Synthesis and Summary Report on State of the Art, Drivers and Stakeholders of Energy Efficiency in Agriculture, and Potential of Energy Saving Measures

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Preface

Improvements in the energy efficiency of agricultural production have the potential to significantly reduce energy inputs and thereby reducing production costs and greenhouse gas emissions.

Energy efficiency analysis depicts the distribution of energy inputs in a given agricultural production system and enables the determination of activities in areas where significant energy savings can be achieved.

The implementation of energy efficiency policy for energy saving measures in agricultural practice is a process which requires mobilization of available resources in order to create enabling environment of drivers, developments, and stakeholders.

This report is a part of Work Package 2 of the KBBE.2011.4-04 project "Energy Efficiency in Agriculture" (AGREE) supported by the 7th Framework Program. It summarizes: the state-of-the-art on energy use and energy efficiency of agriculture, the analysis of stakeholders and drivers of energy efficiency in agriculture , and the energy saving measures and their potential for energy savings in agriculture. All the data on energy inputs, energy saving measures, and stakeholder and driver analyses were provided in individual reports from the six countries involved in the AGREE project: Finland, Germany, Greece, the Netherlands, Poland, and Portugal.

1. Introduction

Energy efficiency is the goal of efforts to reduce the amount of energy required to provide products and services. The Common Agricultural Policy (CAP) governs not only an adequate quantity and quality of agricultural production but also acts for economic development of rural areas and for environmental aspects. All the parallel agricultural policies relating to production, economics, and the environment interact and are strongly linked to energy consumption and efficiency.

Agricultural production relies mainly on the use of energy from fossil resources, either directly with the use of fuel or electricity or indirectly with the use of energy embodied in agricultural machineries, fertilizers or pesticides, plastics and feed. Besides, the different production systems in various environments across Europe vary substantially in their energy use and energy saving potential. In agricultural production the need for energy as an production input can determine the profitability of farming which, in turn, impacts heavily upon the farmers' investment in improved farming systems. Therefore, cost-effective energy measures are needed from an economic point of view and have the promise to reduce carbon emissions at the same time.

There are many drivers and stakeholders who create energy efficiency conducive/enabling environment including ministerial, legal, financial, R&D, and educational institutions as well as non-governmental, farmer and agricultural associations, and farmers. The enabling environment is always specific for a given country but synchronization of national policies at the EU level may accelerate the process of implementation. Such environment will facilitate recognition and removing barriers and on the other side governance of energy efficiency implementation policy into agricultural practice. Energy efficiency governance combines legislative frameworks and funding mechanisms, institutional arrangements, and co-ordination mechanisms, which work together to support the implementation of energy efficiency strategies, policies and programs[1].

2. Purposes and Methods

2.1. The state of the art on actual energy use: the purpose of this part was to give an outlook for energy use in the main agricultural sectors of arable, perennial, greenhouse and livestock production. [2]

Method. The results of this study are based on the specific input of primary energy per cultivation area (GJ ha^{-1}) and on the specific input of primary energy per ton of agricultural product (GJ t^{-1}).

The analysis has been determined on the basis of the data provided by six countries: Finland, Germany, Greece, the Netherlands, Poland, and Portugal. The approach based on the life cycle analysis (LCA) has been chosen with the system boundary at the farm gate and have thus excluded processing into consumer goods. Specific energy input has been established for those agricultural products which have a decisive role in the EU foodstuff production, including:

- crop production: wheat, sugar beet, potatoes, cotton, and sunflower;
- greenhouse production of tomatoes, cucumber, and sweet pepper;
- perennial crops production such as vineyards and olive trees;
- livestock production such as dairy cows, pigs, and broilers.

The analysis is based on average production figures, or best estimates, (should average figures be unavailable). In several cases figures have been found for different production systems within one country and up to three scenarios have been described. In this way, low, average, and high primary energy consumption (PEC) of the various production processes have been taken into consideration.

2.2. The state of the art on drivers, developments and stakeholders: the purpose of this part was to create an image of the enabling environment of energy efficiency in agriculture which will contribute to energy saving potential.[3]

Method. Reports from the six countries present the drivers, stakeholders and barriers of the process of improvements in energy efficiency in agriculture. A general characterization of agriculture in the context of energy consumption in agricultural production is followed by the review and classification of the drivers, actors and barriers for the creation of enabling environment for the purpose of energy savings implementation into the agricultural practice. The DESTEP method[4] was applied to the systematic analysis of the external drivers (incl. demographic, economic, social, technological, R&D&D, ecological and political group of drivers).

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[1] Energy Efficiency Governance. IEA 2010.
[2] The results from the analysis on energy use supported by economic data will be input to WP3 "Economics and Environment".
[3] The resulting generalisation will be input to WP4 "Agenda for Transnational Collaboration".
[4] Cornelissen J. 2004. Corporate communications : theory and practice. TJ International, Cornwall.

2.3. The state of the art on actual and potential energy saving measures: the purpose of this part was to provide an inventory of energy saving measures categorized according the agro-production sector, farm activities, financial data like investment and payback time and the expected time scale of implementation.[5]

Method. In the six national reports from Finland, Germany, Greece, the Netherlands, Poland and Portugal and for 13 subsectors of agriculture, 481 energy saving (ES) measures in total were identified and classified into seven categories with a country-specific meaning: 1) type of energy input: indirect, direct; 2) type of an ES measure: operational level, systems level, process monitoring, farm management, market orientation, capital goods; 3) importance: from 1-low to 5-high; 4) R&D: yes, no; 5) potential of the measure: achievable at present or not immediately ready for implementation; 6) indication of an investment cost: from €1000 to over €1000000; 7) estimated payback time: from 1 to over 5 years.

In general, ES measures refer to the reduction of main energy inputs, including fertilizers and pesticides; transportation fuels for tractors and other machinery; fuel use for heating, cooling, and ventilation in farm buildings and facilities; electricity use for pumping, lighting; and energy embodied in buildings and equipment.

3. State-of-the-Art on Energy Efficiency in the EU Agriculture – Deliverable 2.2

3.1. Energy Inputs in Subsectors of Agricultural Production.

According to European energy statistics the total final energy consumption (FEC) of the EU-27 countries amounted to 49205 PJ in 2008. [6, 7] The FEC of the sector "agriculture/forestry" was estimated to be 1071 PJ corresponding to 2.2 % of the total FEC in the economy. This percentage varied between the six participating countries from 0.4 to 6.2 %.

In total, the 13 analyzed subsectors of agricultural production in the countries under consideration consume various amount of primary energy. The highest energy use is in Germany where it represents 223.93 PJ. In the Netherlands and Poland the total energy use in the subsectors show similar figures of 158.45 PJ and 169.57 PJ. Energy use in the agricultural sectors considered is relatively low in Greece (83.0 PJ), Finland (18.8 PJ), and Portugal (16.9 PJ). There are some discrepancies when our data are compared to the Eurostat statistics on energy use. The overall conclusion is that the actual energy consumption of the European agriculture reported in the Eurostat statistics is underestimated (Table 1). The main reason is that indirect energy which is required for the production of agricultural inputs and the fuels is not allocated or not allocated entirely to the sector of "agriculture/forestry" in the Eurostat statistics, e.g. production of fertilizers and consumption of fuels for agro-machinery (which is reported in the transportation sector of the EU countries' economies). The efficiency of energy use in agricultural production is specific to the EU country and geographical location. The total and specific energy consumption varies substantially for all products considered

[5] The list and the corresponding analysis (the identification of drawbacks and pitfalls in disseminating and implementing these measures) will be input to WP3 and WP4.
[6] http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/main_tables
[7] Values converted from tons of oil equivalents (toe) to PJ using 1000 toe = 0.041868 PJ

across Europe. Reasons have been identified, and discussed, in terms of various production practices, different agricultural machinery types, varying yields and climates.

Table 1: Total primary energy consumption for the agricultural subsectors considered in the study in comparison with the Eurostat data (2008).

	Finland	Germany	Greece	Netherlands	Poland	Portugal
Number of subsectors considered in the analysis	4	10	6	9	6	7
Total PEC (PJ) for the **subsectors considered** in the study	18.8	223.9	83.0	158.4	169.6	16.9
Total FEC (PJ) in **all** Agriculture/ Forestry acc. to Eurostat (2008)	35.0	42.0	46.0	132.0	152.0	15.0

The main energy input for the field crops is associated with the use of fertilizers and diesel. In some cases the energy input for irrigation, drying and/or storage is substantial but with great variations between geographical locations and related climate, and the intensity of the production systems. Greenhouse vegetable production in the Central and Northern EU countries is characterized by a very intensive direct energy input and differs significantly from the production system in the Southern EU countries. For the crops grown in the Southern countries little or even no energy input is needed when grown directly on soil; and only a higher energy input is needed in hydroponic systems. In the Southern EU countries the total primary energy consumption by perennial production contributes significantly to the total energy use in agriculture. Olives production in Greece amount to 5.59 PJ and in Portugal 4.03 PJ and in comparison with vineyard production these figures are two-fold higher. The subsector of vineyard production is present in the Central EU countries and in Germany where it accounts for 2.16 PJ.

In milk and broiler production there is a highly differentiated amount of energy accumulated in feed. However, energy use for feed in pig production is very similar across the studied countries, but the specific energy input does depend on the level of direct energy inputs. The direct energy input in the total energy use for pig production in the study countries were as follows: Finland 35%, Poland 16-23%, Portugal 21%, Germany 10%, and the Netherlands 7%.

The results of the energy use analysis for subsectors under consideration were scaled up to the national level (Table 2). In Germany the most energy consuming subsectors are dairy cows, wheat, and pig production.; in the Netherlands are dairy cows, pigs, and tomatoes and sweet pepper production; in Poland – dairy cows, wheat, pigs and potato production; in Finland – dairy cows and pigs, in Greece – wheat and cotton, and in Portugal – dairy cows, olive groves and broiler production.

Table 2: The total PEC as weighted means from scenarios for the agricultural subsectors in PJ.

Subsector	Finland	Germany	Greece	Netherlands	Poland	Portugal
Wheat	2.51	58.17	46.09	2.16	42.60	1.46
Sugar beet		4.95		1.23	4.34	
Potatoes		6.65		3.81	11.33	
Sunflower		0.32				0.08

Cotton			27.19			
Tomatoes		3.61	2.15	25.64		0.43
Cucumber		3.32	0.37	9.44		
Sweet pepper				15.00		
Olive groves			5.59			4.03
Vineyards		2.16	1.58			1.91
Dairy cows	9.64	94.59		59.18	75.73	5.52
Pigs	5.56	43.23		32.73	23.30	
Broilers	1.10	6.93		9.27	12.28	3.44
Totals	18.81	223.93	82.97	158.45	169.57	16.86

3.2. Crop production

At the European scale the highest absolute total primary energy consumption in crop production is associated with wheat production in Germany 58.17 PJ, Greece 46.09 PJ, and Poland 42.60 PJ (Table 1). The next crop is cotton cultivated in Greece – 27.19 PJ, and then potatoes in Poland 11.33 PJ and Germany 6.65 PJ, and sugar beet in Germany 4.95 PJ and Poland 4.34 PJ. Total energy consumption for sunflower production is relatively low 0.32 PJ in Germany and 0.08 PJ in Portugal.

The specific energy use varies substantially for all crops considered across Europe (Figure 1). The ranges of specific energy input in crop production are as follows: wheat 2.08 - 4.29 GJ t^{-1}; sugar beet 0.20 - 0.29 GJ t^{-1}; potatoes 0.63 - 0.87 GJ t^{-1}; sunflower 3.98-5.06 GJ t^{-1}; and cotton 15.4 GJ t^{-1}.

The structure of direct and indirect energy use may reflect the potential for energy savings. In wheat, sugar beet, and potato production, as well as in sunflower production in Germany direct energy use shares about 30 % - 50 % of the total specific energy use (Figure 1). This means that only a little higher potential for energy savings is associated with reduction of indirect energy use. The extremely high direct energy use, over 90%, is for sunflower production in Portugal and for cotton production in Greece. Thus, in these cases the inputs associated with direct energy use may contribute significantly to energy savings.

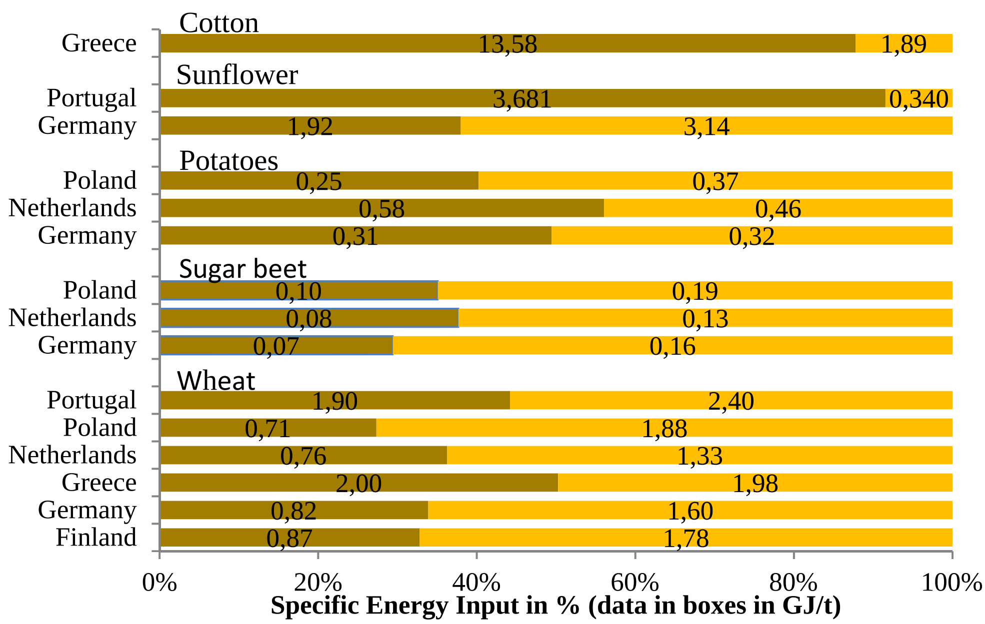

Figure 1: Direct (darker boxes) and indirect energy inputs in crop production by country (average scenarios).

Wheat. The energy efficiency indicators for wheat productions are specific for the three EU geographical areas. A relatively low specific energy input for wheat production is characteristic of the Central EU countries: the Netherlands (2.07 GJ t^{-1}) and Germany (2.43 GJ t^{-1}). Medium energy input is specific for the northeast EU countries of Finland (2.66 GJ t^{-1}) and Poland (2.60 GJ t^{-1}) and a comparatively high energy input for wheat production in the Southern EU countries Greece (3.99 GJ t^{-1}) and Portugal (4.29 GJ t^{-1}). Between 44.0 % (Greece) and 65.4 % (Poland) of the total primary energy consumption (PEC) in wheat production is used for fertilizers. Diesel use ranges between 14.1 % in Finland and 50.4 % in Greece. Drying has been found to require 18.8 % and 12.4 % of PEC, in Finland and Germany (average scenarios), respectively.

Root crops. The structure of the energy input in the production of sugar beet and potatoes in the Central and Eastern EU countries is similar but the production shows different energy efficiencies. Production of the root crops in the Eastern EU country of Poland is characterized by lower yields and lower energy input than in the Central EU countries of the Netherlands and Germany. In comparison with the highly efficient sugar beet production in the Netherlands (0.204 GJ t^{-1}) and production of potatoes in Poland (0.627 GJ t^{-1}) and Germany (0.634 GJ t^{-1}), specific energy input in Poland is 0.286 GJ t^{-1} for sugar beet and in the Netherlands it is 0.893 GJ t^{-1} for potatoes.

Sunflower. In sunflower production the level of yield, specific energy input, and the structure of energy input is distinctly different between central and southern Europe. Energy input in Germany is 5.06 GJ t^{-1} while in Portugal a lower yield of 0.72 - 0.80 t/ha is obtained at a lower energy input of 2.31 - 4.05 GJ/ha.

Cotton production takes place only in the Southern EU countries. The reported input-output energy balance is negative with a predominant energy input for irrigation. A high specific energy input of 15.4 GJ t^{-1} comes with an average yield of 4.5 t/ha.

3.3. Greenhouse production

Across European study countries the highest primary energy consumption in greenhouse production is in the Netherlands (Table 1). In the country the total primary energy consumption by tomato, sweet pepper and cucumber production account for 25.64 PJ, 15.00 PJ, and 9.44 PJ, respectively. In Germany, greenhouse production use 3.61 PJ in tomato production and 3.32 PJ in cucumber production. From the Southern EU countries, the great amount of the total primary energy use 2.15 PJ is for tomatoe production in Greece given if the production is at the relatively low specific energy use 2 GJ t^{-1}.

Tomatoes and Cucumbers. The specific energy input for greenhouse production of tomatoes and cucumbers is specific for the two distinct regions – the central, temperate zone, countries represented by the Netherlands and Germany and the Southern European countries represented by Greece and Portugal. In Central Europe the direct energy input is predominant accounting for over 99% of the total energy input, while in the Southern countries it accounts for 10-40% of the total energy input (Figure 2).

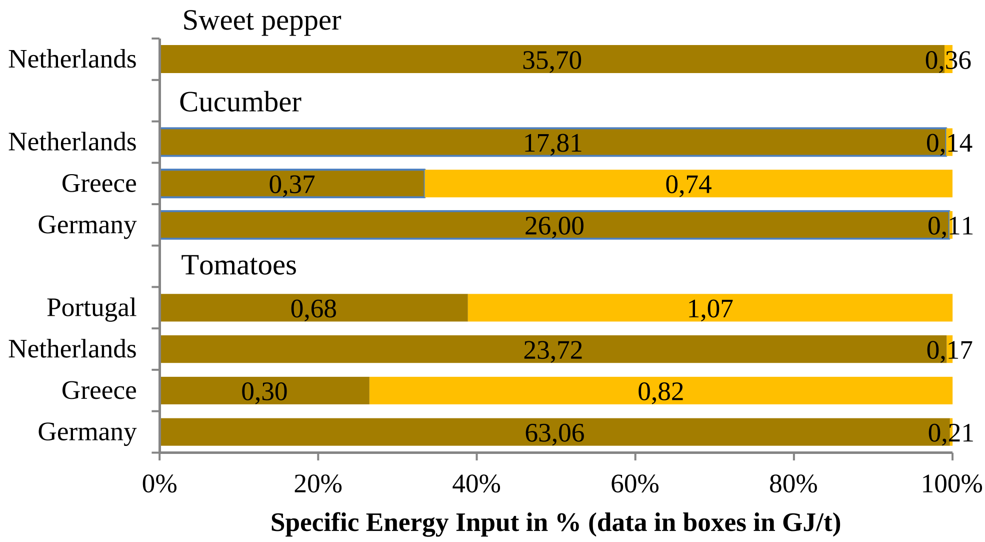

Figure 2. Direct (darker boxes) and indirect specific energy input in crop production by country (average scenarios).

In Portugal, the indirect energy input is associated with application of greenhouse materials (substrates), pesticides and irrigation, while in Greece it is associated with greenhouse materials (thermal screens, solarisation and Low Density Polyethylene, films) and fertilizers. In the temperate zone countries, tomatoes and cucumbers are produced at a very high specific energy input of 63.3 and 26.1 GJ t^{-1} (12654 and 13053 GJ/ha) in Germany. The equivalent values for the Netherlands are 29.0 and 20.1 GJ t^{-1} (15110 and 15074 GJ/ha) for tomatoes and cucumber. In Greece and Portugal, the specific energy inputs for tomato production are 2.0 and 3.1 GJ t^{-1}, respectively. In Greece, a value of 0.9 GJ t^{-1} was determined for cucumber production.

Sweet Pepper. A high specific energy input of 36 GJ t^{-1} (11539 GJ/ha) has been determined for the production of sweet pepper at an average yield of 320 t/ha (The Netherlands).

3.4. Perennial crop production

In the Southern EU countries the total primary energy consumption by perennial production contributes significantly to the total energy use in agriculture. Olives production in Greece share 5.59 PJ and in Portugal 4.03 PJ and in comparison with vineyard production the figures are two-fold higher (Table 1). The subsector of vineyard production is present in the Central EU countries and in Germany accounts for 2.16 PJ.

The ratio of direct to indirect energy inputs is country specific. In the olive grove production in Greece and vineyard production in Germany the ratio of direct to indirect energy inputs is 3-4:1 while in Portugal the ratio is 2:3 for olives production and 1:1 for vineyard production (Figure 3).

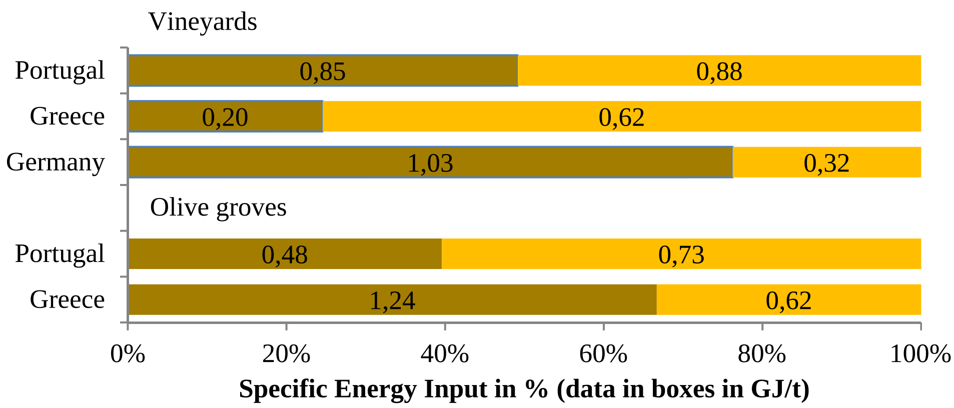

Figure 3: Direct (darker boxes) and indirect energy inputs in perennial production by country (average scenarios).

Olive Groves. In the southwest EU country (Portugal) olives are produced in significantly higher yield per hectare, but at a lower energy efficiency than in the southeast EU country (Greece). More specifically, the olive yield in Portugal amounts to 8.0 t/ha and is obtained with a specific energy input of 1.21 GJ t^{-1}. In comparison the yield in Greece is lower, reaching 5.5 t/ha (lower by 31%), but also the specific energy input is lower at 1.07 GJ t^{-1} by 11%.

Vineyards. The most energy efficient production of grapes for wine is in Greece where the yield of 20.0 t/ha is produced at a specific energy input of 0.82 GJ t^{-1}. The yield in Germany amounts to 15 t/ha with a higher energy input of 0.53 GJ t^{-1}. The production system of quality wines in Portugal assumes reduction of yield by pruning of fruits in early growth stages giving 4.5 - 7.5 t/ha at the corresponding specific energy input of 2.49 GJ t^{-1} - 1.39 GJ t^{-1}, respectively. Such production requires a high amount of energy associated with pesticides, which in Portugal accounts for between 8.7% and 70.2% of the total energy input. The similar scenario of the vineyards production system in Greece assumes a yield of 14 t/ha at an energy input of 1.08 GJ t^{-1} with high amount of energy used for irrigation (59%). In Greece and Germany fertilizers and diesel are the main energy inputs. In Greece, the main energy input stems from fertilizers (56%) whereas in Germany, energy input arising from diesel use is predominant (70-78%).

4. Livestock production

The livestock subsectors comprise a great share of primary energy consumption in agriculture and they are equaly important in any EU countries. The most energy consuming subsector in study countries is milk production followed by pig and broiler production (Table 1). The scale of primary energy consumption depends on the country. The highest absolute quantity of primary energy consumption by livestock production is in Germany. In this country dairy cow, pig and broiler production account for 94.58 PJ, 43.23 PJ, and 6.93 PJ, respectively.

The proportion between direct and indirect energy use in dairy cow production is very similar at the ratio of 2:3 (Figure 4). It points out that energy saving potential in milk production will result from the activity in the both groups of the inputs. In pig and broiler production the ratio is in the range from 1:5 to 2:3. Thus, the highest potential in energy savings will have reduction of indirect inputs.

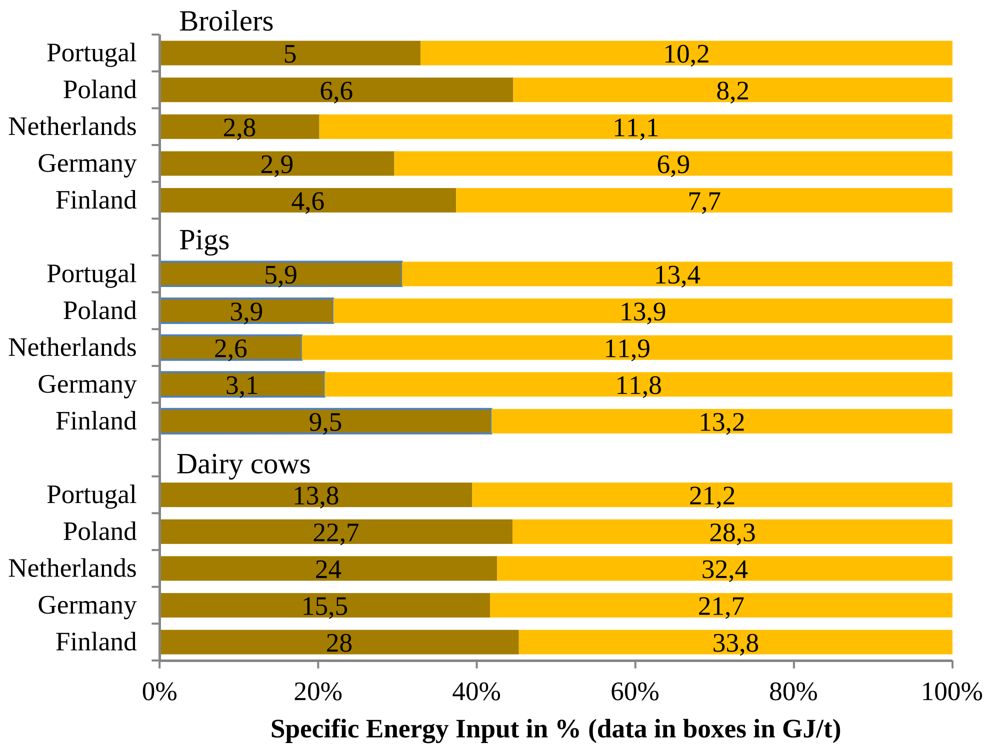

Figure 4. Direct (darker boxes) and indirect specific energy input in livestock production by country (average scenarios).

Dairy Cows (milk). Across these six EU countries the average energy input for milk production is in the range from 2.71 GJ t^{-1} (Germany) to 5.05 GJ t^{-1} (Poland). The main energy input for milk production is energy associated with feed (60-85%) and direct energy consumption. The latter varies by country, i.e. diesel use for transport and farm operations in the Netherlands, Poland and Portugal, electricity use for milk storage in Germany, and electricity and wood chips used for heating water and cowsheds (buildings) in Finland.

Pigs. The specific energy input in pork production is in the range from 14.5 GJ t^{-1} in the Netherlands to 22.6 GJ t^{-1} in Finland. The indirect energy input is associated mostly with piglet production (19-30%) and feed (38-62%). Direct energy use is, again, specific for the countries – diesel use in Poland (11.1-11.8%), wood chips in Finland (35%) and electricity use in the other countries the Netherlands 7%, Germany 10%, and Portugal 21%.

Broilers. The specific energy input in chicken meat production accounts for 9.8 GJ t^{-1} in Germany, 12.3 GJ t^{-1} in Finland, 8.9 - 12.6 GJ t^{-1} in Portugal, 14.0 GJ t^{-1} in the Netherlands, and 14.8 GJ t^{-1} in Poland. There is no clear regional difference in the energy use for broiler meat production, except for Portugal where over 90% of total energy input is associated with feed. In the other production systems energy for feed requires 53-74% of the total energy input.

5. Drivers and Stakeholders of Energy Efficiency in Agriculture – Deliverable 2.2

Driving forces (drivers) are the factors that determine development and implementation of the energy efficiency and energy saving activities into the agricultural practice. Eventually, all the identified drivers add to the rationale of decision if the investment on the application of the new energy-efficient technology in the production, farm or commune or organizational change in the production process should be made or not in spite of the unsatisfactory effect of implementation due to a low profitability and/or limited feasibility.

There are many drivers that may be combined in various conventional groups of drivers depending on the significance of the driver for energy efficiency. Some of them are strictly attributed to the group like energy efficiency legal regulations as a political driver and the other driver may be the element of different groups like fiscal regulations that may be considered as political and/or economic drivers. Besides, under some conditions a driver may be considered as a barrier and vice versa.

In the table 3, a list of factors were chosen to compare the drivers in the project countries on energy efficiency development. More specific drivers are elaborated and analysed in the country studies (Deliverable 2.2). The analysis is based on experiences and observations by the authors of the studies.

Table 3: External factors related to energy efficiency

External factor	Factor related to energy efficiency
Demographic	Demographic development of farms and agricultural sectors
Economic	Energy market (price, supply)
Social	Level of education and research Societal demands
Technological	Technological developments
Ecological	Climate change concern Sustainability demands in supply chain
Policy	Taxes Legislation (CAP) Funds

In the long-term the most important drivers for changes in energy efficiency in agriculture are demographic developments, level of education and research, technological developments and climate change concerns. Demographics are important from a global as well as a farm perspective. Their implications will have long term effects on the investment and production strategies of farms. The quality of research and the level of education will determine the adoption of new technologies in the long-run. The efforts to find appropriate and resource efficient technologies is fuelled by the climate change concerns, especially in the previous years. It might be one of the most important long-term drivers for the implementation of energy efficiency and energy saving measures. Climate change is mostly concerned with emission of greenhouse gas (GHG). The pressure to reduce emissions in all nations will also affect the agricultural sector.

In the short-term, drivers such as taxes, energy prices and legislation (e.g. the Common Agricultural Policy – CAP) are the driving forces for energy saving measures at farm level. In recent years the concerns about the rise in energy prices are of direct impact for higher costs of agricultural production. Taxes are a short term measure to implement policies. National legislations are likely be adopted relatively fast at the farm level. Energy price levels are particularly important for heated greenhouses where direct energy use is high and energy prices threaten the short term economic feasibility of farms.

The identified stakeholders were assessed and allocated into four groups depending on their influence and interest in the subject of energy efficiency in agriculture. The following figure 5 demonstrates the results of the stakeholder analysis from the country studies for Finland, Germany, Greece, Netherlands, Poland and Portugal.

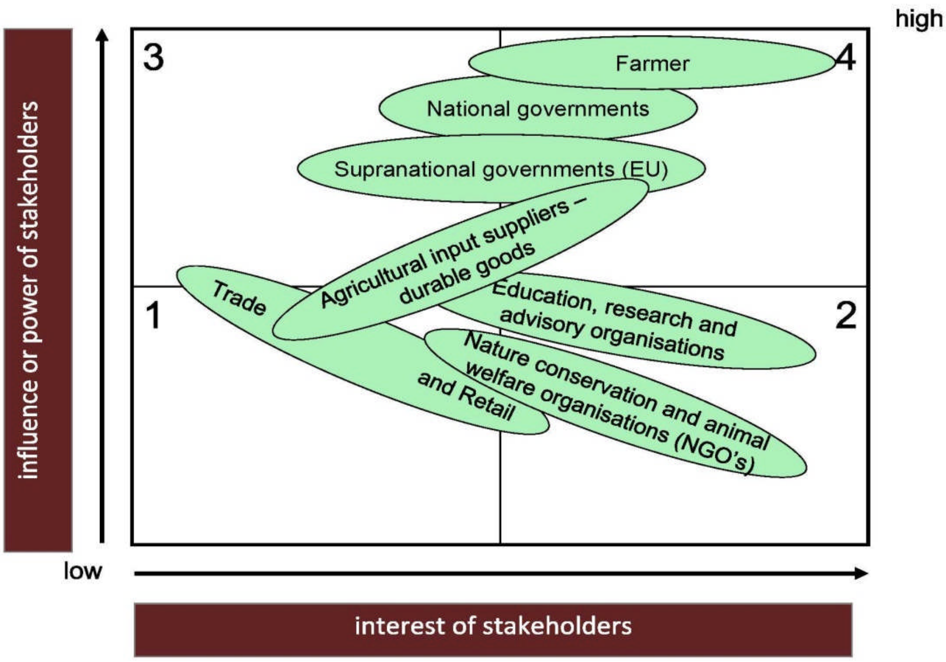

Figure 5.: Influence/Interest grid for stakeholder prioritization

The country studies followed a similar method to identify, analyse and allocate stakeholders in four different groups according to the diagram in the figure 5, i.e. stakeholder with high interest in EE but limited influence or power for change are allocated under square number two. Stakeholder in square number 4 are assumed to have high interest and high influence for EE issues, especially energy saving measures.

The actions and respective stakeholders proposals for actions to be taken to satisfy the needs of stakeholder groups are presented in the table 4.

Table 4: Actions to be taken according to priorities of stakeholders

Action	Stakeholder
Managed closely	• Farmers • National government • Supranational government (EU)

	• Farmers' organisations (partially)
Keep satisfied	• Suppliers (durable goods) • Agricultural and food processing industry (south-east and south-west)
Keep informed	• Research, education and advisory organisations • NGO's
Monitor (minimal effort)	• Trade organisations (commodities) and Retail

The relevant stakeholders in the project countries, the stakeholders with the most interest and influence are, not surprisingly, the farmers themselves, who are responsible to make decisions on possible investments in energy saving. National government and the EU are the also important stakeholders for energy efficiency development in the agricultural sectors. As a consequence, these stakeholders should be involved in the process of establishing energy saving strategies and the adoption of energy saving measures at farm level. Other stakeholder groups, i.e. research and nature conservation and animal welfare organizations (NGO'S) are interested but mildly influential for the decision making at farm level. Nevertheless, they have an important position to provide expertise or to point out the social context to the decision makers. In most countries, agricultural input suppliers (upstream chain partners) are very powerful in the decision making and might be involved if interest is expressed on energy saving issues. As for trade and retail (downstream chain partners), the subject of energy efficiency does not seem to have high priority yet , though sometimes it is part of a marketing strategy of such a company, i.e. selling products with low energy footprints. Stakeholders might have different influence and interest in the countries and should be involved accordingly, i.e. farmers' organizations, agricultural input suppliers. In general, the perception of stakeholders on the subject might be increasing in the future and it is important to provide up to date knowledge to facilitate the process for improvements in energy efficiency.

5.1. Summary Country Reports on Drivers and Stakeholders of Energy Efficiency in Agriculture

5.1.1. Finland

As a whole there are good possibilities to promote energy efficiency in agriculture in Finland. It has been possible to get money for research programmes and Finland tries to stay in the front row in energy efficiency and as a user of renewable energy.

Finland has ratified the Kyoto climate agreement and the EU directives 2006/32/EC and 2009/28/EC oblige Finland to cut CO2 emissions and to increase energy efficiency. So, the national government has a high interest to promote these two things. The economic situation is so far acceptable (though getting worse) and thus it can't be used as an excuse to slip the obligations.

NGO's have also a high interest to increase energy efficiency, but the big difference between NGO's and governments is that governments are at the same time the committed bodies and organizers of the energy reform. NGO's can state requirements which other organizations are responsible to implement. NGO's can create pressure to administration but they are powerless to do these reforms. Education, research and advisory organizations put policy into action, but their resources depend on the economic situation and there is normally a delay of years between the action and the impact. The union of farmers has interest in energy efficiency but they are a small group with low resources. The Farm Energy Program is an example how the farmers union has added its power by allying with MAF.

In the dimension of influence and power there are input suppliers, trade and retail, and governmental organizations on the top. The main focus of commercial enterprises is in making business. Promoting energy efficiency is on their agenda if it supplies business. It is certainly possible to combine these two things but promoting energy efficiency alone seems implausible. Governmental organizations are powerful also in this dimension because they can make laws and decrees, and they decide how tributes are used. Of course, at economically tough times there is not much leeway in the state budgets and politicians may be prisoners of their electors.

5.1.2. Germany

Energy efficiency in agriculture is mainly driven by farmers, their goals and their business philosophy. This in turn is determined to a large extent by cost-price relationships and their impact on farmer's income and welfare. Education and access to information is important to create an awareness of energy efficiency on farms. The economic and political environment was detected as main external drivers for energy efficiency in agriculture. Governmental institutions, NGO and industries have an impact over the market or the propagation of energy efficiency in general. Governmental institutions have a specific impact with research funding of energy efficient technologies in agriculture. There have been some funding lines especially from the Federal Ministry Food, Agriculture and Consumer Protection, resulting in increased awareness and diffusion of new efficient technologies.

The stakeholder analysis has shown, that energy efficiency in agriculture doesn't seem to be a very important issue for stakeholders involved. For example farmers' organizations surprisingly do not communicate energy efficiency in agriculture significantly. Also for NGOs energy efficiency is not one of the main topics which are addressed. More prominent is the communication of farmers as energy suppliers for renewable energy which is in the political discussion since the reforms in the agricultural sector in the 1990s. Apparently it is difficult to communicate the farmer as a user and supplier of energy and the appropriate ambition for energy efficiency.

5.1.3. Greece

Greece has shown an increase in agricultural land use and livestock production in the period 2005-2007. In terms of labour, 548 000 working hours per year were occupied in agriculture, mainly by family members of the holding owners. Most of the agricultural holding owners are over 55 years old and they are mainly based on private land (not rented). Industrial crops (like cotton and tobacco) and durum wheat were reduced significantly due to CAP reformation. Organic farming was increased significantly during the same period. Average farm size was decreased, a fact that was not expected, but was promoted by the new CAP. Most of agricultural holdings were smaller than 20 ha and in combination with multi-fragmentation, this reduces efficiency and so agricultural income. Animal husbandry concerns mainly sheep, followed by goats, pigs and cattle and poultry. In general, livestock production in Greece is based on small scale units.

A DESTEP analysis was executed, in order to identify the main drivers of Greek agriculture concerning energy efficiency. Demographically, European countries, including Greece, have the tendency of stabilizing their population with a steady trend of aging. This trend could influence food pricing and increases the need for energy efficiency in agriculture to reduce production cost. In Greece, urbanization has slowed down the last 20 years, but not stopped. Therefore, rural population was decreased, but people with rural origin continued part-time occupation in agriculture. Economically, agriculture is of great importance for Greece, as it contributes significantly to world exports of Greece (approx 25%). Hence, energy efficiency in agriculture could improve highly the economics of agricultural products. In addition, energy prices from fossil fuels are increasing continuously and Greece cannot influence global prices. Electricity is sold in relatively low prices (especially in agriculture), but is continuously increasing. Therefore, energy prices can influence significantly agricultural production and energy efficiency would affect a lot the final income. Another important economic factor for energy efficiency in agriculture would be the wages (in Greece there are very high labor cost that affects final product price significantly and could be substituted by machinery that also contribute to energy efficiency) and the land prices (generally high, but they have started to decrease). Socially, in principle, rural population is old fashioned and do not follow new trends as pioneers (like energy efficiency measures). Sustainable agriculture is also a social need that presses in the direction of energy efficiency. The new trend of urban population migration to rural areas could also affect energy efficiency in agriculture as new ideas will be brought in these areas. Unawareness of urban population about the effort of agricultural production is also influencing the agricultural market of Greek products negatively as the key criterion is the product price, but the last years this trend seems to change in favor of quality criteria. Technologically, better fertilizer and pest management could affect energy efficiency in agriculture by minimizing the applied quantities to the exact needs of the plantation (integrated farm management) or null application (organic farming). Irrigation, especially when derived by aquifer pumping, would affect energy use in agriculture if proper pumps are selected and irrigation scheduling is programmed according to the needs of the plantation. Precision farming would be a great tool for lowering inputs for all crop types, but in Greece its implementation is in primer steps, mainly due to high investment requirements. Conservation tillage or no tillage would reduce oil use by tractors, especially since traditional tillage includes deep ploughing (the most energy consuming tillage application). Crop and animal breeding and return in traditional Greek varieties would also minimize input application. Ecologically, soil erosion and fertility has an impact in energy efficiency in agriculture as it is always combined with higher fertilizer and pesticide application. In Greece, climate change has an impact in irrigation scheduling that can increase energy use in agriculture. Politically, EU and WTO policies affect significantly energy use in agriculture, especially when sustainable and organic agriculture is applied.

The main stakeholders in Greece that could cover the above mentioned drivers are national government (like ministry of rural development and food, ministry of development, ministry of finance, etc), supranational government (like EU, EC, WTO, FAO, UN, etc), education and research organizations (like universities, research institutes, etc), agricultural and food industry (dairy industry, mills, pasta industry, olive oil industry, wineries), industry of Agricultural equipment and machinery (plastic films, pipes, nets, all kinds of farm machinery), NGOs (Greenpeace, WWF, Agronomists of the world, etc), traders and retailers, agricultural input suppliers.

5.1.4. Netherlands

The aim of this report is to present the drivers, stakeholders and barriers of the process of improvement of energy efficiency in Dutch agriculture. Based on the DESTEP-method the most important external factors for energy-efficiency in Dutch agriculture are analysed.

The demographic factors are the dual development in Dutch Agriculture. The bigger farms get bigger and the smaller farms become smaller. Also due to the dual development, succession of farms is a problem. Especially small farms do not provide substantial income to successors, therefore many of these farms will disappear in the near future. The working population in the Dutch agricultural sector is declining. The estimates predict a 20% decline in employability. The bigger farms that are still growing are more likely to take (energy-) efficiency measures. The growth is a reason to achieve higher cost efficiency (better cost price). It is expected that high costs for seasonal work and the decrease in supply of professional skilled labour stimulates mechanisation and scale increase. Replacing workers by introducing more mechanisation will probably lead to an increase in energy use.

The economic factors are the increase of energy prices, agricultural commodity prices, land prices and wages. Increase in agricultural commodity prices will mean more revenues for the agricultural businesses. This will possibly improve the investment possibilities for the company. This can lead to investments in energy-efficient storage systems or machinery, but also investment in additional land. The investment in additional land will keep the prices of agricultural land at the current high level or even higher. An energy price increase will translate directly in higher cost prices, especially for energy dependant agricultural sectors e.g. greenhouse horticulture. The higher energy prices are expected to also trigger energy-efficiency in sectors with a low energy consumption e.g. arable farming.

The social factors are the growing gap between citizens and agriculture, the social resistance to industrialized agriculture and the high level of education and research institutes. The social developments in Dutch society on industrialised agriculture could lead to an increase in energy use in animal husbandry. The industrialised agriculture is designed to be as efficient as possible. It is expected that integration of new societal demands in the product or production process will have an influence on energy efficiency. Further the consumption of sustainable food offers an incentive to implement energy-efficient techniques but there is not a strong market demand.

The technological factors are bio-based economy, precision farming, genomics and system innovations. The bio-based economy is not expected to change the cultivated crops very much. The interest in plant parts that are not used are expected to have more impact. Especially the additional harvest steps e.g. for sugar beet leafs could lead to an increase in energy use. A positive side-effect is the additional income potential (money) and the allocation of energy use to the by-product.

The outlook on precision farming show potential of reducing inputs with similar or even higher yields.

Genomics could also lead to higher yields or reduction of inputs. In both cases the energy user per kilogram product is lowered.

The soilless cultivation of outdoor crops is caused by the stringent environmental legislation in The Netherlands. The soilless cultivation of outdoor crops is should result in lowering inputs especially of fertilizer and pesticides. Another system innovation is no-tillage cultivation. The experience of no-tillage trials show potential for saving energy.

The ecological factors are concern of soil fertility, salinization and water management and climate change. A number of bottlenecks of soil fertility became more and more visible to farmers, especially on sandy soils with a high crop rotation. The problems in practice were less plant growth, an increase in fertilizer and pesticides use. The attention to soil fertility is more likely to increase energy use. The additional use or extra use of compost could result in higher energy use. Also the cultivation of crops for green manuring could result in additional energy use.

In the future more extreme weather is expected, more dry periods in spring and summer and more wet years. Also more extreme showers are expected. The extreme weather could lead to increase in energy use. In dry conditions additional energy is needed to irrigate crops and in wet conditions machines and tractors will use more fuel.

The policy factors are the CAP-reforms, the derogation in the Nitrate Directive, national taxes and subsidies. The CAP reforms influence the financial yield per hectare. The financial yield per hectare will be lower, which leads to lower income. The cost price remains the same. To compensate this effect, a lowering of the cost price could further simulate the growth process of bigger farms (see Demographic developments). The CAP reforms could also lead to additional demand on sustainability. This could mean that energy-efficiency will become a condition in de CAP. The end of the derogation exemption to the Nitrate Directive is likely to have a great effect on energy use in agriculture. The organic fertilizer is likely to be processed into products that substitute inorganic fertilizer or become financially more interesting to use for arable farming. The substitution of inorganic fertilizers will lead to a lower energy use. The use of more organic fertilizer in arable farming will increase transport of organic fertilizer between regions in The Netherlands. This will lead to a significant increase in energy use.

Based on the macro factors the most important stakeholders are analysed. Based on the expert judgement of the stakeholders a qualification per stakeholder is made on its importance in energy-efficiency in Dutch agriculture. The stakeholders that should be managed closely have great influence and great interest in energy-efficiency. These stakeholders are crucial for the success of energy-efficiency in the Dutch agriculture. The stakeholders that should be kept satisfied have great influence, but little interest in energy-efficiency. The stakeholders that should be kept informed are interested, but have little influence in energy-efficiency. The stakeholders that should be monitored have little interest and influence on energy-efficiency.

5.1.5. Poland

The percentage share of agriculture, hunting, and fishing in the gross value added (GVA) of Polish economy is 3.5%. At the same time agriculture and forestry use 5.8% of the final energy consumption at the high intensity of CO_2 emission 3.4 ton per toe of energy use. Both figures are about two times higher than the average energy consumption and its CO2 intensity for EU-27. The potential for energy savings in Polish agriculture is associated with activities to decrease a technological gap between Poland and western EU countries, by implementing energy saving measures for direct energy input and the most energy consuming indirect inputs, i.e. fertilizers in crop production and feed in livestock production.

The implementation of energy efficiency in Polish agriculture requires the enabling environment which comprises agricultural and non-agricultural stakeholders and synchronizes national policies related to the sustainable development, associated with energy, social-and-economic as well as environmental issues. There is not a strict policy on energy efficiency in Polish agriculture, although there are political regulations, which are indirectly related to agriculture including the Second Action Plan on Energy Efficiency-Related Actions (2012). In the near future, governmental policy will be a superior driver for improvement of energy efficiency in Polish agriculture (regulations and fiscal policy). the degree and speed of adapting the energy saving principles in the production process is depending on several factors. Human capital resources, employment rate, social activity and living standard in the rural area as well as the social awareness of the need for agricultural production that uses energy resources economically will determine its implementation. In the last twenty years primary and final energy consumption in agriculture has been falling regularly as a consequence of privatisation of state-owned farmsteads and establishment of modern, large-sized farmsteads in the 1990s as well as with modernisation and restructuring of agriculture in since 2004 when Poland joined the EU. Although economic operations in the rural areas are no longer solely associated with agricultural production, this sector remains the channel through which the major stream of public funds is allocated to the rural areas. The necessity to compensate for a continuing decline in economic importance of agriculture remains one of the major challenges in rural areas in the context of energy efficiency implementation.

Economic drivers with higher probability for broader implementation of energy saving in agricultural production processes are: increasing commodity production and specialisation in high quality agricultural products like cereals, fruit, milk, beef, pork, and chicken meat; growing productivity per ha of agricultural area or LU in livestock production; growing tendencies to sustain specific profile of regions – organisation of producer groups as a new form of team work to compete at the agricultural market. Two important technological drivers for energy efficiency in agriculture result directly from the potential of a farmstead to implement the most energy efficient techniques and technologies which are available at the market and R&D policy including efficiency of knowledge transfer from labs to production practice. Presently in Poland there are no exemplifications of research projects or research-and-implementation projects directly related to the energy efficiency in agriculture.

The mentioned above drivers are of overall and general profile and the others are strictly specific to agriculture. When we put a general driver into consideration, it is necessary to have an integrated approach that synchronises a number of policies, for instance energy, agricultural, scientific-and-research, economic policies, etc. Regardless of the nature of the drivers, their implementation may take a long or short period of time. Drivers of energy efficiency are related to demographic and social changes, and energy market with long-term effects.

The national stakeholders which develop, or are interested in implementation, or have a power to implement energy efficiency in agriculture will create enabling environment seen as an arrangement of stakeholders which affects tailoring of energy efficiency policies to what drives farmers to become interested in and consequently implement energy-efficient technologies at their farms, and rural societies to adapt energy saving solutions in their lives. The Polish stakeholders were discussed in the aspect of the power or interest to implement energy efficiency into agricultural practice in the categories: supranational, governmental, finance, advisory services, energy and production means suppliers, nongovernmental institutions and associations of farmers, and R&D institutions. The stakeholders were prioritized depending on their importance in application of energy efficiency and energy saving policy in the agricultural practice. The highest priority in the power and interest were attributed to farmers, farmer association and suppliers of production means and on the other side there were placed stakeholders traditionally engaged in agricultural production like energy suppliers and the stakeholders representing trade and retail sector.

There are a number of identified barriers that may delay implementation of energy efficiency and energy saving policy in a short- or medium-term. The barriers were divided according to their relation to direct agricultural production. General barriers are: adverse exchange rates;

outdated energy sector; no diversification of energy sources; labour market mismatch. Barriers directly associated to agriculture are: energy infrastructure in rural areas, social infrastructure; lack of information on energy efficiency policy; financial barriers; capacity; scarcity of local professional technical services; inefficient and slow political support on energy efficiency in agriculture and dispersing farms.

5.1.6. Portugal

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.

6. Energy Saving Measures in Agriculture

The ES measures reported by project partners can reduce both direct and indirect energy inputs and the overwhelming majority of the ES measures (443 out of 481) were assessed in the range from 3 (moderate) to 5 (high) in terms of their importance for energy saving (Table 5). The implementation of the ES measures in agricultural practice is achievable at present (464 out of 481), including 75 of them which may be implemented without support of R&D sector and 389 ES measures with a potential for further improvement of energy efficiency by progressing research. In the highly industrialized production of swine and broilers, there are many ES measures which may be implemented with technologies which are available on the market such as improved heat insulation, more efficient ventilation, lighting and cooling systems, as well advanced control of the interior climate. The R&D will be especially important for progress in attaining energy efficiency in agriculture when applied to systems involved in the production process, operational activity and capital goods/farm infrastructure engaged in production. The estimated categories of investment costs related to implementation of energy saving measures vary greatly between subsectors. 1/3 of the total number of the measures are estimated to be implemented at a cost under €1000, and 1/3 incur costs in the range from €1000 to €25000. The highest investment costs would be associated with saving energy and improving energy efficiency in the greenhouse and livestock production. Even though these investments can be economically feasible, implementation is difficult when investments cost are high in an industry with rather low margins.

Table 5: The Number of ES Measures in Agricultural Subsectors by Categorized Variables.

Variable/ Categories	Wheat	Sugar beet	Potato	Sunflower	Cotton	Tomato	Cucumber	Sweet pepper	Vineyards	Olive groves	Dairy cows	Pigs	Broilers	**In total**
Type of energy input														
Direct[1]	39	13	15	9	6	24+1	22+1	7+1	10	8	23+4	24	30	**230+7**
Indirect	54	22	23	3	13	26	16	3	27	18	14	11	14	**244**
Type of ES measure														
1. Operational	61	29	31	12	6	23	8	3	24	15	19	16	20	**267**
2. Systems	12	3	3		2							1		**21**
3. Monitoring	1	1	1			1	1	1				1	1	**8**
4. Management	2	1	1								3	1	1	**9**

5. Market												1	**1**
6. Capital goods		1	1		1	14	13	7			4	15	20	**76**
Mixed	17	0	1	0	10	13	17	0	13	11	15	1	1	**99**
Importance														
1	2	1							3			1	2	**9**
2	5	1	4	1		6	5			1	3	1	2	**29**
3	30	6	8	4	6	17	12	2	13	10	14	14	19	**155**
4	29	13	13	3	5	17	11	3	13	8	14	14	11	**154**
5	27	14	13	4	8	11	11	6	8	7	10	5	10	**134**
R&D														
Yes	76	28	31	12	16	48	36	10	33	24	35	19	21	**389**
No	17	7	7		3	3	3	1	4	2	6	16	23	**92**
Achievable or Theoretical														
A	89	34	37	12	18	49	38	11	36	25	39	34	42	**464**
P	4	1	1		1	2	1		1	1	2	1	2	**17**
Investment cost														
< 1000	25	14	15	2	11	25	14	1	18	15	7	2	7	**156**
1000-25000	33	16	16	3	4	16	15	5	13	7	12	16	16	**172**
25000-100000	20	2		2	3	8	8	5	4	4	13	11	13	**93**
> 100000	9	3	5		1	2	2				5	5	5	**37**
Not applicable	6		2	5					2		4	1	3	**23**
Payback time (in years)														
< 1 years	11	7	7	2	4	21	10	3	10	7	14	6	14	**116**
1-5 years	55	25	28	8	11	18	17	5	22	16	11	15	15	**246**
> 5 years	17	3	2	1	4	10	10	3	3	3	12	13	12	**93**
Not estimated	10		1	1		2	2		2		4	1	3	**26**

[1] Additional figures mean that the ES measures has the potential for energy saving in both direct and indirect energy input.

In **crop production**, energy saving will be considerably affected by the ES measures associated with reduction of diesel use by more energy efficient tractors and machineries, reduction of energy use for drying and in storage rooms. On the other hand, reduction of indirect energy input is associated with implementation of ES measures reducing these inputs, for instance high-yield and disease-resistant cultivars, application of alternative sources of nutrients and plant protection (organic and green fertilizers, bioactive microorganisms), advanced monitoring of the production process and use of production means in accordance with the soil fertility and plant uptake. The importance of energy saving activities may be country-specific, e.g. in the southern EU countries more importance will be attributed to the ES measures associated with irrigation of cultivated crops while in the central and north-eastern countries more ES measures are associated with energy effective drying techniques. In the **perennial crop production**, the majority of ES measures is connected with fertilization, plant protection and field operations. In the **greenhouse production**, potential reduction of direct energy inputs is associated with the control of greenhouse atmosphere by energy efficient systems of heating, cooling and ventilation as well optimization of production process or new energy efficient greenhouse designs. There are also important measures connected with new solutions in energy recovery and the use of other, alternative sources of energy. The bio-based economy could lead to higher energy efficiency if agro-waste streams are used for high-end purposes.

The structure of ES measures in the **livestock production** is country dependent. In Portugal, Poland and Finland many ES measures are associated with animal feeding and welfare while in the Netherlands and Germany most of the reported ES measures are related to electricity use as well buildings and associated infrastructure of livestock production. Energy use in the livestock production may be reduced by increased efficiency of production inputs which condition energy consumption, e.g. water use and cleaning, heat insulation, ventilation, reduction of amount of ammonia in buildings, heat recovery, energy use optimization for a given production system.

7. Contribution to WP3 and WP4

On the basis of national reports the Work Package 2 summarizes: (i) the state-of-the-art on energy use and energy efficiency of agriculture (Deliverable 2.1), (ii) the analysis of stakeholders and drivers of energy efficiency in agriculture (Deliverable 2.2), and (iii) the energy saving measures and their potential for energy savings in agriculture (Deliverable 2.3). All the three parts of WP2 deliverables have been compiled in this Synthesis Report – Deliverable 2.4.

The actual energy use was calculated for the main agricultural sectors which account for the largest part of the energy use in agriculture (2.1). The results from this analysis will be developed in detailed showcase analyses of WP3.

Drivers and stakeholders with relevance to energy use (direct and indirect) were mapped and stakeholders as well as their agenda relevant to energy savings in agriculture were described (2.2). Besides, the analysis of ongoing national R&D projects and programs which have relevance to energy efficiency will be datum for WP4.

The inventory of actual and potential energy saving measures in agricultural practice or/and research (2.3) will contribute to WP3 and WP4.