AGRI-2010-EVAL-03

IMPACTS OF RENEWABLE ENERGY ON EUROPEAN FARMERS

CREATING BENEFITS FOR FARMERS AND SOCIETY

1st Interim Deliverable

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CONTENTS

1 INTRODUCTION

This document is the first interim deliverable due in the project Impacts of Renewable Energy on European Farmers. It is meant as a basis for the later deliverables, and will thus be updated three times during the project, until it reaches the status of Final Report.

In this version the Tasks 1.1. to 1.5 and 2.1 are reported, each in a separate chapter.

Potential of on-farm RE production
On-farm RE production has the potential to play a crucial role in the transition of European agriculture, as:

- it provides a new, additional, source of farm income, in a market that is not easily satisfied;
- it supports the rural economy by creating new jobs and added value;
- it reduces CO_2 and other GHG emissions in different economic sectors (agriculture, energy, transportation), thereby delivering a public good;
- it reduces dependence on oil-exporting countries;
- it supports the development of innovative new industries in member states, with the potential of making Europe a front-runner in farm-based energy production.

If well organized, RE production on farms may thus mean a substantial **benefit to farmers and society** on a European level at an unprecedented scale.

Project objective and problem formulation
The overall objective of the current project is to provide a quantitative assessment of the actual contribution of RE produced on-farm to the overall EU targets on renewable energy and on GHG emissions reduction, as well as on the role of on-farm RE production on the farm economy, income and allocation of production factors and general farm production. The project is also to determine existing barriers to successful on-farm RE development and to define policies that can overcome these. This objective is formulated by DG Agri in the respective tender document.

The associated problem formulation of the project is twofold:

a) How can on-farm RE production contribute to the EU targets for renewable energy and rural development ?
b) How can on-farm RE production contribute to the farm economy?

2 TASK 1.1: OUTLINE OF THE PROJECT'S OVERALL APPROACH

2.1 Key questions, specific approaches and expected results

To answer the issues posed by the European Commission, six key questions have been identified. Below we indicate which approach is used to answer these questions and which results may be expected. In the subsequent chapters these approaches are further detailed.

1) How much Renewable Energy (RE) does agriculture produce in the EU at present, and how much can be expected in the medium term (by 2020), in total and by type of RE? What consequences has this for Greenhouse Gas (GHG) emissions?

Approach and results: This question is answered by an EU-27 wide inventory making use of a range of data sources including policy documents, statistics at EU and national and regional levels, but also key informants working in policy, farmers organisations, energy companies, etc. (**Tasks 2.1, 2.2**). Actual RE production will be presented at national level for all EU-27 countries and a distinction will be made in the following types of RE:

- Biomass based RE: Biogas, bioethanol, biodiesel, (forest-based) heat and power
- PV and thermal solar energy
- Wind

Also an inventory will be made of basic data needed for the calculation of avoided GHG emissions (**Task 2.3**).

A RE-balance will be constructed for the member states and the EU as whole (**Task 3.1**).

An estimate will be made of the GHG emissions that can be avoided by 2020 through RE produced by the agricultural Sector, using the model MITERRA (**Task 3.2**). This is all described in Chapter 4.

2) Why do farmers engage in the production of RE, and if they do not, what are the main obstacles?

Approach and results: Through 8 case studies in 4 countries with 'stronger' and 'weaker' development of RE production, the differences between regions and the obstacles for RE development (e.g. investment costs, policy support, local capacity) will be assessed (**Task 1.4**). A farm survey will be held with a large sample of farms, and this farm survey will be analysed statistically to identify the main obstacles (**Tasks 2.4, 2.5**). This is described in Chapters 5 and 6.

3) What are the organisational, economic and technical impacts of the introduction of RE production on the conventional farming activities, at whole farm level and on the surrounding rural economy?

Approach and results: A farm level model, that simulates the farm at a low level of detail, is used to investigate the organisational, economic and technical impacts of introduction of RE on farms (**Task 3.3a**). Types of RE production activities are specified, and offered to the model as innovations. Through the model simulations, these innovations will either be taken up or not by the farm, and main changes in labour use, farm income, investments and production activities are identified. Impacts assessed includes additional income and farm employment generated as well as impact on GHG emissions and general farm (non-RE) productivity. The effect on rural economy is captured by estimating labour required by the non-farming community to establish the RE activities on the farms. This non-farm labour is matched to the local capacity available as identified in the case studies.

4) What role does RE play in the economy of different types of farms? Under which conditions does RE production bring the highest contribution to farm and rural economies?

Approach and results: With the farm level model different types of farms will be studied (**Task 3.3b**). Not only potential, but also optimal RE activities on farms are selected, that fit best with the farm planning and maximise the returns to the farmer. These results in terms of 'best-RE-activities' are confronted with the conditions in the case study regions and can be assessed on the feasibility. Through a focus on investment, the continuity of RE production on farms is assessed, and conditions required to provide this continuity can be identified.

5) What are the main barriers to further development and the problems posed by the current regulatory framework? How could this framework be improved to favour the expansion of farmers' involvement in RE production?
Approach and results: Through an inventory of the current regulatory framework, markets and RE production, strengths and weaknesses are identified EU-wide (**Task 3.4**). By detailed assessments in the case studies, the impact and implications of the regulatory framework can be understood on farmers, and barriers are identified. Regulatory frameworks that favour RE production and take account of barriers can be formulated, either based on success stories of the EU wide inventory or through the insights obtained in the case studies. Main barriers (i.e. economic, institutional, social) are identified in all research activities, either the EU wide inventory, the case studies, the farm level modelling and the statistical analysis.

6) What role does Rural Development (RD) policy play and how can this role be strengthened?
Approach and results: The role of RD policy will be investigated in the case studies and through the EU wide inventory (**Tasks 3.3, 3.4**). The contribution of RD policy to local capacity building and lowering RE investment costs is analysed, just as limitations RD policy poses to the development of farms.

2.2 Theoretical framework for the study

A first important frame for the future development of RE in Europe results from the Directive on renewable energy (2009/28/EC, 2009). In this Directive, ambitious targets for all Member States are set, such that the EU will reach a 20% share of energy from renewable sources by 2020 and a 10% share of renewable energy in the transport sector. Moreover, it creates cooperation mechanisms to help achieve the targets cost effectively and establishes sustainability criteria for biofuels.

Another important policy framework for the current and future development of on farm production of RE is the Common Agricultural Policy (CAP) which supports renewable energy projects in rural areas through its Rural Development (RD) policy. The project will therefore analyse what role RD policy plays and how can this role be strengthened.

Within the 2008 CAP "Health Check" (European Commission, 2008), additional funding was allocated to the EU priorities renewable energy, climate change, water management and biodiversity. However, as Member States and/or regions draw up their rural development programs, how and to what extent RE is promoted varies from region to region. Furthermore, RD measures may interact differently with other support measures, such as national support schemes to RE, state aids, and regional development policy.

For the existing production of renewable energy in the EU-27, use will be made of the National Renewable Action Plans (NREAP's) that have been published for the member states and which are available in a database that has been set up by ECN (http://www.ecn.nl/units/ps/themes/renewable-energy/projects/nreap/ , Beurskens & Hekkenberg, 2011).

3 TASK 1.2: IDENTIFICATION OF SOURCES OF INFORMATION

A systematic search effort has been ongoing to identify actual and potential sources of information to compile the renewable energy balance in agriculture (see description of task 1.3). Data is being collected for all EU Member States.

Data sources at different levels are being consulted:

- EU-level:
  - Eurostat
  - Eurobserv'Er
  - EEA
  - European industrial associations (EWEA - wind, EPIA – solar PV, AUBIA – biomass, EBA - biogass)
  - AEBIOM
  - IEA
  - European farmers' association: Copa-Cogeca
  - Other projects: EuroActiv, ResLegal (for policy overviews)
- National level:
  - NREAPs
  - National statistics offices,
  - National technology/industrial associations
  - Licensing bodies
  - National farmers' unions

For most countries, the data search efforts so far were concentrated on national statistics. The output of this task is a continuously updated list of data sources. The overview of information sources (for both data which is readily usable for the RE balance as well as data which might be useful for making own estimates) identified so far is presented in **Annex 1**.

The main conclusion of the search for information sources so far is that in official European and national statistics there is very limited data readily available on renewable energy capacity and production imported and produced by the agricultural sector. Eurostat provides data on production and consumption of renewable heat from solar, biogas and geothermal resources in agriculture, as well as on biofuel use of the sector, but not much else.

National statistics offices or other organisations in some countries (e.g. Netherlands, Germany, Spain) provide some more information on renewable electricity production in the agriculture sector, but those are the exception rather than the rule. Virtually no organisation is making any distinctions on the amount of renewable energy that is consumed on-farm or is exported to the different grids (power, gas).

Data on the role that individual energy sources play is available for Austria, Germany and Spain,. Statistics, facts, and figures are available for biomass, biogas, solar, photovoltaic, hydro, and wind energy. However, there is no readily accessible information on the production and use of renewable energy on farms. There are also few sources that break down data on renewable energy by state, sector or region. Most of the projects of universities and research institutes are still focused on potentials for biomass plants or wind power.
For most Eastern European states, information on renewable energy production and consumption is more easily available from sources covering the whole of the EU, than in their individual online resources. Specific data broken down by renewable source is not available, or not readily accessible. But it is expected that further search efforts will sort more results. Data available is limited to the national level and not broken down by region or state, nor by economic sector (e.g. agriculture).

With the main data sources more or less identified, the consortium will now start collecting primary data (insofar as the scope of the project allows it), starting with industrial associations and national farmers unions and look into the most suitable model simulation options.

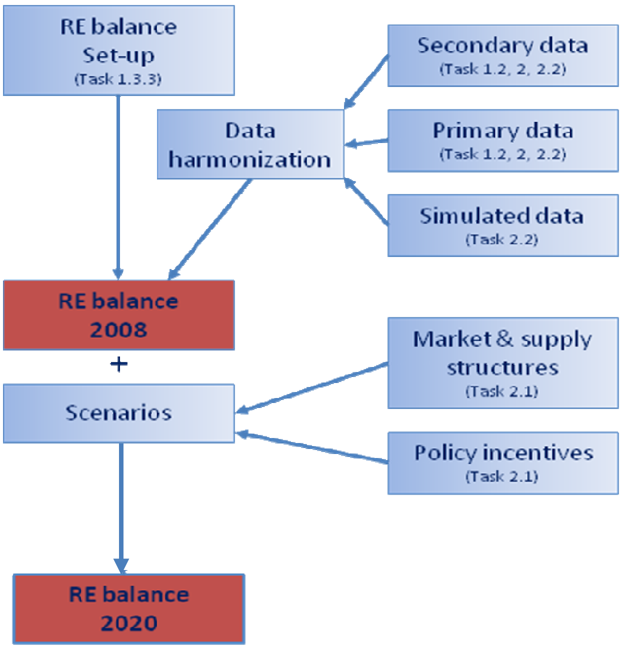
4 TASK 1.3: CREATE METHODOLOGY AND TOOLS – THEMES 1 & 2

4.1 Task 1.3.1: Outline of the analysis of the EU-27 market and supply structures of the relevant types of RE and the contribution of agriculture.

To understand the possible contribution of agriculture to the supply and use of renewable energy, a number of underlying questions need to be answered, including:

a) How much Renewable energy is produced in the EU-27 countries at present?
The answer to this question provides the starting point or baseline for the further questions:
b) Which fraction of the amount under a) is produced on farms?
c) How is the market & supply of the relevant types of RE structured?
d) How much Renewable energy will be produced in the EU-27 countries in 2020 ?
e) Which RE scenario's may be used in the estimation of future RE production under d) ?
f) Which fraction of the amount under d) will be produced on farms in 2020?
g) What are the sources of quantitative and qualitative information?
h) Which knowledge gaps/white spots exist in these sources?
i) Which estimates can we use to bridge these gaps?

To answer the above questions, a combination of quantitative and qualitative methods and tools will be employed in this study, which are described in more detail in the following sections. The main quantitative tool that will be developed for this study is the Renewable Energy Balance for the agriculture sector, which will summarize the flows of primary, intermediate and final energy to and from the agriculture sector in each MS, subject to availability of data. The RE balance will also make explicit exchanges with other sectors, such as import on farm of different feedstocks which can be converted to final energy on farm and export to the power and gas sectors.



The above diagram provides an overview of the steps in the analysis (blue) and outcomes (red) of theme 1. The RE balance will be presented for the current and future (in 2020) flows of RE in agriculture. For future flows, two scenarios will be employed of 2020 developments (4.3.2). The input for the scenarios will come from two qualitative assessments, including:

- a basic analysis of the renewables' market and supply structures in which farmers operate;
- an overview of policy instruments which are currently employed across EU Member States to stimulate production and use of renewable, especially in agriculture.

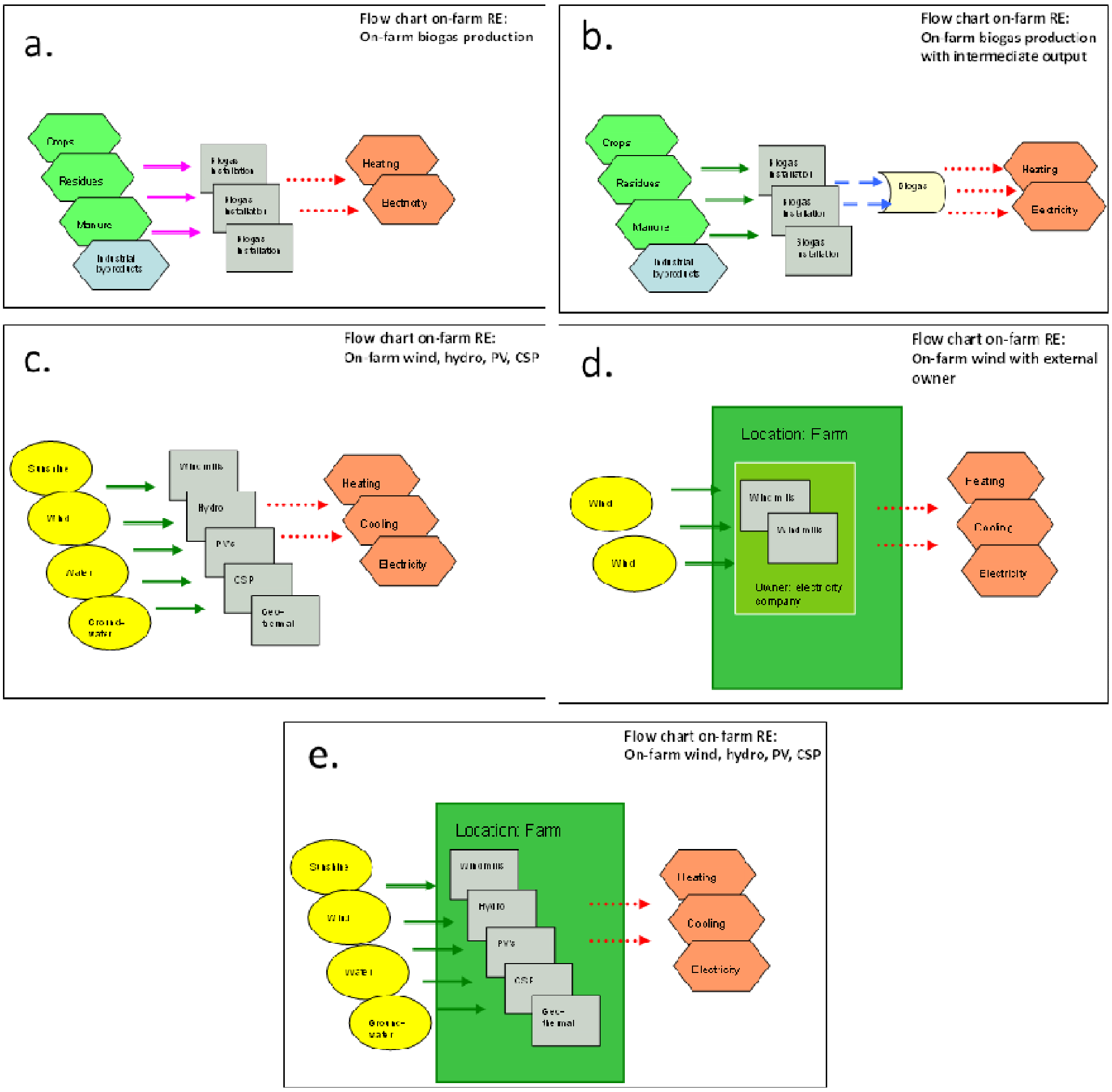
In addition, some specific farm-level information will be used to define the scenarios, which is already available within the consortium.

4.2 Task 1.3.2: Operational definition of on-farm production of renewable energy (RE)

Renewable Energy (RE) is defined as energy derived from natural resources which are renewable (being naturally replenished, e.g. sunlight, wind, rain, tides, geothermal heat, biomass). On-farm Renewable Energy is produced on farms (farms are economic enterprises basically relying on biological processes to generate agricultural products – food, feed, fibres, other natural materials, fuels – from natural resources such as land and/or non-saline water). It covers energy generated by installations paid and/or operated by farms as well as by installations paid and/or operated by other legal entities (whether owned and/or managed by the farmer or not), and includes:

- *primary, intermediate and final RE that is both produced and consumed on the same farm,*
- *final or intermediate RE that is consumed on one farm but produced on other farms,*
- *final energy that is produced on the farm and that is exported,*
- *final or intermediate RE produced on farms from biomass or waste from non-farming activities,*
- *intermediate and final RE produced not on farms but using biomass or waste produced on farms.*

Specific elements of the definition are depicted in the following diagrams. Biogas converted to final energy (diagram a) as compared with biogas produced on one farm but converted to final energy on another farm (b), farmer´s ownership of RE installations (c) versus external ownership of a wind mill (d), and direct export of final energy products from the farm (e).



4.3 Task 1.3.3: Methodology for the calculation of the RE Balance (Theme 1)

4.3.1 Renewable energy balance set-up

The main rationale of the study related to the balance in Renewable Energy (RE) is the underlying goal to quantify the potential of the on-farm Renewable Energy Production. This may contribute to rural development, thus providing a positive impact on the farm income, as well as to the RE share in the overall EU energy consumption.

The RE balance will provide a quantitative estimate of the contribution of the agricultural sector to production and consumption of RE in Europe. The exchanges with other sectors will be made explicit through import of energy sources onto the farm (e.g. woody biomass from the forestry sector) and export from the farm, for example renewable electricity & biomass for power production to the power sector, feedstock for biofuels to the transport sector, heat to the residential sector etc.

This section describes the methodology for the research question *How much RE does agriculture produce in the EU at present, and how much can be expected in the medium term (by 2020), in total and by type of RE?*

Following instruction of the tender, the methodology of the RE balance should be based as much as possible on Eurostat structure and statistics. However, if this recommendation is followed, the "balance" is not a perfect balance as the energy content of all inputs is not equal to the aggregated energy content of the in-sector energy consumption plus energy exports to other sectors. The reason for this is that a.o. Eurostat does not differentiate between feedstock types. Losses are also not explicitly accounted for. Disaggregation of biofuel production into types of feedstock used in the production process often is not provided. Such information is however needed when GHG balances are calculated (Theme 2) or when impacts of biofuel production for non-RE production processes are to be assessed (Theme 3).

In order to address this issue, it is proposed to iteratively improve the data availability and current Eurostat RE balance structure. The aim of this process will be to minimise discrepancies between alternative data sources, which obviously have been collected or assessed at different scale levels. A justification of the process will be provided where appropriate.

An overview of data sources and categories is provided in Figure 1. The balance could be adjusted somewhat depending on data availability, but these would be the main categories.

All the input data in the energy balance scheme in Figure 1 are given in PJ for the respective renewable energy carrier. The energy balance scheme is divided into 3 sections: Final energy, Intermediate fuels and Primary fuels. Intermediate fuels are fuels that are produced on the farm and that are exported. An example is biogas, that may be exported to a local gas network.

Energy balance [PJ]	Import on farm	Production on farm	Export from farm	Consumption on farm Total	Consumption on farm by households	
Final energy						
Electricity		0		0		Input
from solar PV	-					Unrealistic input
from wind	-					**Calculation**
from energy crops	-					No disaggragation possible
from biogas	-					NA = Not Applicable
from ….	-					
Heating		0		0		
from solar	-					
from energy crops	-					
from biogas	-					
from green gas	-					
from geothermal	-					
from ….	-					
Cooling		0		0		
from geothermal	-					
from ….	-					
Biofuels for transport		0		0		
from ….	-		-	-	-	
Biofuels for machinery		0		0		
from ….	-		-			
Intermediate fuels						
Biogas				NA	NA	
from manure	NA		-	NA	NA	
from other waste	NA		-	NA	NA	
from ….	NA		-	NA	NA	
Primary fuels						
Energy crops				NA	NA	
Woody biomass				NA	NA	
Agro waste				NA	NA	
Manure				NA	NA	
Other waste				NA	NA	
….				NA	NA	

Figure 1. Outline for RE balance

In the ***Final energy section***, the energy consumption of the final energy carriers (electricity, heating, cooling and biofuels respectively) is calculated. Green gas is defined as upgraded biogas fit to be delivered to the public natural gas grid (methane concentration being increased to the level normally used in the national grid).

The following assumptions and accounting rules apply:

- Renewable electricity and heat, which is imported on the farm from national grids cannot be disaggregated by source and will be calculated as follows: electricity use by agriculture sector * fraction of electricity produced by renewable sources on a national level.
- All electricity consumed by the agriculture sector which is found in official Eurostat data is imported on the farm.
- Total consumption on farm = (import on farm + production on farm) – (export from farm). Net balance on one row thus should be equal to zero. Consumption on farm by households normally is a fraction of the total consumption on farm.
- All electricity generated from wind is exported from the farm to the power grid, unless specified otherwise.
- All electricity generated from PV is consumed on the farm, unless specified otherwise.
- All heat generated from sun is also consumed on the farm.
- Cooling cannot be imported or exported from the farm; any cooling produced on farm is also consumed there.
- Biofuels normally neither are produced on nor exported from the farm and all biofuels imported on the farm are also consumed there. Exceptions to this rule (cases where specific information on

the on-farm biofuel production and consumption is available, e.g. use of Pure Plant Oil from home-grown feedstock) this will be accounted for.

The ***section of Intermediate fuels*** considers several sources of biogas. Main considerations for this sections are:

- Energy value of biogas is gross energy, as conversion losses will occur when it is converted into final energy.
- Biogas that is produced but not exported from the farm is converted on site into electricity and heat.
- To avoid double counting, we do not account for on-farm consumption of biogas as intermediate fuel, as the different applications of biogas (for power or heat production) is already included under final energy consumption[1].
- We also do not account for the different biogas and biofuel feedstocks as those will be covered separately in the primary fuels sections. In cases where specific information on the on-farm consumption as biofuels of Pure Plant Oil from home-grown feedstock is available, this will be accounted for.

In this section, we may add energy crops such as maize silage as an additional source for biogas; this depends on the extent related data is available in the secondary sources of data (as e.g. is the case for Germany).

The ***section of Primary fuels*** covers on-farm production and import- and export. Farms may receive primary energy carriers from other sectors (Column 'Import on-farm') or, alternatively, produce them on their own land (Column 'Production on-farm' = to be considered as consumption) or deliver them to other sectors (Column 'Export from farm'). We assume that these primary fuels are not consumed within the farm as such but converted into intermediate or final energy elsewhere. The current list of energy carriers is extensive, although not exhaustive. In case other energy carriers have to be added, the RE balance set-up makes this possible.

Several issues complicate the construction of the RE balance, the main being data availability. Availability of consistent data for all MSs is very limited (see explanation under Task 1.2, Chapter 3). Collecting more (primary or secondary) data would require considerable efforts, but also introduce issues of data harmonization.

4.3.2 Modelling not needed since full NREAPs' availability January 2011

In the project proposal the use of the RESolve model was foreseen to provide for data that would not be available from NREAPs:

- To fill data gaps for the RE balance of 2008 (for most Member States the most recent available data);
- To derive a more detailed overview of RE technologies and their potential role in achieving targets as defined in the NREAPs. This provides insight into which technologies could also be taken up by farmers.

As the RESolve is indeed a highly aggregated model which does not explicitly define origination sectors of renewable energy, it was intended to define allocation rules for each technology in the 2020 portfolio, to determine how much of it could be contributed by the agricultural sector.
This changed end of January 2011, when all MSs had submitted their NREAPs, from which the trajectories and 2020 targets could be extracted. In addition, sufficient MSs presented enough technological detail in their NREAPs to make the use of the RESolve model redundant. The decision of not using the RESolve model but completely rely on the NREAPs also modified to a certain extent the scenarios.

[1] On the other hand, Eurostat publishes data on the use of biogas in agriculture without specifying its final use. In case of data restrictions for final energy we might return to the consumption of biogas as an intermediate fuel.

The "pure NREAP" scenario in which growth factors for production of different renewable sources on farms with no additional incentives specific to the agriculture sector will be calculated. The growth factors are purely based on the NREAP projections of renewable energy development trajectories. These growth factors are applied to each data category in the RE balance to derive estimates for 2020. For categories of final energy for which no data was obtainable but are projected to be part of the country's 2020 renewable energy mix, the aforementioned allocation rules were applied to the NREAP projections (instead of RESolve projections).

The allocation rules followed are presented in the below table (they are not explicitly mentioned in the second deliverable):

RE type	Allocation rule NREAP scenario
Solar electricity	proportion of agricultural holdings in total dwellings (residential + non-residential); as proxy for rooftop area of agricultural buildings in total building stock
Wind electricity	proportion of agricultural land in total land area (underlying assumption: no offshore)
Electricity from solid biomass	unlikely development on farms
Electricity from biogas	extrapolation of current relative importance of "other biogas" (which includes agricultural biogas) in biogas-based electricity production (based on Eurobserv'Er Biogas Barometer)
Solar heat	proportion of agricultural holdings in total dwellings (residential+non-residential); as proxy for rooftop area of agricultural buildings in total building stock
Heat from solid biomass	full extrapolation of current situation (underlying assumption: continuation of use of traditional use of solid biomass for space heating in farm households)
Biogas heat	proportion of "other biogas" in total biogas production (proportion of "other biogas" heat output not available)
Heat from cooling milk	extrapolation of current situation

The NREAP+Agri scenario was not prepared using a higher degree of refinement but just by taking into consideration the fact that the contribution from farming to reaching renewable energy targets from NREAPs could be larger than in the other scenario because of additional stimulation measures for on-farm RE-development. No additional market or supply chains have been taken included beyond those implicit in the NREAP projections. In this sense, both scenarios are consistent, the only difference being the assumption that in regions where favorable circumstances allow the development of certain on-farm RE activities, the right incentive schemes would indeed lead to their optimal deployment, resulting in an above average growth. Above average implies above the average growth rate needed to reach the NREAP targets by 2020 (as compared to 2008 baseline). The latter however only applies to those RE-activities that are particularly suitable to develop on farms given specific regional circumstances and farm structural characteristics in different EU regions.

Section 2.2.3 in the second interim deliverable provides a detailed overview of the new scenario approach. As a matter of fact, a clear link here exists with Theme 4 since the model run will reveal how additional policies to stimulate agricultural RE production and consumption affect renewable energy mixes.

4.3.3 Boundary conditions

The study on the RE balance will have a number of limitations. These limitations are derived from the scope of the study as well as from the practical limitation of available data.

The following boundary conditions apply:

- Geographical scope : EU-27 and the individual Member States.
- Type of RE technologies : Biomass based RE: Biogas, bioethanol, biodiesel, (forest-based) heat and power, PV, Wind.
- Only the saved and avoided GHG emissions of RE from the production on farms will be assessed.
- Time coverage: The saved and avoided GHG emissions of RE on farms will be evaluated for 2008 and 2020 respectively.

4.4 Task 1.3.4: Methodology for the calculation of GHG emissions saved or avoided (Theme 2)

4.4.1 Introduction

This section outlines the methodology and research methods applied in Theme 2 assessing the impacts of Renewable Energy (RE) for European farmers. Theme 2 assesses the overall reduction in greenhouse gas (GHG) emissions generated by on-farm RE production by quantifying potential savings or avoided emissions. Calculated amounts of saved and avoided GHG emissions will be reported by RE type and per member state.

4.4.2 Methodology

Calculation of saved or avoided GHG emissions is based on two methodologies each applying to specific types of RE. Calculation of GHG savings for wind and solar energy utilises the RE monitoring protocol (te Buck et al., 2010). GHG emission savings for energy crops and biogas will be assessed using the MITERRA-Europe model (Velthof *et al.*, 2009). This model will be expanded with the (co)-digestion sustainability tool (Zwart *et al.*, 2007) to assess the saved and avoided GHG emissions from digestion.
System boundaries for calculation of the saved and avoided GHG emissions will be in line with the EU Renewable Energy Directive (RED). Several emissions factors, conversion factors and other parameters will be country specific. If it is not possible to use country specific values we will use standard values based on JRC calculations as these have been defined by the BIOGRACE project[2], aiming at the harmonisation of biofuel GHG calculations throughout the European Union.

4.4.3 RE monitoring protocol

To calculate emission reductions from various RE technologies we will use the 'Renewable energy monitoring protocol' (Te Buck *et al.*, 2010). This protocol is used in the Netherlands to calculate and record the amounts of energy produced from renewable sources. The protocol describes the methodology to calculate the contribution of RE and the avoided GHG emissions for many sources of renewable energy. ECN has extensive experience in applying this protocol for projects in the Netherlands.
The following sources of renewable energy are included: hydropower, wind energy, thermal use of solar energy, photovoltaic use of solar energy (two types), geothermal and ground source energy (with and without heat pump). For bio-energy combustion, combustion municipal waste incineration plants, small scale burning, co-combustion, combustion transport fuels and digestion are distinguished. For each of these RE sources a factsheet is included in the protocol, which describes how the RE balanced is computed, see the example calculation for wind energy in Figure 2.
An important difference between the Dutch RE Monitor and the reports of the IEA and Eurostat is that the latter do not use the substitution method, because of the large differences in the 'fuel mix' in countries. For this reason Eurostat and the EU Renewable Energy Directive use the direct output of energy in its first useful form (the so-called production method). In the latest version of the protocol (Te Buck *et al.*, 2010) both approaches are described and the calculation rules that are in line with the EU Renewable Energy Directive will be used.
To make the Dutch RE protocol applicable for other countries it is needed to use country specific CO_2 emission factors, since these depend on the mix of fuel sources (e.g. coal, oil, gas, nuclear or RE). In the IAE report about CO_2 emissions from fuel combustion the CO_2 emission per total primary energy supply

2 http://www.biograce.net/

and per kWh for electricity and heat generation are provided for many countries (IAE, 2010). Data are also available for 2008. For 2020 projections have to be made, for which we can use data from Amann *et al.* (2008), which provides data at MS level about primary energy consumption per MS for the different fuel types. These data are used in the GAINS model and are available for 2005 and 2020. More detailed information and energy sources per MS are also provided by the PRIMES model (Capros *et al.*, 2009).

WIND ENERGY	ABBREVIATION	UNITS AND FORMULAS
design capacity	C	KW
number of full-load hours	V	on land: 2.000 h/yr at sea: 3.000 h/yr
electricity production	E_e or E_e=C*V	measurement (monitoring): in kWh/yr calculation (future project): design capacity (kW) * no. of full-load hours (h/yr)
amount of renewable energy expressed in avoided primary energy avoided primary energy in 2005	E_{prim} = E_e*3.6 / $\eta_{e,A}$	electricity production (kWh) * conversion factor (MJ/kWh) / efficiency of electricity power stations (mix - at production) E_{prim} (MJ_{prim}/yr) = E (kWh/yr) * 3.6 (MJ/kWh) /0.431
avoided CO_2 emissions avoided CO_2 emissions in 2005	ε_{netto} = E_{prim} * $e_{elekCO2}$	E_{prim} (MJ_{prim}/yr) * CO_2 emissions factor for electricity power stations (kg CO_2/MJ_{prim}) K (g CO_2/yr) = $E_{primair}$ (MJ_{prim}/yr) * 70.9 (g CO_2/MJ_{prim})
example - future project		
design capacity on land	C	1 MW
electricity production according to monitoring	E_e	1,700 MWh/yr
amount of renewable energy expressed in avoided primary energy	E_{prim} = E_e*3.6 / $\eta_{e,A}$	1,700 MWh/yr* 3.6 MJ/kWh / 0.431 = 14,200 TJ/yr
avoided CO_2 emissions	ε_{netto} = E_{prim} * $e_{elekCO2}$	14.2 TJ/yr* 70.9 kg CO_2/GJ = 1,007 ton CO_2/yr

Figure 2. Example of the calculation rules for the avoided GHG emissions from wind energy

In case no country specific CO_2 emission factor is available we will use the values as stated in the Annex V of the Renewable Energy Directive, which is 83.8 g CO_2-eq/MJ for the fossil fuel comparator of biofuels, 91 g CO_2-eq/MJ for the fossil fuel comparator of bio-liquids for electricity production, 77 g CO_2-eq/MJ for the fossil fuel comparator of bio-liquids for heat production and 85 g CO_2-eq/MJ for the fossil fuel comparator of bio-liquids used for cogeneration.

4.4.4 MITERRA-Europe

Alterra developed the environmental impact assessment model MITERRA-Europe (Velthof *et al.*, 2009; Lesschen *et al.*, in press), which can assess the impact of measures, policies and land use changes on environmental indicators on a NUTS-2 and MS level in the EU-27. MITERRA-Europe is partly based on the existing models CAPRI and GAINS, and was supplemented with an N leaching module, a soil carbon module and a measures module. The model has been applied in several European project, e.g. in the CCAT project (http://www.ccat.nl/UK/) MITERRA-Europe and CAPRI model were coupled in order to assess the environmental impact of the likely changes in animal numbers and shares due to Cross Compliance. MITERRA-Europe was also used for the assessment of the environmental impact of the Renewable Energy Directive (RED), which will be published in EEA's State of the Environmental Report 2010.

MITERRA-Europe calculates all relevant GHG emissions from agriculture (CH_4 from enteric fermentation and manure management, N_2O from manure management and direct and indirect soil emissions, and CO_2 from changes in soil carbon stocks and cultivation on organic soils) according to the IPCC 2006 guidelines. Additionally, GHG emissions from fertilizer production and fuel and electricity consumption are estimated. The model comprises the same 35 crops as in CAPRI. In addition six second generation energy crops (miscanthus, switchgrass, canary reed, poplar, willow and eucalyptus) are included.

According to the sustainability criteria of the RED the greenhouse gas emissions from the production and use of transport fuels, biofuels and bioliquids shall be calculated as:

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr} - e_{ee}$$

where

E	= total emissions from the use of the fuel;
e_{ec}	= emissions from the extraction or cultivation of raw materials;
e_l	= annualised emissions from carbon stock changes caused by land-use change;
e_p	= emissions from processing;
e_{td}	= emissions from transport and distribution;
e_u	= emissions from the fuel in use;
e_{sca}	= emission saving from soil carbon accumulation via improved agricultural management;
e_{ccs}	= emission saving from carbon capture and geological storage;
e_{ccr}	= emission saving from carbon capture and replacement; and
e_{ee}	= emission saving from excess electricity from cogeneration.

Greenhouse gas emissions from fuels, E, shall be expressed in terms of g CO_2eq/MJ. The emissions from the extraction or cultivation of raw materials, e_{ec}, shall include emissions from the extraction or cultivation process itself; from the collection of raw materials; from waste and leakages; and from the production of chemicals or products used in extraction or cultivation. The emissions from the manufacture of machinery and equipment shall not be taken into account.

Box 1. Calculation rules for GHG impact of biofuels according to the sustainability criteria of the RED (see Annex V of Directive 2009/28/EC)

In Box 1 a summary of the calculation rules for the GHG impact of the production of biofuels and bioliquids according to the RED is given. In most cases the emissions from cultivation, e_{ec}, are the most important ones, which will therefore be assessed in most detail with MITERRA-Europe. The emissions from carbon stock changes due to direct land use change (e_l) and saved emissions from soil carbon accumulation via improved agricultural management (e_{sca}) can also be assessed by MITERRA-Europe. However, data availability at a regional or national scale on direct land use changes and changes in soil management is likely to be very limited, and will probably restrain to include these emissions in the assessment. For the other emissions, as far as they are relevant, the default values from the RED will be used. Emissions from indirect land use change (ILUC) will not be included, since its quantification is very difficult. Currently, research is on-going to establish the so-called ILUC factor, but this is not yet available.
For the bioenergy assessment study of EEA the average GHG emission per ton dry matter biomass was calculated with MITERRA-Europe. This was done for six first and four second generation energy crops for each NUTS2 region for the year 2020, based on CAPRI yield and fertilizer projections. These data can be used to derive the emissions from cultivation (e_{ec}).

4.4.5 Co-digestion sustainability tool

Co-digestion is the simultaneous digestion of manure and a co-substrate and its conversion into biogas. Zwart et al. (2007) report on a methodology to assess the sustainability of bio-energy from co-digestion with emphasis on energy and green house gasses. This includes both the saved CO_2 emissions from fossil fuels and the avoided emissions of CH_4 and N_2O from manure storage. They analysed three cases, i.e. animal manure only or maize only and a mixture of 50% manure and 50% maize. This methodology has already been implemented and applied for the Netherlands. Within this project the methodology will be implemented in MITERRA-Europe in order to calculate the saved and avoided GHG emissions from (co)digestion for all MS.
Figure 3 gives a schematic overview of the main inputs and parameters related to the energy production and consumption and GHG emissions from (co)digestion of manure. In Table 1 the key entries and parameters of the tool are presented as were used for the Netherlands. In some cases the parameters are general and can be applied for all EU countries, whereas for others country specific values (e.g. maize yield and related N_2O emissions) have to be collected or calculated. In most cases this country specific data is already included in MITERRA-Europe.

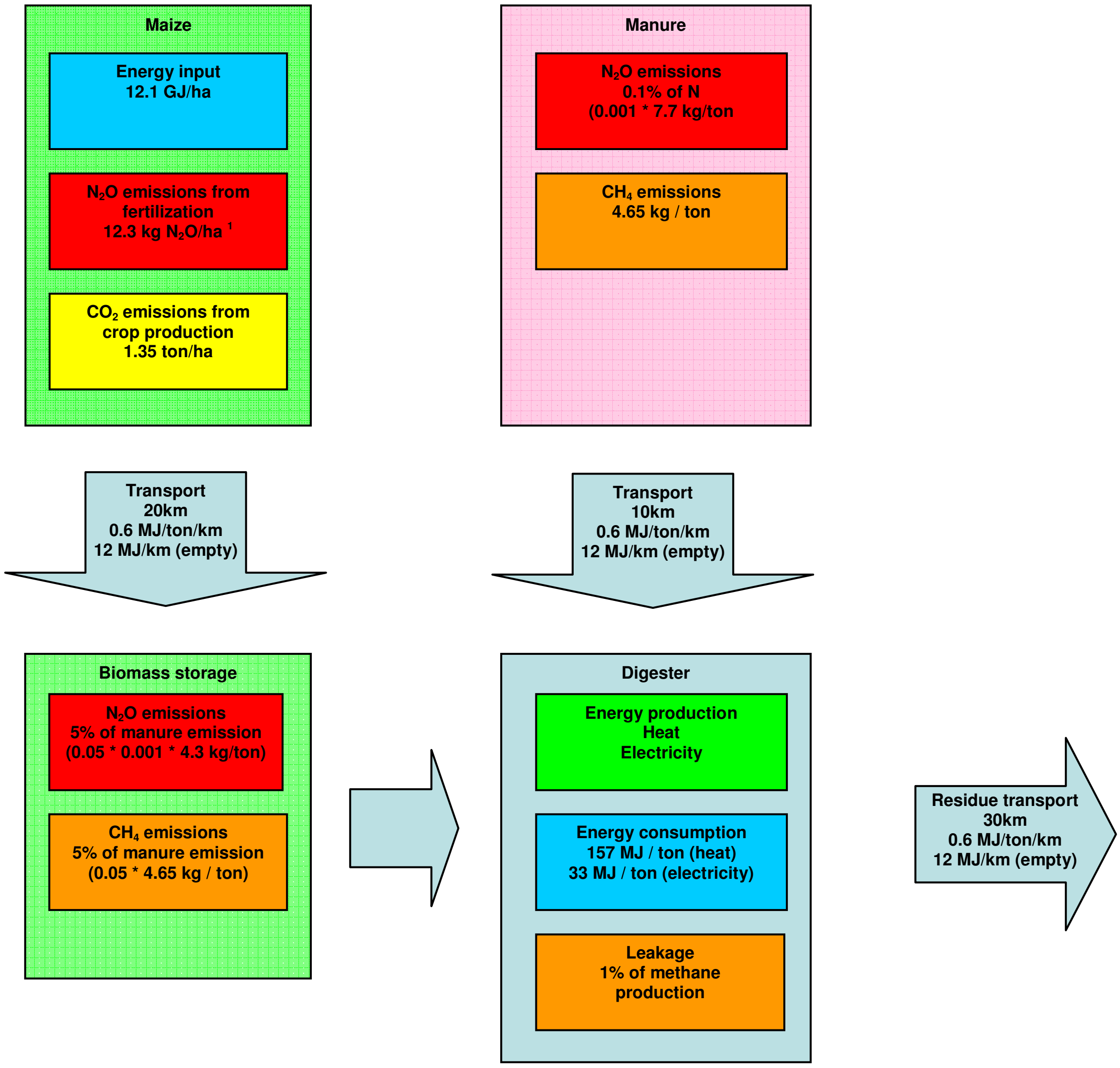


Figure 3. Key figures concerning energy production and consumption and GHG emissions from (co)digestion of manure

Table 1. Digester and co-digestion: characteristics and dimensions

Key entry/number	Value (units)
Dimensions CHP installation	500 kW
Annual full operational hours	7000
Total electricity production	3.5 * 10^e6 kWh
Methane	39.8 MJ/m^3
Conversion MJ to electricity	3.6 MJ/kWh
Overall efficiency	70%
Methane in m^3 per m^3 pig slurry	19.25 m^3 biogas or 11 m^3 methane
Methane produced per ton maize	204 m^3 biogas or 112 m^3 methane
Heat consumption digester 500 kW (250 kW_e and 250 $kW_{thermal}$)[3]	157 MJ per m^3
Electricity consumption digester 500 kW	33 MJ per m^3
Yield maize	45.0 ton fresh weight per ha
Cropping energy	1.35 ton CO_2 eq per ha [4]
N_2O emission for maize	8.2 kg N_2O per ha direct (2.542 ton CO_2 per ha) and 4.1 kg N_2O indirect (1.271 ton CO_2 per ha)
Transport (truck without load)	12 MJ per km
Transport (load)	0.8 MJ per ton per km
Emission transport	0.073 kg CO_2 per MJ or 0.88 kg CO_2 per km
Conversion Electricity to CO_2 using standard fossil fuel mix	0.0694 kg CO_2 per MJ
Conversion heat to CO_2	0.056 CO_2 per MJ
Conversion CH_4 (fuel) to CO_2	2.19 kg CO_2 per m^3 CH_4
Reduction factor methane emissions from manure storage due to digestion	95 %
Methane emission from manure storage	4.95 kg per ton
Methane emission from maize storage	3.1 kg per ton [5]
CO_2 equivalents methane	21 kg CO_2 per kg methane
CO_2 equivalents N_2O	488 kg CO_2 per kg N- N_2O

[3] This number is the demand for a farm based digester of 500 kW; for larger facilities this heat demand drops to 50% of this value

[4] Including energy needed for seed and pesticide production, fertilizer production and cropping (Zwart *et al.*, 2007)

[5] Assumed value, calculated as the average for pig manure and cattle manure (Zwart *et al.*, 2007)

5 TASK 1.4: SELECTION OF THE CASE STUDY REGIONS

5.1 Selection Criteria

The consortium will carry out eight regional countries in four Member States. For the selection of the case studies, the following criteria have been defined after a group discussion at the internal kick-off meeting (in descending order of importance):

- Dynamism of on-farm RES development;
- EU-wide distribution;
- Climatic and ecological conditions representing different environmental zones;
- Agricultural activities and main crop types;
- Farm types;
- Types of RE used;
- Availability of micro-economic, farm-level data;
- Availability of or access to primary data.
- Difference in energy-related infrastructure endowment.

The original idea of the proposal was to compare a region and type of farm where RES production had shown dynamic growth in recent years to a region with a similar factor endowment but slow or no development of RES production. In order to assess the dynamism of RES production in a consistent manner, the project team defined the following indicators:

- RES capacity installed at present and trend over time (starting from 2000), taking into account what share is estimated to come from on-farm production;
- Existence of regulation for supporting small-scale installations;
- Existence of dedicated subsidies for RES production on farms;
- Investment capacity of farmers/ farmers' access to financial resources;
- Existence of 100%-RES villages which aim to cover their total energy demand from RES;
- Trend in energy consumption per ha or any other production unit.

The importance of each of these indicators varies by country. While the first indicator, the level of RES capacity installed, can be applied in countries that have already reached a considerable share of RES in total energy production, the following indicators are more appropriate in countries where the development of RES is still in the start-up period. In these cases, the indicators help to identify the regions with most potential for a dynamic build-up of on-farm RES capacity in the near future.

5.2 Application of the criteria

A first screening of potential case study regions showed that most regions represent a mix of unique characteristics. As a consequence, the original idea of finding two regions with similar factor endowment and a comparable policy environment for RE promotion, but with differing levels of activity proved hard to realize in practice. For example in Germany regional RE development partly depends on the type of RE under consideration. While wind energy is predominantly in the North, Southern German regions install more PV installations than Germany on average. For Austria, regions with similar factor endowment, especially lowland areas with arable farming as main activity, also engage in similar levels of bioenergy production. In addition at this early stage, the contribution of farmers to RE production in any of these regions can only be estimated as data still has to be collected.

The consortium therefore proposes to strive for a selection of case studies that, across all criteria, tries to represent the diversity of the EU to the extent possible. Thus, for each country we still propose a dynamic region and a region with slower RES growth (or smaller near-term potential), but the regions will not necessarily share the same factor endowment. Rather they aim to represent the diversity of farm types and agricultural activities in the MS and in the EU as whole, as well as representing different ecological zones and different types of RES.

Finally, availability of existing micro-economic, farm-level data and access to primary are also important selection criteria in order to ensure the successful implementation of the case studies. In particular, the case regions have to be big enough to allow collection of 100 completed questionnaires. Thus, all case study regions have been defined at a size corresponding to NUTS 2-level.

Table 5.1. Characteristics of NUTS2-level regions in Germany

NUTS region	Environ-mental zone	Climate zone	Perspec-tives for rural Develop-ment	Current RE develop ment	Typs of RE found	Data availa-bility / contacts	Total score
1 Schleswig-Holstein	Atlantic North	Humid oceanic	++	+++	Wind, biogas,	++	+++
2 Hamburg	Atlantic North	Humid oceanic	+ (City)	+	Wind, Solar	+	-
3 Braunschweig	Atlantic North	Humid oceanic	++	++	Biogas, Wind	++	+++
4 Hannover	Atlantic North	Humid oceanic	+++	++	Biogas, Wind	++	+++
5 Lüneburg	Atlantic North	Humid oceanic	++	+++	Biogas, Wind	++	+++
6 Weser-Ems	Atlantic North	Humid oceanic	+++	+++	Wind, Biogas	++	+++
7 Bremen	Atlantic North	Humid oceanic	+ (City)	+	Wind	+	-
8 Düsseldorf	Atlantic North	Humid oceanic	+	++	Wind, Solar	+	+
9 Köln	Atlantic North	Humid oceanic	+	++	Wind, Solar	+	+
10 Münster	Atlantic North	Humid oceanic	++	+++	Wind, Biogas, Biofuels	+	+
11 Detmold	Atlantic North	Humid oceanic	+	+	Wind, Biogas	+	+
12 Arnsberg	Atlantic North	Humid oceanic	++	++	Wind, Biogas, Biofuels	+	+
13 Darmstadt	Continental	Humid continental	++	+	Solar, Biofuels	+	+
14 Gießen	Continental	Humid continental	++	+	Solar, Biofuels, Wind	+	+
15 Kassel	Atlantic North		+	+	Solar, Biogas	+	+
16 Koblenz	Continental	Humid continental	+	+	Solar, Wind	+	+
17 Trier - - - - - -	Continental	Humid continental	+	+	Solar	+	+
18 Rheinhessen-Pfalz - Rheinland-Pfalz	Continental	Humid continental	++	++	Solar,	+	+
19 Stuttgart	Continental	Humid continental	++	++	Solar, Biogas	++	++
20 Karlsruhe	Continental	Humid continental	++	++	Solar, Biogas	++	+++
21 Freiburg	Continental	Humid continental	++	+++	Solar, biogas	++	+++
22 Tübingen	Continental	Humid continental	++	+++	Solar, biogas	++	+++
23 Oberbayern	Continental	Humid continental	+++	+++	Solar, biogas	+	+
24 Niederbayern	Continental	Humid continental	++	+++	Solar, biogas	+	+
25 Oberpfalz	Continental	Humid continental	++	+++	Solar, biogas	+	+
26 Oberfranken	Continental	Humid continental	+++	+++	Solar, biogas	+	+
27 Mittelfranken	Continental	Humid continental	+++	+++	Solar, biogas	+	+
28 Unterfranken	Continental	Humid continental	+++	+++	Solar, biogas	+	+
29 Schwaben	Continental	Humid continental	+++	+++	Solar, biogas	++	+++
30 Saarland	Atlantic Central	Humid oceanic	+	+	Solar, wind	++	+++
31 Berlin	Continental	Humid continental	+ (City)	+	Solar	+	-
32 Mecklenburg-Vorp.	Continental	Humid continental	++	++	Wind, biogas, Biofuels	++	++
33 Chemnitz	Continental	Humid continental	+	++	Biogas, Wind, Solar	+	+
34 Dresden	Continental	Humid continental	+	+	Wind, Biogas	+	+
35 Leipzig	Continental	Humid continental	++	++	Biogas, Wind, Solar	+	+
36 Sachsen-Anhalt	Continental	Humid continental	++	++	Biofuels, Biogas, Wind	+	+
37 Thüringen	Continental	Humid continental	+	++	Biogas, Biofuels, Wind	+	+
38 Brandenburg-NO	Continental	Humid continental	+++	+++	Wind, biogas, Biofuels	+++	+++
39 Brandenburg-SW	Continental	Humid continental	+++	+++	Wind, biogas, Biofuels	+++	+++

Legend: + poor, ++ moderate, +++ good

5.3 Criteria applied in the chosen countries

Following the approach discussed above, a selection was made of regions that could be used to collect additional information for analysis of Themes 3 and 4. This was done by creating an overview of a small number of characteristics at NUTS 2-level for each of the proposed countries. This overview is presented in Tables 5.1 to 5.4. In addition to this, a brief representation of the selection process is presented below.

For **Germany**, being the strongest Member State with respect to RE development, a dynamic region was selected with strong RE development. Several regions could be selected (Table 5.1), including regions in the North (e.g. Lüneburg, Weser-Ems), South (Bavaria) or East (Brandenburg). It was decided to select Brandenburg, the dynamic region hosting the largest number of RE types (wind, biofuels and biogas).
In contrast to this, a region was to be selected showing no or slow RE development. Here, again, multiple options could be found. It was decided to select a region representing the atlantic climatic zone, in contrast to the continental conditions found in Brandenburg (no other country from the atlantic zone was selected). Many of the atlantic regions are showing reasonable development levels of the rural economy, which sometimes partly is explained by strong economic urban centres (e.g. Hamburg). In contrast, a region was selected (Saarland) that seems to have bleak perspectives for both RE and the general rural economic development.

In **Spain**, differences between the regions are more referring to rural development and environmental and climatic conditions (Table 5.2). Differences with respect to RE dynamism are much smaller here (as compared to Germany). As Spain is to represent a large number of regions around the Middle Sea (including the middle and South of Italy, Greece, Cyprus as well as parts of the Balkan countries), it was decided to select a region representing sub-tropical dry conditions of the Mediterranean South.

Table 5.2. Characteristics of NUTS2-level regions in Spain

NUTS 3 regions	Environmental zone	Climate zone	Perspectives for rural development	Current RE develop-ment	Types of RE found	Data availability / contacts	Total score
1 Lugo	Lusitanian	Humid Oceanic	+	+		+	+
2 La Coruña	Lusitanian	Humid Oceanic	++	+		+	+
3 Orense	Lusitanian	Humid Oceanic	+	+		+	+
4 Pontevedra	Lusitanian	Humid Oceanic	+	+		+	+
5 Asturias	Lusitanian	Humid Oceanic	++	++	W, B	+	++
6 Cantabria	Lusitanian	Humid Oceanic	++	++	W, B	+	++
7 Vizcaya	Lusitanian	Humid Oceanic	++	+		+	+
8 Guipuzcoa	Lusitanian	Humid Oceanic	++	+		+	+
9 Álava	Lusitanian	Humid Oceanic	++	+		+	+
10 Navarra	Mediterranean North	Humid Oceanic	++	+		+	+
11 La Rioja	Mediterranean North	Humid Oceanic	++	++	B, W, PV	+	++
12 Huesca	Mediterranean Mountains	Humid Oceanic	++	+++	H, B, W	++	++
13 Zaragoza	Mediterranean South	Semiarid	++	+++	PV, ST, W, B	++	++
14 Teruel	Mediterranean Mountains	Subtropical Dry Summer	+	+		+	+
15 Lérida	Mediterranean North	Subtropical Dry Summer	++	+		+	+
16 Gerona	Mediterranean South	Subtropical Dry Summer	++	+		+	+
17 Barcelona	Mediterranean South	Subtropical Dry Summer	+++	+		+	+
18 Tarragona	Mediterranean South	Subtropical Dry Summer	++	+		+	+
19 León	Mediterranean North	Subtropical Dry Summer	++	+++	W, B, PV, ST	+++	+++
20 Palencia	Mediterranean	Semiarid	+	++	B, W	+	+

NUTS 3 regions	Environmental zone	Climate zone	Perspectives for rural development	Current RE develop-ment	Types of RE found	Data availability / contacts	Total score
	North						
21 Zamora	Mediterranean North	Semiarid	+	++	B, W	+	+
22 Valladolid	Mediterranean North	Subtropical Dry Summer	+	++	B, W	+	+
23 Salmanca	Mediterranean North	Subtropical Dry Summer	+	+		+	+
24 Ávila	Mediterranean North	Subtropical Dry Summer	++	+		+	+
25 Segovia	Mediterranean Mountains	Subtropical Dry Summer	++	+		+	+
26 Soria	Mediterranean North	Subtropical Dry Summer	+	+++	W, B, H	+++	+++
27 Burgos	Mediterranean North	Subtropical Dry Summer	+	++	W, B,	++	++
28 Madrid	Mediterranean South	Subtropical Dry Summer	+++	+		++	++
29 Guadalajara	Mediterranean North	Subtropical Dry Summer	+	++	W, B,	+	+
30 Toledo	Mediterranean South	Subtropical Dry Summer	+	++	B, PV, ST	+	+
31 Cuenca	Mediterranean South	Subtropical Dry Summer	+	++	B, PV, ST	+	
32 Ciudad Real	Mediterranean South	Subtropical Dry Summer	++	+++	B, PV, ST, W	+++	+++
33 Albacete	Mediterranean South	Subtropical Dry Summer	++	+++	B, PV, ST, W	+++	+++
34 Cáceres	Mediterranean South	Subtropical Dry Summer	+	++	PV, ST, B	+	+
35 Badajoz	Mediterranean South	Subtropical Dry Summer	++	+++	PV, ST, B	++	++
36 Castellón	Mediterranean South	Subtropical Dry Summer	++	++	PV, ST, W, B	++	++
37 Valencia	Mediterranean South	Subtropical Dry Summer	++	+++	PV, ST, B, W	+++	+++
38 Alicante	Mediterranean South	Humid continental	++	++	PV, ST	++	++
39 Murcia	Mediterranean South	Semiarid	++	+		+	+
40 Almería	Mediterranean South	Semiarid	++	+++	ST, PV	+	++
41 Granada	Mediterranean Mountains	Subtropical Dry Summer	++	++	ST, PV, B	+++	++
42 Jaén	Mediterranean South	Subtropical Dry Summer	+	++	ST, PV, B	+	+
43 Córdoba	Mediterranean South	Subtropical Dry Summer	+	++	ST, PV , B	+	+
44 Malaga	Mediterranean South	Subtropical Dry Summer	++	++	ST, PV, B	+	++
45 Sevilla	Mediterranean South	Subtropical Dry Summer	++	++	ST, PV, B, hydro	+	++
46 Cádiz	Mediterranean South	Subtropical Dry Summer	++	++	ST, PV, W, B	+	+
47Huelva	Mediterranean South	Subtropical Dry Summer	++	++	ST, PV, B	+	++
48 Baleares	Mediterranean South	Subtropical Dry Summer	++	++	ST, PV, W	+	++
49 Las Palmas	Subtropical Atlantic	Subtropical Dry Summer	+	+++	ST, PV, W	+	++
50 Santa Cruz de Tenerife	Subtropical Atlantic	Subtropical Dry Summer	+	+++	ST, PV, W, H	+	++

Legend: + poor, ++ moderate, +++ good,
W –Wind, B – Biogas, PV – Photovoltaic, ST – Solar Termal, H – Hydro

While several regions could be found, dynamic RE development is very limited. It was decided to select a region near the coast with strong agricultural (horticulture) development, hosting a healthy agricultural sector providing a considerable amount of biomass. Valencia is representing a range of RE available in Spain, including PV, solar thermal, biofuels and wind energy. It also has the advantage of good data availability.
As contrasting region, the choice for Soria was a logic one. It does not represent conditions of weak RE development that are more dominant in other regions (e.g. Segovia, Avilla), nor is it the region with the bleakest perspectives for rural development. It has, however, three distinctive characteristics. It is hosting large-scale arable farming depending on irrigation, which allows farmers to develop hydro-electric energy production. Farmers in this region could, in theory, develop as a stronghold for biofuel crop production in Spain. Finally, Soria is the host of SoriActiva, a participating institution of the project, offering excellent conditions for both data collection and analysis.

For **Poland**, differentiation in RE development is even smaller than in Spain. Following Table 5.3, only one region can be considered as representing dynamic RE conditions. Data availability in Zachodniopomorskie is, however, limited and it was decided to select a region with a somewhat less dynamic RE track record. Mazowiecki represents a strong and dynamic agricultural development with moderate RE involvement. It covers solar thermal energy and biogas, two RE types being most common in Poland. One of the advantages of selecting Mazowiecki is the continuous strongly increasing demand for energy in this region, hosting one of the strongest industrial zones of the country.

Table 5.3. Application of selection criteria to NUTS3 regions in Poland

NUTS 3 regions	Environ-mental zone	Climate zone	Perspectives for rural development	Current RE develop-ment	Types of RE found	Data availability / contacts	Total score
1. Dolnośląskie	Continental	Temperate-Continental	+++	+	W, ST, Bg	++	++
2. Kujawsko-Pomorskie	Continental	Temperate-Continental	++	++	W, ST, Bg, H	+	++
3. Lubelskie	Continental	Temperate-Continental	+	+	W, ST, Bg	+	+
4. Lubuskie	Continental	Temperate-Continental	+	+	ST, Bm	+	+
5. Łódzkie	Continental	Temperate-Continental	+++	+	ST, Bg	+	++
6. Małopolskie	Continental	Temperate-Continental	+	++	ST	++	++
7. Mazowieckie	Continental	Temperate-Continental	++	++	ST, Bg	+++	++
8. Opolskie	Continental	Temperate-Continental	++	+	Bg	+	+
9. Podkarpackie	Continental	Temperate-Continental	++	+	W, Bm, H	+++	++
10. Podlaskie	Continental	Temperate-Continental	++	+	W, Bm, Bg	+	+
11. Pomorskie	Continental	Temperate-Continental	++	++	W, Bm, ST, Bg	++	++
12. Śląskie	Continental	Temperate-Continental	+++	+	ST, Bg	++	++
13. Świętokrzyskie	Continental	Temperate-Continental	++	+	Bg	+	+
14. Warmińsko-Mazurskie	Continental	Temperate-Continental	+++	+	W, Bm	+++	++
15. Wielkopolskie	Continental	Temperate-Continental	+++	++	W, ST, Bg	++	++
16. Zachodnio-pomorskie	Continental	Temperate-Continental	+++	+++	W, ST, Bg, Bm	+	++

+ poor ; ++ moderate; +++ good
W –Wind; Bm – Biomass; Bg – Biogas; PV – Photovoltaic; ST – Solar Thermal; H – Hydro

In contrast to this region showing strong general economic and agricultural development a region was selected where energy infrastructure is weak. Warminsko-Mazurskie is a typical representative of a poorly developed, weak economic region as found more often in Poland and the EU. While the current RE status is poor, there is sufficient potential for future development. This is most welcome, given high unemployment ratio, low alternative job opportunities and non-agricultural investments currently found here. As currently, almost all energy in Warminsko-Mazurskie is imported from elsewhere, there seems hardly a place where identification of RE supporting policies (reducing existing investment and development barriers) can provide a way out.

Case region selection in **Austria** has been more or less dominated by the request in the tender to include on-farm forestry energy production as one option for RE development. An alpine region was selected combining forestry with livestock production. Farming conditions and agricultural development in Carinthia are not very favourable, providing a chance for RE to improve perspectives for rural development. The second region proposed for this country is showing stark contrasts in terms of agro-climatic conditions (lowland, livestock plus arable farming), agricultural and RE development (both well advanced).

5.4 Proposed case studies

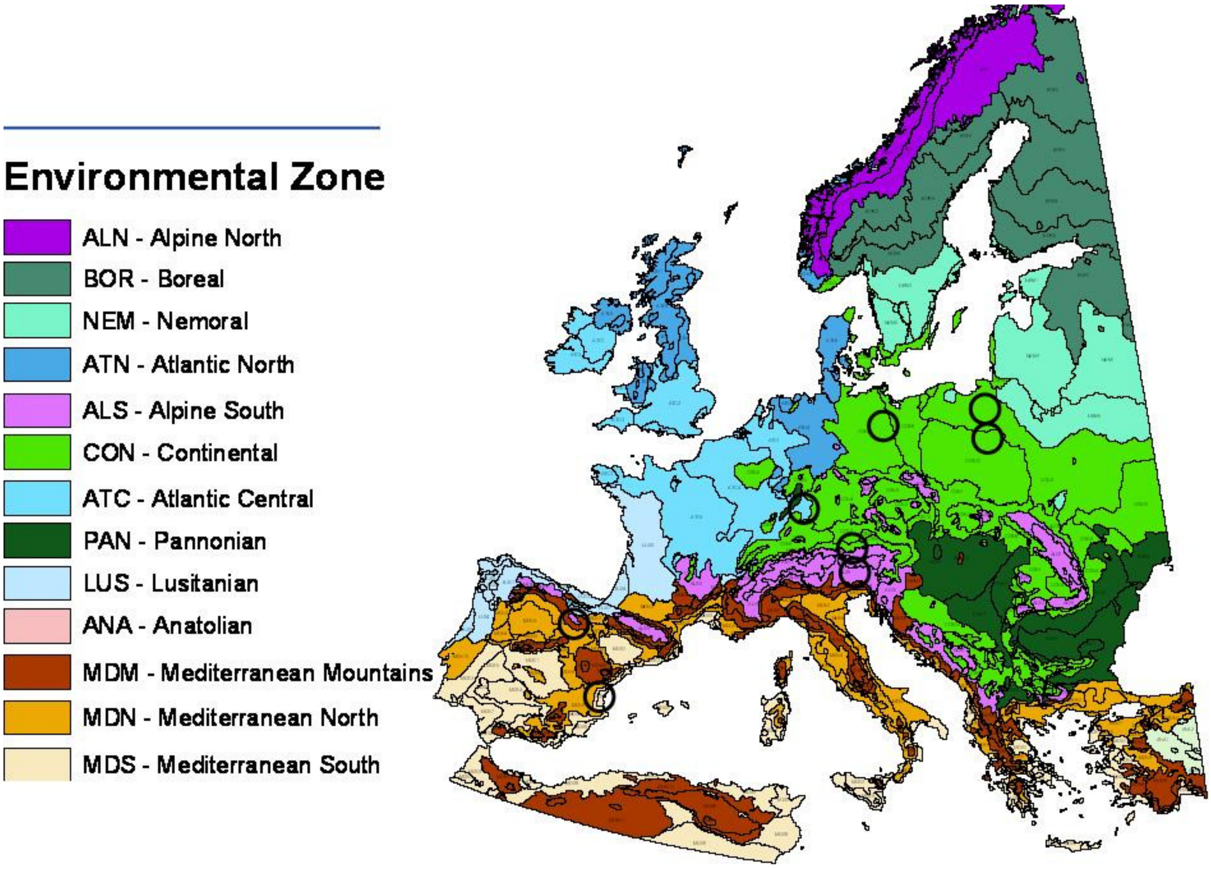
5.4.1 Overview

Following the reflections presented above, eight cases are proposed: North East Brandenburg and Saarland (Germany), Valencia and Soria (Spain), Mazowiecki and Warminsko-Mazurskie (Poland) and Northern Upper Austria and Carinthia (Austria). Of these, the first mentioned for each country can be classified as the more dynamic region while the second is less dynamic. This is always on a relative scale, comparing RE activities within the national context. Exceptions to this rule are PV in Germany (being more important in Saarland) and forest-based bioenergy in Austria (being mostly located in forested regions like Carinthia).

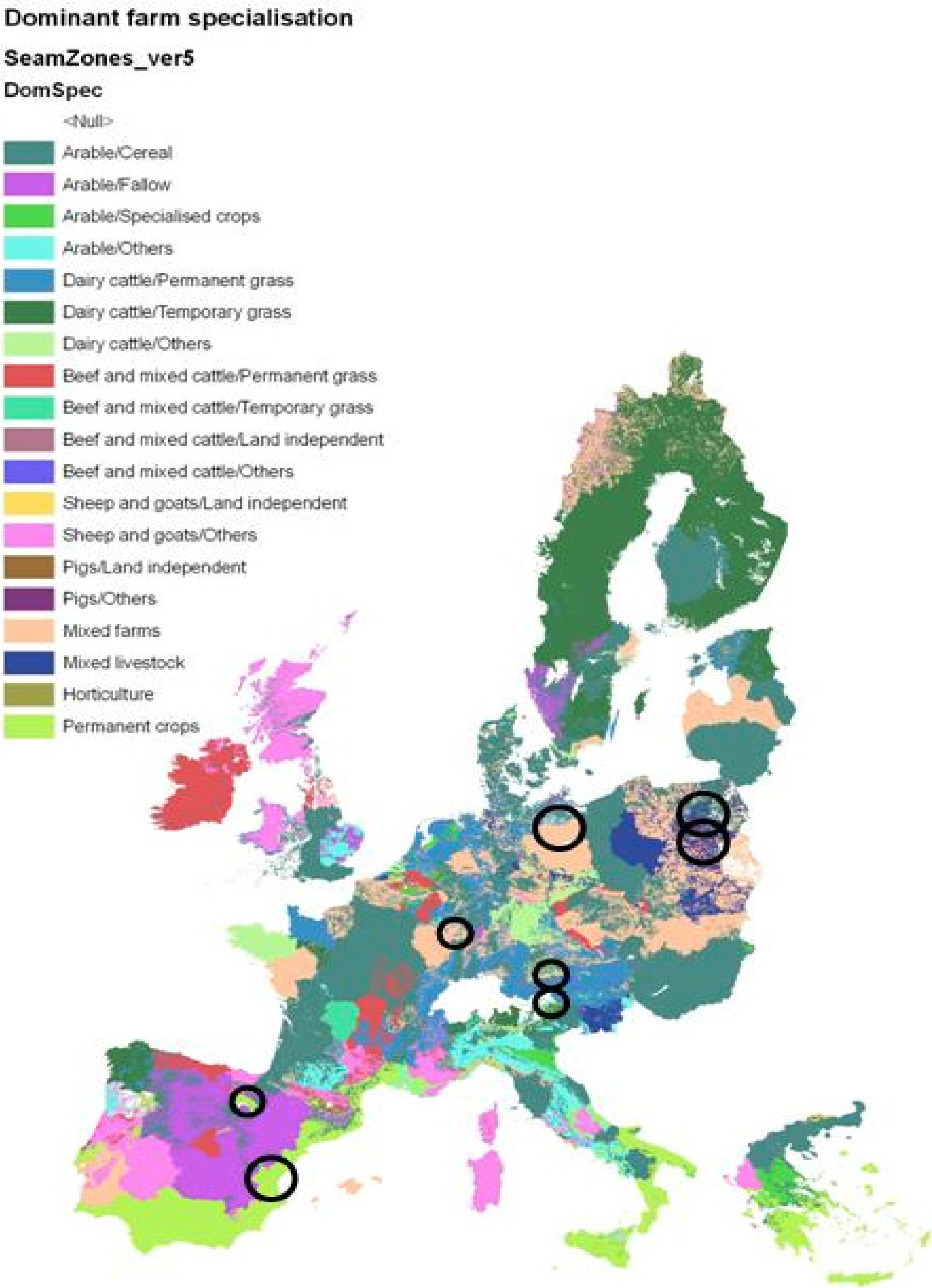
The proposed cases cover all major geographical regions of the European Communion plus major climatic conditions: humid oceanic (Saarland), humid (North East Brandenburg), dry (Soria) and temperate continental (Northern Upper Austria; Mazowiecki, Waminsko-Mazurski), coastal Mediterranean (Valencia) and alpine (Carinthia). The cases also represent major EU farm types (small and large scale, livestock, arable and mixed), plus main bioenergy feedstock crops (maize, wheat, rape, sunflower but also fruit/horticulture and on-farm forestry).

The proposed cases cover different EU countries in western, central-eastern and southern Europe and all major environmental zones: Atlantic central (Saarland), continental (North East Brandenburg Mazowiecki, Waminsko-Mazurski), Mediterranean North and mountains (Soria), Mediterranean South (Valencia) and Alpine (Northern Upper Austria and Carinthia) (see Map 1). The cases also represent major EU farm types (small and large scale, livestock, arable and mixed), plus main bioenergy feedstock crops (maize, wheat, rape, sunflower but also fruit/horticulture and on-farm forestry) as is illustrated in Map 2.

RE activities in the case regions include wind, PV, solar, small hydro, biogas, biofuels and forestry-based. Table 5.4 presents an overview of the regions. It also discusses issues of data availability and energy infrastructure availability. Details on the proposed case regions as well as their perspectives and representativeness for other regions in the Union are provided below.



Map 1: Location of cases in major environmental zones (Metzger et al., 2005)



Map 2: Location of cases in Seamzones classified according to most dominant farming specialization type

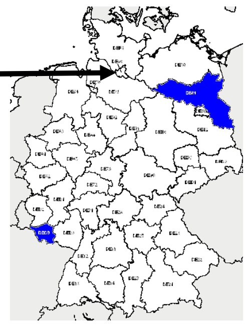
Table 5.4: Overview of case study regions

Region	Dynamism	Geographic zone	Geographic zone	Environmental zone	Climate zone	Main farm type (cropping, animal husbandry, mixed)	Main feedstocks	Types of RES used	Data availability	Access to primary data	Energy-related Infrastructure
North East Brandenburg, DE	High (except for PV)	Central Europe	Central Europe	Continental	Humid continental	Large-scale, mixed	Maize, wheat, rape	Wind, biogas, biofuel	Region in Seamless model	Personalcontacts to regional research institutes	German average
Saarland, DE	Low (except for PV)	Central Europe	Central Europe	Atlantic	Humid oceanic	Small-scale farms		PV, biomass			German average
Soria, Spain	Medium	Southern Europe	Sou-thern Europe	Mediterranean North & mountains	Dry Continental-Mediterranean	Large-scale, mixed	Maize, wheat, rape, sunflower, legumes, forage crops	Biomass Small Hydro	National, regional and private statistics are available	Good	Spanish average (high quality)
Valencia, Spain	High	Southern Europe	Sou-thern Europe	Mediterranean South	Coast-Mediterranean	Small-scale mixed	Fruits, citrus, horticul-ture, olives, vineyards and winter cereals	Wind, biomass bio-ethanol, Hydro, Solar	National, regional and private statistics are available	Good	Spanish average (high quality)
Mazowieckie, Poland	High economic dynamism, but lower RES developmen potential	Central-eastern Europe	New Member States	Continental	Temperate-Continental	Small scale, mixed	Cereals, Potatos, Silage Maize, Horticulture, Forage crops - meadow	Small scale wind, biomass, biogas, solar	National, Regional (National Agricultural Survey 2010)	Personal contacts	Polish average
Warminsko-Mazurskie, Poland	Low economic dynamism, but high RES development potential	Central-eastern Europe	New Member States	Continental	Temperate - Continental	Large scale, animal husbandry	Cereals, Rape, Forage crops	Large scale wind, biomass, biogas, solar	National, Rerional (national agricultural survey 2010)	Personal contacts	Below Polish average
Northern Upper Austria, Austria	High	Central Europe	Central Europe	Alpine-continental	Continental	Livestock farming, arable crops	Maize, cereals	Biogas, biofuels		Contacts available	Austrian average
Carinthia, Austria	Low	Central Europe	Central Europe	Alpine	Alpine	Forestry, livestock		Forest-based biomass biogas		Contacts available	Austrian average

5.5 Germany

Dynamic Region: North East Brandenburg

Less dynamic Region: Saarland



5.5.1 Region 1: North East Brandenburg

NUTS Region:	NUTS 2 region DE 41 encompassing NUTS 3 regions Barnim (DE412), Märkisch-Oderland (DE413), Oberhavel (DE414), Oder-Spree (DE415), Ostprignitz-Ruppin (DE416), Prignitz (DE417) and Uckermark (DE418).
Size of the region:	15,351 km²
Population:	1,095,420, 76 inhabitants per km²
Main agricultural activities:	arable cropping
Main crops:	rape, silage maize, rye, winter wheat
Average farm size:	Small scale farms coexist (2-5 ha) with many large scale farms (>50 - 500 ha)

Northern Brandenburg, consisting of different districts bordering on Berlin in the north, belongs to the lowest populated areas in Germany. Located in Germany's periglacial relief the area is characterized by extensive plains and lowlands dominated by arable land. grassland and forests. Moreover, especially the centre of this area is famous for its numerous lakes. In Northern Brandenburg small-scale farms coexist with many large scale farms, the latter can mostly be found in the Eastern Part of Germany due to the GDR history. There is a high share of farms larger than 50 ha, farm size ranging between 500 and 8000 ha.

Due to sandy soils and low precipitation rates (520mm/yr), the soil fertility of the majority of agricultural land is relatively low. Most grown crops in this area are rape (13 %), silage maize (14 %), rye (14%), winter wheat (14 %). Low population density and extensive land use locally made the land predestined for protected areas. This can affect perspectives for farming. In the biosphere reserve Schorfheide-Chorin in the heart of the area, for example, a high component of organic farming and eco-tourism provides a significant source of farm income.

Compared to other regions in Germany farmers in Northern Brandenburg have quite beneficial perspective due the different income opportunities that still have the potential for dynamic development and the comparably high competitiveness of large scale farms. This is also true for other regions in Eastern Germany, which thereby differ significantly from western German regions where small-scale farming is predominant. In Brandenburg, bioenergy and eco-tourism are sectors for which dynamic development can be still expected in the future. Such beneficiaries compensate to some extent for the poor soils and the high share of protected areas, which might limit production in some areas of the region.

In terms of RE development Northern Brandenburg can be seen as a dynamic region especially with respect to wind energy and biogas plants. Brandenburg has, compared with other German Länder the highest installed capacity of wind energy per person (1648 MW) and the third highest density per 1000 km2 (141.5 MW) and a reasonable number of biogas plants (176 for the whole Land, about half of which are situated in the case-study area of Northern Brandenburg). Furthermore, the world largest biogas plant (Penkun) with 20 MW installed power is located in Northern Brandenburg, in an area with large-scale agricultural structures and a comparably low population density.

As everywhere in Germany RE producers in Brandenburg mostly benefit from the German Renewable Energies Act, which implies a guaranteed feed-in tariff for all renewable energies that eases financial planning for investors and also farmers. In addition, Brandenburg has established a grant programme to support investments in renewable energies and energy efficiency. The financial support emphasis on market launches of newly developed technologies including pilot and demonstration projects but also on promising technologies on a broader scale.
Northern Brandenburg was also chosen because of good data availability. Besides personal contacts to local agricultural reaseach institutes (Institute for Agricultural Engineering Potsdam-Bornim, ATB and Centre for Agriculatural Landscape Research, ZALF), which conducted several research projects in this area and are in personal contacts with farmers, the region was also integrated in the SEAMLESS model, which include farming system, environmental, economic and social data sets.

5.5.2 Region 2: Saarland

NUTS Region:	NUTS 2 region DEC0 comprising NUTS 3 regions Stadtverband Saarbrucken (DEC01), Merzig-Wadern (DEC02), Neunkirchen (DEC03), Saarlouis (DEC04), Saarpfalz-Kreis (DEC05) and St. Wendel (DEC06)
Size of the region:	2,569 km2
Population:	1,020,000, 397 inhabitants per km²
Main agricultural activities:	husbandry, arable cropping, horticulture, orcharding and winegrowing
Main crops:	cereals, mainly winter wheat and rye, rape and maize silage
Average farm size:	48 ha

Saarland is the smallest German Bundesland (except for city states), positioned in the West of the country sharing borders with France and Luxembourg. Agriculture is dominated by animal husbandry and arable cropping. In addition, horticulture, orchading and vineyards also play an important role. With these characteristics, the region is representative for South West Germany, but also for neighboring regions in France and Luxembourg. Grasslands represent 51 % of total utilized agricultural area while 48 % is arable land. In 2007, there were 1 660 farm holdings in total, 55 % of these engaged in husbandry, 15 % in arable cropping, 6 % in horticulture and 3 % in orcharding and winegrowing. [6]

Saarland`s economy is dominated by the industrial sector. As a Bundesland with a small land area, agriculture plays a minor role in overall economic development. For this reason perspectives for farmers are more limited than in other regions in Germany, where farmers can benefit from additional funding programmes and higher representation in political decsion-making.

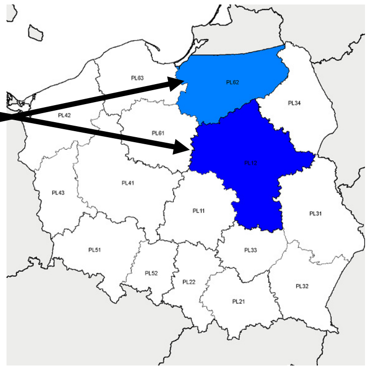
As opposed to Brandenburg, installation levels of renewable energy technologies and feedstock production for bioenergy are among the lowest in Germany. This coincides with a lack of regional support programmes for on farm renewable energies in the Saarland. The only exception is photovoltaics where Saarland ranks third in terms of capacity installed per square km (in comparison to all other German Länder). This does contrast nicely with Brandenburg, which shows a very dynamic development for all RE types, except for photovoltaics.

[6] Statistische Amt Saarland (2010): Landwirtschaft im Saarland. Statistische Kurzinformationen, Saarbrücken.

5.6 Poland

Dynamic Region: Mazowieckie

Less/Not dynamic Region: Warminsko-Mazurskie



5.6.1 Region 1: Mazowieckie

Size of the region:	35 558 km²
Population:	5 222 167 (2009), 145 pers./km²
Main agricultural activities:	Arable crops, husbandry, horticulture, orcharding, mixed
Main crops:	Cereals (Wheat, Rye, Oat, Triticale), Potato, Maize
Average farm size:	8.44 ha

Mazowieckie Voivodship, the biggest administrative region in Poland, is characterized by high polarization of spatial functionality. Warsaw, a metropolitan area dominating business and finance in the region, is generating most of the income and gathering most of the population. The remainder of the region mostly (75%) consists of agricultural land. The Mazowieckie Region is one of the biggest electricity consumers in Poland. It is hosting a significant part of the installed capacity of coal power plants – the Kozienice power plant in the south (2820 MW) and Ostroleka plant in the north (647 MW). In addition, a very important part of local power is generated by Warsaw CHP's capacity (965MW).

The region is characterized by strong and constantly developed agriculture. In fact, it is the region that has the highest share of electricity consumption, which is derived from agriculture in Poland and the only region in the country where electricity use on rural areas is constantly and regularly growing. Weak grids on rural areas may be a barrier in further development, creating a potential demand for local renewable energy resources, which could improve security of supply and bring further rural economic development. A well-developed agriculture RE sector can also serve as a potential energy and fuel supplier for urban areas. So far, however, RE investments have not taken place on a broader scale leaving its opportunities and potentials still unexploited.

Current development of energy crops plantations is not significant. Available area available for the purposes of new plantations development is limited, compared with other parts of Poland. Existing plans for development of renewable energy sources mainly include co-firing of biomass in existing and planned only CHP's. Considering the growing interest in development of biomass (mostly wood) co-firing in big coal fired power plants, more land could be dedicated for such purposes by farmers, but this will require political support and new regulations. In this respect it is not clear whether wood co-combustion with coal in industrial power plants will be supported in Poland. Additionally, the significant surplus of straw in Mazowiecki region could serve as a successfully source of local energy.

According to the studies done previously on the area the regional technical potential of renewable energy resources is currently used only in small percentage e.g. the undeveloped area of unused lands covers 16,2% of total agricultural lands. Existing plans for RE development are including mainly co-firing of biomass in existing and planned CHP's as well as smaller scale RES use on rural areas (mostly agricultural biogas).

The central part of Poland with the Mazowiecki region has relatively good solar energy potentials. The use of solar thermal collectors may be economically justified on the whole area of the region, especially on rural areas and in eastern part of Mazowiecki region. Currently the potential is used only marginal, usually by home owners and in public buildings. So far farmers are using pilot installations only.

Being a region of strong agriculture, Mazowieckie has one of biggest potentials of agricultural biogas in Poland. This potential is currently not used (similar as on the whole area of Poland) and in the future its contribution to the regional energy balance is expected to grow significantly, in terms of heat, electricity and fuel (methane) supply. The main barriers here may be limited grid capacity for bigger biogas plants (weak grids) and the generally still low economic profitability of smaller biogas plants use in Poland (within current system of green electricity supporting measures).

The wind energy potential in the region is not high (low wind speeds), thus the interest of development of big wind farms in the area is not very likely. However there is a growing interest between individual persons (also farmers) in location of smaller scale (single) wind turbines for individual use or in order to sell electricity and green certificates.

The Mazowsze region is economically strong, and has a flourishing agriculture (investment levels in agriculture were one of the highest in Poland, amounting to €161,6m (2008)7, an increase by 47% as compared to 2005. The index of investments outlays per ha is far above the national average, but investments in renewable energy are rather slow - a trend that is not likely to change significantly in the near future. In the medium term, however, escalating electricity prices (after 2013) and expected problems with the refurbishment of the low and medium voltage grid may stimulate larger farms – which have the highest electricity demand and sufficient investment capacity– to look for investments in RE.

The region of Mazowieckie can be representative for fast developing regions of Eastern Germany, Czech Republic and Slovakia as well as capital regions of other new EU Member States.
RE Policy in Poland is mainly governed at a National level (for details see Annex). However, the regional government launched a variety of programmes and strategies to enhance the RE development in the region, such as:

- Possibilities for renewable energy development in Mazowieckie Voivodship (Warsaw 2006)
- Regional Development Programme of Mazowieckie Voivodship for 2007-2013 (Warsaw 2007)

Aiming particularly for higher energy security the strategies address the development of alternative energy sources in order to increase the diversification of energy production from various sources. Besides for biomass and water energy, incentives are given for geothermal, wind and solar energy. Furthermore, the region promotes the enlargement of the HV grid (400kV and 220kV) and its incorporation into the Warsaw power grid node to improve feed-in conditions for RE.

5.6.2 Region 2: Warminsko-Mazurskie

Size of the region:	24 173 km²
Population:	1 426 155 (2009), 59 inhabitants/km²
Main agricultural activities:	Animal husbandry, arable cropping
Main crops:	Cereals (Wheat, Barley, Triticale), Rape, Forage crops
Average farm size:	16.5 ha

In terms of development, Warminsko-Mazurskie Voivodship belongs to the economically weakest regions in Poland (14 place among 16 regions) and in EU. The main historical reason for this is a decommissioning of public state owned farms in early 90s. Formerly they possessed more than 50% of agricultural lands. Also underdeveloped industry was not able to create jobs for immense number of low qualified workers from "state farms". The dominating industry in Warminsko-Mazurski region is tourism, agrotourism, food production, wood processing and furniture. Despite lower economic development, lack of heavy industry etc., there are good preconditions for RES development.

7 * Average exchange rate for 2008 was 1PLN = 0,2832€.

Rural areas are requesting large investments in development of technical infrastructure, especially energy security. Currenlty, the rate of investment still is two or even three times lower than that in most dynamic regions in Poland (amounting to €62,5m in 2008, an increase of 30% from 2005. Economic transformation (mostly because of changes in agriculture) is the reason for sustaining the highest level of unemployment among all regions in Poland (19.5%, or twice the national level of 9.5%), although in last years employment rates have gone down noticeably. Development of RE might improve local technical/energy infrastructure while creating a considerable number of local sustainable (green) jobs.

Warminsko-Mazurskie Voivodship is almost completely dependent on external energy supply (energy self-sufficiency ratio being 0.08). RE (biomass, hydro) makes up only 8% of local energy production. There is a significant potential of renewable energy resources, but the regional biomass market is poorly developed while mutual agreements between the heating companies and producers of renewable fuels are lacking. There is a need for agro-energetic companies that produce energy and supply feedstocks to the heating companies while industry is not sufficiently aware of the possibilities of RES use. Still, the newly established Regional Energy Agency and well-recognized in Poland agricultural University of Warmia and Mazuria currently are playing the role of initiators and boosters in regional biomass energy development.

The straw surplus is one of the highest in Poland and some straw fired CHP's are already planned in the region. RE is perceived as on unique, short-term, solution for improvement of energy security, receiving political support. The region is well suited for the development of energy from renewable resources: it has good size structure of farms (an average farm has a size of 16.5 ha arable land and is twice as average in Poland), a large amount of labour force, good natural conditions (climate and soil) for plantations of energy plants, potential consumers of energy near places of its produce, available large area of unused arable lands (29,6% of total agricultural lands). The dominating farm type, animal husbandry (72.9%), may not be very keen to pick up biomass production, a change that may bring risks. On the other hand, it would create a high potential for biogas plants development.

It is, therefore, expected that biomass will be used mainly locally, on a small scale. While the voivodship has 10% (over 170.000 ha) of the country´s unused rural areas, the 2007 energy crop areas was only 1.000 ha. In Warmińsko-Mazurskie voivodship there is also big potential for straw for energy purposes. More than half of rural straw, or over 500.000 tons per year, may be used, theoretically containing over 7,6 PJ of renewable energy annually. Additionally the wind potential in the region is one of the highest in Poland (however not uniform on the whole area) attracting the wind farm investments, as well as potential individual users. Also the potential of solar energy is high in that Voivodship and the use of solar panels (especially thermal) is economically justified at the same time the installations are very rare and uncommon.

One of the obstacles in wider use of the RE potential in Warminsko-Mazurskie might be relatively high level of environmental protection of the rural areas, and thus necessity of considering sustainability issues in decision making process. The Warminsko-Mazurski region can be representative for the peripheral regions of Spain, Germany, Austria, Sweden, Baltic States as well as Southern-Central Europe, where there are no large economic and industrial centers, tourism sector is well developed and high potential of RES development exists.

RE Policy in Poland is mainly governed at a National level (for details see Annex). However, the regional government launched a variety of programmes and strategies to enhance the RE development in the region, such as:

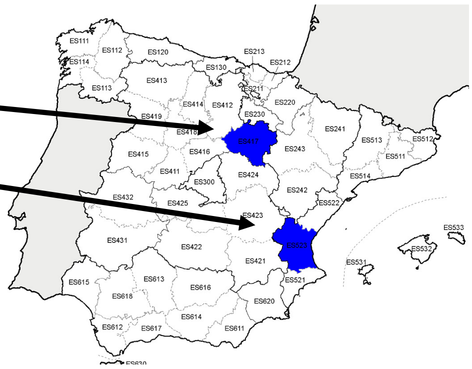
- Eco-energetic Programme for Warminsko-Mazurskie Voivodship for years 2005-2010 (Olsztyn 2006)
- Regional Development Programme of Warminsko-Mazurskie Voivodship for 2007-2013 (Olsztyn 2007)

The strategic documents and programmes mainly aim for the development and modernisation of the power grid in the whole region, especially in rural areas. Inadequate power grids can be seen as the most important limiting factor in renewable energy development and energy security.

5.7 Spain

Dynamic Region: Soria

Less dynamic Region: Valencia



5.7.1 Region 1: Valencia

Size of the region:	297,376 ha
Population:	494,421 inhabitants
Main agricultural activities:	agro-industry Mediterranean crops
Main crops:	Fruits, citrus, horticulture, olives, vineyards and winter cereals
Average farm size:	2 to 30 ha

The province of Valencia, in the autonomous region of Comunidad Valenciana (3 provinces: Valencia, Alicante and Castellon) is located in the southeast of Spain near the Mediterranean coast. Valencia is one of the most intensive regions in Spain regarding agricultural production. More than 75% of the arable lands (150,000 ha) are occupied with fruits and citrus, implying higher technology and input use and income levels than the other case study region (Soria). In 1999, there were 126,000 farmers censed in the province of Valencia, almost half (45%) being over 55 years old. The warm weather close to the sea, but also olive groves and vineyards (about 100,000ha) and intensive horticulture and nurseries (about 7500ha) make this region a typical European Mediterranean zone, comparable with Puglia and Sicily (Italy), or southern regions in Greece.

Renewable energy development in Valencia started to grow intensively in 2005 but came to a halt at the arrival of the financial Spanish crisis in 2009. As is the case in many regions of Spain, it iis mostly taking place in urban areas or by private companies using PV solar panels and hydroelectric applications. Nevertheless, biomass wastes from tree cuttings, bioethanol from citrus industries residues and windmills for electricity production increased rapidly during the last five years.

The collaboration from the "Instituto valenciano de investigaciones Agrarias, IVIA" - Valencian Agricultural Research Institute" will be valuable since they provide technical assistance and have a strong cooperation with local farmers in the province, providing then good availability of data for this study. Additionally, IVIA in collaboration with CIEMAT (National Center for Research on Environment, Technology and Energy) has a regional programme for the development of energy crops in Valencia, and works actively with farmers from cooperatives and rural organizations that show more and more interest in renewable energies as an alternative in rural areas. Soriactiva, will then work with IVIA and the assistance of CIEMAT to select farmers for surveys.

5.7.2 Region 2: Soria

Size of the region:	1.030.645
Population:	93.070 inhabitants
Main agricultural activities:	mixed cropping and livestock
Main crops:	cereal, legumes, oil crops, forage crops, beef and sheep cattle and swine farming
Average farm size:	150 ha

Soria is a cold and dry region located in the middle-north of Spain. These climatic characteristics represent a big part of the very varied Spanish biogeography (Castilian region. Dry mediterranean-continental climate). Big oscillations of temperature throughout the year, and short summer periods, make agriculture a big challenge in this region. Water, needed for irrigation is available in some areas only while low temperatures limit farmers willingness to invest in high-value crops. Large farm sizes (about 150 ha) especially in comparison to other regions, makes cereal production most suitable (labour extensive) and profitable crop. High cereal incomes make farmers unwilling to invest in irrigation infrastrucutre or new renewable energy (RE) activities.

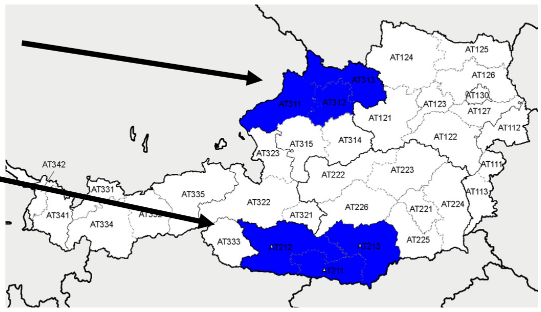
In spite of this, some initiatives exist related to irrigation works and RE investments on farms. This is the case of biogas production from pig slurry, energetic crops (herbaceous and woody) (278.000 ha) and efficient forest management (440.000 ha) for biomass and biodiesel production. Small hydro units for electricity production in irrigation channels are another important initiative taken by irrigation unions.

Soriactiva foundation has been working in Soria region for many years on agricultural advising and local development. Research related to energetic crops is being developed in association with the National Center for Research on Environment, Technology and Energy (CIEMAT). Support for development of irrigation by farmers is currently being started. Due to its position as an advisor, Soriactiva is well informed on the agricultural situation of the region. A large number of data are currently being managed, while good contacts with the farmers will facilitate efficient questionnaire management and making a representative selection of the farms.

5.8 Austria

Dynamic Region: Northern Upper Austria

Less dynamic Region: Carinthia



5.8.1 Region 1: Northern Upper Austria

NUTS regions:	NUTS 3 regions Innviertel (AT311), Linz-Wels (AT312) and Mühlviertel (AT313)
Size of the region:	7,225 km²
Population:	1,020,835, 141 inhabitants per km²
Main agricultural activities:	livestock (cattle, milk production, pigs)
Main crops:	maize grains and maize silage maize, winter wheat, winter barley, clover grass
Average farm size:	31.2 ha (forest and agriculture), 16.5 ha (agriculture)

Northern Upper Austria is one the richest and most populated rural areas of Austria with a strong agricultural sector due to the favourable conditions of these low-lying areas. Upper Austria equally is a very dynamic region with respect to RE production. It has the highest density of biogas plants in Austria (6.5 plants per 1,000 km2 as of 2009), the majority of which are based in the Northern part of the Bundesland that is our case study region.[8] In addition, there are approximately 800 biomass heating plants with a capacity of over 100 kW, approximately 35,000 biomass-based boilers heaters and several biomass-

[8] Baumgartner, B., Kupusovic, M, Blattner, H. (2010): National Report on current status of biogas/ biomethane production – Austria, WP deliverable 5.1.

based district heating systems. In total, 1.25 m t of solid biomass is used for energy production per year. The regional government supports investors by paying out grants.[9]

The case study regions encompasses the following administriative units (Bezirke): Braunau am Inn, Grieskirchen, Ried im Innkreis, Schärding, Linz, Linz-Land, Wels, Wels-Land, Eferding, Urfahr-Umgebung, Freistadt, Perg and Rohrbach. It is suggested to exclude the southern parts of Upper Austria (NUTS 3 regions Steyr-Kirchdorf and Traunviertel) because these are of an alpine character, with similar agricultural structure and factor (land, labour) endowment to the second case study region (Carinthia). Excluding these regions is ensuring a high level of contrast between the two case study areas. Upper Austria is representative for most lowland areas in Austria that have undergone an enormous development of farm based bionenergy production in recent years.

The total cultivated area of Upper Austria is 1,132,454 ha, whereof 451,732 ha (39.9 %) are covered by forests and 557,008 ha (49.1 %) are considered utilized agricultural area (UAA). Almost 54 % of the UAA is arable land, the remainder is grassland which is mostly located in mountainous regions. In total, agricultural area is managed by 36,500 holdings. Minor land use further includes wood energy areas (322 ha) and Christmas tree plantations (245 ha).[10] Average farm size (forest and agricultural area) is 31.2 ha, 8.2 ha of arable land, 7 ha grassland, 12.4 ha forest und 3.6 ha of other areas (incl. non-productive areas)[4], average farm size (only agricultural area) is 16.5 ha.

Major feed and food crops cultivated entail maize grains and maize silage maize, winter wheat, winter barley and clover-grass mixtures. Maize grains and silage maize are the dominant crops with a share of 24.9 % (72,800 ha) of the UAA.[11] Livestock is dominated by cattle (586,839; 17,865 holdings) and pigs (1,171,531; 8,938 holdings). Upper Austria is hosting 30 % of the total number of cattle and 36 % of the total number of pigs in Austria are kept. Moreover, the region provides a share of 32 % of the Austrian milk production.[12]

According to the latest agricultural structure survey (2007) there are 29,930 forest farms and majority of forest farmers own an area of less that 5 ha.[13] Further survey results reveal that there are 103,251 agricultural and forestry workers. Majority of these employees are family members (89,432; 86.6 %), while the rest is non-family labour.

By far the greatest improvement of incomes from agriculture and forestry was recorded by the cash crop farms, followed by forage production and processing and mountain farming in the third place, forestry is last in line.[14]

The biogas sector in this region mostly benefits from national legislation, mainly by the Green Electricity Act 2002, which often undergoes changes in specific regulations. This act governs support for green energy and combined heat and power generation by defining guaranteed feed-in prices for given time periods. Fixed prices for electricity generated by biogas plants provide an important basis for the financial returns to biogas production investments in Austria.

[9] Grüner Bericht Oberösterreich 2009: 15.

[10] Grüner Bericht Oberösterreich 2009: 10.

[11] Grüner Bericht Oberösterreich 2009: 17.

[12] http://www.land-oberoesterreich.gv.at/cps/rde/xchg/ooe/hs.xsl/599_DEU_HTML.htm

[13] Grüner Bericht Oberösterreich 2009: 33.

[14] Grüner Bericht Oberösterreich 2009: 44.

5.8.2 Region 2: Carinthia

NUTS regions:	NUTS 2 region Carinthia (AT21) encompassing NUTS 3 regions Klagenfurt-Villach (AT211), Oberkärnten (AT212) and Unterkärnten (AT213)
Size of the region:	9,536 km²
Population:	559,019, 59 inhabitants per km²
Main agricultural activities:	Livestock (cattle) and milk production with a high share in mountainous regions
Other activities:	Forestry
Main crops:	Cereals (mainly barely), grain maize and forage crops/ rotation meadow
Average farm size:	46 ha

Carinthia is characterised by mountainous forest areas, some 60 % of the Bundesland being covered by forests. Due to its position on the border to Slovenia and Italy, its low population density and its small-scale agrarian structures, Carinthia's economic performance is less dynamic than Upper Austria's one. Median income is the third lowest of all nine Austrian Bundesländer.[15]

With respect to biogas energy production, the region is equally less dynamic than its comparator Upper Austria. The Bundesland has 3.5 biogas plants per 1,000 km² or less than half the rate of Upper Austria. Being a strongly forested region, however, Carinthia would make an interesting case to study farmers' engagement in forest-based bioenergy production. In this respect, the case study is also representative for a number of Northern and Eastern European Member States such as Sweden, Finland and the Baltic States which equally derive a large share of their RE production from forests.

Carinthia's share of forest area is more than 60 % (578,000 ha), while the utilized agricultural area (incl. Alps) amounts to approx. 28 % (236,000 ha), comprising 172,000 ha of permanent grassland and 62,000 ha of arable land. Dominant crops are cereals (mainly barely), grain maize and forage crops/rotation meadow, together covering ca. 75 % of the crop land.[16] The permanent pastures consist of intensive grassland farming (high input grassland; 14 %) and extensive grassland farming (84 %), which is located in the mountains (alpine meadows). Cattle grazing as well as forage production are major farming practices in grasslands.

Agricultural and forest areas are managed by 19,000 holdings, corresponding to 10 % of the total number of farms in Austria. About one quarter (27.9 %) of these holdings is managed full-time (average size 57 ha), while 63.4 % farms are considered part-time farms (average size 22 ha), the rest belongs to legal entities.

Besides the national Green Electrictiy Act mentioned above, Carinthia has set ambitious targets for further RE development. These targets include inter alia the installation of solar plants on a third of all buildings in the region. Furthermore, the energetic use of wood should be increased from the current 60% to 80% of all increment wood.

15 Ambrosch, P. (2008): Einkommen in Kärnten. Eine Analyse der Arbeiterkammer für das Jahr 2006, AK Kärnten.

16 Grüner Bericht Kärnten 2008: 77/78.

6 TASK 1.5: CREATE METHODOLOGY AND TOOLS – THEMES 3 & 4

6.1 Objective

Following national (MS) and EU-level analyses presented in previous chapters, specific aspects of (decision making on as well as impacts of) implementation of on-farm RE will be studied of Themes 3 and 4. The main aim here is to find answers to the following questions:

1. what are the investment costs for farmers to adopt different forms of RE production?
2. what are impacts on farm income and cropping/livestock patterns choice for farmers adopting RE production?
3. what types of RE production are most suitable on farms?
4. what sort of support and conditions (e.g. new policies, minimum price level, required technological development, etc.) is needed to make such an introduction of renewable energy production introduction happen in reality?
5. what are the gains in GHG emissions if RE options are taken up on farms?

6.2 Approach

Methods and tools applied to answer the questions listed above include information collection from existing data sources and publications, survey research among farmers in regions of the four case study countries and modelling work. The work will be organised in three phases (Table 6.1).

In the **first phase**, existing data sources (statistical national and regional agricultural databases, additional sources on RE production and investments, plus other relevant sources) are used to provide an overview of farm structure and RE development in the case regions. Data on farm structure are taken from SEAMLESS databases plus additional FADN data (for new regions), plus additional data from local statistics and relevant secondary sources. Information on RE development is taken from a range of sources including national statistics and professional RE organisations contacted to provide relevant information.

The **second phase** encompasses the setup and application of the questionnaire in the case study regions. Questionnaires, following a general setup, are customised in order to allow maximum representation of local conditions (e.g. farm income levels, education systems, variation in farm type composition etc.). Outcomes are analysed to provide information on farm-related RE investments plus impacts on (farm) income, employment and productivity.

In the **third phase**, information, data and analysis results from the first 2 phases will be used to generate parameter values for the modelling work. Model selection and application will be discussed.

An overview of the indicators addressed in the different phases is presented in Table 6.1. Most issues are covered by all activities, but the level of detail will depend on data availability (in local primary and secondary sources). The questionnaire design is aimed at the collection of basic information on farms and farm RE activities and their (indirect) effects.

6.3 Phase 1: collection of primary and secondary data

Available sources in case study regions as well as national and EU-wide data will be used to provide an overview of farming activities and farm structure plus farmers' role in RE production. Basic data on farm structure as available in SEAMLESS and FADN will be supplemented with information from local and regional sources, including key resource persons and farmers' and industrial organisations. Information on RE development will be collected from a range of sources including national statistics and professional RE organisations.

Table 6.1. Indicators addressed in Themes 3 and 4

Indicator	Phase 1: inventory of existing sources	Phase 2: (analysis of) questionnaire	Phase 3: prospective modelling
Farm income (changes due to RE)	XXX [1]	XXX [2]	XXX [3 4]
Employment (idem)	XXX [1]	XXX [2]	XXX [3]
RE investments	XX[1]	XXX [2]	XX [3]
Local RE capacity	XXX[1]	XXX [2]	XX [3]
(Indirect) environmental effects	XX[1]		XXX [3 4]
(Impacts on) food security	XXX [1]	XXX [2]	XXX [3 4]
Policy		XX [2]	XXX [4]

1: FADN, local statistics, other sources (industry, energy boards, etc.)
2: income: questions 14-15 and 28; employment: question 28; investments: question 16-17, 22-26, 29; food security: questions 28-29; policy: questions: 29-31. See other sections of this Chapter for more detail.
3: comparison of 2020 NREAP with base scenario
4: 2020 NREAP+ scenario focussing on stimulating agriculture´s role in RE production

Potential data sources for agricultural and RE production in the case regions includes:

- North East Brandenburg and Saarland (Germany)
  - FNR (Agency for Renewable Resources), http://www.fnr-server.de/cms35/index.php?id=139
  - BEE, Bundesverband Bioenergie e.V. (BBE), http://www.bioenergie.de/
  - Bundesverband der deutschen Bioethanolwirtschaft e.V. (BDBE), www.bdbe.de/
  - Bundesverband Pflanzenöle e.V. (BVP), www.bv-pflanzenoele.de/
  - Bundesverband WindEnergie e.V., http://www.wind-energie.de/
  - Deutscher Energie-Pellet-Verband e.V. (DEPV), www.depv.de/
  - Fachverband Biogas e.V. Fördergesellschaft nachhaltige Biogas- und Bioenergienutzung e.V. (FnBB), www.fnbb.de/
  - Verband der Deutschen Biokraftstoffindustrie e.V. (VDB) - http://www.biokraftstoffverband.de/
  - Union zur Förderung von Öl- und Proteinpflanzen e.V. (UFOP) - http://www.ufop.de/
  - Regional Ministries for Agriculture and Energy
  - Deutsches BiomasseForschungszentrum Leipzig www.dbfz.de
- Valencia and Soria (Spain)
  - Statistical bureau of Spain (data on farms structure, etc): http://www.ine.es/jaxi/menu.do?type=pcaxis&path=%2Ft01%2Fp044&file=inebase&L=1
  - Ministry of Industry (documents about energy in Spain, Market of energy, Kyoto Protocol, Solar captors, etc.): http://www.mityc.es/energia/es-ES/Paginas/index.aspx
  - Electricity net (Compañía Operadora del Mercado Español de Electricidad; OMEL): info@omel.es
  - Electricity market in Spain: www.ree.es
  - Renewable energy production: http://www.iberdrolarenovables.es/wcren/corporativa/iberdrola?IDPAG=ESINICIORENOVAB&codCache=12950194271454964
  - Ministry of agriculture and environment: www.marm.es
  - Expert information on renewable energy (e.g. bioenergy crops): www.ciemat.es
  - Spanish institue for diversification and saving of energy (IDEA): http://www.idae.es/index.php/mod.pags/mem.detalle/idpag.16/relcategoria.1021/relmenu.41
- Mazowiecki and Warminsko-Mazurskie (Poland)
  - The Regional Agricultural Advisory Centres i.e. Mazowiecki Ośrodek Doradztwa Rolniczego (http://www.modr.mazowsze.pl/) and Warmińsko-Mazurski Ośrodek Doradzta Rolniczego (http://www.w-modr.pl/),
  - Regional Energy Agencies i.e. Mazowiecka Agencja Energetyczna (http://www.mae.com.pl) and Warmińsko-Mazurska Agencja Energetyczna (www.wmae.pl),

  - State Research Institute of Soil Science and Plant Cultivation – IUNG (http://www.iung.pulawy.pl/),
  - The Central Statistical Office (http://www.gus.gov.pl) – particularly with regard to Agricultural Census 2010
  - The Ministry of Agriculture and Rural Development (http://www.minrol.gov.pl/) and its institutions, i.e. The Institute of Technology and Life Sciences (http://www.itep.edu.pl), The Institute and The Agency for Restructuring and Modernisation of Agriculture – ARiMR (http://www.arimr.gov.pl/) or The Institute for Land Reclamation and Grassland Farming – IMUZ (http://www.imuz.edu.pl/)
  - Energy Regulatory Office - URE (www.ure.gov.pl)
- Northern Upper Austria and Carinthia (Austria)
  - Österreichischer Biomasse-verband - http://www.biomasseverband.at/biomasse]
  - Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft [in particular its annual „Green Report"]
  - Regional Ministries for Agriculture or Energy
  - ARGE Kompost & Biogas Österreich - http://www.kompost-biogas.info
  - Austrian Energy Agency - http://www.energyagency.at/

The data collected will be used as input in Themes 3 and 4. Data can serve as a reference for analysis of farm data to be collected in Phase 2 and provides key information for model parameterisation in Phase 3.

6.4 Phase 2: implementation of a farmer survey

A core activity of Themes 3 and 4 is the systematic collection of information from farmers providing a better understanding of the type of RE occurring on different types of farms the reasons and local and farm factors influencing the adaptation of RE activities and the contribution of these activities to farm income, environment and wider regional development. The data are collected in a field survey with the help of questionnaires in selected case study regions (see Chapter 5). Activities include farmer selection and identification, questionnaire design, data collection and analysis of the results.
The questionnaires have to be filled in by 800 farmers in the case study regions. Farmer selection is done by regional partners (Ecologic, IEO, SoriActiva) using local data sources and contacts to obtain a representative sample of the farm population in the region. It is crucial that questionnaires are filled by representative samples of the farmers (e.g. farmer's age, farm type). Therefore, the farmers have to be selected in a stratified random way. A key stratifying factor will be RE-activities on farms. Therefore, steps must be taken to ensure that sufficient RE-farmers are selected for the survey. This could mean that RE-farmers are relatively over-represented in the total survey population.
It is proposed to apply random sampling in regions where 50% (or more) of the farmers invested in RE. In regions where less than 50% of the farmers invested in RE, measures are taken to guarantee that half of the questionnaires is filled in by RE-investors. The remainder can be filled by a random sample of the farmers. This approach will guarantee reliable results.
Ideally, farm data collection must be similar in each of the four countries. Due to local differences (e.g., distances, infrastructure, internet accessibility), however, some variation must be expected. Therefore, the local partners are given the opportunity to select the way to distribute the questionnaires (provided they follow selection criteria discussed above). Methods used for collecting the questionnaires include the internet (Germany, Austria), telephone interviews (Spain, Poland) and farmers meetings (Germany, Austria).
The questions included in the questionnaire can be used to answers all the points raised in the tender (point 4B, page 31 in tender). Relatively little attention is given to food security. The impact of RE on food security will be mainly captured by the modelling phase.

The survey is expected to generate a lot of detailed information which, sometimes is difficult to interpret in the light of RE technology or policy development in a given region. Local conditions not related to RE (or RE or agricultural policies) may play a role. This may make differences between regions selected (e.g. between the two regions selected in Germany, Poland, Spain or Austria) difficult to explain while evaluation of the results in terms of effective RE policies may be disturbed. Interpretation of preliminary results therefore will be discussed with (representatives of) regional and national experts on (on-farm implementation of) RE for each of the four select countries. Objective and setup of the so-called ´focus group meetings´ is discussed below.

6.4.1 Design of the farm data survey questionnaire

At the beginning of the questionnaire, farmers are informed about the idea/background of the study (see page 1 of questionnaire). Filling-in the questionnaire will take approximately 30 minutes, but will depend on the way of collecting. Answers will be stored in an Excel database to be provided to the Theme leader.

Questionnaire – part 1
The first part contains general questions on farm, farmer characteristics and economic performance of the farm. Answers from this part of the questionnaire will allow us to determine which specific farm and farmer characteristics influence the decision to invest in RE or not. The general information can be divided into 3 Topics (Table 6.2).

Table 6.2 Brief description of the questions included in part 1 of the questionnaire (general information about the farm).

Topic	*Brief description of questions*	*Questions in questionnaire*
Farmer information	Age, years of experience, education level, successor available, working hours	2, 3, 4, 5, 11
Farm information	Area, kind of farm, size, employees	1, 6, 7, 8, 9, 10, 12, 13
Economic information	Farm income, solvability, investments	14, 15, 16, 17

Questionnaire – part 2
The second part of the questionnaire consists of nine general statements (question 18) about social conditions, price levels of agricultural products and energy price levels. The farmers are asked to indicate to what extent they agree with these statements (fully agree, agree, agree nor disagree, not agree, not agree at all). With the answers of this part of the questionnaire it will be possible to relate the social and personal conditions of the farmers to the willingness to invest in RE.

Questionnaire – part 3
The third part of the questionnaire consists of questions on barriers which limit the up-take or investments in RE and on factors which may favour RE investments. Additionally, there are questions on the impact of RE investment on the farm business. Part 3 is designed in such a way that it consists of different questions for farmers who did already invest themselves, and for farmers who did not invest in RE (Table 6.3).
First, all farmers have to fill in their energy use and production (question 20). Subsequently, for farmers who invested in RE, questions are asked on type of RE investment, total costs of investment, how investment is financed and return on investment, (questions 22 - 27). Subsequently, the farmers who invested in RE have to fill in to what extent they agree with 9 statements (5 classes, varying from “fully agree” to “fully disagree”) on the impacts of RE investments on the farm business. It is for instance asked to what extent they agree with the statement: “The total income from my farm is much more compared to before the RE investment”. Subsequently, in question 29, 8 possible reasons why farmers invest in RE are given and farmers need to indicate to which extent they agree or disagree with these reasons. Additionally, farmers who invested in RE are asked what unexpected problems they have encountered during/after the RE investment (for instance, availability of loans) (question 30).

Question 31 suggests 15 possible reasons why farmers did not invest in RE. Farmers who did not invest in RE have to indicate to what extent these reasons were applicable to their personal situation.. This allows us to determine which reasons to not invest in RE were the most important.

Questionnaire – part 4.
Part 4 concerns the expectations for the future. Farmers who did not invest in RE also have to indicate if they consider investing in RE (question 32). If they do they are asked to explain why. Additionally, all farmers have to give their opinion on the impact of RE-investments on the environment (question 34).

Table 6.3: Brief description of the questions included in part 3 of the questionnaire

Questions filled in by	Brief description of questions	Questions in questionnaire
Farmers who invested in RE	General information General information about RE investment Impact RE on farm business Reasons why invested in RE Problems during RE investment Impact RE on region	19-21 22-27 28 29 30 34
Farmers who did not invest in RE	General information Reasons why not invested in RE Considering to invest in RE? Reasons to consider RE investment Impact RE on region	19-21 31 32 33 34

The questionnaire will collect information on investment costs, on-farm energy costs, solvability, and economic returns, plus the perceived impact of RE investments on non-RE (agricultural) on-farm production. This information is mainly of relevance for Theme 3.

Theme 4 covers indicators for RE investments, plus issues related to income, employment, investments and policies (see Table 1 in the proposal). These are addressed by specific questions (for details Table 6.4).

Table 6.4: Indicators and crucial elements captured by different questions in the questionnaire.

Indicators	***Captured in questionnaire by questions***
Farm income	14
Regional employment	28 (statement 9)
Crucial elements	
Investment costs	17, 24
Local capacity	20
Policy support	26, 29 (statement 4 and 5)
Subsidies	26, 29 (statement 4 and 5)

Farmers who invested in RE answer 30 questions; other farmers have to answer 24 questions. Especially for farmers who did invest in RE, it will be difficult to end the questionnaire within the proposed 30 minutes. A critical view on the questionnaire did us decide to include all questions because all of them are important to answer the objectives of Theme 4.

6.4.2 Analysis of survey data

All answers to the questions in the questionnaire will be filled by the case partners in a Microsoft Access database which then is sent to WUR-BEC for analysis. The statistical analyses will be carried out in SAS (version 9.2). Answers will first be analysed using descriptive statistics. Statistical differences will be determined with a t-test or a chi-square test. An example of a table with descriptive is given (Table 6.5). Averages and standard deviations of the responses in different countries, different regions, and for different groups of farms will be given. Significant differences will be discussed, providing insights in differences between groups. The significance level will be set at 0.05. Special attention will be given to a pairwise comparison of the regions in the four countries surveyed.
Analysing questionnaires using descriptive statistics and multivariate techniques is common scientific practice. Examples are given by Oude Lansink et al. (2001), Aramyan et al. (2008) and Oude Lansink and Pietola (2005) who used this approach to get insight in factors underlying investment decisions of producers in Dutch horticulture. The latter present tables with descriptive statistics (mean and standard deviation) to give a summary of the answers given in the questionnaire. Subsequently, the results of a probit model were presented to indicate which factors significantly explained the decision to invest. Studies listed above show that output tables (on descriptive statistics and multivariate models) can be used to draw conclusions. The example tables presented in this deliverable give a complete overview about the barriers and forcing factors that influenced the decision to invest in RE or not.

In each of the regions, efforts will be made to ensure that the RE farmers are reached. However, it is expected that in the sample, the number of farmers who did not invest in RE will be higher than the farmers who did invest in RE. In order to get a correct estimation of the statistical differences within and between regions, a statistical weighting will be employed. For this method, the real percentage of farmers who invested in RE in the region is necessary. This number is provided by the case partners and will be used to correct the result in such a way that the results can be interpreted in the right way.
The data collection is not substantially differing between the regions within a country. So, it is expected that reliable comparisons can be made between regions within a country. For instance, in Spain all questionnaires are filled-in via personal interviews.
Note that all numbers in this table are *imaginary*, and must be used for illustration purposes only. Based on the *imaginary* results in Table 6.5, it can be concluded that the farmers who invested in Saarland significantly more often have a successor than farmers who did not invest in RE. Also farmers who invested in RE have a higher energy use on the farm than farms who did not invest in RE.

Table 6.5. Imaginary descriptive statistics on farm and farmer characteristics for interviewed farmers in Saarland (Germany) (n = 200). Standard deviations are given between brackets. The p-value indicates whether the distribution over the levels is different between farmers who invested in RE and farmers who did not invest in RE.

	Invested in RE (n=50)	*Not invested in RE (n=150)*	*p-value*
Average age of farmer (years)	42 (5.3)	45 (6.1)	0.521
Successor on the farm			<0.0001
Yes	45	70	
No	5	80	
Kind of farm			0.320
Arable	10	40	
Livestock	20	60	
Arable + livestock	5	110	
Forest	3	10	
Horticulture	12	30	
Total utilized agricultural area (ha)	50 (10.2)	55 (11.3)	0.681
Income from non-farming activities			0.351
Yes	5	25	
No	45	125	
Working hours at the farm			0.251
Part-time	3	8	
Fulltime	47	142	
Yearly family income			0.621
<€20,000	40	110	
>€20,000	10	40	
Money invested in non-RE			0.520
Yes	40	80	
No	10	70	
Electricity use on farm			0.040
None	2	25	
Low	0	25	
Medium	28	80	
High	20	20	

Also an overview of the reasons why farmers invested in RE will be given, for example as in Table 6.6. (Note that all numbers in this table are *imaginary*, and must be used for illustration purposes only). Based on the imaginary results in Table 6.6, it would be concluded that the most important reasons to invest in RE were 'problems with the energy supply for the farm/household', 'the possibility to get a subsidy to finance the RE investment' and 'the willingness to produce own energy to be independent from rising costs for energy prices'.

Table 6.6: Imaginary number of answers on the question: "I did invest in RE because" for the farmers who did invest in RE in Saarland (hypothetically: n=100)

	I fully agree	*I agree*	*I agree nor disagree*	*I do not agree*	*I do not agree at all*
To contribute to an environmentally friendly energy supply	3	30	60	2	5
I had a problem with energy supply for my farm/household	40	40	10	5	5
I could get a guaranteed price/ income for a fixed period of time	30	45	10	5	10
I could get subsidies to finance the investment	55	25	5	10	5
I had the opportunity to join an initiative in the neighbourhood/ unions/ communities/ foundations.	10	12	68	2	8
I want to produce my own energy to be independent from rising costs for energy prices	50	35	10	2	8
I wanted to make better use of residues and waste from my farm (e.g., manure, crop residues)	15	25	40	10	10
I needed to diversify sources of income	20	25	50	2	3

The responses to the questions in the questionnaire may be affected by several factors simultaneously. Therefore, multivariate statistics will be used as well. A random-effects probit model will be developed to determine which joint effects influenced the decision to invest in RE or not. Also plausible interaction terms will be tested. An example of a results from the probit model is given in Table 6.7, providing *imaginary* results to be used for illustration purposes only.

All variables in Table 6.7 significantly contributed to the information whether farmers did or did not invest in RE. If farmers have a successor the odds ratio is 3.45. This means that farmers with a successor are 3.45 times more likely to invest in RE than farmers without a successor. If farmers agree with the statement "I expect energy prices to rise over the next few years" they are 1.92 times more likely to invest in RE than farmers who disagree with that statement. All p-values are below the significance level of 0.05. This means that all variables presented in Table 6.7 significantly contributed to the decision to invest in RE. With the information like in Table 6.7 the objectives of Theme 4 can be answered. For instance, from these tables it can be concluded that not being connected to the grid, having a successor, being concerned about the environment and the expectation that energy prices will rise in the next few years are factors that favour the decision to invest in RE in Saarland.

Additionally, interaction terms will be tested (not shown in the table). For instance, to test whether farmers who are concerned about the environment and who have a successor are more willing to invest in RE than farmers who are concerned about the environment but who don't have a successor.

The questionnaire will give insight in the impact of RE-investments on the farm's environment and the region (question 34). An example of a table presenting *imaginary* results is given below (Table 6.8). Results in Table 6.8 are presented for all farmers in Germany, but they can be divided according to region of respondents (Saarland or Brandenburg) or whether the farmers invested in RE or not.

6.4.3 Focus Groups

Questionnaire outputs and analysis results will be discussed with experts on agriculture and rural RE production. For each of the case study countries, a focus group will be used to improve the interpretation of the results. Aim of the focus groups is to validate the region-specific results related to the impact of on-farm RE implementation (Theme 3) and factors affecting on-farm RE investments, opportunities and barriers (Theme 4) with local experts with a good knowledge of RE or farming in the region.

Objectives:

- Evaluation of the quantitative analyses from Theme 3 (impact on farm income, farm labour, and farm investments);
- Are impacts under or overestimated in the quantitative analyses in Theme 3?

Table 6.7 Imaginary results of the analysis on the variables that effects the decision to invest in RE in Saarland in Germany (n=100). Estimated coefficients, standard error (SE) for the coefficient, odds ratio (OR), and significance level are given for each variable.

Variable	B	SE	OR	P-value
Intercept	-7.167	0.267		
Successor				0.0210
Yes	1.237	0.479	3.45	
No	Ref	-	1.00	
Electricity use from grid				0.0485
Yes	Ref	-	1.00	
No	0.712	0.182	2.04	
"I'm concerned about the				<0.0001
environment"	0.910	0.262	2.49	
agree	0.200	0.080	1.22	
nor agree, disagree	Ref	-	1.00	
disagree				
"I expect energy prices to rise over the next few years"				0.0385
agree	0.650	0.185	1.92	
nor agree, disagree	0.08	0.003	1.08	
disagree	Ref	-	1.00	

- What opportunities are available to local farmers based on the results of Themes 3 and 4?
- Do the observed barriers for RE investments and factors that have favoured RE investments (based on analyses of questionnaires for Theme 4) make sense given the regional situation?
- What barriers are missing in the analysis of Theme 4 and which barriers should have a higher priority according to the experts
- What are promising examples in your region or in other regions in which the barriers identified have been overcome?
- What factors that have favoured the production and investment in RE are missing in the analysis of Theme 4?

Table 6.8 Imaginary number of answers on the question:" Can you indicate to what extent you agree with the following statements" for the farmers Germany (n=200)

	I fully agree	*I agree*	*I agree nor disagree*	*I do not agree*	*I do not agree at all*
There is an observable, ongoing change due to RE in my region	20	50	100	10	20
Farm land rents and farm land prices have increased due to RE	10	10	150	20	10
Costs of fodder for livestock have increased due to RE, animal raising farmers complain	10	20	100	50	20
Market prices for agricultural products have improved due to RE	50	40	40	30	40
Enterprises in my region which use inputs from agriculture or forestry find it increasingly difficult to source their feedstocks and to compete with energy use.	50	20	50	40	40
Economic prospect and quality of life is improving in my area	50	60	10	40	40
The overall economic situation of farming is improving due to RE	60	50	30	20	40
RE energy accelerates modernization and innovation in my area	90	50	20	20	20
RE improves acceptance of farming	80	50	10	30	30

Organisation:

- One focus group will be organised per country studied in order to allow comparison of results for two case regions in a given country. Eventually a focus group can be organised for each of the regions in a specific country if this is deemed more fruitful.
- Basis for the discussion are the preliminary results of the analysis of questionnaires which is expected around 15 May 2011.
- Each focus group includes regional and national experts on farming as well as on RE production a representative of the research consortium.
- Each focus group lasts approximately 2 hours, starting with a presentation on the results of the project, with specific reference to Themes 3 and 4.
- Minutes will be made.
- Focus groups will preferably be organised in second half of May 2011, to allow the results to be considered in the Consortium Workshop (scheduled for 31 May – 1 June).

6.4.4 Thematic issues

Results of the survey will be used to address specific research questions as defined for Themes 3 and 4. Questions that are expected to play a role in this analysis are listed in Table 6.4. Outcomes of the questions are to be interpreted in the light of general data for case studies (on farm structure, on RE production and involvement) as collected in Phase 1.

Major outcomes for **Theme 3** refer to the interaction between farm structure and RE involvement by farmers, plus – more basically – the impact that RE production will or can have on non-RE productivity. Impact in this respect can be analysed along two lines: availability of resources (substitution of land, labour and capital previously available for the production of food and feed) and resource productivity. It is essential that the combined impact of availability and productivity will considered in the analysis, thus assessing the net effect of RE-production on traditional agricultural yield.

Analysis for **Theme 4** will follow a similar approach as defined for Theme 3. It will refer specifically to the following research questions, i.e. to

(i) identify main factors that have favoured production and investments in RE by the agricultural sector, and
(ii) identify and analyse the main barriers that have limited, refrained or delayed RE production and investments.

A final result of Phase 2 (Collecting and analysis of farm survey data) is the use of the questionnaire to define parameter values for perspective modelling (Theme 3). This is described below (6.5).

6.5 Phase 3: Prospective modelling of RE impacts

6.5.1 Introduction

Theme 3 focuses on the relation between farms (farm types), RE production and the environment. It describes how existing farm conditions (farm structure including crop area, number of animals, current energy use but also room to invest, labour availability and farmer´s perceptions and preferences) affect willingness and capability to invest in RE production capacity. It also analyses the impacts of RE on farms in terms of non-RE productivity, GHG reduction and income effect.
The focusis on the whole of the farming system, establishing a comprehensive analysis of the possible effects of RE vis-à-vis other farm enterprises and activities. In the selected case study regions, Theme 3 sets to answer the questions as discussed in the beginning of this Chapter (Section 6.1). The analysis in Theme 3 focuses on impacts in terms of the indicators like farm income, substitutability of farm enterprises, GHG emissions, farm labour and investment costs. Substitutability of farm enterprises refers to the replacement of one farm enterprise with another, for example, growing energy maize as a RE

activity instead of growing silage maize for dairy cattle. For analysing the substitutability of farm enterprises, a crucial step is the specification of possible on farm RE activities with case study partners. The specification of possible on-farm RE activities for a given farm type will be done in terms of yield levels, variable costs, investment costs, economic returns (gross margin), energetic returns, required inputs of by-products sourced off-farm, required inputs of on-farm products and by-products produced after RE processing and their on-farm use. This will facilitate a comparison of productivity both before and after on-farm RE implementation.

Several methods or sources of information are available for the analysis: *A*. the results of the questionnaire analysed with respect to Theme 3, *B*. the characterization of activities (both RE and non RE) and their fit with current farm structures, *C*. prospective modelling and *D*. additional material collected through expert-interviews, literature review and a validation focus group in the case study regions. Table 6.10 describes the relationships between aspects mentioned in the tender specifications, relevant indicators and methods used to address these. With the methods available, some aspects described in the tender specifications get more attention than others. For example, models may be strong in analysing the input-output relationships with a whole farm perspective, that shows the trade-off on conventional or currently common farm structures. The questionnaire, literature review and focus group for validation of questionnaire results as described above will follow table 6.9 and other requirements to achieve a comprehensive analysis.

Table 6.9 Main questions, relevant indicators and methods of investigation

Extractions from **Tender specifications**, identifying the main points to be covered by Theme 3.	**Indicator**	**Method** (shortened to questionnaire (A), activity description (B), modelling (C), and additional material from case studies (D), see text above
Structure of farms producing RE	Farm structure, farm size, activity mix	Questionnaire and model implementation
Different types of farms involved in RE production	Farm type	Questionnaire for current situation and model for future analysis
The existence and role of farm networks	Participation in networks	Questionnaire, and additional material from case studies
Existing competition for raw material and land	Substitutability of farm activities, types of land used for RE	Activity description, modelling
Analysis of input and output flows	Substitutability of farm activities, energy balance, nitrogen balance	Activity description, modelling
Feedstocks used for RE production on farms and/or other outlets for RE production elsewhere	Input types for RE	Activity description, modelling, and additional materials from case studies
The outlet of the RE and RE sources produced on farms.	Outlets	Additional material from case studies
Final destination of by-products or residues from the production of energy or energy sources	Outlets	Additional material from case studies, activity description
Integration of RE production in conventional farming activities and its implications	Substitutability of farm activities, productivity, environmental effects	Modelling
Effects of including RE production in farm activities, the role played in the economy of the farm in terms of income level and stability, costs, financial conditions and risk exposure	Farm income, Investments in RE, Gross margins on RE.	Activity description, modelling
Factors that contribute to the economic success of RE investments	Support measures, local factors	Questionnaire, and additional material from case studies
The role of new technologies, practices, markets and legal developments in RE development	Types of RE adopted	Questionnaire, and additional material from case studies
Integration of RE production in conventional farming activities and its implications	Substitutability of farm activities, productivity, GHG balance, nitrate balance	Modelling

Here, emphasis is on the specific methods relevant to Theme 3, which is the use of modelling and activity description. Identification of on-farm RE activities in the case regions, linking the type and extent of RE activities to farm characteristics in terms of available resources (e.g. land, labour, investment potential, crops, crop residues and manure), current energy use, farm productivity, general farm conditions and farmer´s preferences and perceptions as well as to existing regional conditions using primary and secondary sources has been described above.

6.5.2 Analytical framework

Different analytical tools can be used to assess changes in farm activities and production following implementation of RE-activities. Methods such Multi-Agent Systems, Environmental Risk Mapping, Life Cycle Analysis, Environmental Impact Assessment and Agri-Environmental Indicators are reviewed in Payraudeau & Van der Werf (2005). Bio-economic farm models have advantages: (i) they are based on a constrained optimization procedure and thereby seem to match the reality of farmers, striving, with limited resources, to improve their lot (Anderson *et al.*, 1985); (ii) many activities, restrictions and new production techniques with sound technical specifications can be considered simultaneously (Wossink *et al.*, 1992; Pacini, 2003; Weersink *et al.*, 2004), including linkages between crop and livestock production (Antle and Capalbo, 2001); (iii) the effects of changing parameters, for example prices, can easily be calculated through sensitivity analysis (Wossink *et al.*, 1992), and (iv) they can be used both for short term predictions and long term explorations (Van Ittersum *et al.*, 1998).

Specifically in the case of on-farm impacts of RE, bio-economic farm models have the advantage that they can represent the farm decision making according to economic rationality, whereby it can be inferred which activities would be successful on a farm. The assumption of economic rationality might not always be appropriate for each individual farmer, but to describe the decision making of representative farms for larger groups it is generally accepted.

Bio-economic farm models permit the (*ex-ante*) assessment of technological innovations and policies over a range of different geographic and climatic circumstances. As our bio-economic farm model, we will apply the Farm System SIMulator (FSSIM), developed in the SEAMLESS EU FP6 project to simulate farm decision making in the European (policy) context. FSSIM is based on constrained optimization procedure, in which it is assumed that a farm tries to maximize expected income incorporating a certain degree of risk aversion. To find the optimal expected income, FSSIM chooses between a large set of possible activities offered to the model. Each of these activities describe a production possibility on the farm as a comprehensive set of all inputs required (i.e. for arable, a rotation, seed, fertilizers, variable costs, labour, investment costs) to achieve a set of outputs (i.e. marketable product, by product, side (environmental) effects such as GHG emissions). The set of activities selected by the model is restricted by farm resources, for example the area of land available, the family labour hours, on-farm produced feed for livestock, or the possibilities for investment. Policies and technological innovations influence the selection of the farm activities from the complete set in the optimization procedure. Ultimately, the set of selected activities by FSSIM provide a farm plan. In different scenarios this set of selected activities will change. This will thendemonstrate the substitutability of farm activities based on scenario settings, such as policy parameters, technological innovations and price developments. The FSSIM model is unique as it has already been applied in 16 regions across Europe on multiple different farm types, which so far has not happened with other bio-economic farm models.

In FSSIM, farmers response is simulated given specific farming conditions and a large set of possible activities offered to the farmer including different types of RE. The model optimizes the choice for activities maximizing expected income. Changes in farm activities and structure result and their effects in terms of environmental externalities GHG-emissions) can be assessed from it. While CAPRI models the market and farmers response of the whole EU farming sector, the FSSIM model simulates typical farms within regions providing insight in the most likely RE activities to be taken up and related implications for farm income and GHG emissions. FSSIM results are not representative for the whole farming sector in a region but rather provide insight on the combination of farm and regional factors determining the adaptation RE activities.

In this project, FSSIM has to be extended to take account of investments required for RE and other farm activities. FSSIM utilises RE activities and constraints as defined on the basis of the questionnaire results and other regional specific information as inputs. FSSIM provides as output a selection of production

enterprises, relevant to the farm, which can be based on livestock, cropping or RE activities and calculates a set of whole-farm impact indicators that provide a comprehensive view of the impact on farm.
Farms are considered as economic enterprises, assuming to operate under an economic rationality, focussing on optimizing turnover and profit. Although the primary focus of the analysis is at the farm level, some of the indicators applied here can be upscaled to a higher (regional) level, as representative farm types are used instead of actual farm types. This applies to labour use, shifts in labour use found on representative farm types potentially can be upscaled by multiplying the number of represented farms with the labour use of the representative farm offering an indication of changes regional employment. However, in this way, the whole regional market of supply and demand for labour is not simulated, as the focus is solely on demand, implying that such upscaled impact indicators indicate the regional potential and an approximation.
The use of FSSIM enables linking the type and extent of RE activities to farm characteristics in a wider regional context (e.g. the whole farming system). As regards to farming conditions it involves available resources (e.g. land, labour, investment potential, crops, crop residues and manure), current energy use, farm productivity, general farm conditions and farmer´s preferences and perceptions.
The results of the questionnaire survey provide the basic input data for the FSSIM assessment. Beside these additional information collected by case partners from different sources will be a secondary information source. Both sources will provide valuable information related to on-farm RE investment choices made by farmers under a variety of personal, farm-specific, and regional conditions. It will allow an assessment of interactions between on-farm RE and traditional farming activities in three ways: (i) identifying which farming activities are positively correlated to (decision making for) on-farm RE production, (ii) assessing how on-farm RE production is interfering with traditional farming activities, e.g. competition for land, labour, inputs, and (iii) assessing how on-farm RE change the income and environmental externalities (GHG emissions, N-balance) .
The aim of this analysis is, further, to arrive at values for key parameters as investment costs, on-farm energy costs, investment possibilities (solvability) and economic returns and to analyse the impacts of RE farms. Impacts that can be deduced from the questionnaire are related to farm income and substitution of farm activities from conventional farming activities to renewable farm activities. The parameters derived from the questionnaire are supplemented with key-economic and biophysical management parameters to characterize RE-on-farm activities according to standard gross margin accounts, collected jointly with case study partners.
The second activity of Theme 3 encompasses perspective modelling, or the assessment of on-farm RE implementation following economic, policy and technical conditions in 2020. The analysis focuses on on-farm impacts and understanding the impact on the farm economy and production, i.e. substitution between alternative on-farm activities. Potential regional effects supply or demand effects can be indicated from the FSSIM runs, if these are done for the most important (dominant) farm types representing a large part of the farm population. FSSIM runs experiments on typical farms for a region. These farm types are represented in an EU wide farm typology (Andersen et al., 2007). For every farm type it is known how many of these are occurring in every region. Through the farmtype link it is therefore known how many farms are represented. Finally it should also be emphasised that FSSIM runs focus on on-farm impacts and do not consider the whole chain and regional infrastructure required to achieve RE activities. are only considered to a limited extent.. Bottlenecks in the supply chain or regional RE infrastructure are not considered as part of the quantitative analysis of Theme 3.

6.5.3 Methodology

The questionnaire provides information on farm structure, farming and on-farm RE activities. Results allow the identification of the factors affecting decision making on on-farm RE activities, as well as assessing to what extent on-farm RE activities affect traditional farming production practices. On-farm RE activities will be quantified through variables like variable costs, investment costs, economic returns (gross margin), energetic returns, required inputs of by-products sourced off-farm, required inputs of on-farm products and by-products produced after RE processing and their on-farm use. The quantified activities are regionally specific and need to be collected by case study partners through the survey and other data collection activities.
The questionnaire further provides region specific information on RE-investments, investment possibilities, suitable regional support policies and pricing schemes (or developments) and impacts of RE

on farms. Specifically, it will provide information on the room for manoeuvre farmers have in investment and the required investments for RE technology on farms. This information will be analysed to achieve estimates of investment costs, on-farm energy costs, solvability and economic returns. Table 6.10 provides an overview of questions related to this activity.

Table 6.10: Questions for Theme 3

Information needed for Theme 3	Questions in questionnaire
Investment costs	17, 24
On-farm energy costs	Can be derived from question 20
Solvability	16
Economic returns of RE investment	25
Impacts on non-RE production	28

Other parameters (i.e. by-products used in production and produced, gross margin, variable costs), not obtained through the questionnaire, required to achieve a comprehensive description of RE activities are compiled with regional case study partners by defining budgets of RE activities. These budgets are based on typical description of RE activities and describe both the biophysical and financial inputs and outputs (i.e. yield in terms of energy, variable costs, by-products required, physical yield, etc).
For information on on-farm RE impacts already available a first scan of sources revealed that such information would be more difficult to find and requires a dedicated literature search and expert consultation in the regions, as part of the data collection efforts. For this aspect, which is a necessary part of the analysis for theme 3 in the case study regions, up to 5 experts will be consulted and a 1 day literature search will be executed.
With complete budgets and RE activity specifications, RE farm impacts can be deduced in terms of quantitative implications. For example, if a farmer aims to invest an amount X in RE on his farm, what does this mean in terms of GHG emissions if he chooses activity Y? With such reasoning steps focusing on implications of choices and the impact on the current situation, an estimate can be made with FSSIM of the actual farm impacts (i.e. income, GHG emissions, energy use, activity substitution and investments) occurring at present or in the foreseeable future. These FSSIM analysis can only be done if the case study data collection delivers enough quantitativeand consistent results.

6.5.4 Model background

FSSIM consists of two main components, FSSIM-Mathematical Programming (MP) and FSSIM-Agricultural Management (AM) (Fig. 6.1). FSSIM-AM comprises the activities in the BEFM, while FSSIM-MP describes the available resources, socio-economic and policy constraints and the farm's major objectives (Louhichi et al., 2010). Both components are jointly configured to simulate a mathematical problem of resource allocation depending on the farm type, agri-environmental zones, research question and data availability. The aim of FSSIM-AM is to describe current activities, generate alternative activities and quantify the activities through all the required technical coefficients. Inputs to FSSIM-AM are the RE activities defined with the questionnaire and regional case study partners. Alternative activities are new activities or activities currently not widely practiced in the study area, and include technological innovations and newly developed cropping or husbandry practices (Hengsdijk and Van Ittersum, 2002). Based on the farm typology, the Technical Coefficient Generator (TCG) quantifies inputs and outputs for arable, livestock or perennial activities or combinations of activities. The quantified activities in terms of inputs and outputs are assessed in FSSIM-MP with respect to their contribution to the farms and policy goals considered (Fig. 6.1)
FSSIM uses an integrated pan-European database, which includes datasets on biophysical variables (climate, soils, land use, topography), farming and farm management, crops and livestock, socio-economic aspects (prices, employment, production data, trade flows, income, etc.) and policies (international and EC policies, as well as national and regional policies). Important sources are the European soil map, climate data from the MARS (Monitoring Agriculture with Remote Sensing) database, Farm Accountancy Data Network (FADN), Eurostat and the GTAP databases (Hertel, 1997). In this project we will ensure that most recent sources are used.

For the type of integrated analyses described above it is necessary to link the different types of data, such as e.g. data from farm statistics, data on the biophysical environment and socio-economic data. This is done by making all data spatially explicit for a spatial framework combining administrative borders and biophysical characteristics to regions with assumed homogenous biophysical conditions for crop production. The framework starts with the so-called NUTS-2 regions that are divided into climate zones which are sub-divided into agri-environmental zones with homogenous soil characteristics. More details on the spatial framework is given by Van Ittersum et al. (2008).

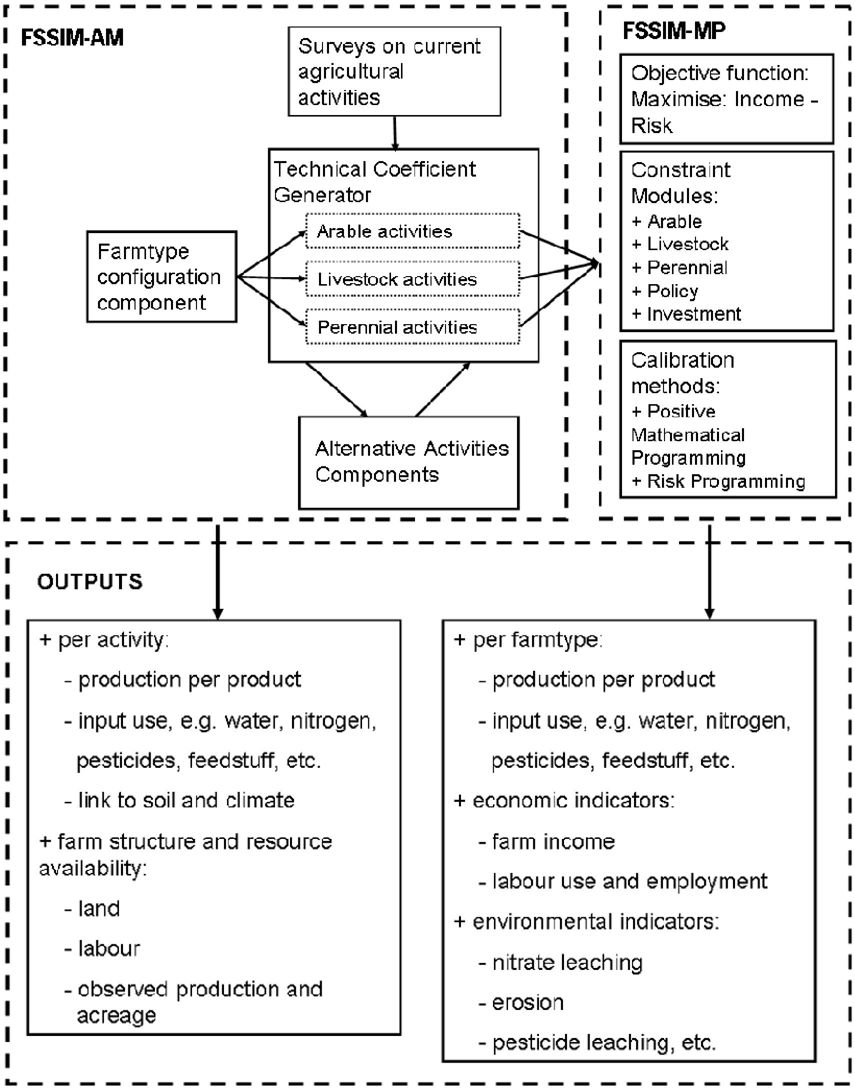


Figure 6.1: Overview of FSSIM with FSSIM AM and FSSIM-MP and the outputs of FSSIM

The variety of environments, conditions and farming systems across the EU-25 27 is enormous. Typologies assist in simplifying this vast amount of information into coherent groups that share the same characteristics. For SEAMLESS-IF typologies have been developed for (1) farming systems (based on farm size, intensity and specialisation/ land use – Andersen et al., 2007); (2) agro-environments (based on climate and soil characteristics) (Hazeu et al., 2010, and (3) socio-economic regions (based on population density, employment and income).

6.5.5 Data requirements and additional data collection for FSSIM

To complete the farm level analysis, different data sources need to be available: farm type data, biophysical data, policy data, RE balances of different RE activities and agricultural management data. Different sources are available already to the consortium:

- Farm type data, as made according to the SEAMLESS farm typology (Andersen *et al.*, 2007) and available in the SEAMLESS integrated database. The typology is based on the Farm Accountancy Data Network FADN (EC, 2008);
- Biophysical data, as made according to a biophysical typology (Hazeu *et al.*, 2010) and available in the SEAMLESS integrated database. The biophysical data is based on the JRC Interpolated climate data (JRC, 2008) and the European Soil Map (ESBN, 2008);
- Policy data, as based on the most recent CAPRI 2020 baseline runs taking into account the most recent CAP health check and the data collection on policy as part of Theme 1 of this project;
- RE balances of different RE activities as collected and compiled in Themes 1 and 2 of this project;
- Agricultural management data (i.e. gross margins, costs, yields, investments, nitrogen and water inputs of relevant crops and similar variables for livestock and perennial activities). These are available for a set of sample regions in the SEAMLESS integrated database, such as Brandenburg, Castilla y Leon, Podlaskie and Zachodniopomoskie. These data will be checked for correctness with case study partners, and for regions where no data is present at the moment, these will be collected in the context of this project. This applies to regions in Austria, Saarland, Warminsko-Mazurskie, Mazowieckie and Valencia. For an example of such variables as need to be collected, see Table 6.11 below.

Table 6.11 Sample of agricultural management variables required for crops

Variable	Unit
SowingDate	[]
Yield	[t/ha]
PestHerbizideApplicationNumber	[]
PestHerbizideApplicationIncredientKg	[kg/ha]
PestInsectizideApplicationNumber	[]
PestInsectizideApplicationIncredientKg	[kg/ha]
PestFungizideApplicationNumber	[]
PestFungizideApplicationIncredientKg	[kg/ha]
PestGrowthRegulation ApplicationNumber	[]
PestGrowthRegulation ApplicationIncredientKg	[kg/ha]
FertilizerNitrogenKG	[kg/ha]
FertilizerPhosphorusKG	[kg/ha]
FertilizerPotassiumKG	[kg/ha]
IrrigationMeanApplicationNumber	[days]
IrrigationMeanApplicationWaterM3	[m^3/ha]
Price	[EUR/t]
TotalRevenue	[EUR/ha]
CostsOfFertilizer	[EUR/ha]
CostsOfCropProtection	[EUR/ha]
OtherVariableCosts	[EUR/ha]
SumOfVariableCosts	[EUR/ha]
GrossMargin	[EUR/ha]
LaborDemand	[h/ha]

Sources for agricultural management data have been identified with case study partners:

- North East Brandenburg and Saarland (Germany)
  - Federal and regional ministries
  - Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V. (KTBL) – www.ktbl.de
  - Leibniz-Zentrums für Agrarlandschaftsforschung (ZALF) e. V. Müncheberg – www.zalf.de

- Valencia and Soria (Spain)
    - Soriactiva's own documentation
    - Farm Associations' advisory services: ASAJA (Young farmers association)
    - Agricultural Chambers
    - Bibliography from agronomy schools in Madrid and Soria, and from the Spanish Ministry on Agriculture and Environment (Ministerio de Medio Ambiente y Medio Rural y Marino).
- Mazowiecki and Warminsko-Mazurskie (Poland)
    - Central Statistical Office - Agricultural Census 2010 (not published yet), Agricultural Census 2002 and Agricultural Annual Reports,
    - Ministry of Agriculture and Rural Development
    - Agricultural Chambers
    - Pierwszy Portal Rolny (http://www.ppr.pl/)
- Northern Upper Austria and Carinthia (Austria)
    - Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft [in particular its annual „Green Report“]
    - Statistik Austria
    - Österreichisches Kuratorium für Landtechnik und Landentwicklung (ÖKL) – www.oekl.at

FSSIM data on farm types, policy data on CAP, biophysical data on soils and climate, are available from European data sources. Additionally the following data need exists:

1. Agricultural management data, i.e. how farmers are managing the crops, animals or perennial crops. This is information like costs, yield, nitrogen use, price, phosphorus use, biocide use, rotations for crops and perennials and herd composition, milk/meat production, costs, medicine use for animals. Based on past experiences we know that collecting this type of information requires about two days, and the idea is that you can get it from farm management handbooks or farm advisory services (for example, KTBL in Germany has this type of data).
2. Specific data on RE activities, RE infrastructures on farms and RE related regional policies. To adequately represent the regional situation on RE, we need to know in the various regions in what RE activities farmers are involved, what policies are at work for RE, what investments farmers made on farms and what capacity they have for producing RE.
3. Supplementary articles available on the impacts of RE on farms in the study regions (impacts in terms of income, investments, employment, returns-on-investment, energy produced, energy potential).

Results from the questionnaires are used to parameterize model investment modules, and assess whether farmers are likely to take up RE on farm under given policy and price developments. For the price developments, both of RE energy and non-RE energy, the questionnaire provides information on the farmers expectations. Representativeness of the data will further be improved using general data on farm structures from the questionnaire. This will improve representativeness of the modelling work.

6.5.6 Scenarios and experiments used

In order to perform with/without assessment of technological innovations, policies or societal trends, a Farm Structure Calibration year, a Policy Baseline scenario and one or more counterfactual experiments (Renewable Energy experiments) will be specified to simulate the research question with FSSIM. In this study, the counterfactual experiments will incorporate different national policies for RE and different technological options available to farms. They will be in line with the scenarios that have been introduced earlier (the ´pure NREAP´ and ´NREAP+Agri´ scenarios defined in section 4.3.3. under Themes 1 and 2). Consequently, modelling work in Theme 3 will be following all relevant policy changes while modelling outcomes will identify consequences of two sets of NREAP policy actions;

1) NREAP scenario: no specific support for RE on farms, so pure market driven.
2) NREAP+ scenario: several support and stimulation measures for on-farm RE development

The model analyses will thus be done for two types of scenarios (Table 6.12). The scenarios give information about the farming conditions (i.e. current arable farming systems and their main crop types), the outlook on the future (e.g. exogenous drivers, Table 6.12) and the implemented policies. For the farm structure information they are based on the Farm Structure Calibration year. The Farm Structure Calibration year is a reference year for which the model will reproduce the observed data on farm crop and livestock patterns. 2006 will be used as the calibration year, as this is the last year for which farm structure data are available. The Policy Baseline provides a counterfactual future reference situation, against which the Renewable Energy scenarios will be compared. It provides a policy baseline for the same year as the Renewable Energy Scenarios (2020). Policy changes made between the Farm Structure Calibration year and the Policy Baseline year (e.g. the Health check and the abolishment of set aside) have been incorporated in both scenarios.

Table 6.12 Definition of the Farm Structure Calibration conditions, and the Policy Baseline and Renewable Energy scenario(s)

	Farm Structure Calibration [2006]	**Scenarios**	
		NREAP [2020]	**NREAP+ [2020]**
Exogenous assumptions		Inflation rate of 1.9% per year	
Price & Yield	2006 price and yield	Projection in prices and yields from 2006 to 2020 accounting for market liberalization	Idem
Renewable energy policies	Not present	Policies already agreed upon	Additional renewable energy policies specifically targeting the farming sector
Set-aside	Set-aside obligation active	Set-aside obligation abolished	
Quota policies	Quota policies present	Quota policies changed and phased out	
EU compensation payment	2003 CAP reform (decoupled payment)	Health check implemented	

Farm Structure Calibration (2006)

The Farm Structure Calibration refers to the year 2006 with respect to the main part of the management and farm resource data. For modelling the base year, PMP (Positive Mathematical Programming) is used to calibrate FSSIM exactly to the observed activity levels (e.g. main crop rotations, areas of crops and perennials, numbers of livestock) of the base year. Data used are FADN farm statistics referring to the most recent year available in the SEAMLESS database. Simple survey data are derived from literature to define management, costs and prices, whereas FADN data are used to define the available resource endowments. The CAP 2003 Reform and the CAP health check changes (i.e., mainly decoupling of compensation payments) are implemented and its effects can be observed in the data available from FADN and CAPRI.

Historic production patterns (e.g. land use and animal levels) of the Farm Structure Calibration year are used to calibrate the model, e.g. ensuring that observed production patterns can be reproduced. Different calibration procedures have been incorporated and model behaviour is evaluated based on the percentage of absolute deviation (Kanellopoulos *et al*., 2010). The percentage absolute deviation (PAD) is defined as the absolute deviation between simulated and observed activity levels per unit of actual activity level. These calibration procedures have been tested in a back-casting experiment based on historical data by Kanellopoulos *et al.* (2010). Subsequently, a future baseline experiment is run using accepted and implemented policies. Results of this baseline experiment are used as benchmark for results of counterfactual experiments with the same time horizons. By using such calibration procedures and experimental set up, the overall aim of FSSIM is achieved, which is to simulate the actual farm responses through realistic and validated (e.g. positive) modelling (Flichman and Jacquet, 2003).

Baseline
The Policy Baseline scenario applies to the year 2020, i.e. the year for which NREAP targets have been set. It involves price and yield changes of crop products for that year. The CAP reform of 2003 and the Health check of 2008 (e.g. changes to SPS and further decoupling, abolishment of set-aside, phasing out of quota policies, reform milk and sugar markets) are taken into account (Table 6.12). The changes to the CAP currently under discussion for the period 2013-2020 will not be incorporated, as these have not yet been agreed upon and the project results for this project should not depend on ongoing discussions. The Policy baseline projections will be based for some drivers as mentioned in table 6.12 on the most recent CAPRI-DG-AGRI baseline which includes both the Health Check measures and the RES2020 targets[17](, (http://www.capri-model.org/). This baseline is a good starting point to evaluate the changes in farming systems over Europe in case of increased production of renewable energy. Experiments with such increased production of renewable energy on farms are described in Table 6.13.

Table 6.13: Values for prices and yields for four commodities in the four member states of relevance as extracted from the baseline scenario used, the CAPRI-DG-AGRI baseline.

	Product							
	Soft wheat		Maize		Rape		Soya	
Member state	Yield (kg/ha)	Price (Euro/t)	Yield (kg/ha)	Price (Euro/t)	Yield (kg/ha)	Price (Euro/t)	Yield (kg/ha)	Price (Euro/t)
Germany	8414.11	132.13	10842.16	118.78	4776.29	282.28		276.56
Austria	5607.99	112.72	13323.17	104.75	3011.87	369.68	3052.96	379.17
Poland	5464.67	119.53	6251.68	108.47	3491.17	285.75	3146.27	233.53
Spain	3312.22	167.6	13307.18	157.88	1532.02	369.65	2937.66	499.23

Renewable energy experiments 2020
The NREAP and NREAP+ are built on the same base line scenario (i.e year 2020, same policies, same exogenous drivers, same product prices) except for the included renewable energy supporr measures and thus the experiments. A number of different experiments may be specified which include options for the farmer to produce renewable energy in several ways and under different stimulation/support measures: a) use of present crops as wheat, rape seed and sugar beet for bio-energy, b) introduction of new crops as e.g. Miscanthus for bio-energy, c) introduction of second generation energy crops, d) introduction of energy production at the farm through biogas, windmills, etc. The effects from the introduction of large-scale renewable energy production on different farm types over Europe can be derived by comparing results from the NREAP and the NREAP+ scenario. Effects can also be compared to the 2006 baseline.
The outputs of FSSIM at farm scale are allocated areas with crop, grassland and perennial activities, or numbers of animals depending on the farm type considered. On the basis of optimal activity levels, different types of indicators will be calculated such as economic indicators for income, gross production and the share of subsidy in income, and environmental indicators for nitrate leaching, energy use, GHG emissions and erosion.

Use of CAPRI-Model runs
Given the relevance of EU agricultural policies and their implications on land use and agricultural production and, hence, on the outcomes of different elements of this study, this sub-section is devoted to specify the role of CAPRI model runs in the project.

[17] Output of this latest CAPRI baseline has already been made available to our consortium by Maria Blanco (Department of Agricultural Economics and Social Sciences Universidad Politécnica de Madrid, ETS Ingenieros Agronomos). Details on the role of CAPRI in the project are discussed below.

In this study use is made of most recent CAPRI model run results in several ways and for different reasons. Since 2007 the CAPRI market part of the model has been further extended to cover bio-ethanol and biodiesel production in the EU, and DDGS as a by-product from bio-ethanol production. In 2010 a study was executed for DG-Agri by JRC-IPTS using the extended CAPRI model to predict effects of the EU biofuel targets on agricultural markets and land use (Blanco Fonseca et al., 2010, Becker, et al., 2010ab). In order to make these predictions input-output relations were created between the AGLINK-COSIMO model and CAPRI. CAPRI takes the EU27 2020 biofuel demands from AGLINK (in a model shock) and then models the changes in supply and other demand (feed, food, processing) for biofuels feedstock (e.g. cereals, vegetable oils, sugar crops, etc.) in Europe and translates these further in changes in cropping and livestock patterns and new market prices by 2020.

This CAPRI assessment produced two scenario runs for 2020:
1) A baseline scenario assuming the implementation of the biofuel targets in EU.
2) A counterfactual scenario (No-RED) assuming a lack of implementation of the biofuel targets.
The CAPRI baseline results are used in this study. These results from CAPRI which became available in 2010 (December) have not taken into account the most recent CAP Health Check reform (2008). The baseline only reflects policies in force just prior to the CAP Health Check, including biofuel policies agreed in the Renewable Energy Directive. However, since January 2011 it has become clear to the consortium that an up-dated CAPRI Renewable energy target scenario run has been finalised. This up-dated run takes account of the most recent Health Check reform, the 2020 EU Targets and the most recent OECD-FAO projections on agricultural prices, population and welfare developments (EC, 2010) [18]. Further details on assumptions and the influence on bioenergy demand from implementation of RED Directive on 2020 projections a provided in the ox underneath. These most recent CAPRI results have only been made available to this consortium in the last week of March 2011. This implies that these most recent runs have not yet been integrated in the assessments reported in Deliverables 1 and 2. For the assessments in Theme 3 where CAPRI-output serves as input for the FSSIM model the most recent CAPRI output will be used.

Box 1; Policy assumptions and influence of biomass demand from RED targets on 2020 prospects for Agricultural markets and income in the EU

The most important assumptions regarding policy and macro-economic development in the 2020 prospective study are:
(1) *Phasing out milk quotas:* Milk quotas are increased by one percent every quota year between 2009/10 and 2013/14. For Italy, the 5 percent increase has been introduced immediately in 2009/10. Milk quotas are abolished by April 2015.
(2) *Intervention mechanisms:* Intervention is set at zero for barley and sorghum. For wheat, butter and skimmed milk powder intervention purchases are possible at guaranteed buying-in prices up to 3 mio t, 30 thousand t and 109 thousand t respectively. Beyond these limits intervention is possible by tender.
(3) *Decoupling:* The payments that some Member States kept coupled after the 2003 CAP reform will be decoupled and moved into the Single Payment Scheme (SPS) by 2010 for arable crops, durum wheat, olive oil and hops and by 2012 for processing aids and the remaining products, with the exception of suckler cow, goat and sheep premia, where Member States are assumed to keep current levels of coupled support.
(4) The Member States currently applying the *single area payment scheme (SAPS)* are assumed to adopt the regionalised system from 2014 onwards.
(5) *Set-aside:* The requirement for arable farmers to leave 10 percent of their land fallow is abolished.
(6) *Modulation (shifting money from direct aid to Rural Development):* direct payments exceeding an annual € 5 000 shall be reduced each year by 7% in 2009 up to 10% in 2012. An additional cut of 4 percent will be made on payments above €300 000 a year.
(7) All commitments from the *Uruguay Round Agreement on Agriculture* regarding market access and subsidised exports are assumed to be fully respected.

[18] EC (2010), Prospects for agricultural markets and income 2010-2020. http://ec.europa.eu/agriculture/publi/caprep/prospects2010/index_en.htm

(8) The main assumptions regarding macro-economic development include:
a) *Inflation rate* averaged at 1% in 2009, then increased to 1.8% by 2010 and is expected to stabilise towards 2020 to 2%.
b) The *EU population* is expected to show an annual growth rate of 0.4 to 0.3% per year over the projection period with a slightly higher growth rate in the EU15 and a marginal decline for EU12.
c) The *price of crude oil* is expected to continuously increase towards 2018 to 99 USD/barrel. In the 2 final years towards a slight downward projection is expected resulting in a 2020 oil price of 96 USD/barrel.

The use of the CAPRI results is very logical within the context of this project as it is the only study available which models EU-market and production responses at regional level (approx.. Nuts 2) for the whole EU27 territory. This makes it the only source of information available giving a plausible overview of what land use changes can be expected by 2020 and to which extend they can be related to dedicated bioenergy cropping and other RE activities on farms. It also provides predictions of new 2020 market and income parameters for agricultural products (e.g. prices, demand, supply, farm income) and therefore also provides an important source of exogenous information for modelling farmers individual responses to policy and market incentives for development of Re activities on farm. The emphasis in the CAPRI run (Blanco Fonseca et al., 2010) is on predicting biofuel cropping response. However, in addition to this specific information it also provides detailed information on the agricultural land use cropping patterns and livestock patterns. This implies that in a post model process the CAPRI model output serves as an excellent basis for two main activities in this project[19]:

First, it provides additional information that can be used in the scenario approaches in **Theme 1 and 2 to make more quantitative predictions of RE production on farms in 2020** and translate these further into agricultural energy and GHG balances.
Second, it serves as a basis of input information for model runs implemented in this project with the **FFSIM model for predicting individual farmers response to policy and price incentives to set up RE activities** (Themes 3 and 4).

Ad 1) In the Theme 1 and 2 scenario approaches the following information provided by CAPRI is of particular relevance:
1) Land use and land released from agriculture between 2004 and 2020 potentially available for dedicated cropping of (woody) biomass (on land not competing for food or feed production)
2) Straw potential in 2020 (based on cereal cropping area+yield level+competing uses for straw)
3) Woody by-products (pruning material) from agriculture derived from fruit and nut trees, citrus, vineyards, olive trees.
4) (Excess) manure potential (based on number and type of animal heads per region in 2020 matched with land use to calculate nitrogen and manure production per hectare).

The above parameters can be used in the scenario approach in 2 ways:
1. As an additional source of information on where (which regions) dedicated cropping for biofuels and perennial biomass crops is more or less likely to happen by 2020.
2. As an additional source of information on where (which regions) agricultural potential for RE development for biogas (manure) and solid biomass production (straw, prunnings and dedicated perennial cropping) is more and less likely to be develop by 2020.

In the scenario approaches in Themes 1 and 2 the most important basis for predicting RE-production on farms is the detailed NREAP targets information 2010-2020. However, NREAP targets do not provide information detailed information on dedicated cropping targets as no distinction is made between biofuel, woody and biogas crops. Furthermore no distinction is made between biogas types. The CAPRI 2020 data can therefore be used as additional information to identify farming regions with no and high potential to contribute to production of different types of RE-targets set in the NREAPs.

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[19] Alterra (coordinating partner) is well informed about CAPRI output data. Alterra is working for the EEA on an up-date of the study 'The environmentally compatible biomass potential from agriculture' (EEA, 2006). In this up-date CAPRI output data are used in a post-model analysis to make new prediction of the 2020 biomass potential from agriculture.

Ad 2) The FSSIM model in this project is used in Theme 3 to investigate under which circumstances farmers may invest in RE on their farms, what types of RE are most likely to be taken up in what type of regions and by what type of farmers, what financial and income implications and GHG gains are connected to different types of RE. FSSIM simulates farmers response. The results are specific to a typical farm type in a typical region. In order to simulate the farmers response a lot of input information is needed. CAPRI-model output on the price and yield levels for farm activities in 2020 is one of the main information sources used for the FSSIM simulations. These are to be done for a Policy Baseline scenario in the year 2020, i.e. the year for which NREAP targets have been set. This policy baseline has been taken into account already in the mist recent CAPRI run and includes the CAP Health check of 2008 (e.g. changes to SPS and further decoupling, abolishment of set-aside, phasing out of quota policies, reform of milk and sugar markets) and the EU RE targets 2020.

6.6 Reporting

Results from analyses of questionnaire data will be reported separately, as will be outcomes of the modelling exercise. The use of questionnaire results in the modelling will be described in the reporting, to clearly demonstrate the assumptions in adopting the data. In a separate section, outcomes of both exercises from Themes 3 and 4 will be compared, and the degree to which these complement each other will be described.

6.7 Boundary conditions

The study on the RE impact on farms will have a number of limitations. These limitations are derived from the scope of the study as well as from the practical limitation of available data.

The following boundary conditions apply:

- Geographical scope: case studies in EU, which might not give a representative sample for the whole farming population.
- Scenario: the scenarios will cover some diversity in all the policies available, but they certainly cannot capture all diversity in possibilities available.
- The saved and avoided impacts of RE on farms will be evaluated for 2008 and 2020 respectively.
- Model: FSSIM assumes a certain type of farm behaviour (economic rationality with respect to income and risk), so the results are not an actual prediction of future farm behaviour and explain how an aggregate group of farms will behave in the future.

7 TASK 2.1: LITERATURE REVIEW

The tender requires:

a) to review literature concerning relevant RE markets and specific case regions, development of RE in the agricultural sector, relevant technological progress, economic and environmental effects on farms, and

b) to review relevant documents of national, regional and Community administrations, and in particular the RE National Action Plans. This review will be extended with additional sources to provide an overview of national and, where appropriate, regional level policies in support of production and consumption of RE on farms.

Both reviews are discussed below. Results are presented further in this chapter and in the Annexes.

7.1 Approach

With respect to markets **(point a)**, the review will mainly be a qualitative description of the markets for those types of RE, which farmers can engage in, thus wind, solar, biomass & biogas. Each market description is organized as a chapter (please see **Annex II**) with the following sections covering a number of points:

1. Introduction

2. Current status of the technology, including:
    - technology description,
    - recent development,
    - types and average size of installations,

3. Main actors
    - types of operators,
    - Their interaction with farms

4. The role of wind/solar/biomass/biogas energy in agriculture
    - development of the RE technology in the agricultural sector
    - economic and environmental effects on farms
    - a qualitative assessment of the contribution of agriculture to production and consumption of RE & exchanges with other sectors

5. Development in case study reagions

6. Prospects
    - technological progress and perspectives in the agricultural sector

A summary of the results is presented in Section 7.2.

As for policies, **(point b)**, a policy overview is presented covering:

1. EU-level policies
2. Policies in the individual Member States (short overview of main policies).

Main results are presented in **Annex III**.

7.2 Markets

Market descriptions will be presented here based on the literature review presented - in detail - in the Annex. Currently, only results for solar energy (PV, CSP, solar thermal) are available. Texts for wind, biogas and solid biomass will be added as soon as these become available.

7.2.1 Wind

TO BE ADDED

7.2.2 Photovoltaic power (PV)

In 2009, the OECD as a whole produced 18 799 GWh of PV electricity in 2009, roughly 1% of its total renewable electricity production. The two largest producers of solar photovoltaic (PV) electricity in the OECD were EU member States Germany with 6 200 GWh and Spain with 6 103 GWh (IEA, 2010). While being small in absolute terms, electricity from solar PV increased from 19 GWh in 1990 to 18 799 GWh in 2009, achieving a 44% annual growth rate, the fastest of all renewable electricity technologies. However, it needs to be stressed, that accounting for solar photovoltaic output is very difficult due to the widespread use of off-grid and small grid-connected systems for distributed power generation. For that reason, solar photovoltaic output statistics should be considered incomplete.

While the technology of PV systems (and Concentrating Solar Power alike) has matured, their share in electricity generation is still small in Europe. This is because electricity from PV (or CSP) is rather costly compared to fossil-fuel based electricity generation (Comor, 2009). A main impediment to large-scale use of PV (or CSP) in agriculture, is therefore their relatively high cost. However, feed-in tariffs for PV systems have become widely available throughout the EU to overcome this cost barrier.

Technology

Photovoltaic (PV) systems consist of *modules* (based on PV cells) and the '*Balance of System*' (BOS). The evolution of PV modules has paralleled the successes of PV cells. '*Module*' is the term used to identify a grouping of interconnected PV cells into an enclosed, environmentally sealed package. Modules utilize a transparent front material, a cell and cell encapsulant, and a back cover material. Current PV cells and modules are considerably improved compared to some years ago, which is reflected in increasing efficiency levels and reduced replacements of, e.g., inverters (Lako, 2008).

PV systems are generally based on silicon, various PV modules being found: mono-crystalline, poly-crystalline, and amorphous Si (a-Si) cells. Next to this mainstream category, there are various thin-film PV technologies that gradually gaining market share. PV systems further are distinguished with respect to their link to the grid (off-grid and grid-connected PV). When PV entered the market, primarily off-grid PV systems were installed in Europe. However, as PV has become reliable and the cost has come down substantially, grid-connected PV has become the technology of choice, whereas off-grid PV (e.g. to feed water pumps) has become a niche market. As the supply of electricity from PV varies during the day, a balance between supply and demand may be obtained by grid connection.

PV systems may have different sizes. For farmers, the size of a PV system may be tailored to the electricity demand of the farm, in which case a PV system with a capacity of a few kWs would often be appropriate. However, if the farmer needs to irrigate (part of) the agricultural land, the PV capacity may be much higher, e.g. in terms of hundreds of kWs. In Europe, it becomes more and more usual (particularly in Germany) for farmers to consider PV systems as an important additional source of income. If so, the PV system may have a capacity of tens up to hundreds of kWs, if the farmer has sufficient roof space available.

The costs of PV systems and the cost of electricity from PV systems is quite comparable across EU countries with a comparable solar irradiation (e.g. Germany and the Netherlands). In the Netherlands, the investment cost of a PV system of 15 – 100 kW_p is estimated at € 3,375/kW in 2010 (Lensink et al, 2009).

Thus, a typical 30-kW_p system will cost approximately € 100,000. The cost of operation and maintenance is about € 0.027/kWh (variable), and the number of full-load hours is put at 850. For the aforementioned size of a PV system (15 – 100 kW_p), the feed-in tariff in 2010 is € 0.43/kWh. However, PV systems are becoming less and less expensive. Over the past 12 months, prices for turnkey solar power systems have fallen by an average of 13 percent, according to the German Solar Industry Association, BSW-Solar (Internet Source 4).

Photovoltaic (PV) systems are typically modular systems (which is why the term *modules* is used) that are suitable for distributed generation. Owners of PV systems are households, service companies with suitable buildings (roofs oriented towards the south), small businesses with suitable roof areas, and - to a lesser extent - electricity generators.

Concentrating Solar Power (CSP) is another promising technology for renewable electricity generation. It is based on concentration of sunlight to generate high-temperature heat, which is subsequently converted into electricity. In southern Europe (Mediterranean), Concentrating Solar Power (CSP) may be an alternative to PV, however its substantial land requirements make its installation unsuitable on agricultural land.

The role of solar power in agriculture

Farmers may be an important market for PV as they own buildings on their farms that may be used to install PV systems. Examples of on-farm PV use are commonly found.. On a global scale, it is estimated that water pumping (for livestock watering, irrigation as well as potable water) has gained prominence, representing around 12 percent of yearly global PV production and one of the major rural PV markets in developing countries (Campen, Guidi, and Best, 2000). However, PV systems tend to be used on a larger scale, providing a significant source of income to farmers.

The development of the market for PV systems differs a lot among EU countries. Although PV still has a minor share in electricity generation in Germany, PV systems are popular among households, service companies, small businesses, etc, by virtue of attractive feed-in tariffs. This also holds for farmers. In 2009, the potential of PV on roofs of farmers' buildings in Germany was put at 22 GW, and the PV capacity owned by farmers was estimated at 8.5% of this potential or 1,850 MW (Internet Source 1). The potential of PV on roofs of buildings of farmers (22 GW) is equivalent to 3.5% of the estimated total potential of PV in Germany. Characteristics of this market are (Internet Source 2):

- Farmers are among the top PV customers in Germany.
- Farmers tend to be relatively sensitive with respect to the economic attractiveness of PV.

Still in Germany, farmers installed on average 200 – 250 MW of PV per year on their buildings in the years 2005 – 2008. In 2009, another 285 MW of PV could be installed by farmers (Internet Source 1), increasing the aggregate PV capacity on farmers' buildings to approximately 2,150 MW by the end of 2009.

Unfortunately, there is much less information of this type available for other countries. However, any figures would be much lower compared to those for Germany, as the market leader in solar PV. Development of PV in agriculture, critically depends on the financial incentives available on a national scale for renewable electricity generation in general, and for PV (or CSP) in particular.

Developments of solar power in the case study regions

Germany being the European leader on solar power, it is not surprising that the largest amount of PV capacity across our case study regions is found in Saarland and North East Brandenburg, where presumably some 172 MW and reportedly 127 MW have already been installed, respectively (Neue Energie, Februar 2011, p. 58). For Spain, the PV capacity in 2009 was 3520 MW. An estimated 900 MW of PV capacity may have been installed in Andalusia. The PV capacity in Valencia may be estimated at approximately 165 MW in 2009 based on the balance between 3520 MW and 900 MW divided by 16 (Spain has 17 autonomous regions).

Other regions lag far behind these figures. While no precise data is available, it can be estimated that in Austria, both Upper Austria and Carinthia each only have around 5 MW of PV capacity installed (of the country 50 MW total) (EurObserv'ER (2010): The state of renewable energies in Europe - 10th EurObserv'ER report. EurObserv'ER, Paris, France, December 2010). There is almost no PV yet in Poland.

For solar thermal energy (mainly for water heating), the installed capacity in Austria was approximately 3,000 MWth by the end of 2009, based on the aforementioned EurObserv'ER report. The solar thermal capacity in Upper Austria was 723 MWth in the same year (Energiesparverband (ESV), Linz, Austria, http://www.esv.or.at/fileadmin/redakteure/ESV/Info_und_Service/Publikationen/Solar-publ-eu.pdf)

Discussion and conclusion
The availability of roof space is not a real impediment to the growth of PV. For instance, in Germany the roof space occupied by PV systems in 2008 was estimated at 1,700 ha, whereas the roof space (oriented towards the south) that is available is estimated at 234,400 ha (AEE, 2010) – this is the aggregate potential for PV and solar thermal energy in Germany.
As the technology is maturing, and the cost of PV systems has come down, installed systems are increasing in size. In Germany, the average capacity is now 30 kW_p or more. Subsidies for PV systems are starting to be reduced, but it seems that PV econmic performance can be maintained as long as cost decreases can match reductions in feed-in tariff´s. If EU countries are willing to provide financial incentives for renewable electricity generation (e.g. based on feed-in tariffs), there is a very large market for PV in agriculture. For instance, the potential of PV on roofs of farmers' buildings in Germany is estimated at 22 GW (of which less than 10% has been developed in 2010). Therefore, PV will possibly offer a significant secondary source of income for farmers that are able to develop their PV potential.

7.2.3 Solar thermal

Solar thermal energy is based on a collector area on a roof to produce hot water for domestic needs. The main market is domestic hot water. A secondary market is space heating. Solar thermal systems are used in houses, the service sector, and small businesses, e.g. farms. Solar thermal systems often use a gas-fired boiler as back-up. Also, hot water storage is used to balance supply and demand. The technology is relatively mature, although technological progress and cost reductions are still being achieved.

Technology
A solar thermal systems consists of one or more collectors and a hot water storage. The most commonly used type of collectors are flat plate collectors and vacuum tube collectors. Depending on the latitude, up to 50 to 70% of the domestic hot water use with temperatures up to 40 –70°C can be provided by solar heating systems.
It is noteworthy that 68 percent of the solar thermal plants installed worldwide are in China, where the government urged the industry early on to produce collectors (Internet Source 10). The market demand in Europe is approximately 300 – 350 MW_{th} per year. In the Mediterranean, solar thermal systems are primarily used for the demand for domestic hot water of single family houses. In countries in central Europe and the northern part of Europe, these systems are also used for the hot water demand of multifamily houses and for district heating and space heating.

A typical solar heating system in the Netherlands - consisting of two (flat plate) collectors and a yield of 4.8 GJ/year - requires an investment of € 3,300 (Internet Source 6) - specific investment cost about € 700/GJ/year. According to (Internet Source 7), the pay-back period in the Netherlands is 12 – 16 years (investment cost € 3,000 – 4,000; energy conservation € 250/year). A comparable pay-back period is usually between 4 and 14 years (Internet Source 8). Generally, solar heating systems will show a shorter pay-back period in the southern part of Europe than in the northern part and Central Europe - based on a higher solar irradiation in the Mediterranean.
The owners of solar collectors range from houses, buildings (services and commercial enterprises), and small businesses (among which farmers). Solar collectors (with hot water storage) do not require much maintenance. Therefore, they do not pose any problem with respect to ownership.

The role of solar thermal technology in the agricultural sector
Livestock and dairy operations usually have substantial air and water heating requirements. According to (Focus on Energy, 2006), solar thermal technology may be applied in the agricultural sector for the following purposes (Table 7.1).

Table 7.1 Solar thermal applications for the farm (Source: Focus on Energy, 2006)

Application	Description	Considerations
Greenhouse Vent and Louver Openers	A piston device that extends to open and close greenhouse vents or ventilation louvers automatically	

	by employing the sun's heat to expand wax contained in the mechanism, adjusting the vent as temperature changes	
Solar Thermal Air Heating	There is a perforated metal siding product available which is installed with a ventilation system so that solar heated air is drawn up and into the building to be distributed by ducts inside. In the summer, the hot air is directed out of the building by dampers, providing ventilation benefits.	This can be installed either when the building is constructed or added later.
Crop Drying	A combination of passive and active solar air heating, with potential for use with solar electric powered ventilation.	
Root Zone Heating	A way of extending crop seasons in greenhouses, a solar hot water system can be used to distribute heat in bench or floor planting areas by use of hydronic thermal tubing in the soil.	Can be used as a preheating method for conventionally fueled root zone heating.
Water Heating	Solar heated water can be used for barn cleaning, tempering of drinking water and other livestock applications.	This technology can be particularly economical if the farm relies on LPG for heating.
Passive Heating and Daylighting	Translucent roofing panels on livestock barns and other outbuildings can cut use of lighting fixtures during daylight hours, as can appropriate installation of windows on the south side of the building. Thermal mass inside buildings, including stone or brick floors, walls or fireplaces, can capture and store the sun's heat to cut or eliminate the need for other heating purposes.	Most economical when incorporated at the time of building construction.

Development of solar thermal energy in the case study regions
No data available.

Discussion and conclusion
Same as for PV, the availability of roof space is not a real impediment to the growth of solar thermal energy. In Germany the roof space occupied by solar thermal systems is estimated at 1,285 ha in 2009 (Internet Source 11), whereas the roof space that is available is estimated at 234,400 ha – this is the aggregate potential available for PV and solar thermal energy in Germany (AEE, 2010).
Application of solar thermal energy in agriculture depends on the economic feasibility. The investment cost of a typical solar heating system have come down by a factor of two over the past 15 years, which supports the expansion of such systems in agriculture. Depending on the alternative conventional fuels used (LPG, heating oil), using solar systems may also generate significant environmental benefits (reduced air emissions, less fuel - LPG, heating oil - transportation to the farms).

7.2.4 Solid biomass
TO BE ADDED

7.2.5 Biogas
TO BE ADDED

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ANNEX I. OVERVIEW OF INFORMATION SOURCES

EU-level & international sources

AEBIOM (European Biomass Association): European Biomass Statistics 2010
http://www.aebiom.org/
Includes a lot of data about all kind of biomass streams is available.

EPIA (European Photovoltaic Industry Association), www.epia.org.

Eurostat: Supply, transformation, consumption - renewables and wastes
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_1071a&lang=en
In this source the total production of renewables can be found, but it is the question how far this can be related to the agricultural sector. However the final consumption of renewables in the agricultural sector is available in this source.

Eurostat: Supply, transformation, consumption - renewables (biofuels)
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_1073a&lang=en
In this source the consumption of biofuels in the agricultural sector can be found, but for most of the countries no data has been available.

Eurostat: Statistics in focus, 39/2009: Agriculture and fisheries
http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database]
This publication (such as Europe in Numbers) also provides general but useful facts and figures about indicators at the European level. There is information on renewable energy and some agricultural indicators. Although fairly general the advantage is that the figures are regularly updated.

Eurostat 2009: Energy, Transport and environment indicators, pp. 56-61
http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database]
It gives an overview over the share of renewable to final energy consumption and the installed capacity for electricity generation from renewables. However, it is fairly general. The advantage is that the figures are regularly updated.

The EurObserv'ER Barometers http://www.eurobserv-er.org/downloads.asp
Measures the progress made by renewable energies in each sector and in each member State of the European Union in an as up-to-date way as possible (with figures less than 12 months old).
The EurObserv'ER Barometer reports on biofuels, solar thermal, photovoltaic, wind power, and solid biomass can be downloaded here. Although there are some figures for each member state, the analysis is written at the EU level, so figures are general. The barometers report, for example, how much of each energy source was added in the European member states in the past year or how much biofuels each state used in transport.

EUROSOLAR (European Association for Renewable Energy), www.eurosolar.de/en/

EWEA (The European Wind Association) http://www.ewea.org/index.php

Information here is at the European level. Their publications include information on wind energy, job generation and green growth, and fact sheets. An advantage is that all figures are current.

IEA (International Energy Agency) http://www.iea.org/index.asp
Under the link by country, the IEA provides statistics on renewable energy consumption and production, broken down by sector, for Austria, Germany, the Czech Republic, Hungary and Slovakia. For each of these countries there are also links to Publications, Country news, graphs, and other related websites

IRENA, International renewable energy agency,
http://www.erneuerbare-energien.de/inhalt/42623/3860/

National renewable energy action plan of each country, especially table 7.
A database with data of all the countries can be found at http://www.ecn.nl/units/ps/themes/renewable-energy/projects/nreap/,

the individual reports for each country are available from
http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm.
The NREAPs contains a table in which the biomass availability per country is available. Per biomass stream it has to be decided if this stream is within the agricultural sector.

Country-specific sources

Austria

ARGE Kompost & Biogas Österreich http://www.kompost-biogas.info

It includes statistics about biogas production

Austrian Energy Agency http://www.energyagency.at/

Information, facts, and statistics about Energy Technology, Energy Economics, and renewable energy in Austria. There is also information on various price indexes for energy, electricity, and gas.

FJ BLT - Biomass-Logistics-Technology http://blt.josephinum.at/

FJ-BLT Wieselburg specializes in research and development in the field of agricultural engineering and renewable resources, the investigation of methods of agricultural labor economics, including home economics and the ergonomic workplace design, and the examination and testing of products made from renewable resources for the non-food sector.

IG Windkraft: The Austrian Wind Association http://igwindkraft.at/index.php

Under the heading "Wind in Numbers" there is information, statistics and graphs on wind energy production in Austria.

Österreichischer Biomasse-verband http://www.biomasseverband.at/biomasse

Publications are mainly concerned with biomass in Austria and are directed more at the general audience, so the data and figures listed are fairly general. Under the heading "statistic", however, there is more useful and specific information accompanied by charts and graphs.

Photovoltaic Austria Federal Association http://www.pvaustria.at/content/default.asp

Very useful publications with specific figures and graphs on photovoltaic power. Some focus more on the market place of this energy source. There are also some graphs and charts for Germany.

Projekte zu erneuerbarer Energie http://www.energyprojects.at/
This site provides a list of projects for renewable energy production in the different Austrian states. It includes contact information that may be useful for the case studies.

Statistik Austria www.statistik.at

Under the heading Energy and Envrionment, Statistik Austria has statistics on: energy balance, prices and taxes, household energy use, energy use analysis, and energy efficiency.

European Union Intelligent Energy Programme. *EUBIONET III project: Country report of different criterion for sustainability and certification of biomass and solid, liquid and gaseous biofuels.* October, 2009.
This report is part of the EUBIONET project, which seeks to increase the use of biomass-based fuels in the EU by finding ways to overcome the market barriers. This report contains an overview of bioenergy production in Austria; an overview of initiatives to guarantee the sustainability of biomass feedstock. Particularly useful is the overview of the Austrian Agri-Environmental Programme ÖPUL. The report provides some figures on the level of farm participation in the programme.

Statistik Austria. *Österreich: Zahlen, Daten, Fakten.* 2009-2010
Published by the statistics office for Austria. Includes chapters on umwelt, energie, and economy. Helpful graphs and tables on the breakdown of energy consumption in Austria. Also has an individual breakdown for renewables—albeit in very general and terms. Includes some figures for the individual Bundesländer, but nothing very specific.

Belgium
No specific sources related to production and use of RE in agriculture identified so far among official national statistics.

Bulgaria

National Statistical Institute: ENERGY BALANCE SHEETS 2008 'database'
http://www.nsi.bg/publikaciaen.php?n=206&r=|9|&PSP=9&P=179&SP=183

National Statistical Institute: CHP UNITS FUEL INPUTS FOR 2008 'table'
http://www.nsi.bg/otrasalen.php?otr=37&a1=1221&a2=1223&

Czech Republic

Czech Republic: Ministry of Industry and Trade
Under the English section the document, *Fulfilment of the indicative target of electricity production from renewable sources, deals with* the development of electricity production from renewable sources by individual sources (small hydro power plants, biomass, biogas, solid municipal waste, wind power plants, photovoltaic systems) can be download. It includes the outlook from the last two years and up to 2010. A second document, *the National programme for the energy management and the use of renewable sources of energy for 2006 – 2009*, s*ets out the government priorities and targets in the area of energy management.*

Czech Republic: Ministry of the Environment
In its website, the ministry includes some information on how its goals for achieving greater energy sustainability and increased production of renewable energy sources. Specific data, however, is not available.

ENVIROS (energy consultancy)
Skim ENVIROS is a consultancy that supports technology development in the area of renewable energies. Although it provides no data in its website, it may be a useful contact later on.

Cyprus

AgriPolicy.net : Analysis of renewable energy and its impact on rural development (2009) 'report + data' http://www.europartnersearch.net/download.php?id=40

Estonia

Statistics Estonia: Statistical Yearbook of Estonia 2010 'yearbook' http://www.stat.ee/38050

Finland

MTT Agrifood Research Finland
https://portal.mtt.fi/portal/page/portal/Luonnonvarapuntari/Ymp%E4rist%F61/Ilmastonmuutos/Energian%20k%E4ytt%F6_lt

France

REDatabase LRI: Country Assessment of Renewable Electricity Sector: France (2009)
http://www.redatabase.com/country_reports.php?side_pdf_id=1&the_country=France

French Min. Ecology: Observations and Statistics
http://www.statistiques.developpement-durable.gouv.fr/rubrique.php3?id_rubrique=493

Germany

AG Energiebilanzen www.ag-energiebilanzen.de

Amt für Statistik http://www.statistik-berlin-brandenburg.de/
Published by the statistics office for Brandenburg it includes chapters on environment, energy and economy. Helpful graphs and tables on the breakdown of energy consumption. Also has an individual breakdown for renewables—albeit in very general and terms

BMU, The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
http://www.erneuerbare-energien.de/inhalt/3860/
Provides information on Germany's energy policy and the government's official energy strategies. All topics concerning renewable energy are covered beginning with solar and wind energy and ending with geothermal energy, hydropower and biomass.

Some useful sources include:

BMU 2010: Erneuerbare Energien in Zahlen - nationale und internationale Entwicklung

Figures on renewable energies until 2009, electricity, heat, transport, GHG emissions saved, value added by type of RE, number of employees per type of RE, potential for future expansion, use of RE in other EU countries

BEE, Bundesverband Bioenergie e.V. (BBE) http://www.bioenergie.de/

BDBE, Bundesverband der deutschen Bioethanolwirtschaft e.V. www.**bdbe**.de/

Bundesverband Pflanzenöle e.V. (BVP) www.bv-**pflanzenoele**.de/

Deutscher Energie-Pellet-Verband e.V. (DEPV), www.**depv**.de/

Fachverband Biogas e.V. Fördergesellschaft nachhaltige Biogas- und Bioenergienutzung e.V. (FnBB), www.**fnbb**.de/

Verband der Deutschen Biokraftstoffindustrie e.V. (VDB) - http://www.biokraftstoffverband.de/

Deutscher Bauernverband e.V. (DBV) - http://www.bauernverband.de/

Deutsches BiomasseForschungszentrum Leipzig www.dbfz.de

Deutsches Pelletinstitut, www.DEPI.de

ForschungsVerbund Sonnenenergie (FVEE),
www.fvee.de/fileadmin/downloads/presse/pi_07.02_biomasse.pdf
This is a cooperation of non-university based research institutes for renewable energies and provides a profound basis for topics concerning solar energy. The studies are quite specific in relation to market and supply structures or the reduction in greenhouse gas emissions generated.

Union zur Förderung von Öl- und Proteinpflanzen e.V. (UFOP) - http://www.ufop.de/

Institut für Solare Energieversorgungstechnik (ISET)

Statistisches Bundesamt 2009: Statistisches Jahrbuch 2009, p. 285

http://www.umweltbundesamt-daten-zur-umwelt.de/umweltdaten/public/theme.do?nodeIdent=2848

http://www.agenda21-treffpunkt.de/daten/themajahr.php?th=oekostrom&jg=2010

http://www.sonnenenergie.de/index.php?id=30&no_cache=1&tx_ttnews%5Btt_news%5D=33

VTI, http://www.vti.bund.de/

Bundesnetzagentur 2010: EEG-Statistikbericht 2008. Statistikbericht zur Jahresendabrechnung 2008 nach dem Erneuerbaren-Energien-Gesetz (EEG). März 2010, Bonn

Site and size of new and all existing installations, no differentiation between roof-top and ground-mounted systems

DBV 2009: Situationsbericht 2010. Trends und Fakten zur Landwirtschaft. Deutscher Bauernverband, Berlin.

Estimation of agrarian lands used for energy crops in Germany 2009

Bundesregierung (BR) 2009: Verordnung über Anforderungen an eine nachhaltige Herstellung von Biokraftstoffen (Biokraftstoff-Nachhaltigkeitsverordnung – Biokraft-NachV) vom 30. September 2009 (BGBl. I S. 3182).

Bundesregierung (BR) 2009: Verordnung über Anforderungen an eine nachhaltige Herstellung von flüssiger Biomasse zur Stromerzeugung (Biomassestrom-Nachhaltigkeitsverordnung – BioSt-NachV) vom 23. Juli 2009 (BGBl. I S. 2174).

Deutsches Biomasse Forschungs-Zentrum GmbH (DBFZ) in Kooperation mit der Thuringer **Landesanstalt für Landwirtschaft (TLL) 2009**: Monitoring zur Wirkung des Erneuerbare-Energien-Gesetzes (EEG) auf die Entwicklung der Stromerzeugung aus Biomasse, Zwischenbericht „Entwicklung der Stromerzeugung aus Biomasse 2008“. Forschungsvorhaben im Auftrag des BMU.

IE – Institut für Energetik und Umwelt et al., 2007: Monitoring zur Wirkung des novellierten Erneuerbare-Energien-Gesetzes (EEG) auf die Entwicklung der Stromerzeugung aus Biomasse, Endbericht, Leipzig

Mantau, Udo / Sörgel, Christian / Weimar, Holger, 2007: Holzrohstoffbilanz Deutschland, Bestandsaufnahme 1987 bis 2005, Hamburg

Ministerium für Umwelt, Gesundheit und Verbraucherschutz Brandenburg (MUGV) 2009: Agrarbericht 2009, http://www.mugv.brandenburg.de/sixcms/list.php?_siteid=200&sm%5Bvt%5D=fulltext_all&page=mluv_site_suche&sv%5Bvt%5D=Agrarbericht

Vogt, R.; Gärtner, S.; Münch, J. et. al., 2008: **Optimierungen für einen nachhaltigen Ausbau der Biogaserzeugung und -nutzung in Deutschland,** Heidelberg.

Weimar, Holger / Mantau, Udo, 2006: Standorte der Holzwirtschaft – **Einsatz von Holz in Biomasse- und Holzfeuerungsanlagen**, Abschlussbericht, Hamburg

www.hnee.de/Projekte/Bioenergie/Aktuelle-Projekte/NFG-BarUm/NFG-BarUm-Nachwuchsforschung-Erneuerbare-Energien-Barnim-Uckermark-E4157.htm

Databases

Landesämter für Ländliche Entwicklung, Landwirtschaft und Flurneuordnung (LVLF or LELF)
Provides so-called „dibos"- and „InVeKos"-datas (integrated system for administration and control) for each administrative district. These are field-bloc-data in excel on silo maize and other fieldfruits. To get useful informations one has to create useful queries on the specific field crops. InVeKos-datas can be found for example in annual reports of the LVLFs about agriculture and horticulture (*www.brandenburg.de/.../JAhresbericht%202008%20gesamt.pdf*).

The German Biogas Association http://www.biogastagung.org/en/
collects the numbers of their sector and publishes them at the annual conference of the German Biogas with biogas Trade Fair. The basic of these numbers are the collected numbers by the Länder and companies building biogas plants.

The German Biomass Research Centre (DBFZ) www.dbfz.de

extrapolates the results of questionnaires answered by around 1000 farmers concerning their use of biomass, biogas, solar, photovoltaic, hydro, and wind energy.

The boards for agriculture of each Land

http://www.landwirtschaftskammer.de/landwirtschaft/technik/energie/windkraft/windstrom.htm

Provide information of land use of agricultural areas for different renewable energy sectors, see for example Landwirtschaftskammer NRW,

Greece

REDatabase LRI: Country Assessment of Renewable Electricity Sector: Greece (2009) http://www.redatabase.com/country_reports.php?side_pdf_id=1&the_country=Greece

Centre Renewable Energy Sources and Saving, Greece
(national office for statistics) 'various data bases' http://www.cres.gr/kape/datainfo/statistics_uk.htm

Hungary

Hungary: Energy Centre
Some parts in English, but not enough to determine data availability and quality.

Hungarian Energy Office
Some parts in English. Their data and statistics are more relevant to electricity and natural gas production than to renewable energy sources.

Ministry of Transport, Telecommunication and Energy www.khem.gov.hu
Now called the Ministry of National Development. It is supposed to have the same information as before on transport and energy, but no documents or data seem available.

Hungary: Ministry of the Environment
Only a brief overview of the ministry is available in English]

Ireland

'report + data'
http://www.cso.ie/statistics/energy_consumption_sector.htm
Italy

ISTAT, National statistics office for agriculture
http://www.istat.it/dati/dataset/20070613_00/indexnp.html
Includes data on all farms censured.

REDatabase LRI
Country Assessment of Renewable Electricity Sector: Italy (2009) 'database'
http://www.redatabase.com/country_reports.php?side_pdf_id=1&the_country=Italy

Consorzio Nazionale Energie Rinnovabili Agricole 'review ' **http://www.cner.it/**

CETA (Centro di Ecologia Teorica ed Applicata) http://www.ceta.ts.it/Joomla/

Agroenergia: www.agroenergia.it

AIIA (Associazione Italiana di Ingegneria Agraria) www.aiia.info

AIEL (Associazione Italiana Energie Agroforestali) www.aiel.cia.it

AIEE (Associazione Italiana degli Economisti dell'Energia) www.aiee.org

Ambiente Italia (Istituto di ricerche) www.ambienteitalia.it

APER (Associazione Produttori di Energia da fonti Rinnovabili) www.aper.it

ASSOBIODIESEL (Associazione Italiana Produttori di Biodiesel) www.assobiodiesel.it/

ASSOCOSTIERI (Associazione Nazionale Depositi Costieri Olii Minerali) www.assocostieri.it

ASSODISTIL (Associaz. Naz.le Industriali Distillatori di Alcoli e di Acquaviti) www.assodistil.it

ASSOLTERM (Associazione Italiana Solare Termico) www.assolterm.it

ASSOSOLARE (Associazione Nazionale dell'Industria Fotovoltaica) www.assosolare.org/

Atlante eolico dell'Italia www.ricercadisistema.it

ANEV (Associazione Nazionale Energia dal Vento) www.anev.org

Biofuels Italia (Piattaforma Tecnologica Italiana Biocarburanti) www.biofuelsitaliatp.it

CEAR (Consorzio Energia Alternativa per il Riscaldamento) www.consorziocear.com

CETA (Centro di Ecologia Teorica e Applicata) www.ceta.ts.it

CNER (Consorzio Nazionale Energie Rinnovabili agricole) www.cner.it

CNR-IVALSA (Istituto per la Valorizzazione del Legno e delle Specie Arboree) www.ivalsa.cnr.it

ENEA – Centro ricerche Casaccia www.casaccia.enea.it

ENEA - Centro Ricerche Trisaia www.trisaia.enea.it

ETA - Energie Rinnovabili: www.etaflorence.it

FIPER (Federazione Italiana Produttori Energie Rinnovabili) www.fiper.it

FIRE-Italia (Federazione Italiana per l'Uso Razionale dell'Energia) www.fire-italia.it

Fondazione per lo Sviluppo Sostenibile www.fondazionesvilupposostenibile.org

GSE (Gestore dei Servizi Elettrici) www.gse.it

GIFI (Gruppo Imprese Fotovoltaiche Italiane) www.gifi-fv.it

ITABIA – Italian Biomass Association www.itabia.it

ISES Italia (International Solar Energy Society) www.isesitalia.it

Legambiente www.legambiente.com - www.fonti-rinnovabili.it

Ministero dell'Ambiente e della Tutela del Territorio e del Mare
www.minambiente.it

Ministero delle Politiche Agricole, Alimentari e Forestali www.politicheagricole.it

Renael (Rete delle Agenzie Energetiche Locali, c/o Rete di Punti Energia) www.renael.net

SEE (Sustainable Energy Europe): www.sustenergy.org – www.campagnaSEEitalia.it

Latvia

Latvian Statistics: Production, Imports, Exports and Consumption of Rnenwable Energy Resources, Charcoal and wastes 'database'
http://data.csb.gov.lv/Dialog/varval.asp?ma=EN0050a&ti=EN05.+PRODUCTION%2C+IMPORTS%2C+EXPORTS+AND+CONSUMPTION+OF+RENEWABLE+ENERGY+RESOURCES%2C+CHARCOAL+AND+WASTES%2C+in+natural+units+%28NACE+Rev.2%29&path=../DATABASEEN/vide/Annual%20statistical%20data/Energy/&lang=1

Lithuania

Statistics Lithuania: Regional database – energy 'databases'
http://www.stat.gov.lt/en/pages/view/?id=1659

Lithuanian Energy Institute: Energy in Lithuania 2007 'yearbook'
http://www.lei.lt/_img/_up/File/atvir/leidiniai/Lietuvos_energetika-2007.pdf

Malta

AgriPolicy.net: Analysis of renewable energy and its impact on rural development (2009)
http://www.europartnersearch.net/download.php?id=48

Netherlands

LEI/CBS: Land- en tuinbouwcijfers 2010 'Publication'
http://www.cbs.nl/nl-NL/menu/themas/landbouw/publicaties/publicaties/archief/2010/2010-landentuinbouwcijfers-pub.htm

Includes data for on-farm production of
- Wind and solar electricity and
- solar heating

CBS: Renewable energy in the Netherlands 2009 'Database'
http://statline.cbs.nl/StatWeb/publication/?VW=T&DM=SLNL&PA=71457NED&D1=a&D2=40&D3=a&HD=101109-1102&HDR=T&STB=G1,G2

Includes data for on-farm production of
- electricity from biogas and
- solar and geothermal heating

NREAP (National Renewable Energy Action Plan) 'Database'
http://www.ecn.nl/units/ps/themes/renewable-energy/projects/nreap/

Includes data for on-farm production of various biomass sources

Poland

Central Statistical Office: Regional Data Bank – Energy 'databases'
http://www.stat.gov.pl/bdren_n/app/strona.indeks

Central Statistical Office: Energy from renewable sources 2009 'yearbook'
http://www.stat.gov.pl/cps/rde/xbcr/gus/PUBL_se_energia_zrodla_odnawialne_2008.pdf

Energy Regulatory Office: Map of Renewable energy sources 2010 'map / database'
http://www.ure.gov.pl/uremapoze/mapa.html

Portugal

RE Database LRI: Country Assessment of Renewable Electricity Sector: Portugal (2009)
http://www.redatabase.com/country_reports.php?side_pdf_id=1&the_country=Portugal

EREC: Renewable Energy Policy Review
http://www.erec.org/fileadmin/erec_docs/Projcet_Documents/RES2020/PORTUGAL_RES_Policy_Review_09_Final.pdf

Romania

National Institute of Statistics: Statistical yearbook 2008 - Industry and construction 'yearbook'
http://www.insse.ro/cms/rw/pages/anuarstatistic2008.en.do

Slovakia

Slovak Republic: Energy Centre Bratislava
This is a non-governmental, not-for-profit information and consulting organization. Among their other activities, they conduct data collection and elaboration of energy information. However, this is not available online. They may be a useful contact later on.

Slovak Republic: Ministry of Economy
Documents available for download include Slovakia's national energy strategy and the energy security strategy. The first, *Energy Policy of the Slovak Republic,* includes general, but satisfactory data on the production and consumption of renewable energy sources, broken down by source.

Slovenia

National Renewable Energy Action Plan

Spain

REDatabase LRI: Country Assessment of Renewable Electricity Sector: Spain (2009)
http://www.redatabase.com/country_reports.php?side_pdf_id=1&the_country=Spain

Wikipedia: Energia renovable en Espana
http://es.wikipedia.org/wiki/Energ%C3%ADa_renovable_en_Espa%C3%B1a
http://www.appa.es/02appa/02b-documentosappa.php

La Energia en Espana 2009
http://www.mityc.es/energia/balances/Balances/LibrosEnergia/Energia_2009.pdf

IDEA (Instituto para la Diversificación y Ahorro de la Energía/Energy Diversification and Saving Institute) 'Database / News / Documents…'
http://www.idae.es/boletines/boletin45/#2
http://www.idae.es/index.php/mod.pags/mem.detalle/idpag.16/relcategoria.1021/relmenu.41)

CIEMAT (Centro Investigaciones Energéticas, Medioambientales y Tecnológicas/Center for Energetic, Environmental and Tecnologic Research)) 'Database / News / Documents…'
http://www.energiasrenovables.ciemat.es/

INE (Instituto Nacional de Estadística (National Statistics Institute)) 'Database / News / Documents…'
www.ine.es

AVEBIOM (Spanish Association for energetic valorisation of biomass) 'Database / News / Documents…' www.avebiom.es

AEE (Eolic Enterprises Association) 'Databases' www.**aee**olica.es

AVEN (Valencian Energy Agency) 'Databases/news/documents'
http://www.aven.es/informes/datos/datos.html

UK

BERR (2008): Energy consumption in the United Kingdom: overall data tables, 2008 update.
'report + data' http://www.berr.gov.uk/files/file47215.xls
More to be done

ANNEX II. MARKET ANALYSIS

1. General introduction

Agriculture is a relatively small consumer of energy compared to other sectors of the European economy and an even smaller direct consumer of renewable energy. On the other hand, with biomass still dominating the renewable energy mix, and other fast growing renewable markets such as wind, solar and biogas, which can all be produced on-farm, farmers are increasingly feeling the demand pull for non-food agricultural output. In a situation of long-term price decreases for agricultural produce, this is a development, which is very much welcomed by farmers.

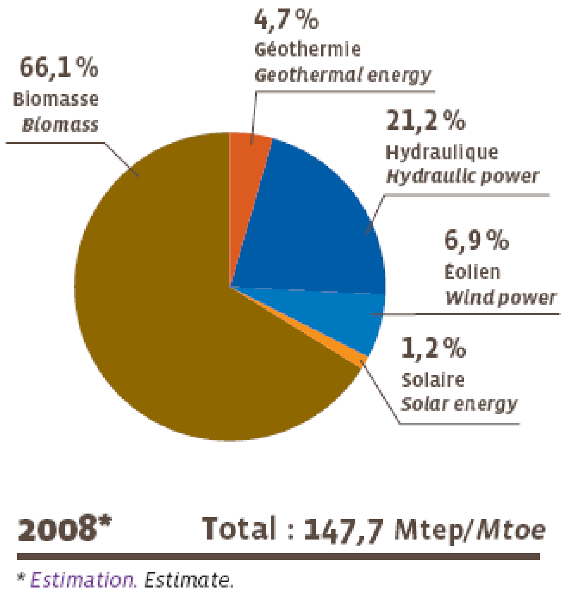


Figure 1.1. Share of each resource in renewable primary energy consumption (in %) in Europe Source: Eurobsrv'Er (2009)

In this respect, farmers are increasingly engaging with the power and transport sectors and many of their actors, including oil and biofuel companies looking for feedstock for their biofuel production and utilities and independent power producers (IPPs), looking to buy power produced on the farm from biogas, wind or sun. This brings about a number of "non-traditional" additional activities to farmers. Depending on their form of involvement, they need to negotiate lease for their land, access to power and gas grids, apply for renewable energy subsidies, sign power purchase agreements with utilities and so on.

As shown in subsequent sections, the potential for agriculture as a supplier of renewable energy is very significant. Agricultural land covers more than half of the areas with Europe's on-shore wind potential. There is significant rooftop area for solar panels on Europe's farm buildings and despite a decline in animal husbandry, still significant potential for production of biogas. With first generation biofuels still dominating the renewable transport fuels there is significant demand for oil and starch crops to be converted to bioethanol and biodiesel. Farmers looking to diversify their income sources are faced with a number of opportunities but also challenges. The following sections explore some of the renewable markets that European farmers are becoming increasingly involved in.
Since the developments of renewables and policy support measures in the case study regions are described in the section on case study selection, they will not be addressed here again.

2. Wind markets

2.1 Introduction

At the end of 2009, the global installed wind capacity reached 158 GW, almost half of which (74,8 GW) in the EU (Eurobserv'Er, 2010), where due to substantial subsidies from national governments, wind energy grew by an average of 30.9% per annum in the past two decades (IEA, 2010). Even during the economic crisis, the European wind market continues its robust growth, adding an additional 9739 MW of new capacity in 2009 (or 13% more than a year before) (EurObserv'ER, 2010). Its share of total power capacity is around 8% (EWEA, 2009a), which in a normal wind year, can produce 4.8% of the EU's electricity (EWEA, 2010).

In absolute terms, the largest European producers of wind power are Germany and Spain, which now produce 71.2 TWh, 37.8 TWh of wind electricity, respectively, although the country with the highest growth rate is Portugal, with 60% per year and an increase in wind power production from 1 GWh to 7 573 GWh between 1990 and 2009 (IEA, 2010). Other members states with mature wind markets are Denmark, Italy, Sweden, Ireland, Belgium, France and the United Kingdom.

Table 2.1. Summary of the wind power capacity installed in Europe in 2008 and 2009 (Source: Eurobsrv'Er, 2010)

	2 008	2 009
Germany	23 896,9	25 777,0
Spain	16 689,4	19 148,8
Italy	3 736,5	4 850,0
France**	3 542,0	4 521,0
United Kingdom***	3 406,2	4 050,9
Portugal	2 862,0	3 535,0
Denmark	3 162,8	3 480,6
Netherlands	2 216,0	2 220,7
Sweden	1 048,0	1 560,0
Ireland	1 027,0	1 260,0
Greece	985,0	1 087,0
Austria	994,9	994,9
Poland	451,1	705,3
Belgium	392,5	563,0
Hungary	127,0	201,0
Czech Republic	150,0	193,3
Bulgaria	120,0	177,0
Estonia	85,2	149,2
Finland	143,0	146,0
Lithuania	54,0	91,0
Luxembourg	43,3	43,3
Latvia	27,0	28,0
Romania	9,5	14,0
Slovakia	3,1	3,1
Slovenia	0,0	0,0
Cyprus	0,0	0,0
Malta	0,0	0,0
Total EU 27	**65 172,3**	**74 800,2**

A comparison of installed wind capacity relative to population, puts Denmark on top of the list, followed by Spain, Portugal and Germany.

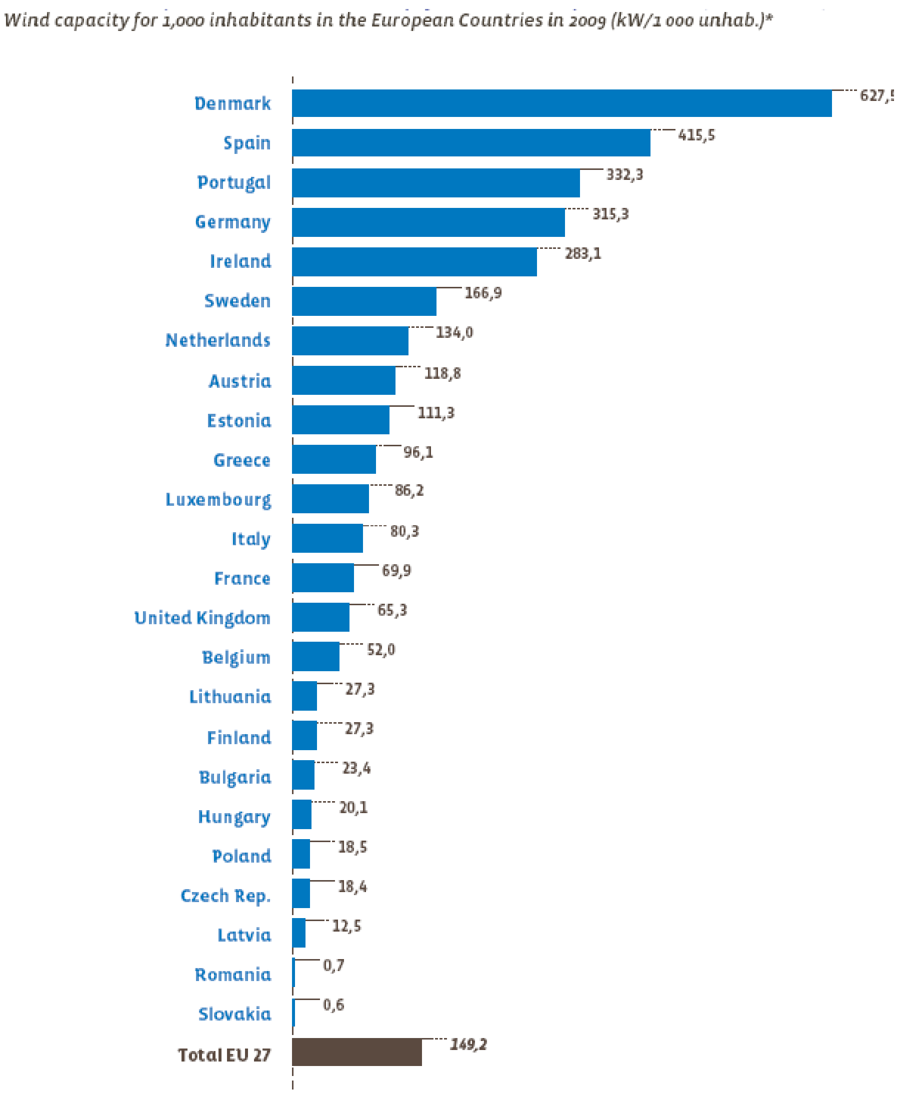


Figure 2.1. Installed wind energy (Source: Eurobsrv'Er, 2010)

2.2 Current status of the technology

The technology behind wind power is mature and well established. Nonetheless, continuous improvements in siting, design and installation are improving the efficiency and reducing cost of wind technology.

Currently, three-bladed, upwind, variable-speed, pitch-regulated turbines dominate the market. The principal design drivers are now grid compatibility, cost of energy (which includes reliability), acoustic emissions, visual appearance and suitability for site conditions (EWEA, 2010).

Size-wise, the market is strongly biased toward larger turbines. In 2007, turbines above 1 MW represented 95% of the market, leaving less than 5 per cent for the smaller machines. Within the MW-segment, turbines with capacities of 2.5 MW or above are becoming increasingly important, even for onshore siting (EWEA, 2010).

Figure 2.2 shows the size evolution of wind turbines over time:

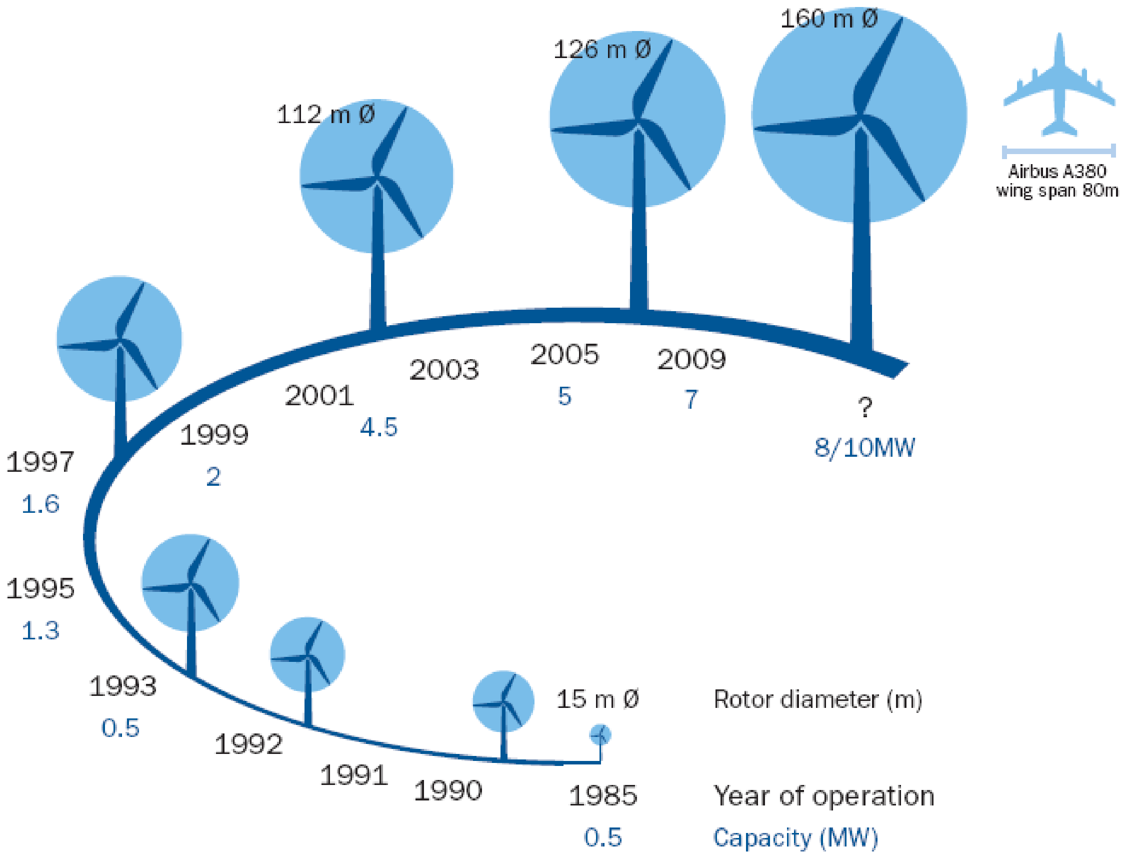


Figure 2.2. Evolution of wind energy installed (Source: EWEA, 2010)

In recent years, three major trends have dominated the development of grid-connected wind turbines (EWEA, 2009):

1. turbines have become larger and taller;
2. the efficiency of turbine production has increased steadily; and
3. in general, the investment costs per kW have decreased, although there has been a deviation from this trend in the last three to four years.

The turbine's power production is determined by the wind regime at the chosen site, the turbine hub height and the efficiency of production. All of these parameters have been steadily improving. Improvements in turbine design have led to a consistent increase of electricity production efficiency, or in other words a steady decrease in cost per unit of power produced. From the late 1980s until 2004, overall investments per unit of swept rotor area decreased by more than 2 per cent per annum. However, between 2004 and 2007, total investment costs of wind turbines rose significantly due to a combination of a marked increase in global demand for wind turbines, rising commodity prices and supply constraints. At present, production costs of energy for a 2 MW wind turbine range from 5.3 to 6.1 euro cents (c€) per kWh, depending on the wind resource at the chosen site (EWEA, 2009).[20]

Capital costs of onshore wind energy projects are dominated by the cost of the wind turbine. The total investment cost of an average turbine installed in Europe is around ¤1.23 million/MW, including all additional costs for foundations, electrical installation and consultancy (2006 prices). The main costs are divided as follows (approximate levels): turbine 76 per cent, grid connection 9 per cent and foundations 7 per cent. Other cost components, such as control systems and land, account for a minor share of the total costs. The total cost per kW of installed wind power capacity differs significantly between countries, from around €1000/kW to €1350/kW (EWEA, 2009).

[20] Offshore wind only accounts for around 1 per cent of total installed wind power capacity in the world, and development has taken place mainly around the North Sea and the Baltic Sea. It will be left out in this assessment as it is not of high relevance to the farmers.

Table 2.2. Cost structure of a typical 2 MW wind turbine installed in Europe (2006-€) (Source: Risoe DTU in EWEA, 2009)

	Investment (€1000/MW)	Share (%)
Turbine (ex-works)	928	75.6
Foundations	80	6.5
Electric installation	18	1.5
Grid connection	109	8.9
Control systems	4	0.3
Consultancy	15	1.2
Land	48	3.9
Financial costs	15	1.2
Road	11	0.9
Total	1227	100

2.3 Main actors

Initially, ownership of wind turbines was concentrated with farmers and small(er) Independent Power Producers (IPPs). This trend is changing. Although there are still many small, privately owned projects, there is a substantial shift towards bigger, utility owned projects, many of which were acquired from IPPs in the wake of the credit crisis. Wind power ownership now includes dozens of multinational players (including RWE, Dong Energy, Vattenfall, Statkraft, Iberdrola, Enel, EDF, EDP and E.ON), owning several GWs of installed capacity. This change brings different financing structure to wind projects and increases their average size. This is also illustrates the industry's scaling up and geographic expansion (EWEA, 2009).

Five main blocks of ownership now characterize the structure of the European market (EWEA, 2009):

1. utilities;
2. Europe's largest independent power producers (IPPs);
3. other Spanish IPPs;
4. German investors;
5. other European investors/IPPs.

The above means that farmers, while so far used to deal more with IPPs, are increasingly dealing with large utilities. It is as yet unclear whether this might weaken their negotiating position for a land-lease agreement in cases where farmers are only landlords. With respect to prices and grid access for those cases where farmers actually own the turbines and sell electricity to the grid, current EU legislation prevents utilities to discriminate any power producer, including farmers.

In terms of manufacturing, in Europe, roughly a dozen suppliers operate in a highly competitive market. Between 2004 and 2007, three players averaged over a 15 per cent market share of annual MW added each, followed by four players with a 5–10 per cent share (EWEA, 2009).

Table 2.3. Top ten suppliers in 2008 (Source: Eurobserv'Er, 2010)

Entreprise Company	Pays Country	MW fournis en 2008 Supplied MW 2008	Part de marché en 2008 Market share in 2008	Chiffre d'affaires 2008 en M€ Turnover 2008 in M€	MW fournis en 2009* Supplied MW 2009*	Salariés en 2009 Employees 2009
Vestas	Denmark	6 160	19,2%	6 035	6 131	20 730
GE Wind	United States	5 239	16,4%	n.a.	n.a.	3 000
Gamesa	Spain	3 684	11,5%	3 651	3 300-3 600	7 200
Enercon	Germany	2 806	8,8%	2 800	3 100-3 300	12 000
Suzlon	India	2 311	7,2%	2 113	1 900-2 100	14 000
Siemens Wind Power	Germany	1 947	6,1%	2 092	2 500	5 500
Sinovel	China	1 403	4,4%	n.a.	3 300	2 000
Acciona	Spain	1 290	4,0%	1 784**	n.a.	629
Goldwind	China	1 132	3,5%	n.a.	n.a.	1 130
Nordex	Germany	1 075	3,4%	1 136	n.a.	2 200
Others		4 955	15,5%			
Total		**32 002**	**100,0%**			

* Données préliminaires ou attendues./Preliminary or expected data. ** Division Énergie d'Acciona (pas seulement l'éolien)./Entire Acciona Energy Division (not only wind power). Les décimales sont séparées par une virgule. Decimals are written with a comma. Source: EurObserv'ER 2010.

A highly competitive manufacturing sector means that farmers wishing to invest in wind energy can buy hardware at lowest available prices, just as any other investor.

2.4 The role of wind energy in agriculture

Farmers in many countries have been harnessing the power of wind for mills or water pumps for centuries, especially in North-West Europe. Figure 2.3 shows the distribution of wind potential in Europe according to underlying land use type. It shows that in more than half the EU Members States, half or more of the technical potential for wind is located over agricultural land, which makes it almost unavoidable for farmers to become involved in development of wind energy, in one way or another.

In fact, farmers in several countries already have experience with wind power. In the 1990s, farmers often invested in single wind turbines, especially in Germany and Denmark. In other countries farmers associations (i.e. the National Farmers Union in the UK) are actively promoting involvement in wind energy among its members, offering support in the form of advice or help in obtaining the necessary finance. The result is that many farmers are seriously looking into investment in wind turbines[21].
For a period of over two decades, farmers were actively investing in wind turbines, generating power to meet own electricity requirements or sell to the grid. In the 'take-off' period of wind energy (1980s), wind turbines of 80 – 250 kW were often built by single farmers, as the investment costs were well within their financial capacity. The single wind turbines were followed up by more economic wind farms, consisting clusters of turbines with capacities from approximately 750 kW to 3 MW each. In the Netherlands for example, the capacity of wind farms owned by farmers - sometimes in a consortium with an electricity generator - was 460 MW (ACRRES, 2009), compared to a total onshore wind capacity of 1,640 MW (3.6 times higher) (CBS, 2010). The electricity generated by farmer-owned wind farms was 1,100 GWh, compared to 3,440 GWh for all wind farms (3.1 times higher). Wind farms owned by farmers even appear to have a slightly better wind climate than an average wind farm.

21 A recent survey by the British National Farmers Union revealed that a vast majority (86%) of dairy farmers are considering investing in renewable energy. And wind power was found to be the most popular choice among those looking to spend money. For more details see file:///M:/Impact%20of%20RE%20on%20EU%20farmers/literature/Dairy%20farmers%20see%20answer%20blowing%20in%20the%20wind%20-%20NFU%20Online.htm

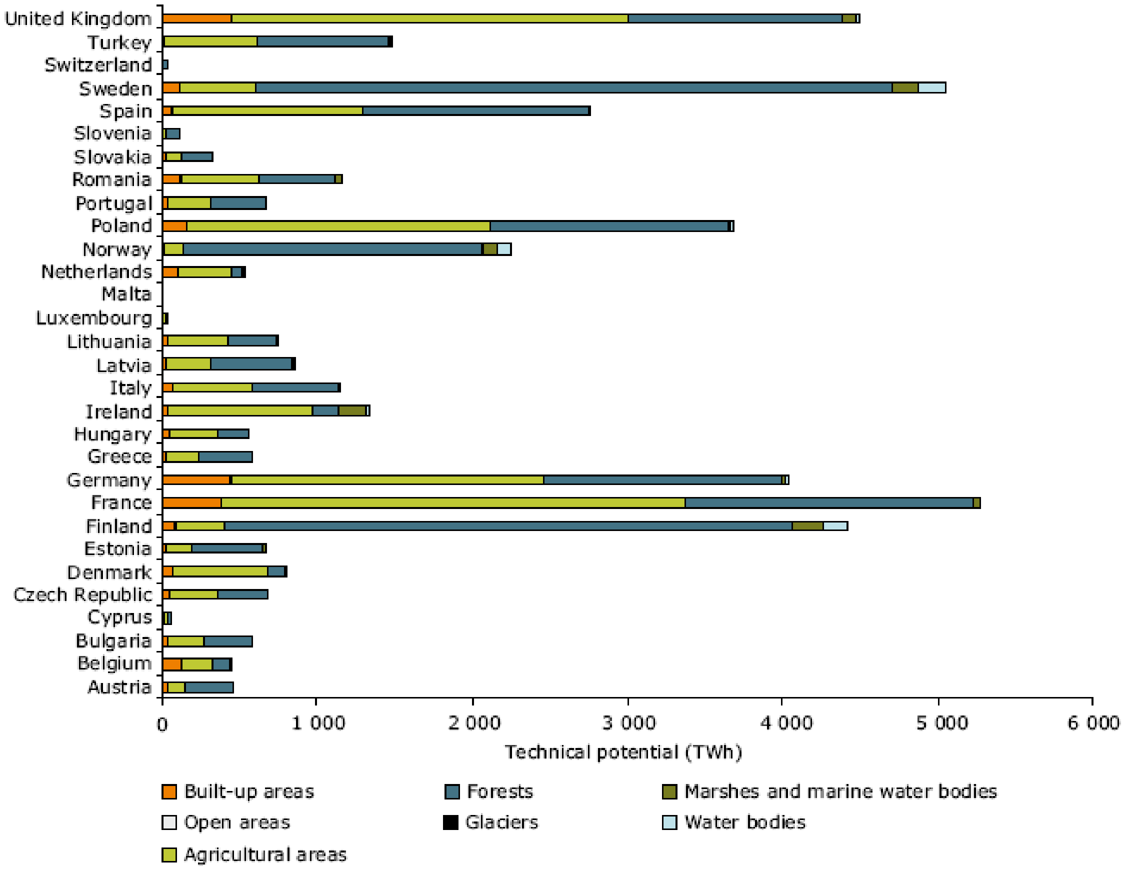


Figure 2.3: Unrestricted technical potential for onshore wind energy up to 2030 (based on estimated 80 m average wind speeds 2000–2005; Source: EEA, 2009)

To be able to invest in wind farms, farmers often organize themselves in cooperatives or cooperate in a joint venture with electricity generating companies. Farmer's ownership of turbines which takes the form of cooperatives often benefits whole communities. Wind projects owned by farmers' groups often re-invest a fraction of their profits into community projects, thereby also increasing acceptance of wind energy and stimulating new investment.
Recently however, farmers more often find themselves in the role of landlords, whereby they simply lease the land where the turbines are installed but owned by a utility or IPP. Likewise, their income from wind energy has shifted from variable revenues from electricity sales to more stable land leases.

Opportunities for wind power development in agriculture may thus be summarized as follows (NFU, 2009):

a) Large commercial wind farms, in which farmers mainly play the passive role of the landlord, and receive rents based on a lease agreement[22]. There may be an opportunity for the landowner to acquire an equity stake in the project, assuming more risk but probably receiving a great income as a result. However, this is likely to be a small share of the type of farmer's involvement, since the total project capital cost range in the order of several million to several tens of millions of Euros.
b) Single turbines or small 'windclusters' which represent a more affordable scale of development for the farmer-entrepreneur (225 kW to 2 MW), or a 'wind cluster' of up to three turbines, costing between few hundred thousand Eur to few million, which could be 100% owned by the farmer.
c) Small wind energy systems which include building-mounted or pole-mounted micro-turbines with outputs ranging from a few hundred watts to about 1.5 kilowatts, a wide range of small turbine configurations up to about 15 kW, and small-to-medium single turbines up to about 100 kW. Small wind systems are usually installed to satisfy on-site electricity demand, or the energy needs of a single

22 An indication of the typical annual rent in the UK is roughly £4000-5000 per megawatt (MW) of installed capacity, but this is usually paid as a fraction of gross income from electricity sales rather than as a fixed amount.

remote farm building. However, they are still usually connected to the mains electricity grid, in order to allow both the import and export of electricity when production exceeds or falls short of local needs. Both the equipment and installation costs per W installed are higher than for larger machines but the lower total amounts make it much more accessible to many farmers.

The economic attractiveness of owning a turbine depends on many factors, including wind potential, the size and cost of the wind turbine, cost of capital, electricity prices and stimulation measures. A key issue is how much of the power the farm uses and how much can be sold to the grid. Some studies suggest that a wind turbine investment pays for itself most quickly when most or all of the power is used on the farm, since the farmer is saving power at the retail price, rather than selling it at a wholesale price, however this does not take into consideration any potential incentives for renewable energy production.

In the Netherlands, the investment cost of an onshore wind farm is put at € 1,350/kW in 2010. The cost of operation and maintenance is about € 26/kW per year (fixed) and 0.011 €/kWh (variable), and the number of full-load hours is 2,200 hours/year (Lensink *et al.*, 2009). The generation costs range from € 0.07/kWh for very favourable sites to € 0.11/kWh for sites with a poor wind climate. However, wind farms on sites with a poor wind climate are not economically viable, as the feed-in tariff (in 2010) is € 0.096/kWh - actually, a feed-in premium is paid that is compatible with this feed-in tariff. Based on the above, a quick calculation shows that a farmer owning an average wind farm of 1.2 MW generating 2.64 up to 2.85 GWh per for the grid - would incur a turnover of ≥ € 250,000 per year. This provides a clear indication that such ownership may be a significant source of income.

In the UK, premium prices for small-scale renewable electricity generation through a new 'Feed-in Tariff' or 'Clean Energy Cashback' from April 2010 are expected to make on-farm power production an attractive investment for UK farmers (NFU, 2009). Other countries too, offer important incentives that farmers interested in investing in wind energy could make use of.

Besides direct costs and benefits, there are also some potential indirect economic effects that should be taken into consideration when assessing the attractiveness of investment into wind power on farms. One of them is the potential impact of the presence of wind turbines on the price of land. On average, there are 14 MW of wind power capacity installed per 1,000 km2 of land area in the EU (EWEA, 2009a). While such assessments seem to still be lacking in Europe, a 2009 US Department of Energy funded report concluded there is no statistical evidence of changes in property values from wind energy projects (EWEA, 2010). However, if the land lease is settled as an up-front payment and the property is sold before the end of the lease agreement, it could complicate the sale as the new landowner who will not receive any income from the wind turbines may want to pay a lower price for the property.

Among environmental impacts, noise and visual disruptions are the two main possible direct impacts on farms or farmers. Noise from turbines is rarely heard at distances further away than 300m and the French Agency for Sanitary Security, Environment, and Work (AFSSET) concluded "noise generated by wind turbines does not have any direct health impact" (EWEA, 2010).

2.5 Developments of wind in the case study regions

Among all case study regions, wind energy is well-developed in the German region of Brandenburg (which already has an installed capacity of 1648 MW) and in Soria, Spain. Although growth rate of installed wind capacity has stalled due to the Spanish credit crisis, it is likely to resume in the coming years. The difference between these two most dynamic regions is that in Brandenburg, many turbines are owned by farmers, while in Soria, this is not the case.

In Poland, development of wind energy has been lagging behind most other large European countries. In the Mazowsze region, the wind energy potential is not sufficient to support large turbines, however there is a growing interest between individuals (including farmers) in smaller scale (single) wind turbines for individual use or in order to sell electricity and green certificates. On the other hand, the Warmińsko-Mazurskie voivodship has one of the highest wind potentials in Poland, which is starting to attract investment in wind farms.

While Austria as a whole falls in the upper half of EU MSs according to installed wind capacity, neither of the chosen case study regions have witnessed strong wind development so far.

2.6 Prospects

In its short-term forecast, EWEA (2009a) expects an additional 66.3 GW of wind to be installed in the European Union over the next five years. For 2020, EWEA's targets are for 230 GW installed onshore and 40 GW offshore capacity, which would produce 14 - 17% of the EU's electricity - depending on total demand (EWEA, 2010).

Germany and Spain are expected to continue their lead in the mid-term, while the UK and France and also expected to significantly expand their wind capacities in the same period, followed by Italy, Poland and Sweden. While currently, 24 EU Member States have wind power all 27 are expected to have operating wind farms by 2020 (EWEA, 2009a).

Further expansion of the sector is supported by new EU legislation (adopted in 2009), often referred to as the "third liberalisation package", which continues the process of open up the power markets and creating a level playing field for all power producers.

In terms of further technological advances, the European Technology Platform for Wind Energy has established four thematic areas for future R&D:

1. wind conditions;
2. wind turbine technology;
3. wind energy integration;
4. offshore deployment and operation.

While the above mainly applies to the predominant large turbines, there are also important developments in small and very small wind turbines that are emerging to meet several distinct needs. As well as the traditional areas of rural electrification and providing power to isolated homes, boats and telecommunications facilities, the prospects for significant demand for 'microgeneration' in urban areas is prompting technical developments in small wind turbine design, which could result in significant improvements in the economics. There is great potential for growth in many of these markets (EWEA, 2009).

3. Photovoltaic power (PV) and Concentrating Solar Power (CSP)

3.1 Introduction

In 2009, the OECD as a whole produced 18 799 GWh of PV electricity in 2009, roughly 1% of its total renewable electricity production. The two largest producers of solar photovoltaic (PV) electricity in the OECD were EU member States Germany with 6 200 GWh and Spain with 6 103 GWh (IEA, 2010).

While being small in absolute terms, electricity from solar PV increased from 19 GWh in 1990 to 18 799 GWh in 2009, achieving a 44% annual growth rate, the fastest of all renewable electricity technologies, with growth being the strongest in the countries of the European Union (Germany, the largest producer due to its high feed-in tariffs for solar photovoltaic electricity generation, experienced the second fastest annual growth rate of 67% between 2000 and 2009 while Spain, the second largest producer, grew by 91% per year, the highest average annual growth rate in the OECD.

It needs to be stressed, that accounting for solar photovoltaic output is very difficult due to the widespread use of off-grid and small grid-connected systems for distributed power generation. For that reason, solar photovoltaic output statistics should be considered incomplete.

Whereas the technology of PV systems (and Concentrating Solar Power alike) has matured, their share in electricity generation is still small in Europe. This is because electricity from PV (or CSP) is rather costly compared to fossil-fuel based electricity generation (Comor, 2009). A main impediment to large-scale use of PV (or CSP) in agriculture, is therefore their relatively high cost. In order to be economically viable, PV needs an appropriate feed-in tariff. Such feed-in tariffs have become widely available throughout the EU.

3.2 Current status of technology

Photovoltaic (PV) systems consist of *modules* (based on PV cells) and the '*Balance of System*' (BOS). The evolution of PV modules has paralleled the successes of PV cells. '*Module*' is the term used to identify a grouping of interconnected PV cells into an enclosed, environmentally sealed package. Modules utilize a transparent front material, a cell and cell encapsulant, and a back cover material. Current PV cells and modules are considerably improved compared to some years ago, witnessed by increased efficiency and reduced replacement of, e.g., inverters (Lako, 2008).

PV systems are generally based on the feedstock silicon. There are various types of silicon-based PV modules, based on mono-crystalline, poly-crystalline, and amorphous Si (a-Si) cells. Next to this mainstream category, there are various thin-film PV technologies that are becoming mature. Thin-film PV may be based on silicon or e.g. on CIS (Cadmium Indium Telluride) cells. These PV systems are offered on a competitive base and thin-film PV systems are gradually gaining market share.

There are two main types of PV: off-grid PV and grid-connected PV. When PV entered the market, primarily off-grid PV systems were installed in Europe. However, as PV has become reliable and the cost has come down substantially, grid-connected PV has become the technology of choice, whereas off-grid PV (e.g. to feed water pumps) has become a niche market. As the supply of electricity from PV varies during the day, a balance between supply and demand may be obtained by grid connection.

PV systems may have different sizes. For farmers, the size of a PV system may be tailored to the electricity demand of the farmer. In that case, a PV system may have a capacity of a few kW's. However, if the farmer need to irrigate (part of) the agricultural land, the PV capacity may be much higher, e.g. in terms of hundreds of kW's. In Europe, it becomes more and more usual (particularly in Germany) for farmers to consider PV systems as an important additional source of income. If so, the PV system may have a capacity of tens up to hundreds of kW's, if the farmer has sufficient roof space available.

The costs of PV systems and the cost of electricity from PV systems is quite comparable across EU countries with a comparable solar irradiation (e.g. Germany and the Netherlands). In the Netherlands, the investment cost of a PV system of 15 – 100 kW_p is estimated at € 3,375/kW in 2010 (Lensink et al, 2009). Thus, a typical 30-kW_p system will cost approximately € 100,000. The cost of operation and maintenance is about € 0.027/kWh (variable), and the number of full-load hours is put at 850. For the aforementioned size of a PV system (15 – 100 kW_p), the feed-in tariff in 2010 is € 0.43/kWh. However, PV systems are becoming less and less expensive. Over the past 12 months, prices for turnkey solar power systems have fallen by an average of 13 percent, according to the German Solar Industry Association, BSW-Solar (Internet Source 4).

Concentrating Solar Power (CSP) is another promising technology for renewable electricity generation. It is based on concentration of sunlight to generate high-temperature heat, which is subsequently converted into electricity. Technologies under this umbrella are predominantly based on direct irradiation in southern Europe (Mediterranean). CSP plants are categorized according to whether the solar flux is concentrated by parabolic trough-shaped mirror reflectors (30-100 suns concentration[23]), central tower receivers requiring numerous heliostats (500-1000 suns), or parabolic dish-shaped reflectors (1000-10,000 suns). The receivers transfer the solar heat to a working fluid, which, in turn, transfers it to a thermal power-conversion system. To give a secure and reliable supply with capacity factors at around 50% rising to 70% by 2020[24], solar intermittency problems can be overcome by using supplementary energy e.g. natural gas, as well as by storing surplus heat.

In southern Europe (Mediterranean), Concentrating Solar Power (CSP) may be an alternative to PV. These power plants use tracking systems to pursue the course of the sun's movement. This way they are able to generate more electricity compared to the fixed or mounted systems. These CSP plants are also built in the USA (Nevada, California, Arizona, etc.), North Africa, and Australia. A substantial amount of these plants are supposed to be incorporated into agriculture (Internet Source 5). However, this may necessitate a shift from wet to dry cooling (SEIA, 2010; Carter and Campbell, 2009).
Figure 3.1 presents a view of the potential areas in the world that could use CSP. The minimum irradiation for CSP is of the order of magnitude of 1,800 kWh/m²/year. Therefore, CSP is applied in the southern states of the USA, the Mediterranean countries, the Middle East, Australia, etc.

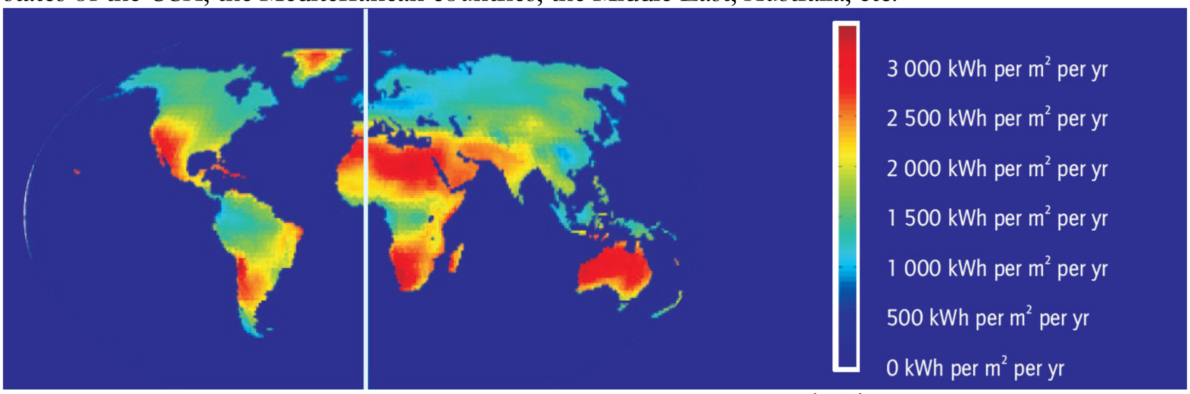


Figure 3.1. Solar resource for CSP technologies [DNI in kWh/m²/y] (Source: IEA, 2010)
Note: DNI = Direct Normal Irradiation

3.3 Main actors

Photovoltaic (PV) systems are typically modular systems (which is why the term *modules* is used) that are suitable for distributed generation. Owners of PV systems are households, service companies with suitable

[23] The term 'suns concentration' for concentrating solar power as well as concentrating PV refers to the concentration factor compared to normal sunlight.

[24] Integration of CSP in, e.g., a combined cycle (CC) based on gas may increase the capacity factor to 70% in 2020, which is equivalent to approximately 6,100 full-load hours.

buildings (roofs oriented towards the south), small businesses with suitable roof areas, and - to a lesser extent - electricity generators.

3.4 The role of solar power in agriculture

Farmers may be an important market for PV as they own buildings on their farms that may be used to install PV systems. Examples of on-farm PV use are commonly found to fulfil the electricity demand of the farmer. On a global scale, it is estimated that water pumping (for livestock watering, irrigation as well as potable water) has gained prominence, representing around 12 percent of yearly global PV production and one of the major rural PV markets in developing countries (Campen, Guidi and Best, 2000). However, PV systems tend to be used on a larger scale, providing a significant source of income to farmers.

The development of the market for PV systems differs a lot among EU countries. Although PV still has a minor share in electricity generation in Germany, PV systems are popular among households, service companies, small businesses, etc, by virtue of attractive feed-in tariffs. This also holds for farmers. In 2009, the potential of PV on roofs of farmers' buildings in Germany was put at 22 GW, and the PV capacity owned by farmers was estimated at 8.5% of this potential or 1,850 MW (Internet Source 1). The potential of PV on roofs of buildings of farmers (22 GW) is equivalent to 3.5% of the estimated total potential of PV in Germany. Characteristics of this market are (Internet Source 2):

- Farmers are among the top PV customers in Germany.
- Farmers tend to be relatively sensitive with respect to the economic attractiveness of PV.

Still in Germany, farmers installed on average 200 – 250 MW of PV per year on their buildings in the years 2005 – 2008. In 2009, another 285 MW of PV could be installed by farmers (Internet Source 1), increasing the aggregate PV capacity on farmers' buildings to approximately 2,150 MW by the end of 2009.

Unfortunately, there is much less information of this type available for other countries. However, any figures would be much lower compared to those for Germany, as the market leader in solar PV. Development of PV in agriculture, critically depends on the financial incentives available on a national scale for renewable electricity generation in general, and for PV (or CSP) in particular.
For PV systems, no significant negative environmental effects are envisioned, provided that the PV systems may be installed on roofs. At the end of their economic lifetime (20 years or more), the PV system will have to be disposed of. However, recycling of materials used in PV systems has become state-of-the-art. The shift to thin-film PV systems may also assist in reducing the environmental burden of disposing of PV systems at the end of the economic lifetime.
For CSP, as far as this technology will be used by farmers in southern Europe (Mediterranean), the only important environmental issue may be the availability of cooling water. Shifting from wet to dry cooling may substantially reduce this possible environmental issue.

3.5 Prospects

The availability of roof space is not a real impediment to the growth of PV. For instance, in Germany the roof space occupied by PV systems in 2008 was estimated at 1,700 ha, whereas the roof space (oriented towards the south) that is available is estimated at 234,400 ha (AEE, 2010) – this is the aggregate potential for PV and solar thermal energy in Germany.
As the technology has become mature, and the cost of PV systems has come down, installed PV systems are increasing in size. In Germany, the average capacity is now 30 kW_p or more. While subsidies for PV systems are starting to be reduced, if the feed-in tariff is reduced at the same pace as the cost of the PV system, PV may remain an attractive economic option for farmers.

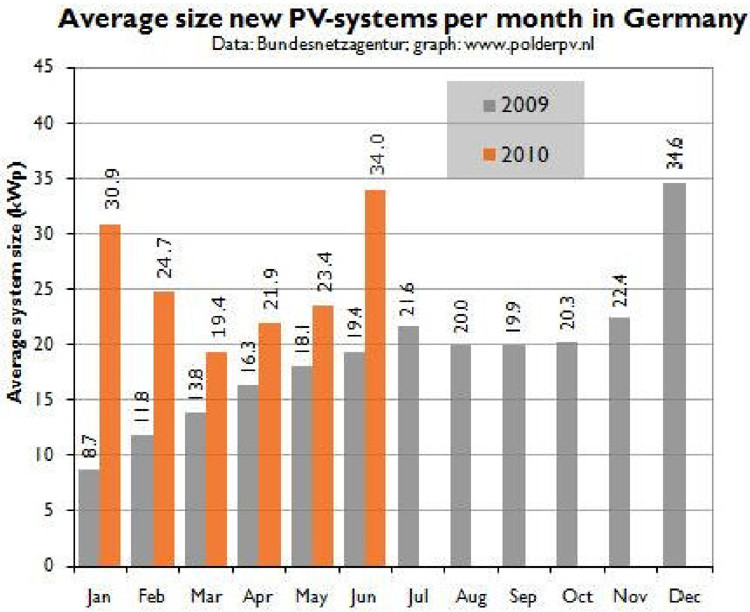


Figure 3.2 Average size of PV systems installed in Germany in 2009 and 2010 [kW$_P$]
Source: Internet Source 3

If EU countries are willing to provide financial incentives for renewable electricity generation (e.g. based on feed-in tariffs) in general, and for PV in particular, there is a very large market for PV in agriculture. For instance, the potential of PV on roofs of farmers' buildings in Germany is estimated at 22 GW (of which less than 10% has been developed in 2010). Therefore, PV will possibly offer a significant secondary source of income for farmers that are able to develop their PV potential.

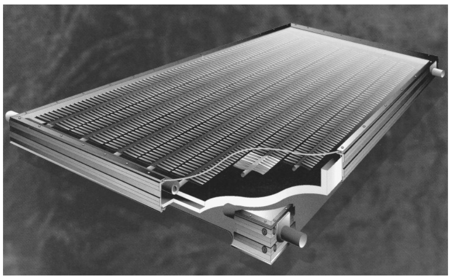
4. Solar thermal energy

4.1 Introduction

Solar thermal energy is based on a collector area on a roof to produce hot water for domestic needs. The main market is domestic hot water. A secondary market is space heating. Solar thermal systems are used in houses, the service sector, and small businesses, e.g. farms. Solar thermal systems often use a gas-fired boiler as back-up. Also, hot water storage is used to balance supply and demand. The technology is relatively mature, although technological progress and cost reduction is achieved.

4.2 Current status of technology

A solar thermal systems consists of one or more collectors and a hot water storage. Figure 4.1 shows a solar collector, and Figure 1.8 shows a typical solar thermal system with hot water storage. The most commonly used type of collectors are flat plate collectors (Figure 4.1) and vacuum tube collectors.



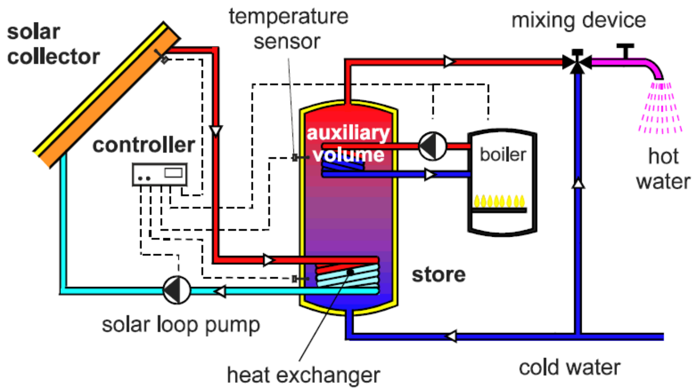


Figure 4.1 Solar thermal collector and solar thermal system with hot water storage (Source: Internet Source 9 and Drück Heideman and Müller-Steinhagen, 2004)

Depending on the latitude, up to 50 to 70% of the domestic hot water use with temperatures up to 40 – 70°C can be provided by solar heating systems.
It is noteworthy that 68 percent of the solar thermal plants installed worldwide are in China, where the government urged the industry early on to produce collectors (Internet Source 10). Figure 4.2 shows the development of the market for solar thermal systems in the EU27 and Switzerland (2003 – 2009). The market demand in Europe is approximately 300 – 350 MW_{th} per year.

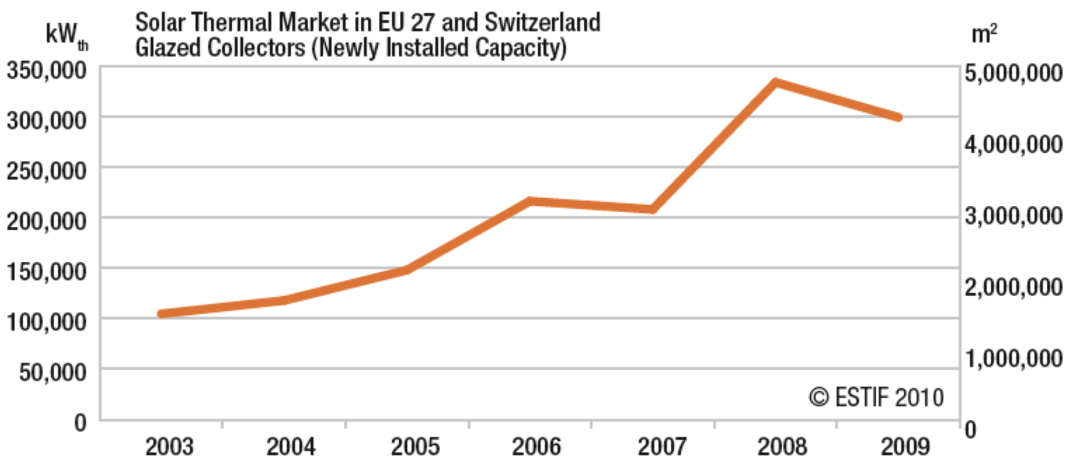


Figure 4.2 Solar thermal market in EU27 and Switzerland [MW_{th}] (Source: ESTIF, 2010)

Figure 4.3 shows a disaggregation of the solar thermal systems by application and country. In the Mediterranean, solar thermal systems are primarily used for the demand for domestic hot water of single family houses. In countries in central Europe and the northern part of Europe, these systems are also used for the hot water demand of multifamily houses and for district heating and space heating.

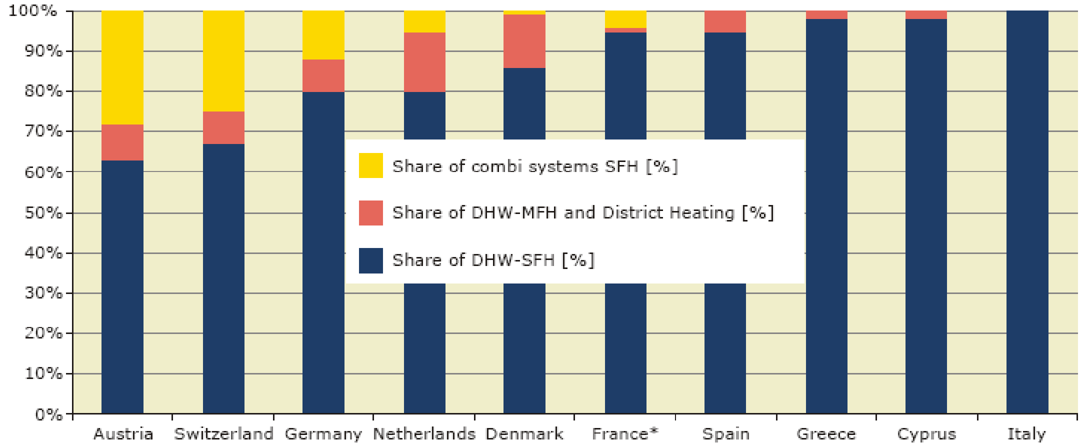


Figure 4.3 Breakdown of different applications of solar thermal systems in Europe [%] (Source: ESTIF, 2009)

In the Netherlands, a typical solar heating system consisting of two (flat plate) collectors and a yield of 4.8 GJ/year, requires an investment of € 3,300 (Internet Source 6) - specific investment cost about € 700/GJ/year. According to (Internet Source 7), the pay-back period in the Netherlands is 12 – 16 years (investment cost € 3,000 – 4,000; energy conservation € 250/year). A comparable pay-back period is usually between 4 and 14 years (Internet Source 8). Generally, solar heating systems will show a shorter pay-back period in the southern part of Europe than in the northern part and Central Europe - based on a higher solar irradiation in the Mediterranean.

4.3 Main actors

The owners of solar collectors range from houses, buildings (services and commercial enterprises), and small businesses (among which farmers). Solar collectors (with hot water storage) do not require much maintenance. Therefore, they do not pose any problem with respect to ownership.

4.4 The role of solar thermal technology in the agricultural sector

Livestock and dairy operations usually have substantial air and water heating requirements. According to (Focus on Energy, 2006), solar thermal technology may be applied in the agricultural sector for the following purposes (Table 4.1).

Table 4.1 Solar thermal applications for the farm (Source: Focus on Energy, 2006)

Application	Description	Considerations
Greenhouse Vent and Louver Openers	A piston device that extends to open and close greenhouse vents or ventilation louvers automatically by employing the sun's heat to expand wax contained in the mechanism, adjusting the vent as temperature changes	
Solar Thermal Air Heating	There is a perforated metal siding product available which is installed with a ventilation system so that solar heated air is drawn up and into the building to be distributed by ducts inside. In the summer, the hot air is directed out of the building by dampers, providing ventilation benefits.	This can be installed either when the building is constructed or added later.
Crop Drying	A combination of passive and active solar air heating, with potential for use with solar electric powered ventilation.	
Root Zone Heating	A way of extending crop seasons in greenhouses, a solar hot water system can be used to distribute heat in bench or floor planting areas by use of hydronic thermal tubing in the soil.	Can be used as a preheating method for conventionally fueled root zone heating.
Water Heating	Solar heated water can be used for barn cleaning, tempering of drinking water and other livestock	This technology can be particularly economical if the farm

	applications.	relies on LPG for heating.
Passive Heating and Daylighting	Translucent roofing panels on livestock barns and other outbuildings can cut use of lighting fixtures during daylight hours, as can appropriate installation of windows on the south side of the building. Thermal mass inside buildings, including stone or brick floors, walls or fireplaces, can capture and store the sun's heat to cut or eliminate the need for other heating purposes.	Most economical when incorporated at the time of building construction.

4.5 Prospects

The availability of roof space is not a real impediment to the growth of solar thermal energy. In Germany the roof space occupied by solar thermal systems is estimated at 1,285 ha in 2009 (Internet Source 11), whereas the roof space that is available is estimated at 234,400 ha – this is the aggregate potential available for PV and solar thermal energy in Germany (AEE, 2010).

Application of solar thermal energy in agriculture depends on the economic feasibility. The investment cost of a typical solar heating system have come down by a factor of two over the past 15 years, which supports the expansion of such systems in agriculture. Depending on the alternative conventional fuels used (LPG, heating oil), using solar systems may also generate significant environmental benefits (reduced air emissions, less fuel - LPG, heating oil - transportation to the farms).

5. Solid biomass markets

5.1 Introduction

Electricity generation from solid biomass grew in OECD countries from 93.3 TWh to 125.6 TWh between 1990 and 2009, yielding a 1.6% average annual growth (IEA, 2010). As the third largest renewable electricity source after hydropower and wind, solid biomass accounted for 7.1% of renewable electricity generation in 2009. The United States accounted for 32% of electricity generated from solid biomass (40 TWh), where it makes up 9.5% of the country's renewable electricity production. The second largest producer of electricity from solid biomass is Germany (12.9 TWh), where it represents 13.6% of the country's renewable electricity supply. Other large producers of electricity from biomass in the OECD in 2009 are Japan and Sweden, whose shares are 9.4%, and 7.9%, respectively. Biomass was the largest source of renewable electricity in Hungary, Poland, and Belgium where it comprised 74%, 56%, and 52%, respectively, of renewable electricity in 2009. In fact, solid biomass electricity was produced in all OECD member countries in 2009, except for Greece, Iceland, and Luxembourg.

EU21 electricity production from solid biomass taken from NREAP studies is 46.4 Mtoe in 2010 (Beurskens and Hekkenberg, 2010). EU27 primary production from solid biomass is estimated at 70.3 Mtoe (EurObserv'ER online database[25]). This is including biomass use for heating. Bioelectricity production from solid biomass in EU 27 has been assessed at 57.8 TWh (2008).

Biogas: primary energy production in 2008 was 7.4 Mtoe, as compared to 147.7 Mtoe for all renewable energy sources. Of the primary energy, xx Mtoe (20.0 Twh) was gross electivity and 0.4 Mtoe was heat.

Table 5.1. Total renewable heatng and cooling (RES-H/C) energy for 21 countries: Austria, Bulgaria, Cyprus, Czech Republic, Denmark, Germany, Greece, Finland, France, Ireland, Italy, Lithuania, Luxemburg, Malta, Netherlands, Portugal, Romania, Spain, Sweden, Slovenia and UK (Source: Beurskens & Hekkenberg, 2010)

	2005 [Mtoe]	2010 [Mtoe]	2015 [Mtoe]	2020 [Mtoe]	Share [%][a]	Share [%][b]	*Page*
Geothermal	0.4	0.5	1.0	1.9	2.0	0.9	*96*
Solar thermal	0.7	1.4	2.7	5.5	5.8	2.5	*102*
Solid biomass	45.2	46.4	55.0	66.8	70.8	30.6	*110*
Biogas[c]	0.6	1.4	2.5	4.4	4.6	2.0	*110*
Bioliquids	1.1	3.6	4.1	4.4	4.6	2.0	*110*
Biomass (subtotal)	46.9	51.4	61.6	75.4	80.0	34.6	*110*
Aerothermal heat pumps	0.1	2.3	3.7	6.1	6.5	2.8	*116*
Geothermal heat pumps	0.2	1.2	2.3	4.0	4.2	1.8	*116*
Hydrothermal heat pumps	0.0	0.2	0.3	0.5	0.5	0.2	*116*
Renewable energy from heat pumps (subtotal)	0.6	3.9	7.0	11.5	12.2	5.3	*116*
Total renewable heating and cooling	48.6	57.2	72.3	94.3	100.0	43.3	-

[a] The percentage refers to the share of the individual technologies in total renewable heating and cooling in the year 2020

[b] The percentage refers to the share of the individual technologies in total renewable energy (electricity, heating and cooling and transport) in the year 2020

[c] In 'biogas' the value for 'Bio-SNG for grid feed-in' as specified in the Dutch NREAP has been included

Heat

The proportion of biomass heat in EU27 has been estimated by AEBIOM as part of the final energy consumption (1,158 Mtoe in 2007). About 48% of the final energy demand in Europe is heat. Heat comprises space heating, hot water and heat for industrial processes. Households are the largest consumer of heat, followed by industry and services.

25 http://observer.cartajour-online.com/Interface_Standard/cart@jour.phtml?NOM_PROJET=barosig&NOM_USER=&Langue=Langue2&Login=OK&Pass=OK

Table 5.2 Biomass heat by sector in EU27 (2008) (Source: Eurostat (2009), AEBIOM calculations)

Sector	Final energy (Mtoe)	Heat	
		%	Mtoe
Industry	323	55	178
Households	285	86	245
Commerce, Services & Agriculture	173	76	132
Transport	377	0	0
Total	1158	48	554

EurObserv'ER (2009) provides information on heat sold via a community heating network (heating plants which are either operated by industrial groups that sell off their surplus heat product, managed networks or energy service undertakings). The figures presented in the latest EurObserv'ER report are only a part of the biomass heat in EU27 as the domestic sector which accounts for the main bulk of the heat consumption is not included. Also, these statistics do not include industrial heat production used on site for heating factory premises, heat produced by domestic heating appliances, collectives or industrial operations not linked to the network. Figure 5.1 below presents the heat sales in EU27 for 2008 based on these statistics. Sweden, Finland and Denmark account for over two-thirds of the identified heat sold in the European Union member states (67.4% in 2008).

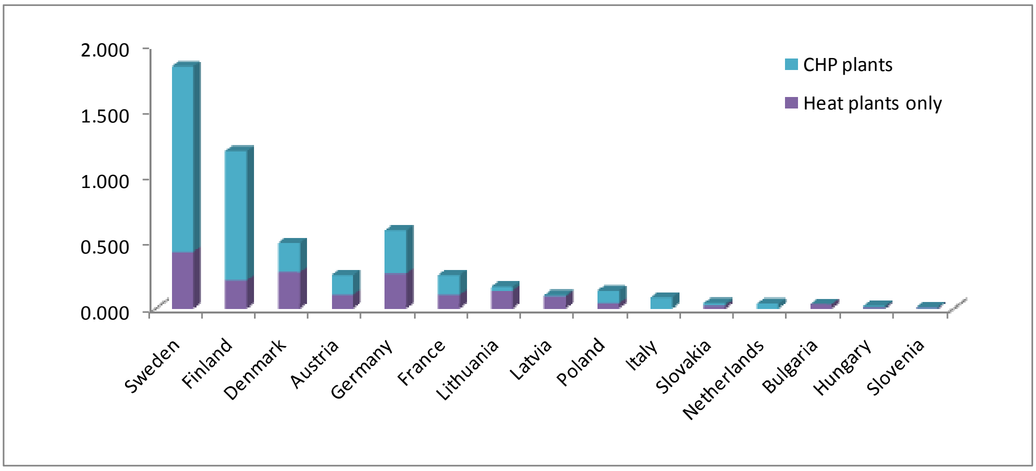


Figure 5.1 Heat sales in EU27 for 2008 (EurObserv'ER 2009)

The increase in heat sales kept pace with electricity production in 2008 (up 10.8% on 2007), adding a further 0.5 Mtoe, after a drop in production in 2007 following the mild winter which limited heating needs. Over two-thirds of all the heat sold (67.4% in 2008) was delivered by cogeneration plants (EurObserv'ER 2009).

Biomass for Electricity

According to AEBIOM, EUROSTAT and EurObserv'ER, bioelectricity production from solid biomass reached 57.76 TWh in 2008 (at 10.8%), compared to 51.8 TWh in 2007, and 20.3 TWh in 2001 when EU issued the Directive on the Promotion of Electricity from Renewable Energy Sources. Because of this Directive, significant efforts were made in almost all Member States, though still more than half the production (51.2% in 2008) is concentrated in Germany, Sweden and Finland (EurObserv'ER 2009). Biomass electricity generation is based on three fuel types: solid biomass, biogas and the biodegradable fraction of MSW. Electricity from biomass grew by 15-20% in the last years.

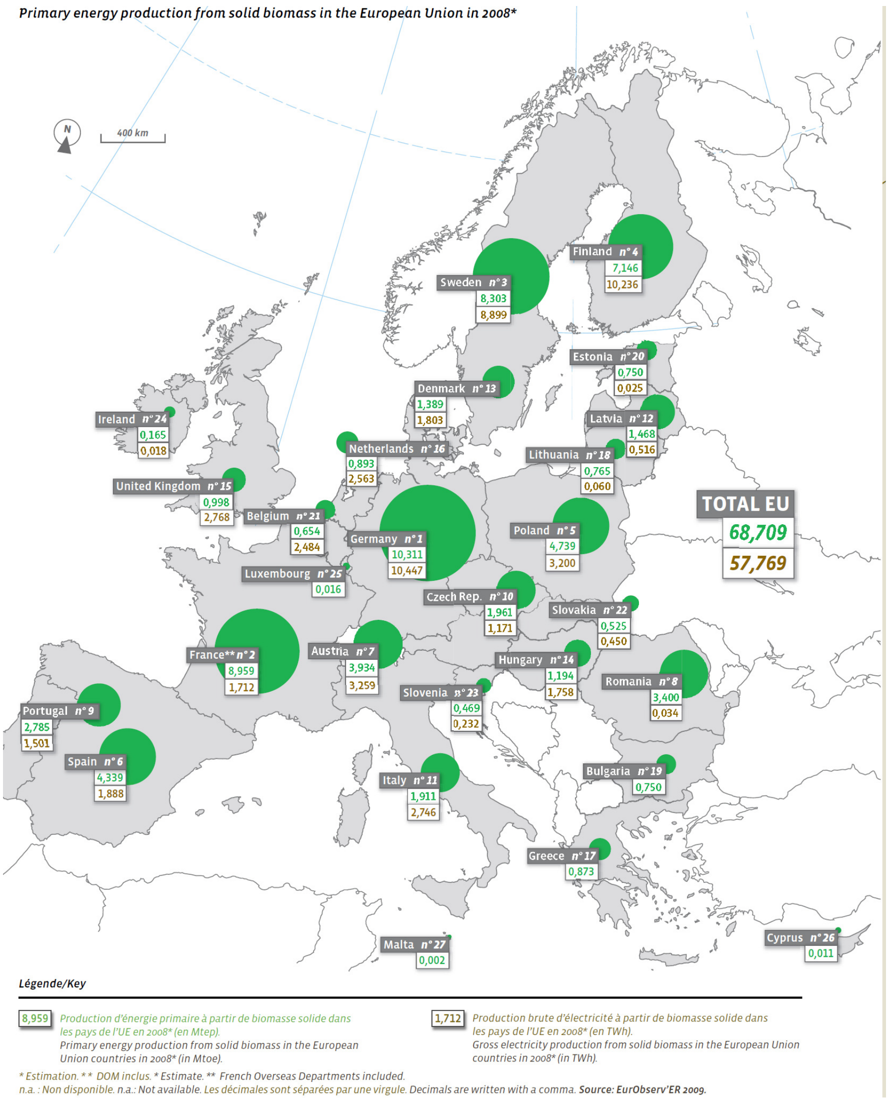


Figure 5.2 EU27 Primary energy production in 2008 form solid biomass (Mtoe) and electricity generation (TWh) (Source: EurObserv'ER 2009)

CHP

Currently, installed CHP capacity in the EU-27 is about 95 GWe, which accounts for about 11% of electricity demand. Natural gas dominates the CHP market (about 40%), followed by coal with 27%. Renewables, mainly biomass, but also combustible waste, are gradually becoming more important, currently having reached 10%. CHP systems have significant penetration in the EU industry, producing approximately 16% of final industrial heat demand.

It is worth noting that cogeneration (CHP) plants, which produce heat and electricity concurrently, account for almost 63% of EU-27's bioenergy production from solid biomass (EurObserv'ER 2009).

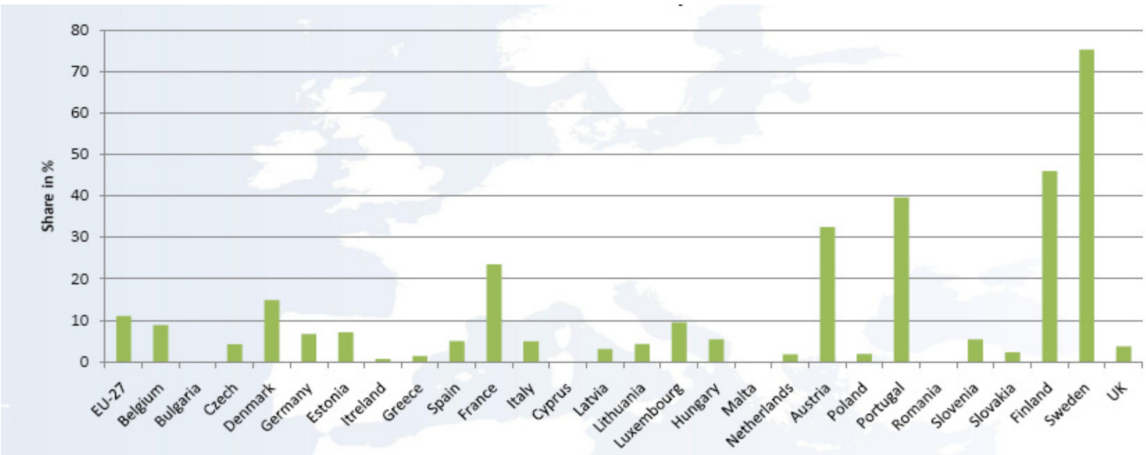


Figure 5.3 Biomass share in CHP plants in EU27 Member States (Source: Cogeneurope, year!)

Figure 5.3 shows that the highest share of biomass in CHP plants are in Scandinavia (Sweden, Finland and Denmark), in France, Austria and Portugal. It is worthwhile to mention that most solid biomass CHP plants are located in countries of considerable forest industry thus woody biomass is the predominant fuel. Regarding scales, smaller capacities (<1 MWe) exist in central Europe, while larger plants (>20 MWe) are located in Northern Europe. Key issues facilitating the market development in these countries are the existence of district heating networks and the strong support policies for respective schemes.

Within the European Strategic Energy Technology Plan (http://setis.ec.europa.eu), the baseline scenario assumes further growth in this segment, to about 23% by 2030. Important growth is assumed in biomass-based CHP, mainly in district heating (DH) but also in industry. In the Strategic Plan the estimated maximum potential for the installed capacity of biomass CHP in the EU-27 is up to 42 GWe by 2020 and 52 GWe by 2030. These CHP capacities would generate about 4.7% and 5.3% of projected EU gross electricity consumption by 2020 and 2030 respectively. Moreover, the assumption is that biomass CHP installations represent approximately 2/3 of the total installed capacities of biomass based power plants.

5.2 Current status of the technology

The most common land resources providing biomass for bioenergy production at present are agricultural and forest lands. In some countries like Finland abandoned lands (former peat mining areas) are also already in use for bioenergy cropping. Other land resources are also delivering biomass feedstocks but their use is still limited. Forest biomass is usually obtained as a by-product from the forest and paper industry and targeted wood production for conversion into bioenergy is not a common practice as yet.

The three different types of energy for which biomass can be used – transport fuel, electricity and heat/cooling – use different (while overlapping) types of biomass and therefore translate into different land uses (Figure 5.4). In the case of transport fuel, it is commonly accepted, given the current state of fuel conversion technology, that until 2020 almost all primary biofuel feedstock will come from crops used for ethanol and biodiesel production. These are mainly rotational crops commonly grown on traditional arable farms. They are starch crops (e.g. wheat, potatoes, grain maize, barley and rye), sugar crops (e.g. sugar beet, sweet sorghum) and oil crops (e.g. rape, sunflower, soy-bean). As from 2015/2020 it can be expected that efficient 2nd generation techniques will be developed for converting ligno-cellulose (woody or grassy) crops and by-products into transport fuels. Part of the biomass for biofuels can also come from forestry, nature conservation areas and other land categories. In agriculture the main crops delivering ligno-cellulose material are short rotation coppice crops like willow and poplar or perennial grasses like Miscanthus, Switchgrass, Reed Canary Grass or Giant Reed.
In the case of electricity, the targets that exist until 2020 are more difficult to connect directly to future agricultural land use, because there is such a wide range of renewable energy sources that could be used to realise these. Biomass is generally the most important source, but bio-energy feedstock for power can come from agricultural crops like short rotation coppice and perennial grasses, or it can be wastes or by-

products from agriculture, forestry and other industries, urban waste or imported pre-prepared fuel. The range of feedstock is also very large and difficult to assess for heat generation from renewable sources.

- ***Primary by-products***: At the source = sugar beet tops, straw, verge grass, prunings, greenhouse residues, etc.
- ***Secondary by-products***, later in the production chain = potato peels, sugar beet pulp, sawdust, etc.
- ***Tertiary by-products***, has had a use = used frying oil, slaughterhouse waste, manure, household organic wastes, used paper, demolition wood.
- ***Specific crops***, rape, energy grain, Miscanthus, switchgrass, short rotation coppice, sugar beet for ethanol, etc.

All these feedstocks can either be produced on the European market or be imported.

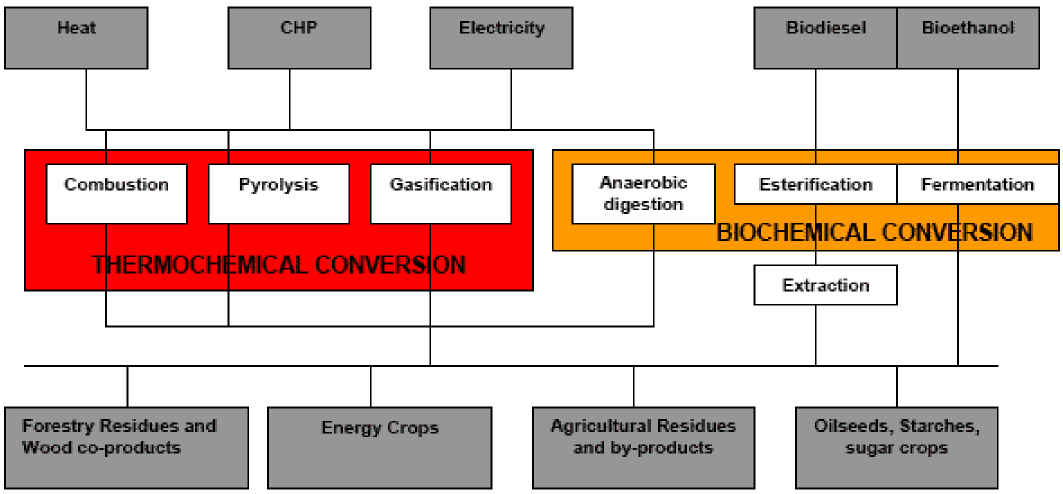


Figure 5.4. Conversion pathways (Source: Natural Scotland, 2006)

Electricity

The structure of final electricity consumption in the EU-27 is shown in Figure 5.5, broken down by major end use sector. Final electricity consumption is dominated by industry and households, which together accounted for almost 70% in 2008, with services, agriculture and other sectors accounting for the remainder. Overall, electricity consumption continues to be dominated by industry, which accounted for 40% of the total in 2008; households accounted for 29% and the service-agriculture sector also accounted for 29%.

Final energy consumption in services, agriculture, etc., covers quantities consumed by small-scale industry, crafts, commerce, administrative bodies, services with the exception of transportation, agriculture and fishing.

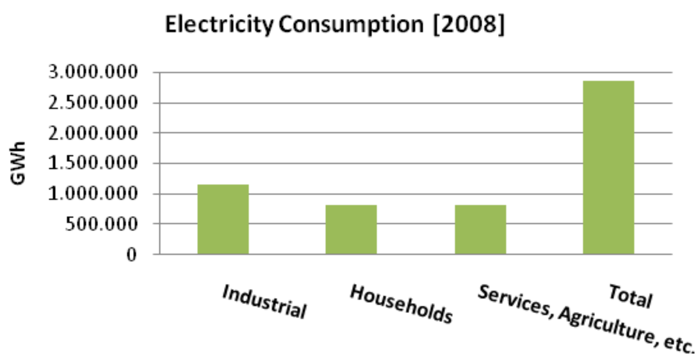


Figure 5.5: Structure of final electricity consumption in the EU-27 for 2008

Heat

Heat consumption in the EU-27 was 45,593 Mtoe in 2007, which was a 5% decrease from 47,956 Mtoe in 2006. About 81% of the European countries reported heat consumption occurs mainly in France, Germany, Italy, Poland, Finland and Sweden, together accounting for 83% of the European reported heat consumption in 1980 and 60% in 2007. Over the same period, heat consumption has declined in Hungary and Poland as older heat plants have been closed and replaced with decentralized heat in some areas, while growth has been particularly strong in Austria, Denmark, Finland, France, Iceland, Portugal and the United Kingdom.

These data do not refer to the consumption of heat produced in industrial undertakings or service industries for their own use. In this section heat consumption refers to heat sold to third parties by both main activity producers and autoproducers. In 2007, about 39% of third party heat consumed in EU countries was used in the industrial sector, about 21% in the residential and about 11% in the commercial/public services sector.

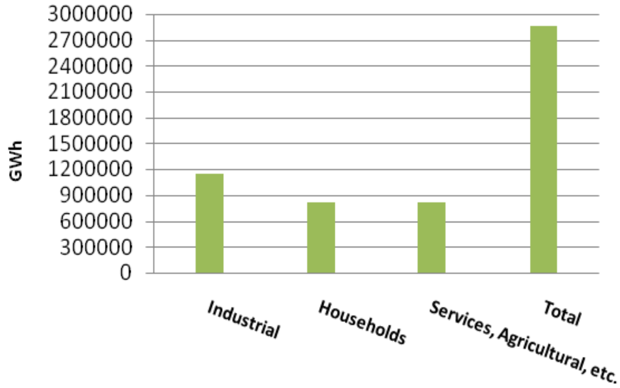


Figure 5.6. Structure of heat consumption (only heat sold to third parties) in EU27 for 2007

Combined Heat and Power (CHP)

Combined heat and power (CHP) or cogeneration is a technology used to improve energy efficiency through the generation of heat and power in the same plant, generally using a gas turbine with heat recovery. Heat delivered from CHP plants may be used for process or space-heating purposes in any sector of economic activity including the residential sector. CHP thus reduces the need for additional fuel combustion for the generation of heat and avoids the associated environmental impacts, such as CO2 emissions (Eurostat, 2001).

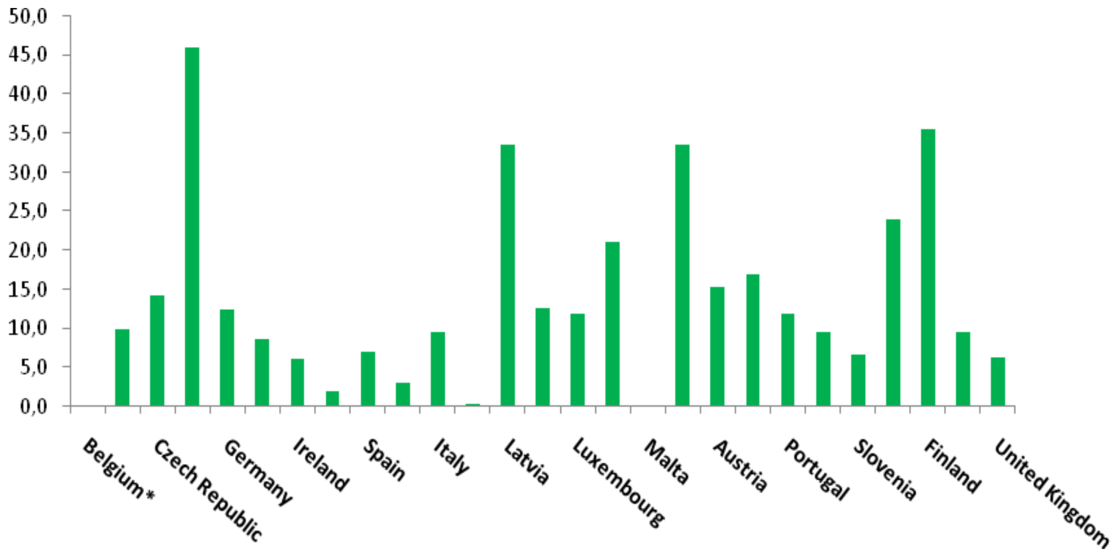


Figure 5.7 EU CHP Generation [2008]

These data do not refer to the consumption of heat produced in industrial undertakings or service industries for their own use. In this section heat consumption refers to heat sold to third parties by both main activity producers and autoproducers. In 2007, about 39% of third party heat consumed in EU countries was used in the industrial sector, about 21% in the residential and about 11% in the commercial/public services sector.

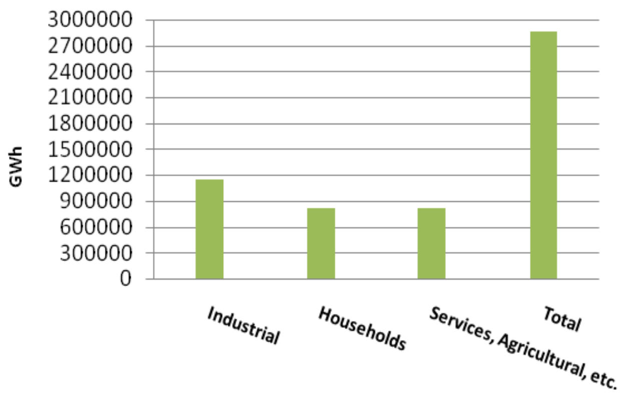


Figure 5.8. Structure of heat consumption (only heat sold to third parties) in EU27 for 2007

Combined Heat and Power (CHP)

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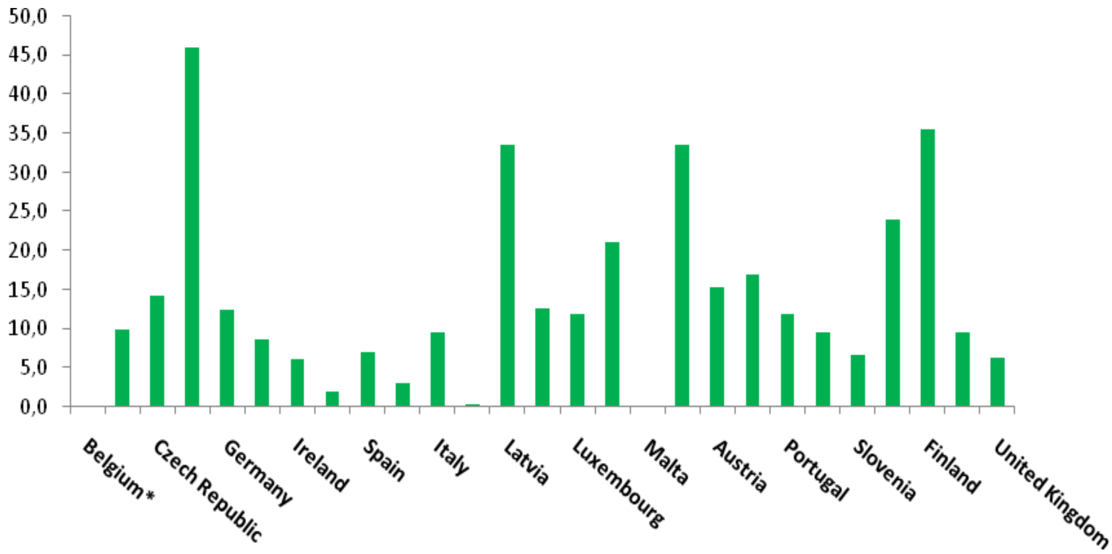

Figure 5.9. EU CHP Generation [2008]

5.3 Main actors

As can be deduced from the above, the field of solid biomass is extremely variegated in terms of ownership of energy plants and transport facilities, ranging from farm enterprises to multinational companies.

5.4 The role of energy from solid biomass in agriculture

Bioenergy cropping in agricultural areas can start either on existing arable land or through the conversion of grasslands and permanent crop land or other types of semi-natural land categories into arable fields for e.g. cereals. The latter is however not a very common practice in Europe at this moment, while large areas of former compulsory set-aside land have now been taken into agricultural production for food and feed crops. Increased conversion of more extensive land uses could be encouraged if biomass demand and support leads to a significant increase in prices.

In EU conditions typical energy crops are oil crops (oil seed rape, sunflower), cereals, maize (for biogas mainly) and sugar beet which are also used for food and feed purposes (see Table 5.3). Perennial biomass cropping, e.g. Miscanthus and Reed Canary Grass, is not yet taking place at large scale as demand for ligno-cellulosic biomass is still limited under the present state of 1st generation conversion technologies. In spite of this there are some countries with some large-scale plantations of Reed Canary Grass such as Finland and of Miscanthus, such as UK, which are now only used as feedstocks for conversion into electricity and heat. The advantage of these perennial crops is that their input levels are generally lower then for annual crops, they are not used for food and feed purposes and they can also be grown on lower quality soils, e.g. abandoned lands, not suited for rotational arable crops. Their environmental footprint seems to be smaller and competition effect on food and feed markets is therefore limited. In spite of this they still compete for land, especially if demand for biomass increases significantly. Last but not least, there is still a large (scientific) knowledge gap on the biodiversity and environmental effects (e.g. Green House Gas balance, Soil Carbon balance) of converting abandoned lands to (large scale) perennial biomass plantations.

Table 5.3 Overview of main biomass crops presently grown for bioenergy conversion purposes in the EU (Source: Dworak et al., 2009, Report for DG-Environment)

	Total area per crop type (x 1000 ha)						**Total energy cropping area**	
	Oil crops	**Cereals**	**Sugar-beet**	**Maize**	**Other arables**	**Peren-nials**	**1000 ha**	**% / UAA**
Austria	15.0	1.5	0	40.0	0	0.1	56.6	1.7
Belgium (only Flanders)	1.0	1.4	0	0.7	0	0	3.0	0.5
Bulgaria	258.1	0	0	0	0	0	258.1	**5.4**
Cyprus a)								
Czech Republic	104.0	0	0	0	0	0	104.0	2.6
Germany	1,105.0	128.0	3.0	295.0	0		1,531.0	**9.6**
Denmark	95.0	0	0	0	0	0	95.0	**5.7**
Estonia b)								
Spain	150.2	33.1	0	0	20	a	183.3	0.8
Finland	0.8	0.4	0	0	0	17.0	18.3	0.9
France	952.4	300.0	50.0	50.0	0	A	1,352.4	**5.1**
Greece	11.2	0	0	0	0	0	11.2	0.4
Hungary	18.5	0	0	0	0	0	185.0	0.3
Ireland a)								
Italy	65.0	0	0	0	0	a	65.0	0.5
Lithuania b)								
Luxembourg a)								
Latvia b)								
Malta a)								
Netherlands	2.5	0	0	0.5	0	0	3.0	0.2
Poland	740.7	0	0	0	0	0	740.7	**4.1**
Portugal a)								
Romania	568.7	0	0	0	0	0	568.7	**4.8**
Sweden	50.0	35.0	0	0	0	14600	99.6	**4.2**
Slovenia b)								
Slovakia b)								
UK	320.6	16.0	0	0	0	13602	350.0	2.6
Total	**4,458.6**	**515.3**	**53.0**	**386.2**	**20**	**45,325**	**5,458.4**	**2.6**

a) No significant biomass cropping, but detailed data not available
b) Some biomass copping expected, but detailed data not available

Also side-products of agriculture like straw are used for conversion into bioenergy. Nowadays short-rotation coppices e.g. willows (mostly *Salix viminalis*) or poplar are grown in agricultural land, e.g. in Sweden and UK (Ball et al., 2005).

The total number of hectares currently involved in biomass production is less than one third of the 17.5 million hectares of land that would be required to reach the EC's 10% biofuels target (EC, 2008).

5.5 Developments of solid biomass in the case study regions

In the case study regions the use of solid biomass for energy purposes is widespread in almost all cases. Only in Brandenburg this is not yet very important. In Carinthia the solid biomass is primarily forest-based. In all regions an increase in the use of solid biomass is expected in the coming decades, as is valid in general for Europe (see next paragraph).

5.6 Prospects

The prospects for biomass electricity and biomass heat are positive in all countries with increases varying from slight to strong (see Fig. 5.10 and 5.11 resp., Beurskens & Hekkenberg, 2010). Also when environmental consideration are taken into consideration, the bioenergy potential for the agricultural sector in the EU is large (EEA, 2006).

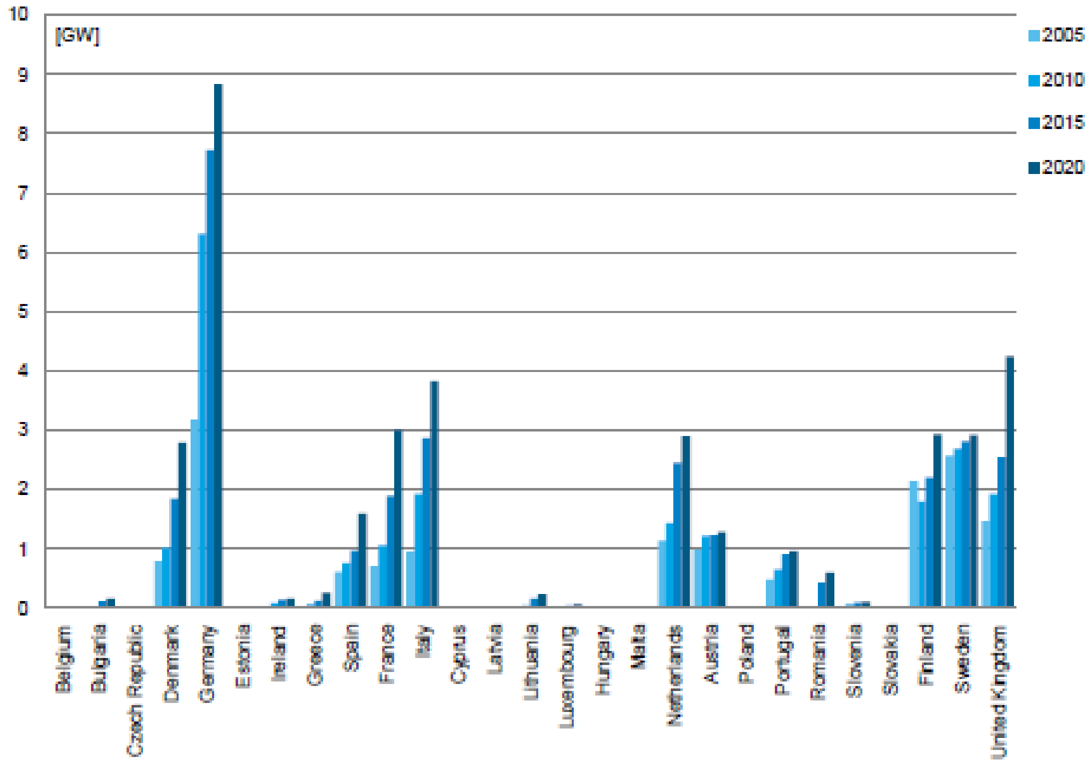

Figure 5.10. Projected total biomass electric capacity [GW] for the period 2005 - 2020, all biomass input categories (Source: Beurskens & Hekkenberg, 2010)

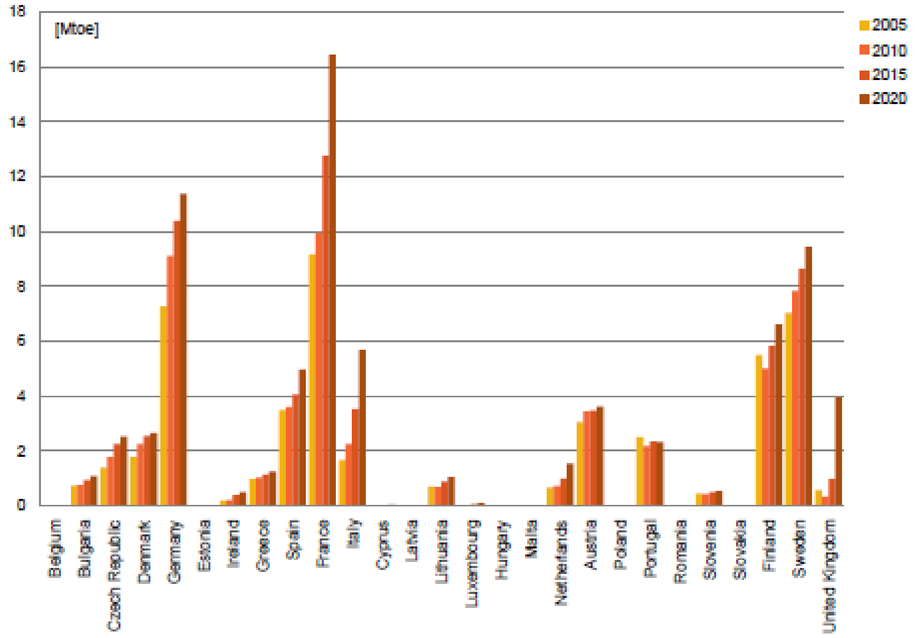

Figure 5.11. Projected total biomass heat energy [Mtoe] for the period 2005 - 2020, all biomass input categories (Source: Beurskens & Hekkenberg, 2010)

Table 5.4. The environmentally-compatible bioenergy potential (in MtOE) by Member State and sector in 2010, 2020, 2030 (Source: EEA, 2006)

	2010				2020				2030			
	Agriculture	Forestry	Waste	Total	Agriculture	Forestry	Waste	Total	Agriculture	Forestry	Waste	Total
Austria	0.6	3.3	3.0	**6.9**	1.4	3.3	3.1	**7.8**	2.1	3.5	3.1	**8.7**
Belgium	0.1	0.1	2.1	**2.3**	0.1	0.1	2.1	**2.3**	0.1	0.2	2.0	**2.3**
Germany	5.0	6.3	14.9	**26.2**	13.7	5.3	14.8	**33.8**	23.4	4.8	15.0	**43.2**
Denmark	0.4	0.1	2.3	**2.8**	0.1	0.2	2.2	**2.5**	0.1	0.2	2.2	**2.5**
Spain	7.8	1.7	7.1	**16.5**	12.9	1.8	7.3	**22.0**	16.0	1.5	7.5	**25.1**
Finland	1.9	1.7	6.1	**9.6**	1.8	1.8	6.2	**9.8**	1.3	1.8	6.2	**9.4**
France	2.6	12.7	16.1	**31.4**	7.8	13.2	16.2	**37.2**	17.0	14.2	16.2	**47.4**
Greece	0.0	n.a.	1.6	**1.6**	1.7	n.a.	1.6	**3.4**	2.2	n.a.	1.7	**3.8**
Ireland	0.0	0.1	1.0	**1.1**	0.1	0.1	1.0	**1.2**	0.1	0.1	1.0	**1.3**
Italy	4.1	5.6	6.5	**16.2**	8.9	3.3	6.5	**18.7**	15.2	3.0	6.6	**24.8**
Luxembourg	n.a.	n.a.	0.0	**0.0**	n.a.	n.a.	0.0	**0.0**	n.a.	n.a.	0.0	**0.0**
Netherlands	0.2	0.1	2.4	**2.6**	0.5	0.1	1.6	**2.2**	0.7	0.2	1.6	**2.4**
Portugal	0.7	0.2	2.7	**3.6**	0.8	0.2	2.9	**3.9**	0.8	0.2	3.1	**4.1**
Sweden	0.6	2.2	8.9	**11.7**	1.1	2.4	9.5	**13.0**	1.4	2.4	9.7	**13.5**
United Kingdom	3.4	1.5	8.6	**13.5**	8.8	1.5	8.7	**19.0**	14.7	1.1	8.6	**24.5**
EU-15	27.2	35.7	83.3	**146.2**	59.8	33.2	83.7	**176.6**	95.0	33.3	84.7	**213.0**
Czech Republic	0.8	0.8	2.2	**3.8**	1.3	0.8	2.3	**4.5**	1.6	0.9	2.5	**5.0**
Cyprus	n.a.	n.a.	0.3	**0.3**	n.a.	n.a.	0.3	**0.3**	n.a.	n.a.	0.3	**0.3**
Estonia	0.4	0.2	0.9	**1.5**	1.1	0.2	0.9	**2.2**	1.3	0.2	1.0	**2.6**
Hungary	1.2	0.2	2.1	**3.6**	2.2	0.2	2.1	**4.5**	3.1	0.4	2.0	**5.6**
Lithuania	2.0	0.7	1.4	**4.1**	5.6	0.6	1.4	**7.6**	7.9	0.4	1.6	**9.9**
Latvia	0.4	0.6	0.3	**1.3**	1.0	0.6	0.2	**1.9**	1.5	0.6	0.3	**2.4**
Malta	n.a.	n.a.	0.05	**0.05**	n.a.	n.a.	0.05	**0.05**	n.a.	n.a.	0.04	**0.04**
Poland	14.5	2.0	7.3	**23.8**	24.1	1.5	7.4	**33.0**	30.4	1.2	7.8	**39.3**
Slovenia	0.0	1.3	0.5	**1.8**	0.1	1.1	0.5	**1.7**	0.2	1.0	0.5	**1.8**
Slovakia	0.2	1.0	1.0	**2.2**	0.6	0.9	1.0	**2.4**	1.2	0.9	1.5	**3.6**
New EU-10	**19.5**	**6.8**	**16.0**	**42.4**	**36.0**	**5.9**	**16.2**	**58.1**	**47.3**	**5.7**	**17.5**	**70.5**
EU-25	**46.8**	**42.5**	**99.3**	**188.5**	**95.8**	**39.2**	**99.8**	**234.7**	**142.4**	**39.0**	**102.1**	**283.4**
Net competition effect for forestry						2.1	- 0.8	1.3		16.2	- 6.3	9.9
EU-25	**46.8**	**42.5**	**99.3**	**188.5**	**95.8**	**41.3**	**99.0**	**236.0**	**142.4**	**55.2**	**95.8**	**293.3**

Note: The agricultural potential comprises dedicated bioenergy crops plus cuttings from grassland. Agricultural residues such as straw and manures are part of the category waste. The forestry potential consists of residues from fellings and complementary fellings. The 'net competition effect for forestry' includes an additional potential due to wood chips redirected from pulp and paper to energy production, which is partly offset by a reduction in the black liquor potential due to the decrease in pulp and paper production. This potential strongly depends on the assumed carbon permit and oil price.

6. Biogas markets

6.1 Introduction

Biogas is defined as all gas produced by anaerobic digestion of plant material (AEBIOM, 2009). It can be produced from many kinds of organic materials, servicing a large number of applications in replacing fossil fuels: generation of electicity, heat, biofuels and serving as feedstock for the production of chemicals.

6.2 Current status of the technology[26]

Biogas is produced from agricultural by-products, energy crops, manure, sewage sludge or municipal waste in landfills, sewage waste stations and anaerobic digestion plants. Landfill production starts by creating an anaerobic environment. While EU legislation defines the need for capture of methane not all landfills are suitable for the collection of biogas. Sewage waste methane production occurs at waste water treatment plants where sludge is digested as a way to reduce its volume. Generated biogas can be used for heating of the plant or upgraded to bio-methane. Figure 6.1 provides an overview of different biogas feedstocks for Germany.

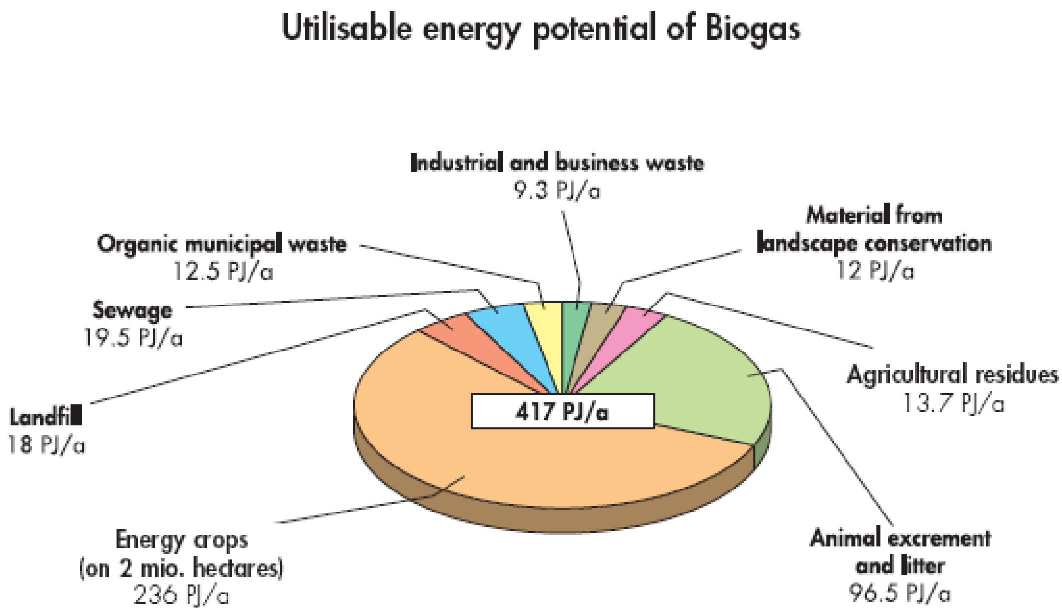

Figure 6.1. Biogas feedstock potentials for Germany (Source: FNR, 2009)

Anaerobic digestion or fermentation occurs spontaneously in animal intestines, moors and paddy fields and other anaerobic environments. An industrial biogas reactor can be fed with (combinations of) animal manure, crop materials or waste. Optimal temperature requirements and duration of fermentation depend on the feedstock and microorganisms involved. Psychrophylic fermentation occurs at low temperatures (10°-20°C), providing stable but slow processes with long feedstock retention times and low gas yields.
Mesophylic fermentation requires moderate temperatures (30° to 40°C), combining stable fermentation conditions with high yields. Thermophylic processes require elevated (50°-60°C) temperatures, providing rapid feedstock throughflow and high yields. In comparison to mesophylic processes, the latter requires extra heating, is more easily disturbed, and yields biogas mixtures with lower methane concentrations. Thermophylic fermentation is usually applied in larger industrial fermentors; farm-scale installations usually being the stable and cheap mesophylic types (Zwart and Langeveld, 2010).

[26] General description of biogas production processes and technology have been taken from Zwart and Langeveld (2010).

The overall anaerobic digestion process can be depicted as:

Organic matter ⇒ methane + CO_2 + water + minerals + microbial biomass + organic residue

Ammonium, phosphate salts and hydrogen sulphide are the major minerals produced. The mineral solution including the organic residue is mostly referred to as digestate.

Four major steps can be distinguished in the fermentation process (Zwart and Langeveld, 2010): (i) *hydrolysis*, conversion of polymers into monomers (sugars, fatty acids and amino acids), generally the speed limiting step in the process; (ii) *acidogenesis*, the conversions of the monomers into volatile fatty acids (VFAs, alcohols, hydrogen gas, ammonia and carbon dioxide); (iii) *acetogenesis*, the conversion of VFAs and alcohols into acetate, hydrogen and carbon dioxide; and (iv) methanogenesis, conversion of acetate, hydrogen and carbon dioxide into methane.
Each step is conducted by a specific group of anaerobic bacteria. These groups operate synergistically, reinforcing each other's efficiency. The acidogenic and acetogenic steps, which generate hydrogen, only yield energy, at very low hydrogen concentrations. Slightly elevated concentrations bring the reactions to a halt. This is prevented by methanogeneous bacteria that take up hydrogen effectively thus ensuring low hydrogen concentrations.

Early farm installations mainly ran on pure animal manure. More recently, additional (cofermentation) materials are added like energy crops, agricultural or industrial by-products and/or grass (co-digestion). Most large-scale fermentors are stirred, solid materials making up no more than 15 per cent of the feedstock, but some large reactors run on dry solid substrates (Dry Anaerobic Composting).
Modern reactors often consist of three closed reactor tanks. The first reactor converts easily degradable materials (cellulose, sugars, amino acids, fats and glycerol) into biogas, a process accompanied by the build up of Volatile Fatty Acids (VFAs) and lactate. Resistant lignocellulosic components are digested in the second reactor, the third reactor serving mostly as a digestate storage tank. During this stage, production of biogas continues, albeit at a low rate. Older installations lost biogas during storage; but newer fermentors need to capture biogas emissions so as to enhance the environmental performance (Zwart and Langeveld, 2010).

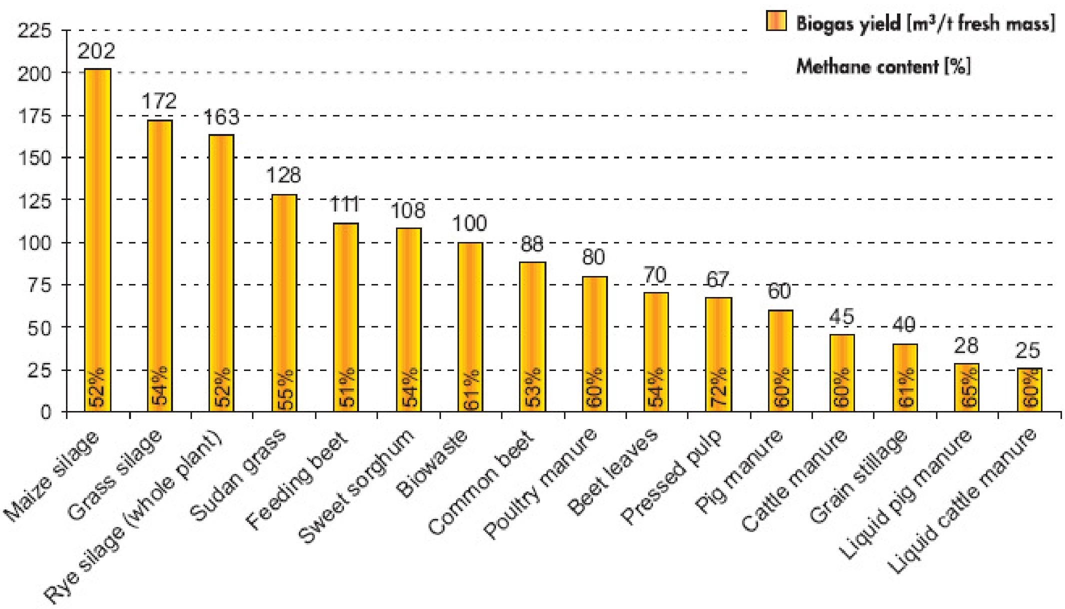

Figure 6.2. Biogas yields (Source: FNR, 2009)

Typical biogas composition is 50-55% of methane, plus carbon dioxide, water plus small amounts of ammonia (NH_3) and hydrogen sulphide (H_2S). Biogas yields are defícted in Figure 6.2. Highest yields are derived from energy crops, especially silage (maize, grass, rye). Manure biogas production is low, especially liquid cattle and pig manure.

6.3 Main actors

Many European countries have establised favourable conditions for electricity production from biogas. Large biogas producers are Germany and the UK, followed at a distance by Spain, Italy and France. New member states generally show a low production level. Germany had over 4000 biogas plants operating in 2009, mostly situated on farms being applied for cogeneration (AEBIOM, 2009). UK biogas production originates mostly from landfills.

Most biogas is used for the production of electricity and heat. Sweden and the Netherlands represent two peculiar cases, upgrading biogas for injected into the natural gas network or as motor fuel. So far only Sweden has established a market for biomethane-driven cars. Sweden traditionally has used biogas for heat production, less focussing on biogas for electricity. About one quart of the biogas is upgraded and applied as a vehicle fuel. Upgraded biogas is also injected into the natural gas grid, currently replacing 2% of the fossil gas in this country (AEBIOM, 2009).

Economic performance of biodigesters is sensitive to unit size and feedstock price. Small-scale plants are often uneconomic, but centralised digestion may be limited because of the distances over which manure has to be transported as this increases feedstock price. Farm-based biogas digestion may have considerable difficulties in selling surplus process heat due to lack of economic demand plus and high cost of grid connection in scarcely populated or developed rural areas (Bauen, 2009).

Following from the nature of the anaerobic digestion process, biogas producers have only limited ability to adjust to changes in feedstock prices and availability. High failure rates in the past have reduced economic viability of biogas units, increasing complexity of their design and operation. This limitation has been largely overcome in Germany, where manufacturers developed simpler designs and adequate technical support for plant operators. Further optimisation and cost reduction still is possible, which can significantly improve the economic viability of especially smaller (farm level) units. Main fields of improvement include biomass pre-treatment (in order to reduce time needed for fermentation), cost reduction, improvement of the biogas cleaning processes (mainly of corrosive H_2S) and of thermophilic digesters robustness (Bauen, 2009).

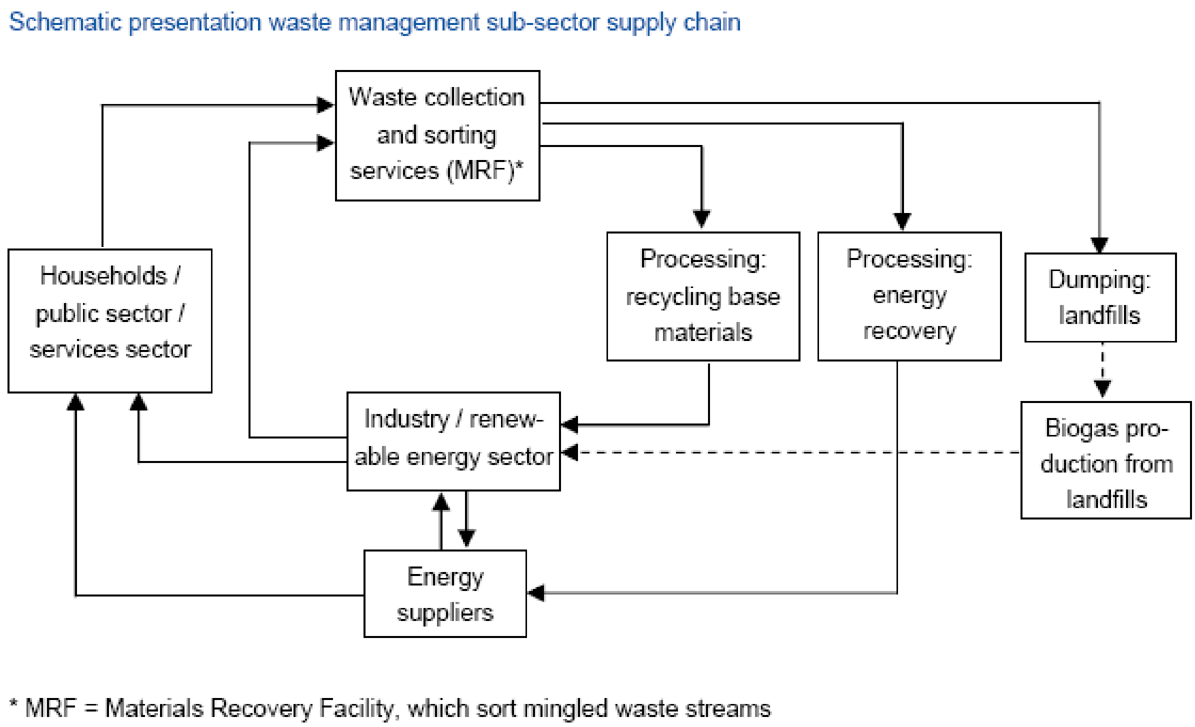

Figure 6.3. Actors involved in landfill biogas production (Source: Ecorys, 2009)

Customers from biogas producers include a range of groups, individuals and institutions depending on the source of biogas and outlet of the product. Landfill biogas producers generally have direct links to industrial biogas users and/or electivity producers. Links to households and public sectors are more indirect (Figure 6.3; Ecorys, 2009). Given the size of their production, they must be able to develop a reasonable negotiating position depending on annual production level and probably also quality of the product. This must also be expected for biogas producers from sewage sludge. On-farm producers will generally face a different perspective. They are mostly reliant on the grid, be it for electricity or for (upgraded) gas. This weakens their negotiating position and they will mostly depend on national (regional) policies defining their rights on issues such as access to the infratstucture, service and technical support from grid owners, qiality control issues and backup facilities.

With respect to employment, current employment levels in European eco-industries (Ecorys, 2009) indicate that present development of the bioenergy sector basically still is in its infant stage. Total employment in 2008 was estimated at some 167,000 jobs growing with over 16% per annum. Extrapolating this figure to current levels – assuming the same growth rate – would suggest an employment level of some 226 ,000 jobs. This would mean that bioenergy, in terms of personnel supported, still would be one of the smaller eco-industry (Figure 6.4). Further, it must be feared that actual growth will probably have been lower, while the proportion of agricultural (or even rural) jobs will be limited. Currently, we have no estimations as to the exact (or probable) rate of agricultural employment.

	employment (2000)	employment (2008)	Employment: annual growth rate	EPE: annual growth rate corrected for inflation
Waste management	844.766	1.466.673	7,14%	5,89%
Water supply	417.763	703.758	6,74%	4,04%
Wastewater management	253.554	302.958	2,25%	3,62%
Recycled materials	229.286	512.337	10,57%	13,12%
Others	129.313	193.854	5,19%	6,23%
Renewable energy	49.756	167.283	16,37%	17,65%
Air pollution	22.600	19.067	-2,10%	3,10%
Biodiversity	39.667	49.196	2,73%	5,29%
Soil & Groundwater	14.882	18.412	2,70%	3,02%
Noise % Vibration	4.176	7.565	7,71%	7,76%
Total	*2.005.764*	*3.441.102*	*6,98%*	*6,69%*

Figure 6.4. Employment in European eco-industries (Source: Ecorys, 2009)

6.4 The role of energy from biogas in agriculture

Primary biogas production from landfills, sewage sludge and other sources (including agriculture) have been assessed by AEBIOM (Internet source 12). Figures for 2007 are presented in Table 6.1. AEBIOM does not identify agriculture as separate source of biogas. In stead, it is included in a rest category. Average other (agricultural) biogas production for the EU25 is 36%. Shares for individual countries vary between zero (UK, Greece, Estonia, Finland, Lithuania) and 100% (Portugal, Cyprus, Luxemburg). Significant contributions (>60%) from agriculture are also reported for Austria, Denmark and Germany. Medium high contributions (30 to 60%) for Netherlands and Slovenia. Other member states report a low role for agriculture.

Table 6.1. Primary biogas production in the EU25 (2007, ktoe)

	Landfills	Sewage sludge	Other incl agriculture	Total	Other as % of total	Gross electricity produced (Gwh)
Austria	11	2	126	139	91%	493
Belgium	48	18	13	79	16%	279
Cyprus			0,2	0,2	100%	1
Czech Republic	29	32	17	78	22%	223
Denmark	14	21	63	98	64%	295
Estonia	3	1		4	0%	14
Finland	26	10		36	0%	22
France	161	144	4	309	1%	541
Germany	416	270	1697	2383	71%	9.520
Greece	38	10		48	0%	175
Hungary	2	12	6	20	30%	22
Ireland	24	8	2	34	6%	119
Italy	358	1	48	407	12%	1.382
Lithuania	2	0,8		3	0%	6
Luxemburg			10	10	100%	37
Netherlands	43	48	83	174	48%	497
Poland	19	43	0,5	63	1%	160
Portugal			15	15	100%	65
Slovakia	0,5	8	0,5	9	6%	4
Slovenia	8	0,6	4	13	32%	48
Spain	250	49	21	320	7%	687
Sweden	9	17	0,8	27	3%	99
UK	1433	191		1624	0%	5.299
EU25	2905	887	2108	5901	36%	19.938

Source: AEBIOM (Internet source 12)

Total electricity production in 2007 amounted to 20,000 Gwh. Half of this was generated in Germany. Other large producers are the UK (5,300 Gwh) and Italy (1,380 Gwh). For animal farms, biogas production provides a way to generate extra income from animal manure, a by-product. The main role of biogas production in agriculture may however be to provide stable additional incomes (electricity prices showing fluctuations which are not so high as do primary agricultural commodities). This allows some kind of mollification of volatile agricultural markets. Medium to large on-farm biogas installations also can serve as a source of rural employment, a source often utilised by farm members or workers already employed on the farm. The digestate generated by digestion, finally, can serve as a source of additional nutrients for arable farming.

6.5 Developments of biogas in the case study regions

Table 6.1 provides a good overview of the development stage and relative importance of on-farm biogas production in case study countries. Germany is clearly ahead, generating highest total and agricultural biogas production levels. Austria produces relatively small amounts of biogas, but its agricultral biogas is well developed. Poland and Spain are relative low providers of agricultural biogas electricity. As to case study regions, biogas is one of the main sources of RE production in many of the regions that have been considered in this study. It is dominant in North East Brandenburg, but not prevailing on a significant basis in Saarland.

Biogas is playing no role of importance in Spain, neither in Valencia nor in Soria, although it may provide some opportunities for RE development in the latter. As to Poland, biogas is one of the main potential RE sources for Mazowiecki region, offering unique opportunities to develop cheap, local, decentralised energy infrastructure in Warminsko-Mazurskie. On-farm biogas production is a major RE activity in the lowland areas of Upper Austria, hosting the highest density of plants in the country. Carinthia, the other Austrian case region that is suggested currently is showing very little biogas production.

6.6 Prospects

Biogas potentials for 2020 have been assessed by AEBIOM (Internet source 12). Assuming that, for the EU27, 25 million ha of agricultural land can safely be used for energy in 2020 (without harming food production or the environment), one fourth (5 million ha) of this could be devoted to biogas crops, providing a potential biogas production of 27 billion m³ of methane. To this can be added 32 billion m³ from agricultural wastes. Actual biogas production from agriculture in 2020 is estimated at 36 billion cubic metres of methane, or 31 Mtoe (up from 6 Mtoe in 2007: see also Table 6.2). This does not include potential use of catch crops.

Table 6.2. Potential biogas production in the EU25 in 2020

	Potential production (Billion m³ of methane)	Realised in 2020 (%)	Actual production in 2020 (Billion m³ of methane)	Actual production in 2020 (Mtoe)
Energy crops	27.2	100%	27.2	23.4
Agricultural by-products	31.7	28%	9.2	7.9
Straw	10.0	5%	0.5	0.4
Manure	20.5	35%	7.2	6.0
Landscape management	1.2	40%	0.5	0.4
Total agriculture	58.9	62%	36.4	31.3
Municipal solid waste	10.0	40%	4.0	3.4
Industrial waste	3.0	50%	1.5	1.3
Sewage sludge	6.0	66%	4.0	3.4
Total waste	19.0	50%	9.5	8.2
Grand total	77.9	59%	45.9	39.5

Source: Internet source 12

Potentials for further biogas production, thus, seem fair to good. It is expected, however, that the actual development of production infrastructure by farmers will show large variations, especially depending on national and regional investment and tariff legislation.

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6. http://www.nuon.nl/producten-en-diensten/zonne-energie/zonneboiler/prijzen.jsp?tab=Prijzen
7. http://www.zonneboilers.org/zonneboiler-prijzen.html
8. http://www.unep.fr/energy/information/publications/factsheets/pdf/thermal.PDF
9. http://www.arturo.derisi.unisalento.it/Dowloads/Energie_Rinnovabili/ERSolarTherm_3.pdf
10. http://www.dw-world.de/dw/article/0,,5275444,00.html
11. http://en.solarwirtschaft.de/fileadmin/content_files/factsheet_st_engl.pdf
12. http://www.aebiom.org/?cat=58

ANNEX III. POLICY OVERVIEW

1. Introduction

In December 2008, the European Parliament adopted the 'Directive on the promotion of energies from renewable sources' (Directive 2009/28/EC) as part of the EU Climate and Energy Package. Above all, the Directive set a general binding target for the European Union to have 20 per cent of its final energy consumption provided by renewable sources by 2020. It also includes a specific target of having a minimum of 10 per cent of the total energy used in the transport sector coming from renewable energy sources. The latter target is accompanied by a novel policy instrument: All biofuels and other bioliquids counting towards the target must meet a set of mandatory sustainability criteria to achieve greenhouse gas reductions compared to fossil fuels[27] and to mitigate risks related to areas of high biodiversity[28] value and areas of high carbon stock[29].

The Directive should be implemented by Member States by December 2010. A key element of the implementation are National Renewable Energy Action Plans (NREAPs) in which Member States have to report to the European Commission how they intend to fulfil the targets set by the Renewables Directive. Based on existing data sources and information, this document will give an overview of the status quo, starting with the specific RE targets of the Member States, followed by the instruments being applied within them to promote the development of renewable energies, and finalizing with the identification of remaining barriers and highlights from selected NREAPs.

2. Renewable Energy Targets of the Member States

Following a burden sharing approach, in its climate and energy package the EU has divided its overall targets of 20 per cent share of renewable energy sources into individual targets for each of the Member States. The specific measures and goals to be pursued by each country in each individual area (electricity, heating/cooling, transport) in order to achieve the overall target are – with some exceptions – left to the discretion of the local governments. However, every Member State must outline their sectoral targets and objectives, as well as the proposed measures to be taken to achieve these targets, in its national renewable energy action plan. The following chart (Figure 1) shows the assigned targets for each of the 27 Member States.

[27] According to Art. 17.2 of the RED, biofuel production must comply with a GHG saving of 35% in 2008 compared to fossil fuels. This rate increases up to 60% in 2018.

[28] Land of high biodiversity value is address in the RED in Art. 17.3 as "primary forests and other woodlands", "nature protection areas" and "highly biodiverse grassland".

[29] The aim of Art. 17.4 of the RED is the protection of areas with high carbon stock to avoid the emission of high amounts of GHG by land conversion. Here wetlands, forested areas (tree cover above 30%) and areas with a tree cover of 10-30% are addressed. These land categories may be used for biomass production as long the status of these areas will not change. For example, a forested area can be logged, but it must be guaranteed that the forest will re-grow. In Art. 17.5 the protection of peatland is covered in a similar manner. Peatland can only be used when it is proven that cultivation and harvesting of biomass does not involve drainage of previously undrained soils.

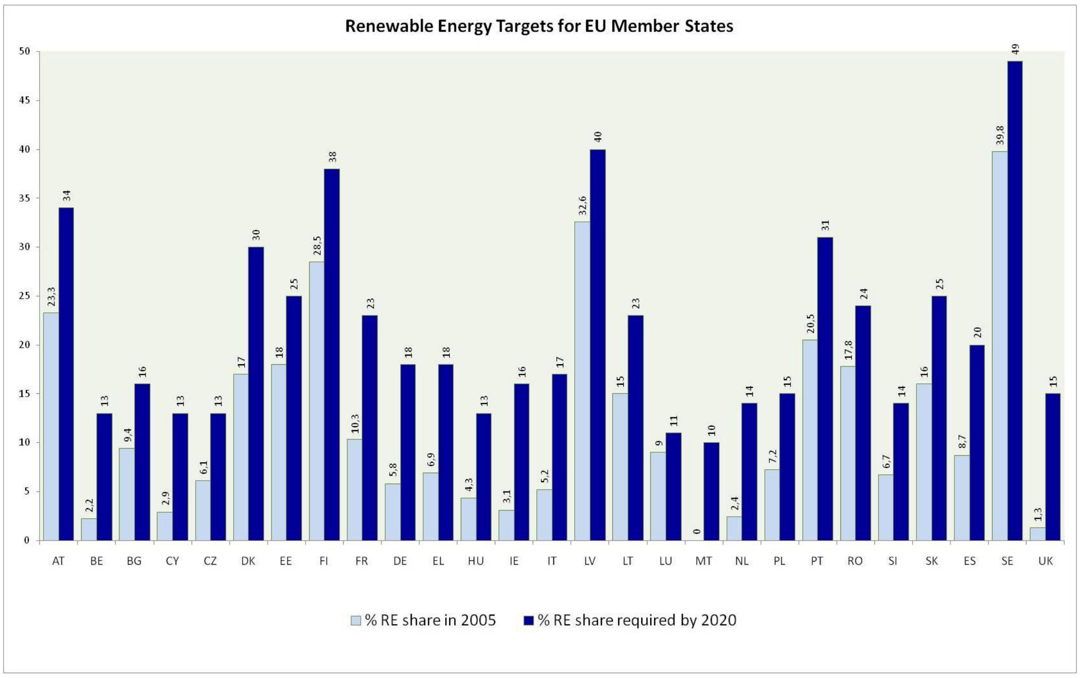

Figure 1. RE targets for each Member State: Comparison between actual RE share in 2005 and targets for 2020

Based on: Euractiv.com, *EU renewable energy policy*. Published: 02 August 2007, updated: 22 June 2010, available on the internet at <http://www.euractiv.com/en/energy/eu-renewable-energy-policy/article-117536> (last accessed on 05 November 2010).

3. Promotion Policy Types

In order to reach the envisaged targets Member States apply a wide range of different policy instruments and legislative measures. This section briefly describes the most relevant instruments and gives an overview in which Member States they are applied.

Quota system

Quota systems are a promotion mechanism used to assure that a specified percentage of the total amount of energy (e.g. electricity, heat, fuel) sold by a party is being generated from renewable resources. Member States set the particular targets in the selected sectors or industries and enforce them by charging penalization fees to those suppliers who have failed to meet their allowances. Green certificates, which can be obtained either by allocation after the production of energy through renewable means or trade in the certificate-market, are used as proof that the quota has been met. The provision of marketable green certificates creates incentives for suppliers to tap renewable sources even after they have reached their individual targets.

Belgium, Italy, Poland, Romania, Sweden and the United Kingdom use quota systems currently.[30]

Feed-in Tariffs (Price regulation mechanisms)

A feed-in tariff is a mechanism that encourages the production of energy from renewable resources by enhancing the competitiveness of the technologies used for this purpose and thus increasing attractiveness for investment. This is done by guaranteeing a producer of renewable energy (mainly electricity) to charge either a fixed price per unit or receive a bonus on top of the market price being realised.

There are 21 Member States using some sort of price regulation as a main promotion instrument. Italy uses feed-in tariffs as an alternative to the quota system for smaller systems.[31]

[30] RES-Legal, available on the internet at <http://res-legal.eu/en/glossary.html> (last visited on 05 November 2010).

[31] RES-Legal, supra, note 1.

Tax Allowances (Fiscal regulation mechanisms)
Tax incentives can take the form of exemptions and/or deductions. This is, making the consumption of energy from renewable sources tax-free and/or making investment costs for renewable energy generation systems tax deductible.[32] This mechanism is widely used in the Transport Sector.

Tendering Models
Promotion through tenders serves as a competition scheme to allocate subsidies, loans or other means of resources for the increase of generation-capacity for renewable energy sources. This scheme is used to different extents in Ireland, France and Latvia.[33]

Grants
Grants for the promotion of renewable energies consist of financial aid given by the Member States to grantees in order to support the funding of their projects and to engage them in their investments. This mechanism differs from a loan in that it is not to be repaid, though periodic progress reports are usually requested by the granting party.[34]

Soft Loans
Soft loans differ from conventional loans in that they issue special payment conditions and/or interest rates that make investments more accessible/affordable to the beneficiary, for instance by offering extended grace periods and below-market interest rates.[35]

Regulation
Special state guidelines or parameters that do not fall into the classification of quota systems, feed-in tariffs or fiscal regulation described above. These regulations can be sector or industry specific and use various means for the promotion of renewable energy sources.
For instance, the Energy Declaration of Buildings Act in Sweden's National Programme for Energy Efficiency and Energy-smart Construction is a legislation that promotes energy efficiency in buildings by setting performance standards and inspections to assess energy use and indoor environment of new and existing buildings.

Renewable energy stimulation in Rural Development Programmes
As from 2007 in rural development programmes in most EU member States (new RDP programmes 2007-2013) a range of possibilities are offered to support farming practices and investments that can contribute to climate change mitigation including the increase of the use of Renewable Energy (RE) resources. Attention for renewable energy in RDPs has been stimulated strongly since the Health Check (HC) of the Common Agricultural Policy (CAP) in which 'new challenges' of the RD policy include 'climate change' and 'renewable energy' for which an additional budget of around 1 billion EUR have been made available for Member States (MS) to spend on this issues[36]. As a consequence, the operations related to these newly introduced Community priorities have been further strengthened in the RDPs of most MS.

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[32] RES-Legal, supra, note 1.

[33] RES-Legal, supra, note 1.

[34] Investopedia, available on the internet at <http://www.investopedia.com/terms/g/government-grant.asp> (last visited on 05 November 2010).

[35] Investopedia, available on the internet at <http://www.investopedia.com/terms/s/softloan.asp> (last visited on 05 November 2010).

[36] This relates to 19.8% of the total additional funds that were released in the Health Check. The budget allocated to the 'new challenges' includes the funds released by the HC of the CAP (including voluntary modulation and transfers according to Art. 136 of Regulation (EC) No. 73/2009) and the European Economic Recovery Package (EERP).

An overview of all National RDP specifications including stimulation measures for renewable energy activities can be found at :
http://enrd.ec.europa.eu/rural-development-policy/country-information/rural-development-policy-fiches/en/rural-development-policy-fiches_home_en.cfm

Information
Promotion measures supporting outreach and communication activities and capacity building.

R&D
Mechanisms including financial and/or technical support designated specifically for research and development activities.

4. Overview of information on RE policy instruments for specific RE types

Electricity Generation
According to the information available and the revised national action plans, it is clear that electricity generation has been the most widely explored sector in terms of the development of both policies and technology for the adoption of renewable energies. Several reasons like ease of implementation and smaller political costs have been noted as being influential to this outcome.
Across the EU, each Member State has at least one policy instrument in place to incentivize the use of renewable energies in the private and domestic segments of electricity generation. The establishment of price regulation frameworks like feed-in tariffs, which in countries like Germany have yielded successful results, has arisen in 21 Member States to become the most proliferate policy used by governments to enhance the competitiveness of their renewable energy sources.
Government Grants and Tax Incentives come as the second and third most popular schemes respectively in this sector.

Heating & Cooling
The Heating & Cooling sector is the second most developed in terms of RE policies of the three regarded in this study. Here, a lesser number of Member States have active measures in place, which mainly deal with increasing the efficiency of systems and processes. The most commonly applied promotion instruments in this sector are grants and regulation.

For example, the Federal Promotion of Extraordinary Efficiency in Buildings is a programme that was rolled out in Austria in early 2006 to offer funding options for buildings exceeding regulatory standards. In Denmark, the Heat Supply Act gives the state the faculty to ban the use of electric heating under certain circumstances. The fact that some governments have established district heating in their territories appears to be a main differentiating point in the maturity of the sector. Through the years these countries have become more experienced in optimizing these processes and adopting new technologies and the expertise gathered has been further applied not only in the public sector but also in private industrial processes.
As is the case for Electricity Generation, the Heating & Cooling Sector relies secondly on Grants as an instrument of promotion for renewable energy sources. Regulations are also being currently used by one third of the Member States for this sector.

Transport Sector
The policy instruments for the endorsement of renewable energy sources in this sector are constrained to a small amount of applicable options and the technologies that have been developed for this sector are less varied (based mainly on liquid biofuels (biodiesel and bioethanol and, to a much lower extent biomethane). Most preferred policies in transport are employing quota systems and tax allowances for biofuels, of which a great number of Member States have at least one active measure in place.

The following tables provide an overview of all relevant measures applied in the different Member States.

Table 1 - Promotion measures employed by MS and RE types promoted. Electricity Generation Sector.

ELECTRICITY GENERATION

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted
AT		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Bf-Hy-Co		Wi-So-Hy		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Bf-Hy-Co	Wi-So-Bm-Hy
BE	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Bf-Hy-Co		Wi-So-Ge-Bg-Bm-Bf-Hy-Co		Wi-So-Ge-Bg-Bm-Bf-Hy-Co	Wi-So-Ge-Bg-Bm-Bf-Hy-Co	Wi-So-Ge-Bg-Bm-Bf-Hy-Co
BG		Wi-So-Ge-Bg-Bm-Hy							
CY		Wi-So-Bg-Bm			So-Wi-Hy				
CZ		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy			
DK		Wi-So-Ge-Bg-Bm-Hy			So-Hy	Wi			
EE		Wi-So-Ge-Bg-Bm-Hy							
FI		Bm	Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy	Bm		Bm	Bm
FR		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy			Co		
DE		Wi-So-Ge-Bg-Bm-Hy			Ge-Bm	Ge-Bm			Ge-Bm
EL		Wi-So-Ge-Bg-Bm-Hy			Wi-So-Ge-Bg-Bm-Hy		So		
HU		Wi-So-Ge-Bg-Bm-Hy				Bm-Co			
IE		Wi-Bg-Bm-Hy							

Key: Wi = Wind Energy; So = Solar Energy; Ge = Geothermal Energy; Bg= Biogas; Bm = Biomass; Bf = Biofuel; Hy = Hydropower; Co = Combined heat and power

ELECTRICITY GENERATION (cont'd.)

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted	RE Type Promoted
IT	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy				Wi-So-Ge-Bg-Bm-Hy		
LV		Wi-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy					
LT		Wi-So-Bg-Bm-Hy			Wi-So-Ge-Bg-Bm-Hy				
LU		Wi-So-Bg-Bm-Hy	So		Wi-So-Ge-Bg-Bm-Hy				
MT		So			Wi-So				
NL		Wi-So-Bg-Bm	Wi-So-Ge-Bg-Bm-Hy						Wi-So-Ge-Bg-Bm-Hy
PL	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy			Wi-So-Ge-Bg-Bm-Hy			
PT		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy						
RO	Wi-So-Ge-Bg-Bm-Hy								
SI		Wi-So-Ge-Bg-Bm-Hy			Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy			
SK		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy				
ES		Wi-So-Ge-Bg-Bm-Hy	Wi-So-Ge-Bg-Bm-Hy						
SE	Wi-So-Ge-Bg-Bm-Hy		Wi		So				Wi
UK	Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy		Wi-So-Ge-Bg-Bm-Hy				Wi-So-Ge-Bg-Bm-Hy

Key: Wi = Wind Energy; So = Solar Energy; Ge = Geothermal Energy; Bg= Biogas; Bm = Biomass; Bf = Biofuel; Hy = Hydropower; Co = Combined heat and power

Based on: IEA, Global Renewable Energy Policies and Measures Database, available on the internet at < http://www.iea.org/textbase/pm/?mode=re> and RES LEGAL, Legislation on Renewable Energy Generation Database, available on the internet at <http://res-legal.eu/en.html> and L. Pelkmans et al., Inventory of biofuel policy measures and their impact on the market, September 2008.

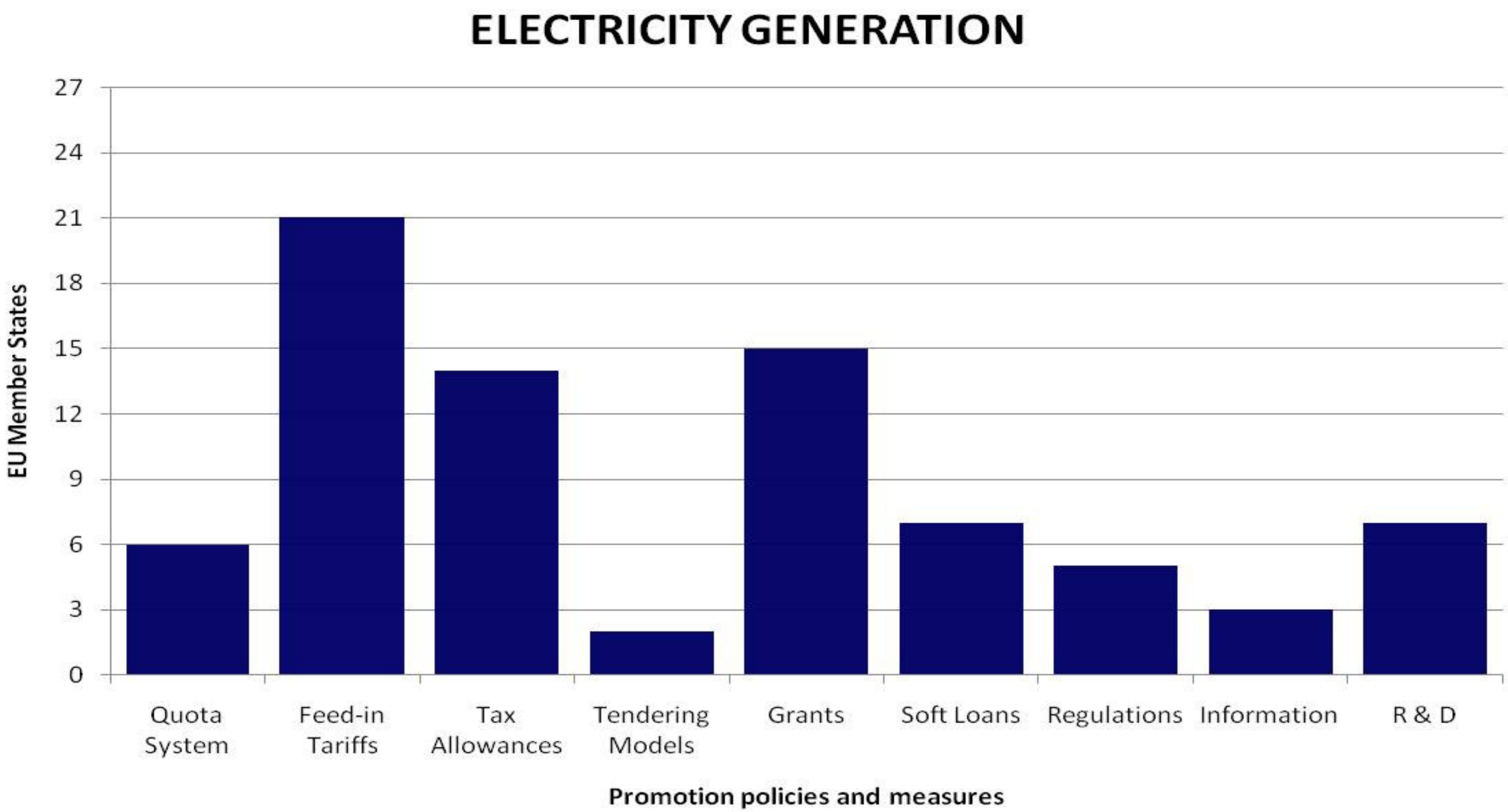


Figure 2 - Most recurrent promotion measures currently active in the Electricity Generation Sector
Based on: IEA, Global Renewable Energy Policies and Measures Database, available on the internet at < http://www.iea.org/textbase/pm/?mode=re> and RES LEGAL, Legislation on Renewable Energy Generation Database, available on the internet at <http://res-legal.eu/en.html> and L. Pelkmans et al., Inventory of biofuel policy measures and their impact on the market, September 2008.

Table 2 - Promotion measures employed by MS and RE types promoted. Heating & Cooling Sector.

HEATING & COOLING

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered
AT					So-Ge-Bm-Co		So-Ge-Bg-Bm-Co	So-Ge-Bg-Bm-Bf-Co	So-Bg-Bm
BE			So-Ge-Bg-Bm-Bf-Co		So-Ge-Bg-Bm-Bf-Co		So-Ge-Bg-Bm-Bf-Co	So-Ge-Bg-Bm-Bf-Co	So-Ge-Bg-Bm-Bf-Co
BG									
CY									
CZ					So-Bm		So-Ge-Bg-Bm-Bf-Co		
DK							So-Ge-Bg-Bm-Bf-Co		
EE									
FI					Bm	Bm		Bm	Bm
FR							Co		So-Ge-Bg-Bm-Bf-Co
DE				Co	So-Ge-Bg-Bm	So-Ge-Bg-Bm	So-Ge-Bg-Bm-Co		So-Ge-Bm
EL		Co					Co		
HU						Bm-Co			
IE					So-Ge-Bm				

Key: So = Solar Energy; Ge = Geothermal Energy; Bg= Biogas; Bm = Biomass; Bf = Biofuel; Co = Combined heat and power

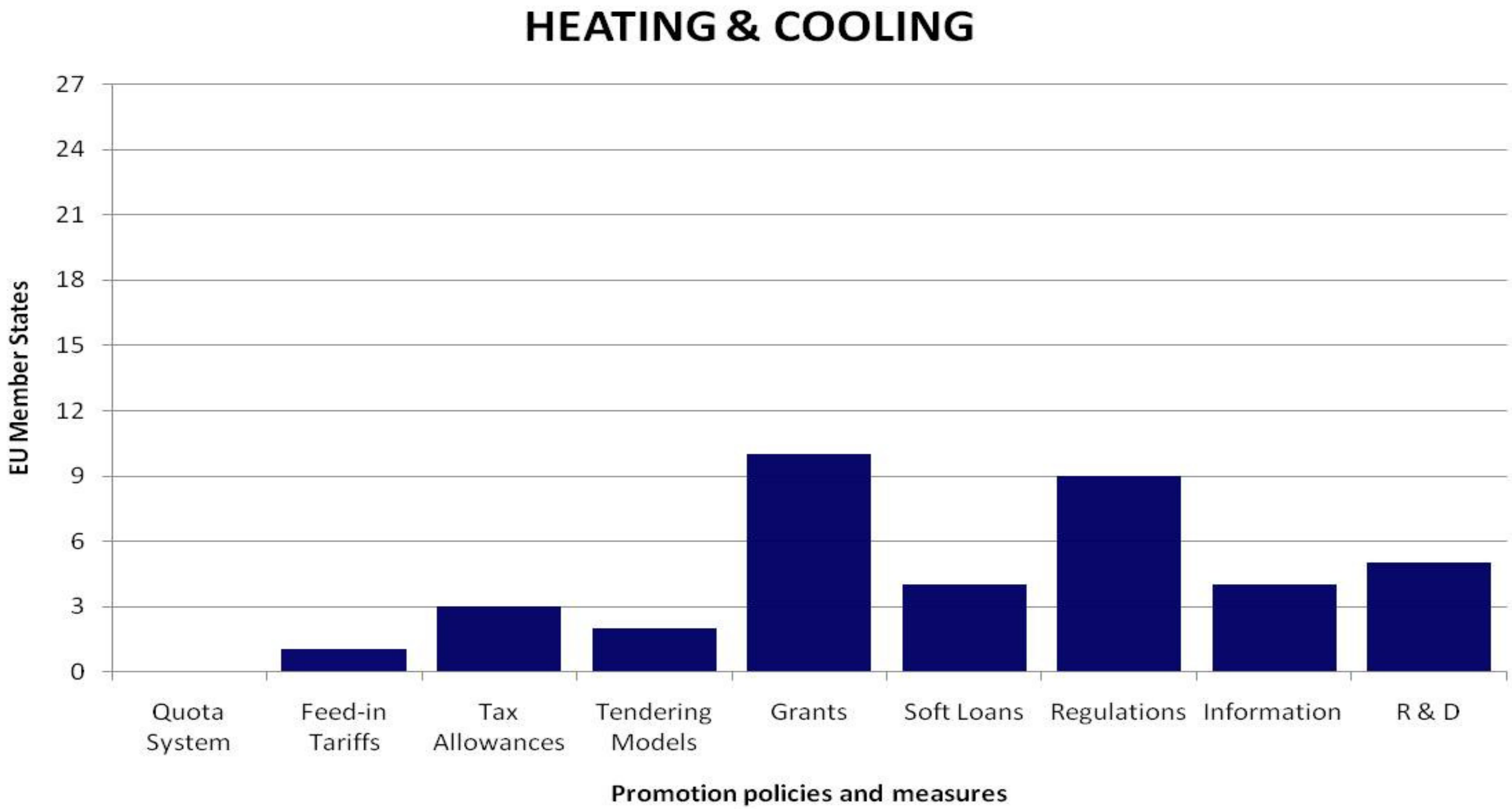
HEATING & COOLING (cont'd.)

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered
IT									
LV									
LT									
LU				Co			Co		
MT									
NL			So-Ge-Bg-Bm-Bf-Co						
PL									
PT					So	So			
RO									
SI									
SK					So-Bm				
ES									
SE					So-Ge-Bm		Bm	Bm	
UK			Bm		Bm-Co				

Key: So = Solar Energy; Ge = Geothermal Energy; Bg= Biogas; Bm = Biomass; Bf = Biofuel; Co = Combined heat and power

Based on: IEA, Global Renewable Energy Policies and Measures Database, available on the internet at < http://www.iea.org/textbase/pm/?mode=re> and RES LEGAL, Legislation on Renewable Energy Generation Database, available on the internet at <http://res-legal.eu/en.html> and L. Pelkmans et al., Inventory of biofuel policy measures and their impact on the market, September 2008.

Figure 3 - Most recurrent promotion measures currently active in the Heating & Cooling Sector



Based on: IEA, Global Renewable Energy Policies and Measures Database, available on the internet at < http://www.iea.org/textbase/pm/?mode=re> and RES LEGAL, Legislation on Renewable Energy Generation Database, available on the internet at <http://res-legal.eu/en.html> and L. Pelkmans et al., Inventory of biofuel policy measures and their impact on the market, September 2008.

Table 3 - Promotion measures employed by MS and RE types promoted. Transport Sector.

TRANSPORT

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered
AT	Bf		Bg-Bf				Bg-Bf	Bg-Bf	Bg-Bf
BE	Bf		Bg-Bf		Bg-Bf		Bg-Bf	Bg-Bf	Bg-Bf
BG									
CY									
CZ			Bf				Bf		
DK									
EE									
FI					Bf		Bf		
FR			Bf						Bg-Bf
DE	Bf		Bf						
EL			Bf						
HU	Bf		Bf						
IE			Bf						

Key: Bg= Biogas; Bf = Biofuel

TRANSPORT (cont'd.)

Country	Quota System	Feed-in Tariffs	Tax Allowances	Tendering Models	Grants	Soft Loans	Regulations	Information	R & D
	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered	RE Type Covered
IT	Bf		Bf						
LV									
LT			Bf						
LU									
MT									
NL	Bf		Bf						
PL	Bf		Bf						
PT	Bf		Bf				Bf		
RO									
SI	Bf		Bf				Bf		
SK	Bf		Bf						
ES	Bf		Bf		Bf		Bf	Bf	Bf
SE	Bf		Bf				Bf		
UK	Bg-Bf		Bf						

Key: Bg= Biogas; Bf = Biofuel

Based on: IEA, Global Renewable Energy Policies and Measures Database, available on the internet at < http://www.iea.org/textbase/pm/?mode=re> and RES LEGAL, Legislation on Renewable Energy Generation Database, available on the internet at <http://res-legal.eu/en.html> and L. Pelkmans et al., Inventory of biofuel policy measures and their impact on the market, September 2008.

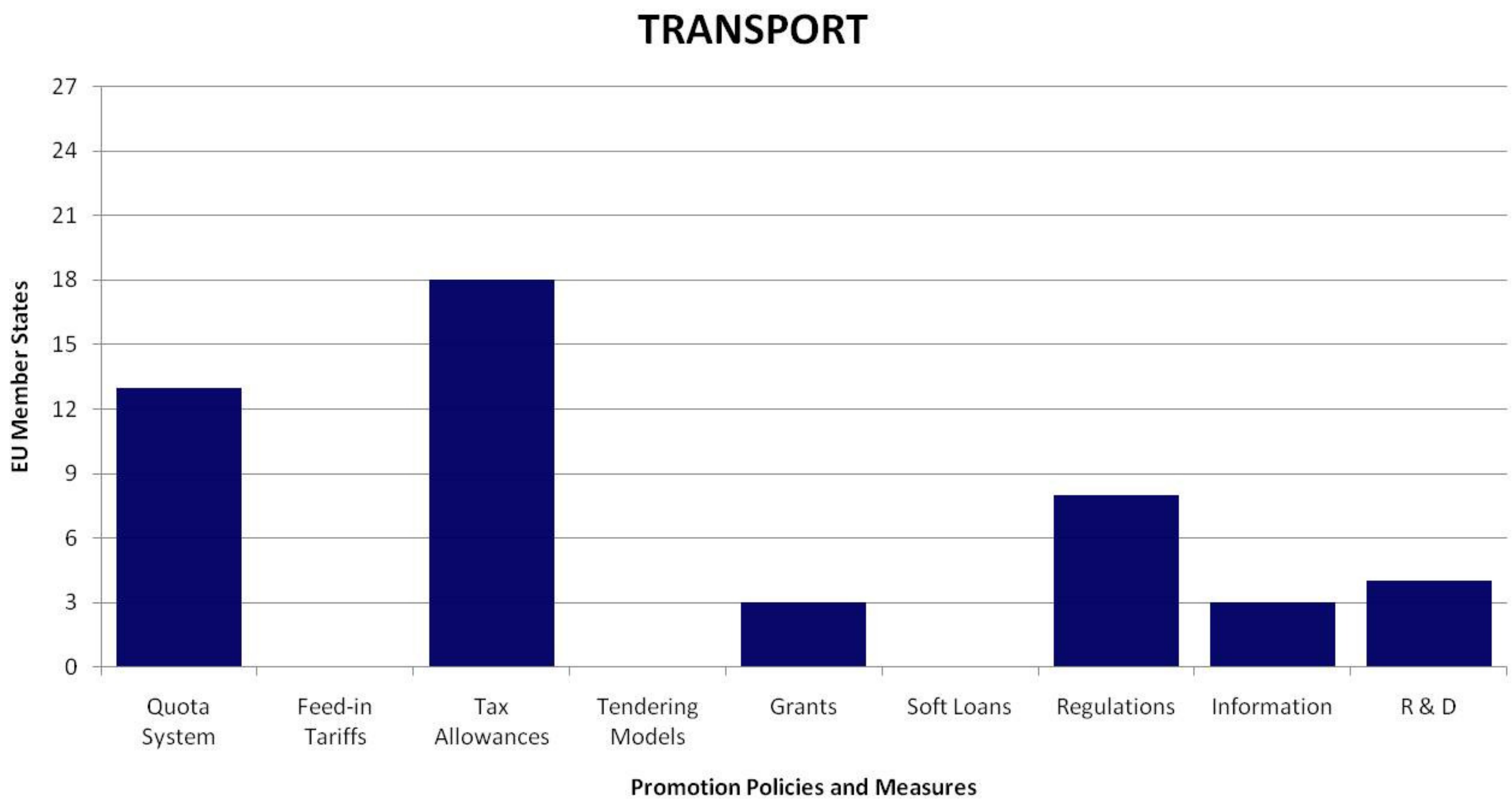


Figure 4 - Most recurrent promotion measures currently active in the Transport Sector
Based on: IEA, Global Renewable Energy Policies and Measures Database, available on the internet at < http://www.iea.org/textbase/pm/?mode=re> and RES LEGAL, Legislation on Renewable Energy Generation Database, available on the internet at <http://res-legal.eu/en.html> and L. Pelkmans et al., Inventory of biofuel policy measures and their impact on the market, September 2008.

Agricultural sector

An overview of the stimulation measures taken per country for RES activities you find underneath.
OVERVIEW WILL BE ADDED IN NEXT INTERIM REPORT
Source: http://enrd.ec.europa.eu/rural-development-policy/country-information/rural-development-policy-fiches/en/rural-development-policy-fiches_home_en.cfm

5. Remaining barriers

Twenty-one Member States have now presented their NREAPs giving a clear view on how the national targets are to be reached and the roles different technologies will be playing in this endeavour. Nevertheless, this phase is only the first step towards attaining the projected goals. Today, the questions lie, among others, on issues concerning the financing of the projects outlined in the action plans, the projects' weight in the local governments' political agenda, and the ambitiousness of the targets and actions to be performed by the different Member States.

As supported by the tables analysed above, there appears to be more development in the Electricity Generation sector than in Heating & Cooling and significantly more advance than in these two than in the Transport sector. By failing to address the opportunities in the Heating & Cooling Sector, a high potential area for the use of sustainable resources is left unattended. In the worst of cases, this could combine with achievements in electricity generation being lower than expected, leading to Member States falling short from their targets and with little or no time to activate other options.

Funding renewable energy projects has always been a problematic matter due to technologies being generally novel and information on standard costs being vague or rapidly fluctuating. This leads to uncertainty that in turn wards off investors. Although in the last decade these problems have been engaged through the elaboration of mechanisms to incentivize the use of renewable energy sources, there are specific technologies like offshore wind power and biomass that are still susceptible to the mentioned obstacles.

A current example of the potential drag that the need for financing could bring is the concern of a necessary investment on the existing electrical grids of European Member States. The lack of infrastructure that is appropriate for full cooperation and electricity transmission across the European Union is already raising questions on how to finance the execution of such ambitious plans.

Another issue hampering the overtaking of the energy market by renewable sources is the struggle between political forces, conflicts of interest, and contradicting policies. Discussions on these matters have arisen throughout the years in various fronts. Strong influence to maintain investment on non-renewables, the favouring of local technologies in order to benefit the country's industry and economy, the lack of ambition or political will, are all issues that can significantly slow down the advances. On the other hand, conflicting environmental policies appear to have become more frequent, where land-use planning and sustainability assessment plays a role of growing importance, but then can also fall into arbitrary practices.

In addition, there are increasing concerns raised by environmental NGOs, science and others about the sustainability of further expansion of renewable energies. Most importantly the promotion of biofuels has long been criticized and still is in terms of their GHG balance and the immense need for land that leads to further deforestation and degradation mainly in exporting countries. Further concerns include windmills that represent a barrier of migrating birds or further intensification of agriculture due to more demand for biomass.

Some of these barriers have already been identified in the Member States' national action plans, although some others remain unattended. In order to assure the proper development and execution of these plans, the obstacles they encounter should be engaged immediately through precise and influential measures.

6. NREAP Highlights

A quick scan of the recently submitted NREAPs was performed to identify any MSs' measures specifically targeted at the production and consumption of renewable energy in the agricultural sector. An immediate conclusion of this activity was that almost all measures relating to renewables in agriculture focus on unlocking the sector's potential as a provider of biomass for energy (mostly described under section 4.6 in the NREAPs). Few countries give explicit consideration to other renewable energy sources which could be both produced and consumed on farm, with France representing the most notable exception.

That said, it has to be noted that farmers in many countries can benefit from a number of incentives available to any producer or user of renewable energy, as reviewed in the previous sections.

What follows in a country overview limited to the NREAPs available in English. For the countries where NREAPs are not available in English, an abstract in English will be made of the summary, to allow an analysis of the headlines of these NREAPs.

6.1 Austria

The Austrian NREAP mentions a number of "horizontal" policy measures, which target final consumers by a number of national programs, thus including farmers. Most fall under the general environment and climate protection programs, and promotion of renewable energy.
Measures that target more specifically the agricultural sector include:

a) Under the cluster "horizontal" policy measures, the Austrian programme for a sustainable agriculture (ÖPUL), running between 2007-2013, which promotes compliance with good agro-environmental practices.
b) Under the cluster for "Energy Supply" two relevant initiatives can be found:
   - Biogas and biomethane strategy for the chain from application to marketing, which aims at expanding the use of biomethane in all applications segments through the creation of instruments on the demand side.
   - Mobilisation of biomass and use of local and district heating networks (incl. microgrids) aiming at a better and more sustainable use of the county's biomass potential.

   However, neither of these programs are explained in much more detail.

6.2 Bulgaria

The only agriculture-specific measure mentioned in the Bulgarian NREAP is the "Measures for growing energy crops", which are planned under the Rural Development Program. No details on what such measures might entail are provided.

6.3 Cyprus

The only support measure specific to the agriculture sector mentioned is a series of financial support programs in place since 2003 on the energy use of animal farm waste. The financial support is disbursed through grant schemes implemented by the Ministry of Agriculture, Natural Resources and Environment and aim to establish support for investments in infrastructure and equipment for rational management of pig-waste / waste from piggeries, dairy farms, poultry abattoirs and manure so as to avoid the risk of environmental pollution and pollution of water resources in particular.

A Special Fund has been set up to implement the grant schemes. The First Grant Schemes in 2004 offered a capital grant on the total cost of the investment for energy utilisation of animal farm waste. In 2007, the first scheme encouraging generation of electricity using biomass was implemented; the scheme subsidises the energy generated with the use of animal farm waste that is fed into the grid. In the Support Schemes for 2009–2013, there is a subsidy for the generated kWh, while the plan for a 40% subsidy of the eligible cost is preserved.

6.4 Czech Republic

NREAP only available in Czech.

6.5 Denmark

The government's Green Growth plan includes the expansion of agriculture's role as supplier of green energy such as energy crops and biogas. A Green Development and Demonstration programme has been established, which is intended to create a better connection between the research, development and demonstration of knowledge in the food, agricultural, fisheries and aquaculture sectors.

The "Green Growth 2.0" agreement from April 2010 contains several regulatory, economic and information initiatives targeting the agriculture sector to promote the generation of biogas and energy crops (the details of which are not presented in the NREAP). The government of Denmark expects this to lead to an increase in subsidized planting of perennial energy crops.

6.6 Estonia

NREAP not yet submitted.

6.7 Finland

No specific measures for the agriculture sector have been identified.

6.8 France

Of the countries reviewed, France has devoted most attention to the agriculture sector. There are several initiatives that are focused specifically on farms or mention them explicitly as beneficiaries of a program. Some of the most important programs include:

a) The Energy Performance Plan for farms (PPE), launched by the Minister of Agriculture and Fisheries in February 2009, enables farmers to take part in achieving the Grenelle Environment Forum targets. The plan covers both energy saving measures and the production of renewable energies and aims at increasing the number of low energy dependence farms.

   The PPE is divided into 8 areas, of which Areas 1 (Better evaluate the energy balance sheet for farms) and 2 (Broadcast energy diagnoses on a massive scale) translate into aid for the execution of an energy performance diagnosis of the farm, which would include an assessment of the opportunity for some farms to produce their own renewable energy. The target of the energy performance plan is to carry out 100 000 diagnostics by 2013.

   Depending on the recommendations of the diagnosis, aid for investments may be granted, and in particular aid for investments aimed at producing renewable energies. Area 5 of the PPE, "promotion of the production of renewable energy" provides for aid for investments for the installation of solar water heaters, biomass boilers, thermal exchangers and heat pumps, and for methanisation units and equipment linked to the production of electricity on an isolated site not connected to the network (small wind farms and photovoltaic panels).

b) The Heat Fund launched in December 2008, was implemented in order to support the production of heat from renewable resources and recuperated energy. The aim of the Heat Fund is to support, between 2009 and 2020, the production of renewable heat up to 5.5 Mtoe.

   It mainly supports the development of the use of biomass (forestry, agriculture, production and thermal recovery of biogas, etc.), geothermal energy, heat pumps and solar thermal. Agriculture is one of the directly concerned sectors (together with collective housing, tertiary and industry). It has a budget of around one billion euros for the period 2009-2011.

The French NREAP also mentions some forms of renewable energy that could be produced by the agriculture sector but are actively discouraged, such as land-based solar facilities whose power rating exceeds 250 kW. The installation of such facilities on agricultural or natural land is very strongly discouraged (since December 2009, by the application of the Town Planning Code), as this land is not intended to be used for the production of electricity.

6.9 Germany

Germany's most widely known mechanism for the support of renewable energies is the Renewable Energy Sources Act (EEG), which came into force in 2000 and put into practice the first price regulation methods known as feed-in tariffs. This measure has been considered a success story and one of the pioneering ventures for the promotion of renewable energy sources. Nevertheless, the EEG will not be everlasting and so adaptations and new frameworks need to be deployed into the future in order to achieve the more challenging targets of the next decades.

In addition to the EEG, the national action plan announces a series of other instruments that are aimed at contributing to the achievement of the targets set in the Directive on the promotion of energies from renewable sources. These include:

- Low-interest loans from the state-owned KfW (*Kreditanstalt für Wiederaufbau*) development bank, which are issued within the framework of the "Renewable Energy" development programme;
- The National Climate Initiative, comprising a variety of information and promotion measures for exploiting energy efficiency potential and for the development of renewable energies across the board;
- The EnWG (*Energiewirtschaftsgesetz*) energy market law that sets the framework conditions for the development of the electricity and gas networks, as well as the relevant market regulations;
- The EnLAG (*Gesetz zum Ausbau von Energieleitungen*) law for the development of power lines that is designed to help accelerate the extension of the power grid by identifying urgent requirements for individual power lines and carrying out a pilot scheme for laying underground cables as an alternative to overhead power lines.

In line with the last mentioned instrument in taking actions for the upgrading of the electricity infrastructure, the federal government indicates that the expansion of joint capacities with neighbouring countries is planned and this is to be included in a variety of documents (Transmission Development Plan of the ENTSO-E, EnLAG, TEN-E guidelines). In its energy concept, the federal government confirms its commitment to supporting the setting up and development of a European-wide electricity grid and proposes a series of measures to achieve this goal. Amongst other things, the government - together with other countries on the North Sea – is pursuing the idea of an offshore grid in the North Sea.

Germany strongly promotes research in RE in agriculture, especially in biomass use and bioenergy. The Federal Ministry of Agriculture and Consumer Protection founded its own agency on renewable resources (FNR) which manages several research programmes on energy feedstock, farming practices and plant installations. It also launches a competition for regions that can apply for financial support to become a so-called Bioenergy Region aiming for energy independence. Moreover, Germany has devoted funds derived from the emission trading certificates to a broad research programme under the National Climate Initiative (NKI) that also includes bioenergy applications in the agricultural sector. Pilot-projects and plant installations can also be funded under specific rural development programmes with support from both the federal state and the *Bundesländer* where such programme is applied.

6.10 Greece

Greece's RE development strongly focuses on wind and solar power. The Greek NREAP contains 34 different regulatory, financial and technical measures to boost RE in the country. The majority of these measures is already in place, some more are planned for the future. Only one measure specifically addresses farmers. The "Improvement of environment and countryside and of the Programme of Rural Development of Greece 2007-2013 for developing scenarios for short rotation coppices and to perennial grasses" is a planning instrument that should investigate the potential which can be derived from farm grown woody biomass, an information which is currently missing in biomass potential estimates in Greece.

Moreover, there are a wide range of regulatory and financial mechanisms and grants also farmers can possibly benefit from, e.g.

- Feed in tariffs for electricity produced from renewable energies
- Framework for the installation of PVs on buildings and open yards
- Annual quota allocation for biodiesel production and distribution to oil refineries for blending

6.11 Hungary

NREAP not yet submitted.

6.12 Ireland

In Ireland, farmers can benefit from a different financial mechanisms that focus specifically or among others on the agricultural sector:

- ReHeat (Financial incentive) aims for increased deployment of renewable heating technologies in the commercial, industrial and public sectors. Provides financial assistance for boilers fuelled by wood chips and wood pellets, solar thermal collectors, and heat pumps.

- CHP Deployment grant scheme (30% on equipment purchase and 40% for feasibility studies) is a financial incentive aiming to increase the deployment of small scale (<1MWe) biomass CHP systems across Ireland in accordance with requirements of EU Directive on CHP.

- Bioenergy scheme for the production of non- food crops (Financial incentive) offers grant support for the planting of perennial biomass crops (willow and miscanthus) – contributes to biomass needs of renewable energy sector.

On the regulatory level, Ireland provides for conditional planning exemptions for renewable technologies that meet specified criteria, a measure that encourages the uptake of energy from renewable technologies and can also alleviate the installation of plants in farming areas.

In addition, the Irish government promotes different information channels to increase the knowledge of and investments in RE by farmers. Among others a guide for Irish Farmers in developing farm based Anaerobic Digestion Plants was elaborated together with scientific institutions.

6.13 Italy

Italy has not adopted measures for the promotion of renewable energies that specifically address farmers or agriculture. However, farmers can indirectly benefit from more general measures applied (see also Greece).

6.14 Latvia

NREAP not available in English.

6.15 Lithuania

The current Lithuanian Rural Development Programme already includes financial incentives for farmers to increase their share in the electricity production from wind power and biogas. More specifically under measure 6 "Modernisation of Agricultural Holdings" the following activities are supported by RD budgets:

- production of biogas from agricultural waste (however, the biogas produced can be used only for the needs of the holding);
- cultivation of short-rotation plantations;
- construction of small-capacity (with capacities of up to 250 kW) wind power plants associated with the production and processing of agricultural produce or services to agriculture and preparation for realisation.

Additional measures are still in the implementing process. The NREAP states that the national Plan of Measures for the Implementation of the National Strategy for the Development of Renewable Energy Sources for 2010–2015to prepared legal and economic measures encouraging the cultivation of energy plants in unused agricultural lands. This also includes the promotion of short-rotation coppices for the production of biofuels.

6.16 Luxemburg

Luxemburg aims for a substantial increase in the installed capacity and the energy generation from RE also in the agricultural sector. Investment assistance for agricultural operations is granted within the framework of the 'Soutien au Développement rural'. The measures apply to investments in the area of electricity, heating and biofuels based on renewable energy sources.

Furthermore, the planting of trees using short rotation forestry should be supported by 2013, especially in excavated areas. Tackling in particular the competition between different biomass uses and increasing the knowledge of potential synergies, the government will prepare an analysis on the interactions between the different biomass uses and land use.

6.17 Malta

No specific measures are implemented or planned for agricultural activities in Maltese RE policies. Policies rather focus on the promotion on specific technologies and on behavioural changes.

6.18 The Netherlands

The Netherlands have also presented their NREAP in which the projected outcomes are expected to slightly overcome the targets set by the directive going up to 14.5% share of renewables in the grid.

It can be said that the country is planning to exploit majorly two sources: biomass and wind. Initially the Netherlands will rely strongly on the use of biomass for both the Energy Generation and Heating & Cooling sectors as a base contributor for achieving the goals in 2020. This initial phase holds with the current trends of the Netherlands in renewable energy resources. According to the published action plan, biomass in the two mentioned sectors will account for roughly 40 per cent of the final target. On what could be described as a second phase attention is set on wind energy, which is projected to grow considerably from 2010 to 2020. Wind power alone would account for over a third of the set target by 2020.

The main instrument for the promotion of RE in the Netherlands is the financial incentives scheme called SDE (*Stimuleringsregeling Duurzame Energieproductie* – Incentive Scheme for Sustainable Energy Production), which also covers renewable energy production in agriculture. Of the measures supporting the expansion of biomass as a major renewable energy resource, one of the most interesting ones for farmers is the Subsidy scheme for fermentation installations (OVMEP), which is a transitional scheme for producers of renewable electricity using fermentation installations. The scheme was set up shortly after the then-main Dutch support scheme for renewable energy, the so-called "MEP" (the predecessor of the current SDE), was discontinued in August 2006 so that advanced investment plans, particularly in fermentation installations of primarily small agricultural undertakings, could still be implemented. Like the MEP, the OVMEP offers a fixed subsidy tariff for the 10-year period. However, one difference is that, in the subsidy grant, a maximum is imposed on the number of kWh that are eligible each year for subsidy. Additionally, the subsidy scheme budget was capped at EUR 326 million.

Given the present issues regarding the sustainability of biomass and the slowdown that this has led to, together with the above mentioned difficulties to develop wind power fast due to social disapproval for onshore and strong investments for offshore, it appears that the Netherlands will have to engage in immediate actions and the development of regulations to meet specific sustainability criteria and assure the necessary investments on infrastructure.

On the other hand, it is also important to mention the involvement of the Netherlands in the "Pentalateral Energy Forum" in which, along with Belgium, Luxembourg, Germany and France, efforts are being taken in order to set up a North West European electricity market that could be one of the ground stones for the projected European electricity market. This could trigger incentives for investment and new ways of meeting the targets through cooperation.

6.19 Poland

In November 2009, the Council of Ministers adopted a Polish energy policy with implications for the period until 2030. The document contains a long-term development strategy for the energy sector building on forecasts in fuel and energy demands. Further, it includes an action programme until 2012. In the area of renewable energy sources (RES) projects will be developed in order to achieve the objectives of the EU climate package for different types of renewable energy sources and related technologies.

The document sets the following targets for Poland: By 2020, 15 percent in final energy consumption will come from RES. Another 15 percent should be achieved in the years after 2020. However, no specific timeline to fulfil this target is given. In addition and in line with the EU Directive on Renewable Energies, 10 percent of the market share in transport fuels should come from biofuels by 2020. Poland will also strive to make greater use of second generation biofuels.

The biogas as well as wind energy sector in Poland mostly benefits on energy quotes and a system of green certificates as the implementation of Directive 2001/77/EC. Moreover, the solar thermal energy sector benefits from subsidies given by the National Fund for Nature Preservation and Water

Management. The government plans in the for future to exceed subsidization also on other technologies i.e. heating from biomass, heat pumps and small wind turbines.

6.20 Portugal

The Portuguese NREAP introduces a number of new measures that should set Portugal on the pathway towards its national renewable energy targets. While not many measures targeting the agriculture sector could be identified, the following measures and developments could be particularly interesting for farmers:

- The National Energy Strategy includes some provision for incentives for microproduction of renewable electricity (units up to 3.68 kW subsidized regime and up to 5 kW general regime), which are due to be reviewed in 2010. The aim is to improve the functioning and the supply capacity for the Immediate Renewables program, with a view to installing, by 2020, a capacity of 250 MW in microproduction units.
- A new miniproduction programme, although aimed primarily at the services sector (schools, public buildings and markets and industrial sector), for a new range of capacities up to 250 kW, could also be taken up by larger farms. The aim is to increase the installed capacity of such intermediate plants to approximately 500 MW by 2020, which would supply power to the grid. The main benefit of this program for miniproducers will be a simplified licensing procedure.
- For the transport sector, the NREAP mentions the promotion of use of endogenous resources to produce biofuels, with closer links with national agriculture, however no details on what such promotion would entail are presented.
- Under general measures for the promotion of use of biomass, promotion of cultivation of energy crops in lands that cannot be used for other agricultural purposes is mentioned. It is not clear whether "land that cannot be used for other agricultural purposes" refers to degraded land, especially because there are no estimates of degraded land in Portugal. Again, no details are provided.
- With regard to energy crops, a working group within the National Forest Authority has been charged to identify measures to encourage an increase in the availability of biomass for energy purposes, however no details of this activity are available at this stage.

6.21 Romania

NREAP currently only available in Romanian.

6.22 Slovakia

NREAP currently only available in Slovakian.

6.23 Slovenia

The Rural Development Programme 2007-2013 includes a number of measures to be implemented through public tendering, including:

- Measure 121 on modernising agricultural holdings. The main expected result of this measure is to increase the production of biogas from organic waste in agricultural holdings.
- Measure 123 on increasing the added value for agricultural and forest products. The main expected result is to increase investment in equipment for obtaining energy from renewable sources for own needs.
- Measure 311 on diversification into nonagricultural activities. The main expected result is to increase energy from renewable sources for sale on farms by supporting investment aimed at production of biogas using organic waste and processing biomass.

- Measure 312 on support for establishing and developing microcompanies. (Expected result is the same as for measure 311 but not limited to agricultural holdings).

In addition, the decree on the implementation of direct payments in agriculture aimed at promoting the cultivation of field crops for production of biofuels used to offer direct payments for producing energy crops. However, these financial incentives were ended in 2009.

Finally, although the RDP includes a number of measures to stimulate production of RE on farms, it appears there are still important gaps in legislation that would allow RE produced on farms to be exported from it. An important new measure announced in the Slovenian NREAP is the Ministry of Finance and the Ministry of Agriculture drawing up the regulatory framework that will enable the introduction of energy contracting into agriculture. Furthermore, the Ministry of the Economy should draft by 2011 amendments to the current Energy Act that will allow to include biogas in the natural gas network, including technical rules for connection to the network as well as the tariffs for connecting biogas.

On the energy use side, there are measures aiming at introducing RES to agricultural mechanization. The Ministry of Agriculture, Forestry and Food offers Financial incentives for increasing the share of biofuel users in agriculture.

6.24 Spain

Spanish legislation provided for supporting frameworks for renewable energies since the early 1980s, which has boosted investor confidence and enabled developers and equipment manufacturers to procure the financing required to make significant investments in renewable energies.

The Electricity Sector Law 54/1997 deregulated the electricity market in Spain and established a target of 12% renewable sources of primary energy demand by 2010. To this end, this law called for the preparation of a Renewable Energy Development Plan, which was approved in December 1999. The Plan analysed the status and potential of these energies and fixed specific objectives for the different technologies.

During the last decade, RE development in Spain was mainly regulated at a National level with few regulations that also effect farmers. The most relevant policy was launched in 2005, when the Spanish Government approved a new 2005-2010 Renewable Energies Plan (PER) and an Action Plan to improve energy efficiency. The goal was to renewable energy technologies were being installed and curb rising energy demand. During 2010, a new Action Plan under revision by the commission will produce a new Spanish PER for 2011-2020. The action plan today, in accordance with the European energy policy (2009/28/CE) estimates the following shares for 2020:

- Final Energy Consumption: 22.7% (equivalent to a renewable energy excess of 2.7 Mtoe)
- Electricity Generation: 42.3%

On the other hand, in 2008 two new objectives were included: 5.83% of oil and diesel consumption by the transport sector to be satisfied using biofuels, and a minimum of 29.4% of gross electricity demand from renewable sources. These goals were part of the Hydrocarbon Law developed in 2008.

Thus, over the last decade and especially since 2005, Spanish renewable energies increased their contribution driven by a promoting regulatory framework. Spain supported the sales price of renewable electricity by establishing either a fixed tariff (which differs from one technology to the next) or a premium paid on top of the market price for installations that opt to sell their electricity on the market. The scheme, commonly known as a feed-in tariff, is basically the same as that used in countries such as Germany or Denmark.

Under measures specific to the solar sector, a ten year campaign (2010-2020) is planned which includes measures for dissemination, development and regulatory adaptation of solar facilities (photovoltaic, thermal and thermoelectric) in order to foster their cross-cutting inclusion in all sectors, including agriculture. The main aim of the campaign is to change attitudes towards solar energy.

Under biomass sector measures, the necessary legislation in support of multi-annual plans to harness energy from products, by-products or waste from forestry and agriculture (which aim to achieve 5,500,000 t of this biomass/year used for energy purposes) still needs to be implemented. The drafting of the legislation will only start in 2014.

Due to its high erosion rates, Spain is also looking at reforestation of farmland in areas of low productive capacity or forest areas which have been cut and are no longer productive as a way to promote energy crops (more specifically, forest species with energy-generating capacity such as Quercus, Eucalyptus and Acacia are being considered). The introduction of new energy crops both in forest and farmland entails a set of measures which it is proposed to implement through programmes for restocking of currently non-productive forest land with energy species, and programmes for restocking of farmland which has been abandoned or is being set aside due to low production indices (below 1.2 t/ha per year).

Regarding farmers, no subsidies for RES promotion on farms are taking place in Spain today. The only subsidy that existed until 2010 was related to CAP and consisted on a 45€/ha contribution that the European Union gave as energy crops' aids, in the concept of "carbon credits". This amount was not enough to significantly increase the production of dedicated energy crops. Currently the subsidy stopped. Soria is a region that has developed a quite important activity on this issue. The end of the subsidy is being strongly noticed by the farmers in this region, especially when several biomass plants for electricity generation are expected to begin buying straw and woody biomass during the next 2 years in several areas. Finally, most stakeholders are expecting new developments in accordance with the new PER 2011-2020 that is going to be published during 2010.

Some relevant Spanish laws are:

- LAW 54/1997 of 27 November of the Electricity Sector. This deregulates the electricity generation and commercialisation activities and establishes the target of generating 12% of primary energy using renewable sources in 2010.
- ROYAL DECREE 436/2004 on the legal and economic regime for electricity generation under the special regime.
- ROYAL DECREE 314/2006 of 17 March approving the Technical Building Code (in Spanish CTE). It established the obligation to install solar energy on all new and refurbished buildings. It is estimated that the new CTE will increase building costs (excluding land) of private housing and also rural facilities by 2%. At the same time it will substantially increase building quality and will have a huge impact on the sector by changing building habits, used products and solutions, and the importance of technical reliability of products (track record).
- LAW 9/2006 of 28 April on the assessment of the impacts of certain environmental programmes and plans.
- ROYAL DECREE 661/2007 of 25 May regulating the activity of generating electricity under the special regime.
- LAW 12/2007 of 2 July amending Law 34/1998 of the Hydrocarbons Sector, which establishes the definition of biofuels and the obligation to use biofuels in the transport sector.
- ROYAL DECREE 1028/2007 of 20 July establishing the administrative procedure for presenting planning permission applications for electricity generation installations in domestic waters.
- LAW 45/2007 of 13 December on the sustainable development of the rural environment.
- ROYAL DECREE 1578/2008 of 26 September on the remuneration for electricity generated using photovoltaic solar power.
- MINISTRY OF INDUSTRY, TOURISM AND TRADE ORDER ITC/2877/2008 of 9 October establishing a mechanism for promoting the use of biofuels and other renewable fuels for transport purposes.

6.25 Sweden

In Sweden, as in other Scandinavian countries (except Denmark), the forestry sector is expected to provide a more significant contribution to the country's renewable energy ambitions than agriculture. Nevertheless, there are some incentives that, while not solely aimed at farms, can be particularly interesting for farmers:

- Support for energy identification for SMEs; a financial instrument which provides funding for energy surveying in companies (incl agricultural holdings) that have an energy consumption in excess of 0.5 GWh, up to a maximum of SEK 30,000 per enterprise.
- Landsbygdsprogrammet (the Swedish Rural Development Programme) includes investment aid for energy forests that applies to all arable land. The target as regards multi-annual energy crops is that an area equivalent to 30,000 hectares is to be planted during the period of the programme, 2007-2013. The same program also includes aid for livestock manure digestion.

Sweden is one of the few countries where "punitive" measures are (or will soon be) applied to agriculture as a means towards increasing use of renewable energy in the sector. A particularly interesting case is that of CO2 taxation, to which the agriculture sector will become increasingly subjected:

- The CO2 tax for industry outside of the EU ETS, including agriculture and forestry is set to be increased in two stages, from 21% to 30% of the general CO2 tax level in 2011 and from 30% to 60% of the general CO2 tax level in 2015.
- The reduction in the refund of CO2 tax for diesel oil used in agricultural and forestry machinery will also take place in three stages for the agricultural sector (2011, 2013 and 2015). The outcome of this is likely to be an increase in use of biofuels in the sector.
- The energy tax on fossil heating fuels will be restructured according to the energy content of the fuel and will be introduced in sectors in which the energy tax is currently zero, including agriculture. Again, the aim is to increase the energy efficiency and incentives switch to renewable heat in the sector.

6.26 United Kingdom

The United Kingdom is strongly committed to achieving what appears to be a highly challenging target given the country's current share of renewables being fairly low. In a very similar tendency as the one shown by the Netherlands, the UK is looking for substantial development of its wind energy sector and steady growth in the use of biomass and especially biofuels for the Heating & Cooling and the Transport sectors respectively. These have been presented as the main means to reach the country's renewable energy objectives.

The UK's approach appears as a more holistic one in comparison to the rest of the Member States, this in regard to the measures outlined in the action plan are not only concentrated in electricity generation, but a considerable fraction of the objective is projected to be tackled through the Heating & Cooling and Transport sectors. An interesting matter in the Heating & Cooling sector is the one regarding the roll out of district heating using renewable heat since this would be a powerful way to reach the target for the sector but still no definite actions have been laid out in the NRAEP.

As mentioned before, the technologies favoured by the UK are practically the same as those chosen by the Netherlands, and thus to some extent, the difficulties encountered could also be similar. This is especially important for this Member State since the vast majority of the measures in its NREAP cover biomass and wind energy only.

Through the RTFO Biofuel Sustainability Meta-Standard the UK has taken its first steps towards sustainability reporting. On the other hand, the Planning Act 2008 and the Marine and Coastal Access Act 2009 intend to reduce the burdens presented by former legislation, which made the licensing of onshore and offshore installations slow and complicated. By increasing the efficiency of these procedures the country is aiming at lifting some of the barriers hindering the development of its chosen renewable technologies.

Some measures specific to the agriculture sector are:

- The Rural Development Programme for England 2007-13 (RDPE) mandates the Regional Development Agency to provide grants to develop energy projects or small scale on farm renewable energy technologies, including AD, biomass boilers and CHP, and hydro or wind turbines. RDPE can also support alternative agriculture such as growing the feedstocks for use in low carbon renewable materials and fuel, including bioenergy crops and niche and novel crops.

- The Energy Crops Scheme (ECS) aims to increase the amount of perennial energy crops grown in England in appropriate locations for use in heat and electricity generation. It offers grants to farmers in England for the establishment of energy crops such as miscanthus and short rotation coppice. The scheme's budget is £47 million.
- In Wales, the Better Woodlands for Wales grant scheme from Forestry Commission Wales is aimed at owners and farmers with woodlands and forests and supports good quality woodland management and replaces the Woodland Grant Scheme in Wales. It provides support for many aspects of forest management including design, operations, protection, maintenance and conservation.
- In Northern Ireland the Biomass Processing Challenge Fund (DARD) is supporting primary producers from the land based sector in purchasing of a range of technologies and approaches that improve business efficiency and sustainability at farm/forestry level, utilising cost effective and sustainable methods of processing agricultural wastes and other appropriate biomass material to generate renewable energy.

The UK is also undertaking considerable work to increase the deployment and use of anaerobic digestion to create biogas, however, the main support measure to this sector at present is financing of a number of demonstration installations.

ANNEX IV. QUESTIONNAIRE

(as an example the questionnaire for the case regions in Germany is taken; for some questions the wording (1) or figures (14) are differing per country, to be defined by the consortium partners responsible)

Dear sir/madam,

On-farm renewable energy (RE) production is increasing all over the world. Several farmers have invested in RE (such as windmills, photovoltaic systems and biomass), while others did not do so (yet). With this questionnaire we want to investigate which factors have favored farmers to invest in on-farm RE, and which factors have limited, refrained or delayed on-farm RE investments. This survey will be held in different European countries, and is funded by the European Commission. The European Commission will use the results of this questionnaire to develop policies that benefit on-farm RE production by farmers. Data will be treated confidentially and not be handed on to others.

The questionnaire consists of four parts. In the first part we ask you some general information about yourself and your farm. Next, in part two, we ask your opinion on several issues. In the third part we have separate questions for farmers who invested in RE and for farmers who did not invest in RE. In the last part we consider your expectations for the future.

We would kindly ask you to complete this questionnaire, which contains statements, closed questions and open questions. This will take approximately 30 minutes.

Kind regards,

Name institution

PART 1 - General information about farmer and farm.

1. In which agricultural region is your farm?
   - o North East Brandenburg
   - o Saarland

2. What is your age? ……..... years

3. How long have you been in the profession of farming? ……. years

4. Do you have a successor?
   - o Yes
   - o No
   - o Not yet known

5. What is the highest level of education that you completed?
   - o No school completed
   - o Primary school
   - o Secondary school
   - o "Ausbildung"
   - o High school
   - o University for applied science
   - o University

6. What kind of farm do you have?
   - o Arable
   - o Livestock
   - o Arable + livestock
   - o Horticulture
   - o Forest
   - o Other, ………………………………………………

7. What is the total utilized agricultural area on your farm? ………hectares
   - o …..ha rented land
   - o …..ha own land
   - o ..... ha communal land

8. What is the distribution of crops on your farm? *(only fill in if applicable)*
    - Cereals ……ha
    - Oilseeds ……ha
    - Woody crops ……ha (e.g woody short rotation coppice like willow, poplar)
    - Potatoes ……ha
    - Sugar beets ……ha
    - Maize ……ha
    - Vineyard ……ha
    - Herbs ……ha
    - Vegetables ……ha
    - Horticulture ……ha
    - Forest ……ha
    - Permanent grazing ……ha
    - Temporary grassland ……ha
    - Fallow ……ha
    - Perennial biomass grasses (e.g., miscanthus) ……ha
    - SRC-willow/poplar ……ha
    - Other ……ha

9. How many animals do you have on your farm? *(only fill in if applicable)*
    - …. Cattle
        - ….. dairy cows (including breeding bulls)
        - ….. young stock for dairying
        - ….. beef cattle (≥2 years old)
        - ….. beef cattle (<2 years old)
    - …. Pigs
        - ….. sows (including boars)
        - ….. fattening pigs
    - …. Poultry
        - ….. laying hens
        - ….. poultry for meat production
    - ….. Sheep
    - ….. Goats
    - ….. Other

10. Are you an organic farmer?
    - Yes
    - No

11. Are you working fulltime or part-time on your farm?
    - Fulltime (….. hours a week)
    - Part-time (….. hours a week)

12. How many family members, excluding yourself, are working on your farm? ……..

13. How many employees do you have? …………….

14. Please indicate annual net farm income?
    - ≥ regional average *(Ecologic to provide the figure)*
    - < regional average *(Ecologic to provide the figure)*

15. Do you (or somebody of your household) have other sources of income?
    - Yes
    - No

16. Please indicate the solvability of your farm. The solvability represents the ratio between own and external capital. A very low solvability (e.g., between 0 and 0.2) means that the farm is mostly financed by external capital. A very high solvability (e.g., between 0.8 and 1.0) means that the farm is mostly financed by own capital.
    - 0 - 0.2
    - 0.2 - 0.4
    - 0.4 - 0.6
    - 0.6 - 0.8
    - 0.8 – 1.0

17. Did you invest more or less than 10% of the value of your farm in the last five years (exclude RE-investments)?
    - ≥10%
    - <10%

PART 2 - Statements

This part of the questionnaire contain some general statements on which we would like to hear your opinion.

18. Can you indicate to what extent you agree with the following statements

	I fully agree	I agree	I agree nor disagree	I do not agree	I do not agree at all
I like to be a pioneer					
I want to minimize the risks on my farm					
I consider the opinion of people (non-farmers) when deciding on investments					
I'm concerned about the environment					
My advisors (private or public) are important for my investment decisions					
I expect my farm's income to decrease over the next few years					
I expect energy prices to rise over the next few years					
Energy supply is not a problem for my farm					
The livelihood (availability of schools, stores, clubs) of my region is good					

PART 3 - Renewable Energy (RE)

This part of the questionnaire contains questions to find out which factors have favored, and which factors have limited RE-investments on your farm.

RE is defined as energy derived from natural resources which are renewable (being naturally replenished, e.g. sunlight, wind, rain, tides, geothermal heat, biomass). On-farm Renewable Energy is produced on farms (farms are economic enterprises basically relying on biological processes to generate agricultural products – food, feed, fibres, other natural materials, fuels – from natural resources such as land and/or non-saline water).

It covers energy generated by installations paid and/or operated by farms as well as by installations paid and/or operated by other legal entities (whether owned and/or managed by the farmer or not), and includes:

- primary, intermediate and final RE that is both produced and consumed on the same farm
- final or intermediate RE that is consumed on one farm but produced on other farms
- final or intermediate RE produced on farms from biomass or waste from non-farming activities
- primary, intermediate and final RE produced not on farms but using biomass or waste produced on farms.

More practically, we consider to the following investments as RE-investments: windmills, photovoltaic systems, solar thermal, small hydro, geothermal, solid biomass (used in Combined Heat and Power (CHP) installations or installations for power only or for heat only), biogas with CHP, biogas for power, biogas feeding into grid, heat pipeline = (micro) district heating, short rotation plantations, solid recovered fuels, perennial biomass grasses (e.g. miscanthus), harvesting, logistics, processing of cellulosic or woody biomass, processing/crushing of oilseeds/refining of vegetable oils on farm for biofuels.

19. Did you invest in RE on your farm?
    - o Yes
    - o No, but someone else did invest in RE on my farm
    - o No one invested in RE on my farm

20. Please provide the annual energy use (excluding farm household) of your farm if possible.

	Energy use (per year) [1]	Share produced on the farm (%)	Share produced locally [2] (%)	Share produced regionally [2] (%)
Electricity from the grid	………….kWh	-	-	-
Electricity from wind	………….kWh			
Electricity from CHP	………….kWh			
Electricity from biogas installation	………….kWh			
Electricity from biomass	………….kWh			
Electricity from PV	………….kWh			
Electricity from CSP	………….kWh			
Gas from the grid	………….m^3			
Gas from biogas installation	………….m^3			
Heat from biogas installation	…………. kWh			
Liquid fossil fuels (gasoline, gasoil, others)	………….litres			
Liquid biofuels (gasoline, gasoil, others)	………….litres			
Heat other than from biogas, please specify	………….kWh			
Coal	………….t			
Biomass (fire wood, wood chips, straw etc)	………….m^3			

[1] Other units are allowed. Please specify which unit is used

[2] locally = in same village or municipality or (if municipalities are large or if this is unclear) within 10 km; regionally = within a range of 10 to 25 km

If **no investments** were made in RE on your farm, please continue with question 21.

If you or somebody else **did invest** in RE on your farm, please continue with question 22.

21. I did not invest in RE because

	I fully agree	I agree	I agree nor disagree	I do not agree	I do not agree at all
The investment costs are too high					
There are no possibilities to sell the energy / biomass (e.g. absence of a purchaser)					
The profitability is too low (e.g., long pay-back time)					
There is no subsidy available/ subsidies that were available before are no longer available					
The procedure to get a subsidy is difficult					
It is too costly or time consuming to get a permit					
It is difficult to get permits for RE investment					
There is no RE technology supplier/ installer/advisor/maintenance service in my area					
I have no know-how on RE					
There is too much uncertainty about profitability of RE products					
It is difficult to get loans for RE investment					
There is no space available for new installations on my farm (or land for biomass production is lacking)					
The installation will be soon out-dated due to the fast progress					
Reliability of RE technology is too low					
Lack of acceptance in my neighborhood					
Other reason, ………..					

Please continue with question 32.

22. Please provide annual production capacity and actual annual production for the RE investments made on your farm. Please also indicate on which year your estimate is based. An important element of RE investments is who is actually doing the investment and taking responsibility for the risks. Please indicate if (and if yes, to what extent) you are responsible (accountable) for the investment (e.g., 20%), plus the destination of the RE products.

Type of RE	RE production capacity (per year) [1]	I am accountable for the investment (%) [3]	Actual RE production (per year) [1]	Based on year (e.g., 2010)	Destination (%) [4]
Windmill (kWh)					
Photovaltaic system (kWh)					
Solar thermal (kWh)					
Hydro (kWh)					
Geothermal (kWh)					
Solid biomass (CHP, power only, heat only) (kWh)					
Biogas with CHP (m^3)					
Biogas for power (m^3)					
Biogas feeding into grid (m^3)					
Heat pipeline = (micro) district heating (kWh)					
Short rotation crops (tons) [2]					
Solid Recovered Fuels (tons) [2]					
Perennial biomass grasses (e.g. miscanthus) (tons) [2]					
Other biomass, please specify …………………… (tons) [2]					
Harvesting, logistics, processing of cellulosic or woody biomass (m^3)					
Processing/crushing of oilseeds/refining of vegetable oils on farm for biofuels (litres)					
Other, …………………..					

[1] Other units are allowed. Please specify which unit is used

[2] Please indicate fresh yield or dry matter.

[3] You may be responsible / accountable for investments with your own capital or with borrowed money.

[4] Products go to the grid or to traders; alternatively, to: own farm (including household), other farms nearby (< 10 km), other households nearby (< 10 km), industry nearby (< 10 km), other nearby (< 10 km), destination not nearby (> 10 km). Please indicate share of multiple destinations if applicable.

23. How did you organize the RE investment (*multiple answers possible)?*
    - o I invested individually, as integral part of the farm
    - o I invested individually, as separate entity
    - o I invested in a group, with an energy company
    - o I invested in a group, with a company specialised in planning, developing and/or operating rural RE projects
    - o I invested in a group, a private joint stock company with non-farmers (neighbors, family members)
    - o I invested in a group, a private joint stock company with other farmers
    - o I did not invest, but somebody else did (family)
    - o I did not invest, but a company did
    - o I did not invest, but a trader did
    - o I did not invest, don´t know who invested
    - o Other, ……….

24. How much money did the RE investment cost? €……

25. Is the return on your investment of the RE-investment sufficiently high?
    - o Yes
    - o No

26. How did you finance (your share of) the RE investment (*Multiple responses are possible*)?
    - o Personal funds
    - o Money from the farm
    - o Bank loan backed by farm assets
    - o Bank loan backed by other assets
    - o Loan with subsidized interest rate
    - o Investment subsidies from local/regional sources
    - o Investment subsidies from national sources
    - o Investment subsidies co-financed by EU. (Specify Rural Development Programme, European Fund for Regional Development: ……………..)
    - o Other, ……………….…………………………

27. Where did you get information concerning RE issues from? (*Multiple responses are possible*)
    - o Reports of agricultural extension services or extension officers
    - o Articles from the press
    - o Reports of state and governments organizations and institutions
    - o Colleagues
    - o TV/ radio
    - o Trainings
    - o Private enterprises
    - o Internet searches
    - o Other, ……………………………………..….

We would like to find out what the impact of the RE investment is on the farm business. First, we would like to know what part of the farm (including household) is used in RE production.

28. RE investments on your farm by others relate to:

Type of investment		**Financial compensation (€ per year)**
Use of your land (please specify for what RE purpose) ……………………….	………… ha	rent ………… €
Space on your roof (e.g. for PV or CSP)	………… m^2	rent ………… €
Storage space in your buildings (please specify) …………………………. ………………………......	………… m^3	rent ………… €
Other benefits		**Financial compensation / year**
I work for the investor	………… % of work time	………… €
I use excess heat	……… kWh[1]	………… € [2]
I provide inputs for the RE production		
Manure	…………tons [1]	………… €
Other		………… €

[1] Other units are allowed. Please specify which unit is used [2] Please indicate if you pay for the use of excess heat

Please, indicate to what extent you agree with the following statements, varying from "fully agree" to "not agree at all". If the statements are not applicable for your situation, please fill in "I agree nor disagree".

29. As a consequence of the RE-investment

	I fully agree	I agree	I agree nor disagree	I do not agree	I do not agree at all
The cropping pattern is more diverse					
Other agricultural activities on my farm get less attention					
I sell more food/feed crops					
I have more livestock					
I buy more fertilizers					
I buy more fuels					
I spend more time working on the farm - including the RE activity					
The total farm income is higher					
Jobs are created for either my family, my partners or employees					

The next question focuses on the reasons why you invested in RE.

30. I did invest in RE because

	I fully agree	I agree	I agree nor disagree	I do not agree	I do not agree at all
I want to contribute to an environmentally friendly energy supply					
I had a problem with energy supply for my farm/household					
I could get a guaranteed price/ income for a fixed period of time					
National or regional subsidies were available					
EU subsidies were available					
I had the opportunity to join an initiative in the neighborhood/ unions/ communities/ foundations.					
I want to produce my own energy to be independent from rising costs for energy prices					
I wanted to make better use of residues and waste from my farm (e.g., manure, crop residues)					
I needed to diversify sources of income					
Other reason,……………….					

31. During and/or after my RE investment I have encountered the following unexpected problems

	I fully agree	I agree	I agree nor disagree	I do not agree	I do not agree at all
The total investment costs were higher than I expected					
Selling RE products was more difficult than I expected					
The profitability of the investment was lower than I expected					
Availability of subsidies was lower than I expected					
The procedure to get a subsidy was more difficult than I expected					
The cost of obtaining a permit were higher than I expected					
The procedure to get a permit was more difficult than I expected					
RE technology supply, installation, advise, or maintenance service in my region was more difficult to obtain than I expected					
Availability of resources for RE was lower than I expected					
I required more know-how to start implement RE than I expected					
The prices offered for RE produced on my farm is lower than I expected					
Uncertainty about RE price levels is higher than I expected					
Availability of loans was more difficult than I expected					
The procedure to get loans for RE investment was more difficult than I expected					
Reliability of current RE technology was lower than I expected; the technology will be sooner out-dated than I thought					
Acceptance of RE was lower than I expected					
Other problem, ……………..					

PART 4 – Expectations for the future

The following questions are to be answered by **all** participants.

32. Do you plan to invest in RE in the near future?
    - Yes (please continue with question 33)
    - No (please continue with question 34)

33. I consider to invest in RE because

	I fully agree	I agree	I agree nor disagree	I do not agree	I do not agree at all
I have environmental concerns					
I have a problem with energy supply for my farm/household					
I can get a guaranteed price/ income for a fixed period of time					
I can get subsidies to finance the investment					
I have the opportunity to join an initiative in the neighborhood/ unions/ communities/ foundations.					
I want to produce my own energy to be independent from rising costs for energy prices					
I want to make better use of residues and waste from my farm (manure, crop residues)					
I needed to diversify sources of income					
Other reason, ……………….					

34. Can you indicate to what extent you agree with the following statements

	I fully agree	I agree	I agree nor disagree	I do not agree	I do not agree at all
There is an observable, ongoing change due to RE in my region					
Farm land rents and farm land prices have increased due to RE					
Costs of fodder for livestock have increased due to RE, animal raising farmers complain					
Market prices for agricultural products have improved due to RE					
Enterprises in my region which use inputs from agriculture or forestry find it increasingly difficult to source their feedstocks and to compete with energy use.					
Economic prospect and quality of life is improving in my area					
The overall economic situation of farming is improving due to RE					
RE energy accelerates modernization and innovation in my area					
RE improves acceptance of farming					

Comments you may add:
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…………………………………………………………………………

This is the end of the questionnaire. If you are interested in the outcomes of this questionnaire you can put your (email)address below. Then we will inform you about the outcomes of this project.

(email)address: ……………………………………………………………………

Thank you very much for your cooperation!