In general, the employment in agriculture decreased by 2.6% annually between 2000 and 2010 (GPP, 2011a). The majority of the agricultural population works in very small and small farms, the main income of the families earned from other activities. According to the 2009 Agriculture Census (INE, 2011) there are 305 266 agricultural farms in Portugal, occupying 3 668 145 hectares of Utilized Agricultural Area (UAA), using 367 394 AWU (annual work units), of which 294 415 are family units.

Although the majority of farms in Portugal are small (75.6 % have less than 5 ha of UAA), in 2009, 2/3 of the Utilized Agricultural Area was managed by farms larger than 50 hectares of UAA (INE, 2011). The majority of agricultural farms (70%) and work volume (72%) are in the North and Central regions of the country, while more than half of the UAA (55%) is located in the South (Alentejo region). There is a great percentage (39%) of farms and work volume (40%) in non-specialized agricultural farms (i.e., farms that produce great variety of crops and animal husbandry), and a significant importance of farms dedicated exclusively to bovine cattle (23%) and small ruminants (17%). There is a dominance of small and very small economic farms (91 %), which hold the majority of work volume (78%). However, 67 % of the UAA is occupied by medium and higher economic dimension farms. Moreover, the bigger farms (2.7% of the total number of farms) occupy 40% of the Portuguese UAA.

Agriculture surface use in Portugal is divided into three main types of production: Temporary crops, permanent crops and pastures and permanent grassland (Table 3).

Table 3 – Utilized Agricultural Area in 2009 in ha (INE, 2011)

Use	Portugal Continental	Madeira Islands	Azores Islands	ha (UAA)
Temporary crops				831 592*
Grain cereals	339 910	61	285	340 256
Legumes	12 608	0	69	12 137
Temporary grassland and forage crops	376 035	79	10 400	386 514
Potatoes	16 716	542	463	17 721
Industrial crops	24 713	118	41	24 872
Horticulture and Flowers	46 547	1 064	577	48 188
Fallow Land	341 465	69	0	341 534
Kitchen garden	18 991	183	521	19 695
Permanent crops				690 725
Fresh fruits	39 534	278	103	39 915
Citrus fruits	16 389	100	441	16 930
Subtropical fruits	1 764	849	435	3 048
Nuts	114 980	104	66	115 150
Olive grove	335 841	0	0	335 841
Vineyards	175 773	1 131	926	177 831
Other crops	1 940	20	50	2 010
Pastures and permanent grassland	1 678 288	521	105 790	1 784 598
				3 668 145

* Total values include other non-specified crops; therefore the result is not equal to the sum of individual rows.

As shown in Table 3, near half (49%) of the utilized agricultural area (UAA) was occupied, in 2009, by pastures and permanent grassland, followed by temporary crops (23%) and permanent crops (19%). Table 4 shows the structure of the agriculture production in 2010 and the variation in the period 2000-2010 and 2009-2010 (GPP, 2012). The structure of the production systems is characterized by:

- A marked dominance of crop production (57.6%) over animal production (37.1%);
- Production concentration in four major sectors: vegetables, fruits, wine and milk;

- A decrease in the relative importance of cereals;
- An increase in the relative importance of vegetable production, followed by wine and fruits;
- A positive growth dynamic of animal production, in opposition of a negative growth dynamic of crop production; however, two of the most dynamic components of animal production (poultry and pork) are greatly dependent on cereals, animal feed products and energy, most of which are imported.

Table 4 – Structure of Agriculture Production and respective variation (%) (GPP, 2012)

	Structure 2010	Variation rate (%) 2010/2000		Variation rate (%) 2010/2009		
		Value	Volume	Volume	Price	Value
Cereals	2.8	-48.5	-47.7	-6.4	28.0	19.8
Industrial crops	0.8	-41.6	-34.1	-5.7	0.5	-5.2
Forage crops	3.5	-12.0	-19.5	-5.5	7.7	1.8
Horticulture	20.5	47.6	7.9	-2.4	10.5	7.9
Potatoes	1.6	-17.7	-25.9	-12.1	47.8	29.9
Fresh fruits	12.2	6.6	-3.8	-9.2	2.9	-6.6
Wine	13.9	-9.0	-2.6	8.4	2.5	11.2
Olive Oil	2.1	70.0	22.2	23.2	2.5	10.4
Other crops	0.1	17.0	231.2	0.0	-3.1	-3.1
TOTAL VEGETAL PRODUCTION	**57.6**	**5.2**	**-6.4**	**-1.6**	**7.4**	**5.6**
Cattle	6.9	20.6	5.1	-11.9	6.3	-6.3
Pork	8.7	28.4	18.4	3.2	3.3	6.6
Poultry	6.0	30.0	16.8	3.0	2.1	5.2
Milk	9.7	-3.1	-4.6	-2.5	-6.7	-9.1
TOTAL ANIMAL PRODUCTION	**37.1**	**13.1**	**5.0**	**-1.4**	**1.3**	**-0.2**
AGRICULTURE SERVICES	4.8	72.2	20.9	-1.3	5.6	4.3
PRODUCTION	100.0					

The Agro-Forest complex plays an important role in the international trade representing around 20% and 18% of the exported and imported values, respectively. In 2009, the balance was negative corresponding to 21.8% of the commercial deficit of the Portuguese economy. In 2010, preliminary data showed an improvement, and this indicator decreased to 16.3%. Export of agro-forest products have grown annually in average by 6.2% in the period 2000-2011. While the growth rate for the total exported products was 4.0% in the same period. The export agro-food products are basically wine, fishery products, vegetables, fruits, olive oil, tobacco, milk and other dairy products. The factor that makes the reduction of this deficit more difficult, is the strong dependence on imported cereals and

other animal feed products. This was aggravated by the increase of international prices. The improvement in 2010 was due to the high increase of the forestry export.

According to the Office of Planning and Policies (GPP, 2012) in the period 2000-2011 a strong decrease of the agriculture prices occurred (-28.6%, annual average -3%), resulting from the conjugation of an increase in the prices of production factors (35.2%, annual average 2.8%) and a relative stability in the prices of some of the agro products, which increased by 5.8% (Table 1) in the same period (annual average of 0.5%). In fact, the contrast between the evolution of the agro-products and production factors prices show the fragility of this sector, which is unable to pass for the respective production prices the significantly higher production costs, resulting in a significant decrease of the farmer's income. The low capability to concentrate the agricultural offer can, in part, contribute to this situation.

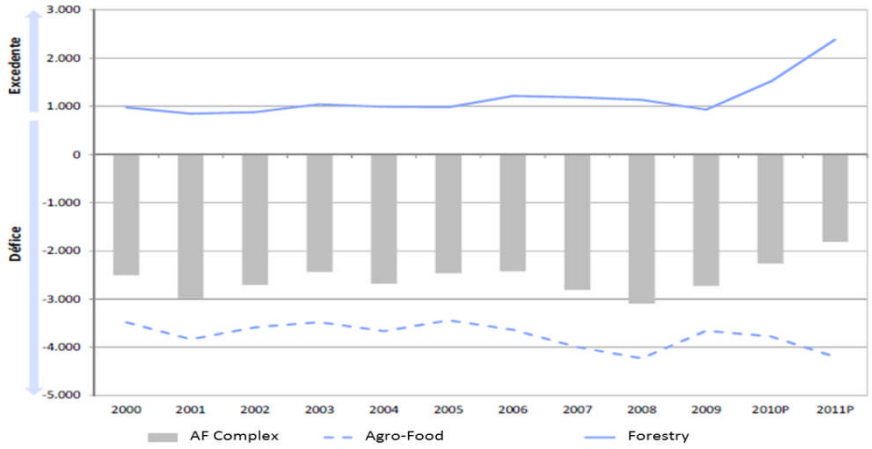


Figure 3 Comercial balance of the agro-forestry complex (milions Euros) (GPP, 2012)

There was a decrease in agriculture investments of -2.8% in average per year in the period from 2000 to 2010. This can be explained by the economic trends in general, the income reduction, but also the transition between the EU support frameworks. It is expected that if no changes occur the investments necessary to increase productivity will be too much demanding for farmers GPP (2011a).

According to INE (2011) some of the most important findings in the structure of farms and agriculture production systems in the last decade (1999-2009) are:

- One of every four farms had ceased its activity but the surface of farms still occupies half of the country;
- The small-sized farms continue to prevail but 2/3 of the Utilized Agricultural Area is now managed by farms larger than 50 ha of UAA;
- Increase of UAA per farmstead by more than 2.5 ha, from an average of 9.3 ha to about 12 ha, as a result of the absorption of the area of small farms by the larger ones;
- The number of holdings as a legal entity (agricultural enterprises) grew by 23% and 27% of the UAA are managed by them;
- Change of the agricultural landscape to more extensive agricultural production systems, with permanent pasture occupying almost half of the UAA;
- Enhanced surface reduction of grain cereals, in about 244 thousand hectares;
- Decrease in irrigated area by 23%;
- Doubling the average size of cattle and pigs herds;
- Increase in the number of tractors by 10%;

- Agricultural family population loses 443 thousand persons but still represents 7% of the resident population;
- Women account for one third of farmers and increased their importance by 8 percentage points;
- The average age of farmers increased by 4 years;
- The average farmer is a male, aged 63, completed the 1st cycle of basic education, has only practical agricultural training and works exclusively in activities on the farm about 22 hours per week;
- Zero tillage is applied on 4% of arable land;
- 10% of arable land is left as bare soil during winter;
- Vegetative cover of soil on permanent crops is practiced at 10% of farms with permanent crops;
- The Portuguese farms represent about 3% of the holdings and 2% of the UAA of the EU;
- The size of farms in Portugal is on average 5 hectares smaller than in the EU.

2.2.Environmental aspects

Susceptibility to desertification exists in 37% of the territory, especially in the interior south, central and north. It has a tendency to aggravate facing to the climatic change scenarios that have been predicted to the Mediterranean region (GPP, 2012).

According with OECD (2008), in Portugal, soil erosion remains a major concern, pollution of groundwater with nitrates is high in some areas, but the situation is improving. Almost 70% of the monitoring stations measured a decrease of more than 50% of nitrates from agricultural sources in vulnerable areas between 1997 and 2003. The use of pesticides increased by 26% over the period 1996-98 to 2001-03, although around three-quarters of pesticide use is in the form of low-toxicity fungicides, mainly sulphur to control mildew in vineyards. In addition, the area under organic farming also increased over the past 15 years to nearly 6% of total farmland by 2005 compared to EU15 average of nearly 4% (2002-04). Irrigation water applied per ha increased between 1991 and 2001 by 18%, compared to a decrease of 9% for the OECD on average. Research suggests farming is over exploiting aquifers and extracting water beyond rates of replenishment in the Algarve, although since the 1980s abstraction from aquifers has to be licensed. Agricultural ammonia emissions increased by 13% between 1990-92 and 2001-03, mainly as a result of the increase in livestock numbers and nitrogen fertiliser use.

If we compare the evolution of GVA by the agriculture sector and its GHG emissions, from 2000 to 2009 there has been an increase of 19.4% for the former, with reduced emissions of GHG by 10% for the same period (8 674 Gg CO2 eq in 2000 and 7 796 Gg CO2 eq in 2009). Thus, and as illustrated in Figure 4, there was a decarbonisation of the sector since the evolution of emissions was inversely proportional to the economic performance of agriculture (particularly in terms of volume), most notably from 2007 (GPP, 2011b).

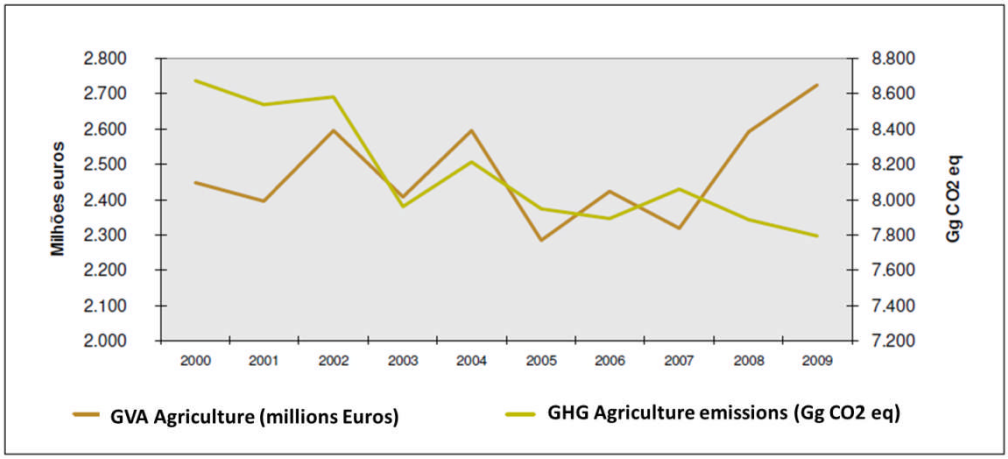


Figure 4 Evolution of GHG emissions and Gross Value Added by agriculture between 2000 and 2009 (GPP, 2011b) (1 Gg = 103 ton)

GPP (2012) refers that agriculture and forest activities had a positive contribution for the ecological equilibrium and territorial occupation. In fact, ¾ of the Utilized Agricultural Area is occupied with extensive production systems such as cereal or animal production in pasture, which provide favourable conditions for preservation of natural resources and biodiversity. Some agro-environmental indicators show:

• Reduction of nitrogen balance due to a more efficient use of the fertilisers and improvements in animal production;

• Reduction of GHG emissions (10% of total national) contributing to the mitigation of climate changes and for the accomplishment of the reduction goals defined in Kyoto Protocol;

• Agriculture and forestry are the only sectors with capability to carbon sequester and in this way can compensate the emissions due to other activities.

• Adoption of biological production and integrated production also contribute to a sustainable production;

• The adoption of better irrigation technologies allowed the reduction of the importance of water use by the agriculture sector;

• Energy consumption is decreasing due to a more efficient use of this production factor;

• Irrigation has a high importance to reduce the vulnerability of agriculture production through water storage and availability for the crops, promoting adaptation to climate changes, avoiding desertification and providing conditions to reduce the depopulation risks.

2.3.Technological aspects

There is no doubt that the need for a worldwide increase in agricultural production over the next 25 years on less land with less water through further intensification will require an increase in technology. Furthermore, it will require also the adoption of new production technologies that can minimize social, economic, and environmental costs, through enhanced productivity and economic profits while simultaneously conserving the environment. To increase our technological knowledge there is the need to invest in agricultural research and agricultural education.

According to Carvalho (2011), the Portuguese agriculture is based on an aged population with low education. Between 1999 and 2009, the average farmer age increased from 59 to 65 years. There is a decrease in younger farmers, which means less capability of technology innovation, required for improving the efficiency of agricultural production.

Portuguese research in the agricultural sector has not been a priority in the last years and is mainly concentrated at the universities, where some groups are internationally recognized. Government policies should support more agricultural research and the activity of young farmers to increase agricultural productivity and efficiency.

However, it is recognized by the Ministry services the needs to increase and to promote the research in agriculture taking into account the intensity and magnitude of impact of climate changes depend largely on the particular conditions of each country/region. It is especially the case of studies to evaluate the interactions between region, crops, climate, soil and cropping practices. In 2010 an internal Working Group was established with the main objective of monitoring and supporting the development of sectorial actions within the various aspects related to climate changes. In fact, the continuous technological progress in agricultural production offers ample opportunities for making energy use in agriculture more efficient.

2.3.1.Specific technological developments

Conservation tillage: conservation tillage practices (no-tillage, reduced tillage) have been applied for more than 25 years in Portugal. There are examples of good results on the application of these technologies in both rain-fed and irrigated cereals in different regions of the country. Basch and Carvalho (1998) found a decrease in surface runoff comparing no-tillage to disk tillage in irrigated maize, which means that it is possible to minimize soil erosion and increase irrigation efficiency with no-tillage. Carvalho and its research group have been studying the use of no-tillage in rain-fed and irrigated crops in Portugal, in the past 25 years, and they have several studies showing the improvement of soil properties subjected to no-tillage. The adoption of no-tillage or direct seeding has increased, in the past years, especially in cereals. It shows good results on reducing fuel use and labour requirements, reducing soil erosion, increasing soil organic matter, maintaining or increasing yields and farm productivity.

Precision agriculture: Precision agriculture techniques are still in a developing stage. Some experiments already showed good potential in its use on different crops such as pastures (Serrano et al., 2012) and vineyards (Marques da Silva et al., 2009). It is a technology that can allow a reduction of costs, due to variable and more efficient application of production factors, such as fertilizers or irrigation water, and at the same time reducing environmental impacts. It requires more research and education of potential users.

Organic farming and integrated pest management: There is a high consumption of pesticides in Portugal, which have increased in the past years. The environmental concerns with this issue, has led to an incentive from Portuguese agriculture authorities to farmers to adopt organic farming and integrated pest management. Many crops have nowadays financial aids, by national programs, for farmers that convert their agricultural system. These practices can present benefits due to a reduction in pesticides application, resulting in less costs and environmental hazards.

Water management and salinization: The decrease in water availability, especially good quality water, requires a better use of water resources. There is still much work to do on improving irrigation technologies, mainly, irrigation water management and water application efficiency. Improvements in

irrigation scheduling and irrigation systems efficiency, through a better irrigation management according to the crop water requirements and soil water status, would allow to save water and energy associated with the use of pressurized irrigation systems. There has been an increase in the use of water with higher salinity levels that has also increased salinization problems and decrease crop productivity. This problem tends to increase and demands a more carefully and efficient irrigation scheduling, and the monitoring of irrigation water quality.

2.4. Policy

International policies

Prospective evolution of world markets of agricultural products and European agricultural policy are determinant drivers for the development of agriculture. Common agricultural policy evolution and implementation has been particularly relevant for the evolution of the Portuguese agricultural sector. As Figure 5 illustrates, support payments received by farmers represented an important contribution for income and revenue of cereal, horticultural and industrial crops such as tomato and cattle, particularly for milk production. Decoupling measures implemented introduced more flexibility in farmer decision production activity mix but maintained historical support to farmers of these crop and livestock activities and sub-sectors relatively to other sub-sectors such as fruit and horticulture crops, vineyards and other permanent crops. However, as Figure 6 indicates, estimated Portuguese farmer average payment per hectare of 174 Euros is well below EU-27 farmer average payment per hectare of 264 Euros.

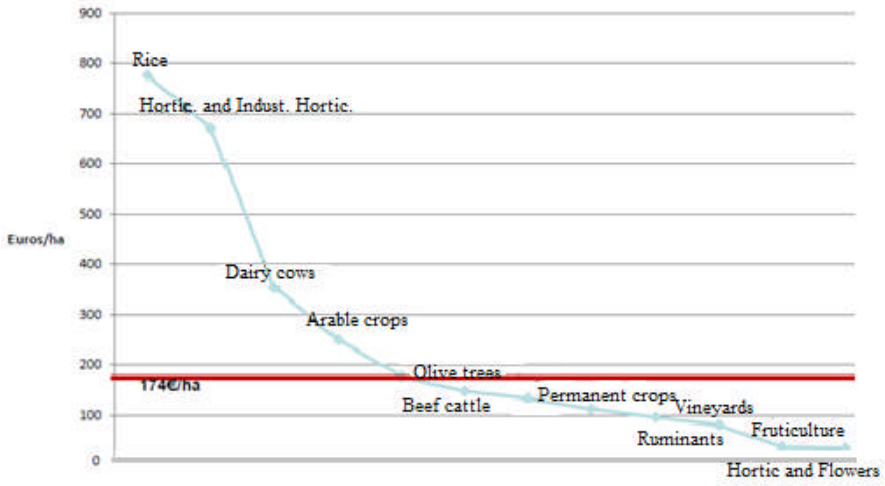


Figure 5 Average payment per hectare and per agricultural production activity (Source: Agroges)

The definition and implementation of CAP pós-2013 will be determinant for Portuguese agricultural sector evolution. Changes in CAP pós-2013 include a new system of payments with a uniform payment per hectare for all farmers. This new scheme will allow for more equity in payment distribution across farmers of different countries and sub-sectors and introduce less distortion in resource allocation. Portuguese envelop is expected to increase of around 7% (a 1/3 of the difference between Portuguese average payment and a benchmark established at 90% of EU-27 payment per hectare) but actual future payment per hectare received will depend on number of farmers and total area eligible.

CAP pós-2013 will also be determinant for Portuguese agricultural sector resulting in implications in economic versus energy and environment trade-offs. A *greening* part of the payment, representing at least 30 % of national envelop available, is to be implemented and might result in substantial changes in energy consumption and efficiency as well as for environmental impact of cropping and livestock systems. The requirement of maintaining agricultural activity implemented through the definition of *active farmer* also has potential implications for energy use and environmental effects.

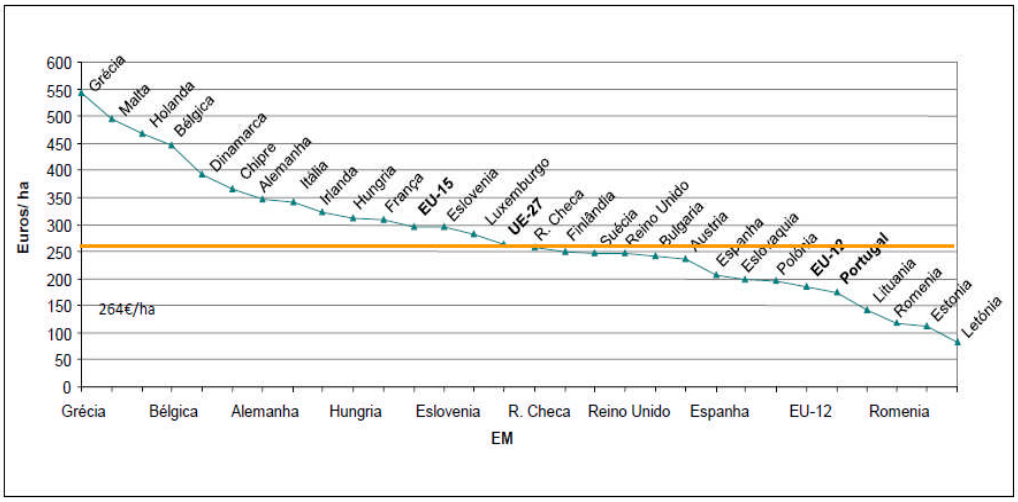


Figure 6 Farmers average payment per hectare and per EU country member (Source: Agroges)

National Policies

With no slack in national Portuguese budget, funds to implement Rural Development Plan pós-2013 needs to be negotiated with European Commission. Portuguese agricultural policy priorities will be defined and implemented through options to be taken and incorporated within this program.

2.5.Research

Presently in Portugal there is no research projects directly related with energy efficiency in agriculture. The projects related with energy efficiency are mainly concerned with buildings, transports and industry. However, the interest in energy efficiency in agriculture is becoming more and more important for producers, government entities and academics. As examples we can mention the works by Serrano et al (2007), Navas e Baptista (2010), Peça et al. (2010), Rodrigues et al. (2010), Baptista et al. (2012a,b), Rosado et al. (2012).

Also some examples start to appear in the production system, like the case presented by João Coimbra in the National Agriculture Fair in June 2012, showing a farm energy sustainable, resulting from the positive join between energy enterprises and farmers.

Some projects like REDIENE and ALTERCEXA are related with renewable energy and have also some agriculture concerns, but only as a lateral issue.

2.6. General drivers analysis

Table 5 summarizes the drivers in terms of their importance to the policy on short and long term. There is the need to lower the energy consumption in agriculture, but this should be done without causing problems to agriculture economic sustainability, since the sector has traditionally low added value.

Table 5 – Importance of drivers for implementing energy efficiency in agriculture

Driver	**Importance**	
	Short run (<3 years)	**Long run (>5 years)**
• Demographic development of farms and agricultural sectors	No significant impacts on short run.	There is an increase in young and more educated people dedicated to agriculture activities. This can improve the use of natural resources and the conversion to a more technological and efficient production system.
• Energy market (price, supply)	Oil prices are increasing in international markets, and as consequence energy price rises.	Energy price will become more and more an important cost factor and a reason for better energy economy. This could contribute to improve energy efficiency and the use of renewable energy sources.
• Level of education and research	The awareness to the need on natural resources conservation and the importance of renewable energies and energy saving has increased in education and research.	Natural resources and environmental conservation can increase the adoption of energy saving production systems. The use of renewable energy systems can increase with the level of education of farmers and the increase in fossil energy prices.
• Technological developments	There is an incentive to adopt new production systems, with more environmental concerns. This can be extended in the short-run to more energy saving production systems.	Increase in the use of conservation tillage systems and developments in precision agriculture can allow the adoption of more energy saving production systems.
• Climate change concern	No major concerns in a short-run.	There is the probability to an increase in desertification due to the climatic changes scenario and the predictions to the Mediterranean areas. This will require an adaptation of agricultural systems, with the increase of irrigated

		crops.
• Taxes • Legislation (CAP)	Taxes are an important part of the energy price. Increased energy efficiency can be promoted with tax reliefs in the favor of lower CO_2-emissions.	Legislation and taxes can be important to control energy use and to promote energy efficiency.

3. Stakeholder Analysis

Identification of the national stakeholders which are interested in the developing and implementation of energy efficiency in agriculture, and those that have the power to implement energy efficiency measures can help the implementation of energy-efficient technologies and production systems. In Annex 1 are presented several examples of stakeholders.

The following key stakeholders were identified (open list).

- **Farmers and farmers' organizations**
  There are different farmers' organisations, which represent (mostly per agricultural sector) the farmers.

- **Agricultural and food processing industry and Trade and Retail companies**
  Energy efficiency can be used as a marketing strategy.

- **Agricultural input suppliers**
  These are many suppliers of agricultural inputs, such as fertilizers, crop protection, energy, technology and mechanisation.

- **Nature conservation and animal welfare organisations** (NGO's)
  Nature conservation and animal welfare organisations are mainly the channel for critical citizens to express their concerns on developments within the agricultural sector.

- **National government**
  The choices made by the national government determine the subsidies (financial aids), taxes and legislation.

- **Supranational government**
  The European government determines e.g. the CAP policy, food safety legislation, renewable energy directive and many more.

- **Education and research organisations**
  The educational institutes educate the farmers and employers of the future. The focus of the educational institutes determines the potential available skills in the agricultural sector in the future. The structuring and financing of research will determine the predominant research areas.

- **Financial institutions**
  These are important mainly due to the financial support they can give to farmers who want to invest in technology that could contribute to energy efficiency.

Table 6: The Interest and Power and Influence of Groups of Stakeholders of Energy Efficiency Implementation in Agricultural Practice.

Group of Stakeholders	Interests in Implementation	Power and Influence to Implement
Supranational	International collaboration of governmental agencies and agricultural organizations is indispensable to participate in development and agreement of energy efficiency development programmers at the European level as well to disclose innovate technologies to reduce energy consumption in agriculture.	European policy determines national and regional policy. Important to finance research and also to support information and publicity action at the supranational level.
Governmental	Reducing energy dependence is a specific goal of national government. Agriculture is one sector that can help to reduce energy dependence and also contribute to climate change mitigation.	National government implements EU and national legislation and have the power to manage energy efficiency by means of decrees, taxes, etc.
Finance institutions	Investment in new technologies for energy saving will require the need for bank loans, which will benefit through lending rates. The increased in profit that can be attained by energy saving can also lead to an increase of companies market shares and the profit of those that have invested in these companies.	Having financial resources it is possible to influence energy efficiency development directly by means of effective decisions on financing implementation projects. For this reason it is an important sector to enable implementation of energy efficient development programmes in agriculture.
Agriculture and Food industries Trade and Retail	Public is more informed and aware of energy and environment aspects. These industries can be interested in selling food and agriculture products that were produced using less energy and less pollution. These can be used in marketing strategies.	Food industry and trade and retail companies has the possibility to define the type of agriculture product they want to buy and that gives some power to implementation of energy efficiency and lower carbon, water, and energy footprints. However, prices are still an important factor on consumers purchasing decisions. In fact, consumers are interested in sustainability but they are not willing to pay much more for that, especially in periods of crisis.
Agriculture input suppliers	Suppliers of agricultural Products needed for agricultural production are naturally engaged in agricultural commodity production. In an energy efficiency context, farmers will decrease their use of some of the production factors. This will affect the supplier's	Suppliers companies not only supply the production means but also support farmers with advisory services and perform experimental studies with new products introduced systematically into the agricultural market. Therefore they have the power, and the means, to

	activity, which will have to implement also energy saving measures in order to decrease their production costs.	advice farmers. Their influence in the farmers decisions will be fundamental for the implementation, or not, of energy saving measures.
Farmers and farmers associations	In general are interested in measures that could improve energy efficiency, but the high age and low instruction level of the farmers are barriers. Also, if some investments are necessary, financial problems are usual. It is necessary to prove that measures are important to reduce production costs.	They are the end energy users, so they have a great influence and the power to implement energy efficiency measures in agriculture production systems.
NGO	Energy efficiency is related with environmental issues. Lowering energy inputs into agriculture contributes to lower greenhouse gas emission, and improves living standards in rural areas. These are the goals of majority of these organisations.	These organisations have organisational capacities and associate people for the purpose of important social issues and can influence governmental decisions.
Educational and R&D institutions	In Portugal, research is much dependent on Universities and other education institutions. There is an awareness of the energy saving needs, in the academic world, that has increased the studies and courses on energy, renewable energies and energy efficiency. And this is fundamental to increase the knowledge and skills of future educated farmers and also to develop the national research activities in this issue. Due to the need for a holistic approach to the subject matter covering interdisciplinary research, it also calls for new research programmes. It is also the opportunity for increasing the international cooperation on research, which would allow national institutions to acquire more funds, and increase the quality of the research programs and activities. This will also be important for technological transfer activities to farmers and agricultural manufactures.	The power and influence is limited in the short run period. Only with quality research that could be applied in practice, strong measures for divulgation near the farmers and younger people with higher level of education there would be capable of influencing people in adopting energy saving practices. For that time is needed.

In Figure 7 is presented the prioritization of the above mentioned stakeholders depending on their importance in application of energy efficiency and energy saving policy in the agricultural practice.

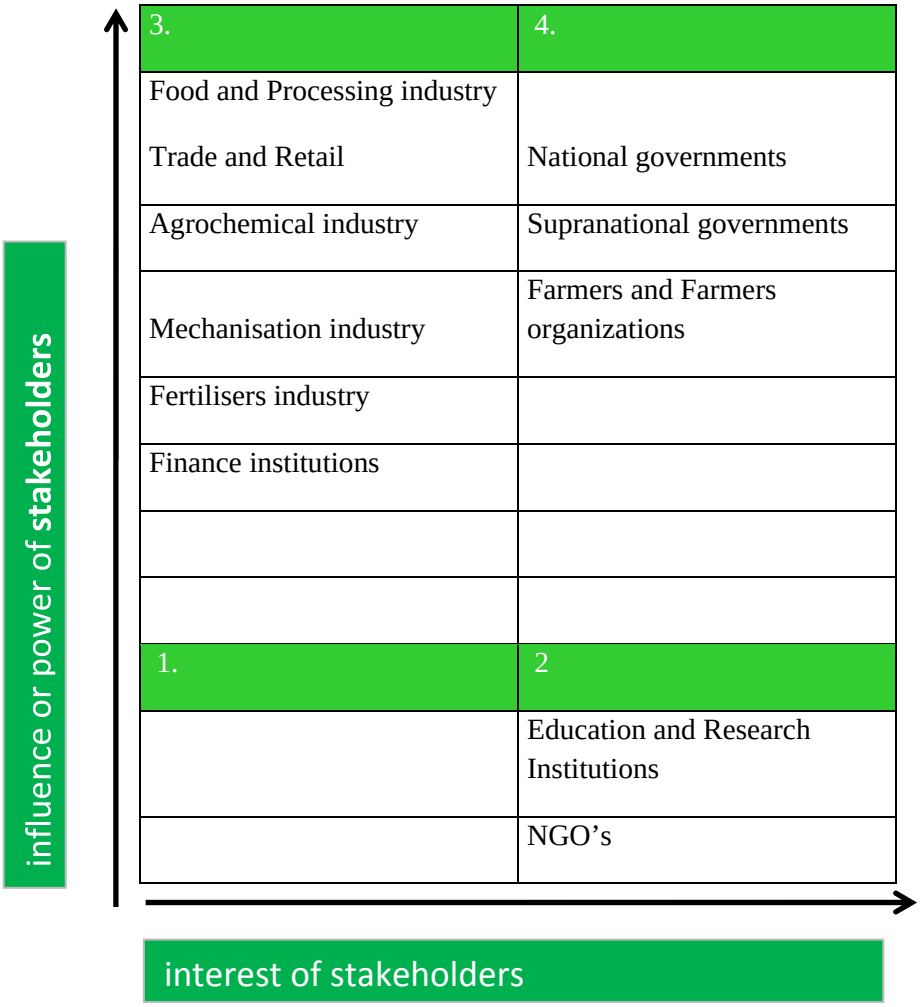


Figure 7 Influence/Interest grid for stakeholder prioritization

Action per quadrant of the diagram:

1. Monitor (minimum effort)
2. Keep informed
3. Keep satisfied
4. Manage closely

Summary

Portugal is in the group of EU countries most vulnerable in terms of negative impacts of climate change. It is expected a reduction yield due to several effects, such as the increased climatic variability, average temperature increase, reduction of rainfall and higher concentration in the winter period and higher occurrence of extreme events. Some national policy measures already take these aspects in consideration, which led, for example to the construction of new irrigation infrastructures and the improvement of existing ones, the encouragement to farmers to use soil conservation practices, among others.

This projects deals with the energy use and energy efficiency in the agriculture sector. Energy is a variable cost that we believe has potential to decrease, contributing to the increase of farm profit margin and to the reduction of environmental negative impacts through the use of innovative technologies. However, energy use efficiency in agriculture is a complex issue, due to the high amount of affecting factors that deserves proper attention in order to identify and improve the knowledge of the various interactions.

Several drivers were analyzed for the Portuguese case: demographic, energetic , education and research, technological developments, climate changes and taxes and legislation. There is an increase in young and more educated people dedicated to agriculture activities. This can improve the use of natural resources and the conversion to a more technological and efficient production system. Energy price will become more and more an important cost factor and a reason for better energy economy. The awareness to the need on natural resources conservation and the importance of renewable energies and energy saving has increased in education and research. There is an incentive to adopt new production systems, with more environmental concerns. Increase in the use of conservation tillage systems and developments in precision agriculture can allow the adoption of more energy saving production systems.

Some groups of stakeholders with interest and influence on agriculture energy efficiency were identified: Supranational, National Government, Finance institutions, Agriculture and Food industries and Trade and Retail companies, Agriculture input suppliers, Farmers and farmers associations, NGO's, Educational and Research institutions.

International collaboration of governmental agencies and agricultural organizations is indispensable to participate in development and agreement of energy efficiency development programs at the European level as well to disclose innovate technologies to reduce energy consumption in agriculture. Reducing energy dependence is a specific goal of national government. Agriculture is one sector that can help to reduce external energy dependence and also contribute to climate change mitigation. Public is more informed and aware of energy and environment aspects. Industry and trade and retail companies can be interested in selling food and agriculture products that were produced using less energy and less pollution. In an energy efficiency context, farmers will decrease use of some of the production factors. This will affect the supplier's activity, which will have to implement also energy saving measures in order to decrease their production costs. Farmers are, in general, interested in measures that could improve energy efficiency, but the high age and low instruction level of the farmers are barriers. Also, if some investments are necessary, financial problems are usual. It is necessary to prove that measures are important to reduce production costs. In Portugal, research is much dependent on Universities and other education institutions. There is an awareness of the energy saving needs, in the academic world,

that has increased the studies and courses on energy, renewable energies and energy efficiency. And this is fundamental to increase the knowledge and skills of future educated farmers and also to develop the national research activities in this issue.

In conclusion we believe there are good possibilities to promote energy efficiency in agriculture in Portugal, but it is necessary to invest in research and demonstration actions for farmers.

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Annex

Example of stakeholders (open list)

ADRAL	http://www.adral.pt
Agência para a energia	http://www.adene.pt
Agência Regional de Energia do Centro e Baixo Alentejo	http://www.arecba.pt
Agrogés	http://www.agroges.pt
Associação de Jovens Agricultores de Portugal	http://www.ajap.pt
Associação de Jovens Agricultores do Sul	http://www.ajasul.com
Associação dos Criadores de Bovinos da Raça Alentejana	http://www.bovinoalentejano.com.pt
Associação dos Produtores de Leite de Portugal	http://aprolep.wordpress.com
Associação dos Produtores de Leite e de Carne	http://www.leicar.pt
Associação Nacional de Criadores de Aves Camprestes	http://www.socampestre.pt
Associação Nacional das Denominações de Origem Vitivinícolas	http://www.andovi.pt
Associação Nacional dos Avicultores Produtores de Ovos	http://www.anapo.pt
Associação Nacional dos Produtores de Milho e Sorgo	http://www.anpromis.pt
Associação nacional dos Produtores de Pêra Rocha	http://www.perarocha.pt
Associação Portuguesa de Agricultura Biológica	http://www.agrobio.pt
Associação Portuguesa de Criadores de Raças Frísias	http://www.apcrf.pt/

Associação Portuguesa de Energia	http://www.apenergia.pt
Associação Portuguesa de Kiwicultores	http://www.apk.com.pt
Associação Portuguesa de Mecanização Agrária	http://www.apma.pt
Associação Portuguesa de Mobilização de Conservação do Solo	http://www.aposolo.pt
Associação Portuguesa de Produtores de Plantas e Flores Naturais	http://www.apppfn.pt
Associação Portuguesa para o Desenvolvimento das Tecnologias de Informação e Comunicação na Agricultura	http://www.agriculturadigital.org
Associação Produtores de Bovinos de Leite (Raça Frísia)	http://www.apcrf.pt
Centro de Estudos e Promoção do Azeite do Alentejo	http://www.azeitesdoalentejo.com
Centro Operativo e Tecnológico Hortofrutícola Nacional	http://www.cothn.pt
CERTIS	http://www.certis.pt
CNA (Confederação Nacional de Agricultura)	http://www.cna.pt
COMPAL	http://www.compal.pt/
Confederação de Agricultores Portugueses	http://www.cap.pt
Coop Agrícola de Brinches, CRL	http://www.coopbrinches.pt
Coop Agrícola de Macedo de Cavaleiros, CRL	http://www.cooperativamacedo.com
Coop Agrícola de Tabuaço, CRL	http://www.cooptab.pt.vu
Coop de Olivicultores de Valpaços, CRL	http://azeite-valpacos.com
COTR	http://www.cotr.pt
Crédito Agrícola	http://www.creditoagricola.pt/CAI

CUF – Adubos de Portugal	http://www.cuf-adp.com/
Direcção Geral de Energia e Geologia	http://www.dgeg.pt/
Direcção Regional do Desenvolvimento Agrário – Açores	http://www.azores.gov.pt/Portal/pt/entidades/sraf-drda/?cName=sraf-drda&lang=pt&area=ct
Energias de Portugal	http://www.edp.pt
Equiporave	http://www.equiporave.pt
Escola Superior Agrária de Bragança	http://esa.ipb.pt/
Escola Superior Agrária da Beja	https://www.ipbeja.pt
Escola Superior Agrária de Castelo Branco	http://www.ipcb.pt
Escola Superior Agrária de Coimbra	http://portal.esac.pt
Escola Superior Agrária de Elvas	http://www.esaelvas.pt/
Escola Superior Agrária de Santarém	http://si.esa.ipsantarem.pt
Federação de Suinicultores	http://www.suinicultura.pt
Federação Nacional das Associações de Raças Autóctones	http://www.fera.com.pt
Federação Nacional das Organizações de Produtores de Frutas e Hortícolas	http://www.fnop.pt
Federação Portuguesa de Associação de Suinicultores	http://www.suinicultura.com
Fundação Eugénio de Almeida	http://fundacaoeugeniodealmeida.pt
Gabinete de Planeamento e Politicas	http://www.gpp.pt
GALP	http://www.galpenergia.com
Instituto da Água	http://www.inag.pt
Instituto de Tecnologia Química e Biológica	http://www.cienciaviva.pt/divulgacao/arteeciencia/itqb.asp
Instituto Nacional dos Recursos Biológicos (Estação Agronómica Nacional)	http://www.inrb.pt/inia
Instituto Politécnico de Castelo Branco	http://www.ipcb.pt

Instituto Politécnico de Viana Castelo	http://portal.ipvc.pt
Instituto Politécnico de Viseu	http://www.esav.ipv.pt/
Instituto Superior de Agronomia	http://www.isa.utl.pt
Laboratório Nacional de Energia e Geologia	http://www.lneg.pt
Ministério da Agricultura, do Mar, do Ambiente e do Ordenamento do Território	http://www.portugal.gov.pt/pt/os-ministerios/ministerio-da-agricultura-mar-ambiente-e-ordenamento-do-territorio.aspx
Olidal - Olivicultores do Alentejo CRL	http://www.olidal.com
Olivais do Sul	http://www.olivaisdosul.com
QREN	http://www.qren.pt
Rede de Agências de Energia	http://www.renae.com.pt
Rede Energética Nacional	http://www.ren.pt
SAPEC AGRO	http://www.sapecagro.pt/internet/empresa/
União Agrícola do Norte do Vale do Tejo	http://www.agrotejo.pt
União de Produtores Horto-frutícolas do Algarve	http://www.uniprofrutal.pt
Universidade do Algarve	http://www.ualg.pt
Universidade da Beira Interior	https://www.ubi.pt
Universidade de Aveiro	http://www.ua.pt
Universidade de Coimbra	http://www.uc.pt
Universidade de Évora	http://www.uevora.pt
Universidade de Trás os Montes e Alto Douro	http://www.utad.pt
Universidade do Porto	http://sigarra.up.pt
Universidade dos Açores	http://www.uac.pt