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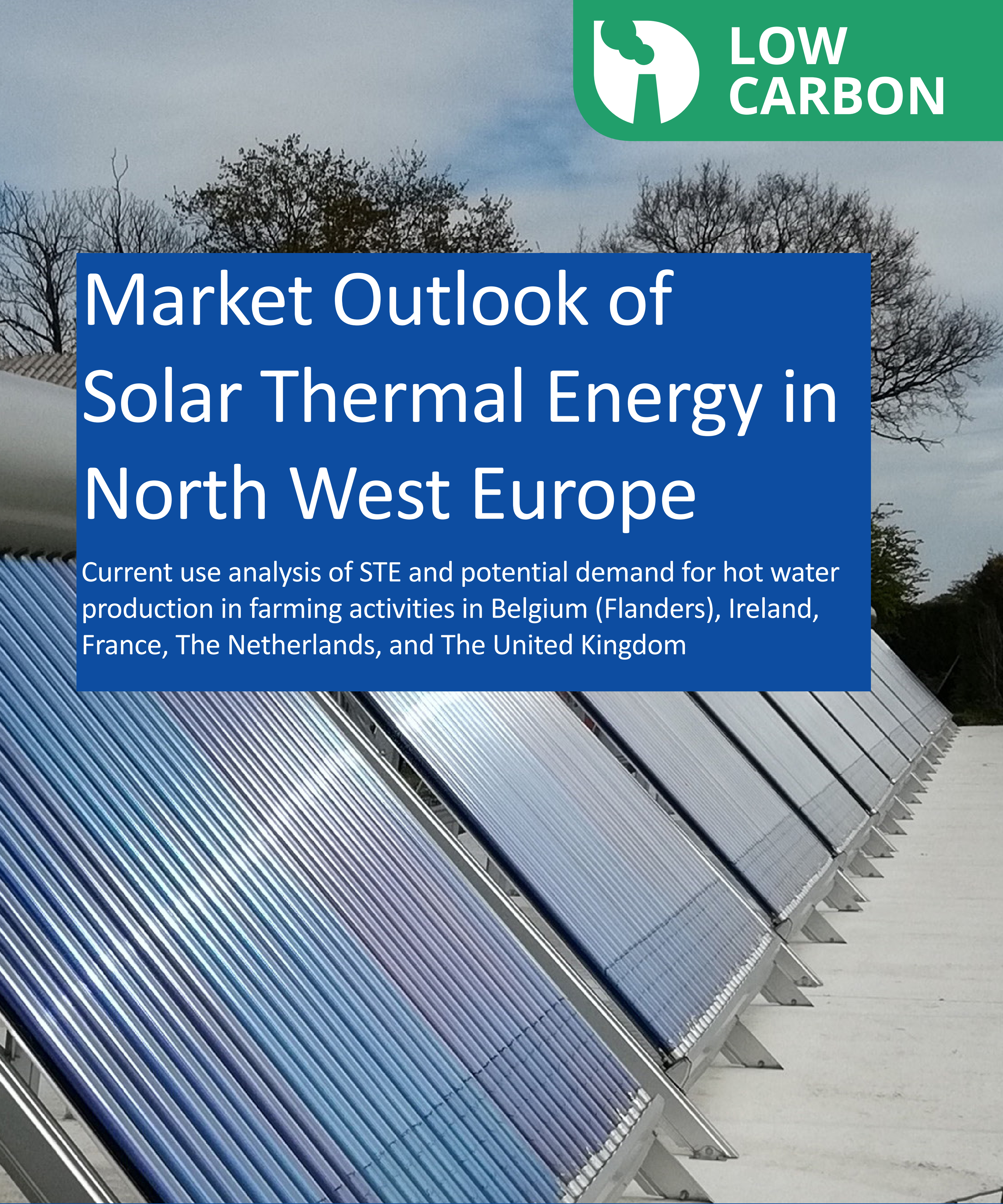

Market Outlook of Solar Thermal Energy in North West Europe

Current use analysis of STE and potential demand for hot water production in farming activities in Belgium (Flanders), Ireland, France, The Netherlands, and The United Kingdom

Total project budget:
€3.37 million

www.nweurope.eu/icare4farms

Interreg
EUROPEAN UNION
North-West Europe
ICARE4FARMS
European Regional Development Fund

Project Partners

Laval Mayenne Technopole

Association des Chambres d'Agriculture de l'Arc Atlantique

Innovatiesteunpunt vzw (ISP)

University of Lincoln

Cornelissen Consulting Services

Université de Bretagne Sud

The Northern and Western Regional Assembly

Feng Technologies SAS

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INTRODUCTION

Since the Paris agreements, the EU member states have committed to reducing greenhouse gas (GHG) emissions and the development of renewable energies as their main priorities. At the European level, these policies continue today with the adoption of the Green Deal and the objective of reducing GHG emissions by 30%. Agriculture, the leading producer of green energy, also consumes large quantities of fossil fuels. Solar thermal energy (STE), long neglected in North-Western European (NWE) countries because of climatic conditions, is today an economical and renewable alternative to energies such as gas, fuel oil and electricity.

The aim of the ICaRE4Farms (I4F) project is to boost the development of STE in agriculture in North-Western Europe.

This document aims to identify the potential uses of STE in order to estimate the number of farms adapted to this application in the different countries of the project and to define the market for North-Western Europe.

This document has been drafted under the coordination of Laval Mayenne Technopole, lead partner of the project. The global approach, methodology of the study and structure of this report have been agreed by the consortium. The detailed planning and review of this document have been worked out within the Market Analysis Working Group, composed of AC3A and its subpartner Chambre d'Agrigulture des Pays de la Loire (FR), Innovatiesteunpeunt (BE), University of Lincoln (UK), Cornelissen Consulting Services (NL), Northern and Western Regional Assembly (IR) and Feng Technologies (FR). Each partner has collected specific data on agriculture and the interested agricultural sectors. With the data collected, each partner wrote its part concerning its country. A global rewriting and harmonisation has been carried out by Laval Mayenne Technopole together with NWRA, and finally validated by the whole consortium.

The work on this report started in July 2020 and has been finalised in June 2021.

Find more information on the ICaRE4Farms project here: https://www.nweurope.eu/icare4farms

SECTION 1: STE Market in agriculture

The purpose of this part is to have a global overview of agriculture in the NWE region (I), and to identify: the sectors that use hot water, the energies that are used to heat the water and to understand the market adapted to STE (II).

As STE is an underdeveloped energy in North-West Europe, knowing its potential application in each sector is a fundamental step in the framework of ICaRE4Farms. The determination of these sectors will then make it possible to analyse the market and other energy sources competing with STE. This part will be essentially done by researching and collecting data from the different project partners for each country represented in the consortium.

1 Global state of agriculture and energies in NWE countries

I. Agriculture in NWE countries

Agriculture is a key sector in all of the European regions. In 2018, it represented €181.7 billion with significant disparities. The data for 5 states in the Interreg NWE zone will be studied in detail: Belgium (Flanders), France, Ireland, the Netherlands and the United Kingdom.

The production, number and size of farms vary according to each state (see table below). On the scale of the 5 countries of the NWE zone, there are about 850,000 farms (out of more than 10 million farms in the EU).

Table 1: General facts about farms in North-West Europe partner regions[1]

	Belgium (region of Flanders)	France	Ireland	Netherlands	United Kingdom
Number of agricultural farms, in 2016 [2]	23,361	456,520	137,560	55,680	185,060
Average size of farms (ha)[3]	26.5	63	43	35	84
Agricultural turnover, in 2016, in billions € (Production without grant)[4]	5.6	77.2	8.6	28.2	29.8
3 largest agricultural sectors (size of farms)	1. Pig 2. Vegetable 3. Milk Products	1. Mixed cattle 2. Dairy cattle 3. Big culture	1. Dairy 2. Sheep 3. Beef	1. Dairy farms 2. Veal farms 3. Grain farms	1. Beef 2. Sheep 3. Cropping

1 Agriculture in these countries is mainly related to livestock: dairy and meat cattle, pigs, poultry, and sheep

2 Eurostats, Farms and farmland in the EU, 2020 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farms_and_farmland_in_the_European_Union_-_statistics

3 More information within annexes related to each specific partner country

4 Eurostat, Agricultural turnover in EU, 2018 https://ec.europa.eu/eurostat/documents/3859598/11495053/KS-GQ-20-009-EN-N.pdf/6f2e2660-9923-4780-a75c-c536514389487t=1604911800000

II. Energy sources used in agriculture in North-Western Europe

Like any economic sector, agriculture is a major energy consumer: in the EU, it consumed on average 24.2 Mtoe (Millions of tons of oil equivalent) out of a total consumption of 855 Mtoe, (i.e., 2.8% of total energy consumption in the EU).

It is also responsible for a significant share of greenhouse gases, linked among other things to energy consumption: it accounts for 10% of greenhouse gas emissions in the EU in 2015[5].

Table 2: Energy consumption and pollution linked to agriculture in NWE partner regions

	Belgium (region of Flanders)	France	Ireland	Netherlands	United Kingdom
Energy consumption of agricultural sector, in 2017, in Million Tons of Oil Equivalent[6]	0.67	3.8	0.21	3.7	1.15
Greenhouse gas emissions of agricultural sector, in 2015, in Metric Tons CO_2e[7]	5.5	76	18.8	19.1	43.4

The countries involved in the I4F project have different production models and different energy policies, which influence the share of different energy sources used. As the following table shows, the energy mix varies from one country to another. For example, Belgian agriculture uses gas for 30% of its direct consumption while electricity represents less than 5% of its consumption. Conversely, British agriculture uses electricity for 35% while its gas consumption represents less than 10% of its energy consumption[8].

This consumption is linked to various factors (public policies, farming techniques, farm structure) and depends largely on energy prices, which vary within the European Union.

It will be advisable to integrate into our survey the price factor of each energy in that they favour or not the potential of solar thermal energy (STE) according to the different countries and sectors.

5 Eurostat, Statistics explained, Agri-environmental indicator – greenhouse gas emissions, 2015 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agri-environmental_indicator_-_greenhouse_gas_emissions&oldid=374989

6 Eurostat, Share of energy consumption by agriculture in final energy consumption 1997-2017 EU-28 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Table1_Share_of_energy_consumption_by_agriculture_in_final_energy_consumption_1997-2017_EU-28.png

7 European Environment Agency, Emissions from agriculture CH4+N2O (kilotons of CO_2 equivalents), 2015, EU-28 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agri-environmental_indicator_-_greenhouse_gas_emissions&oldid=374989

8 See tables below

Figure 1: Energy Mix for European agricultural sectors in 2014

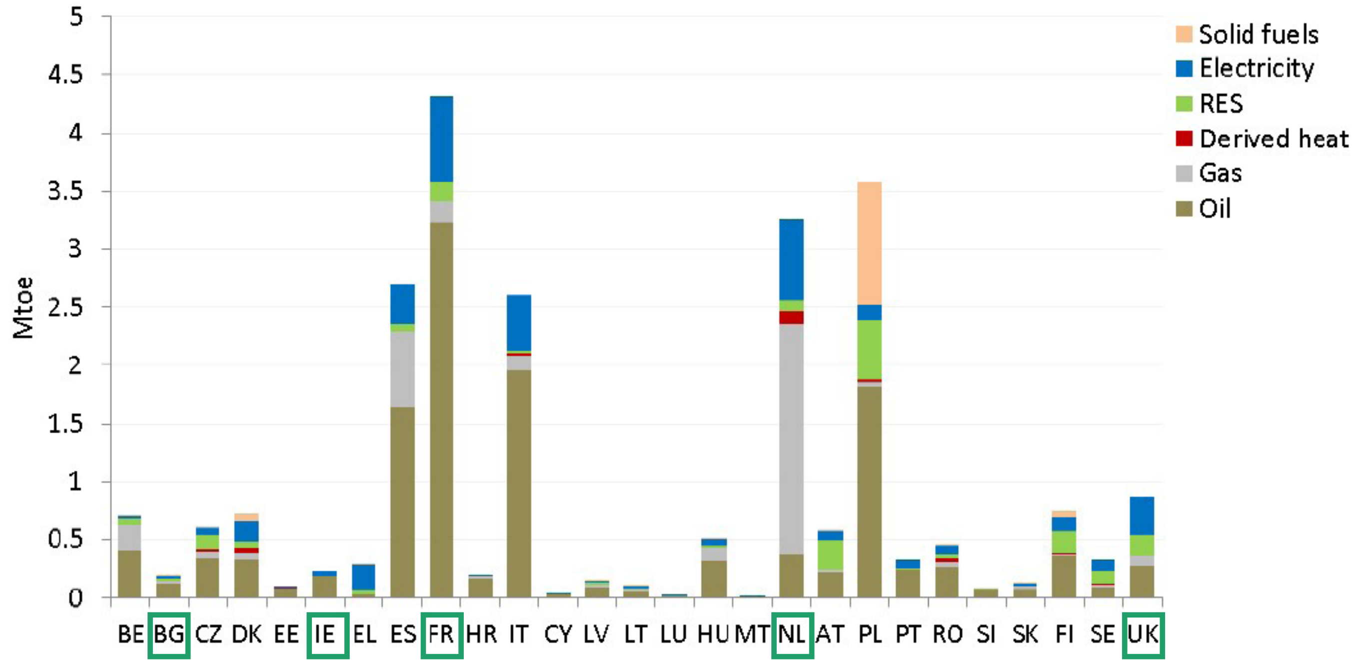


Figure 2: Direct energy use in the agriculture sector in the EU-28

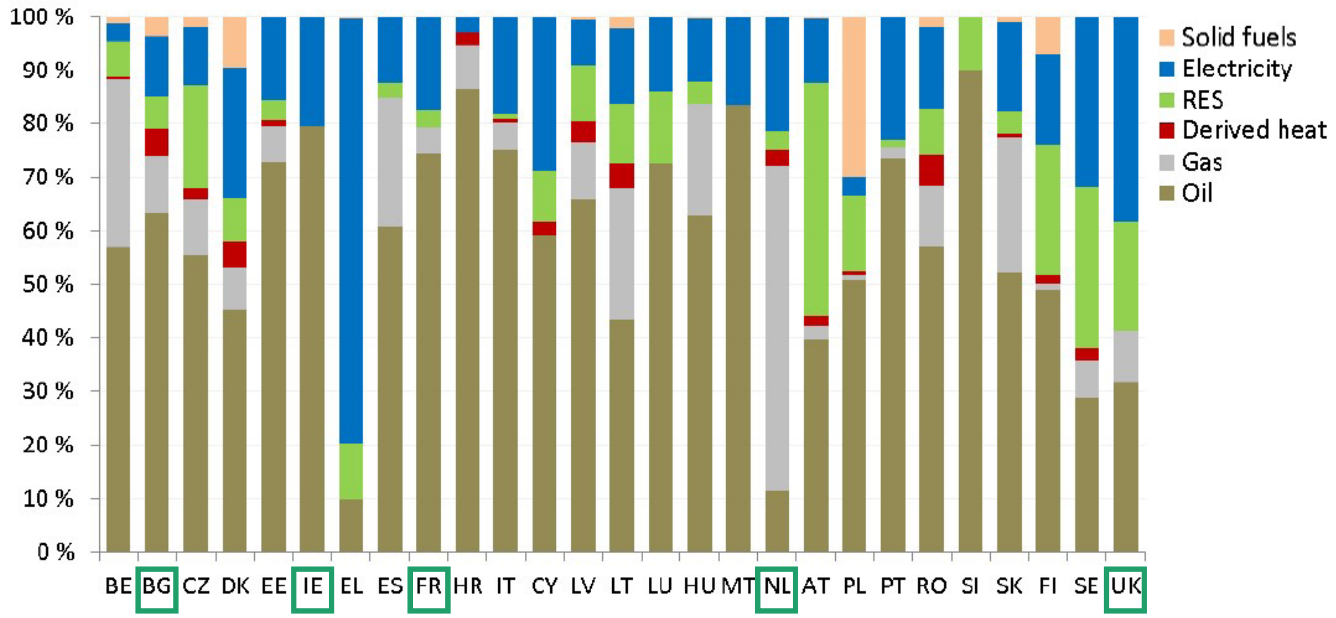


Table 3: The price of different energy sources varies from country to country

	Belgium (region of Flanders)	France[9]	Ireland	Netherlands	United Kingdom
Electricity, in 2019 (€/MWh)[10] [11]	230 (230V) 104[12] - 130[13] (medium voltage)	105	144	103	156
Gas (in HHE : Higher Heating Value), in 2018 (€/MWh)[14] [15]	2018: 38[16] 2021: 39[17]	36.5	35.80	41	27
Price of RE production (20 years) (€/MWh)					
Solar thermal Energy New Generation	n/a	45	n/a	n/a	n/a
Photovoltaic	45[18] - 60[19]	83 - 136[20]	€1,500 - €2,000 per kW installed (ex-VAT)[21]	69 - 80 (100 - 2500 kWp installed capacity)[22]	115
Solar Thermal Energy	75 - 120[23]	47 - 280[24]		80 - 95 (140 - 5000 kWp installed capacity)[25]	
Biomass[26]		62 - 122[27]			highly variable
Wind	80 - 120[28] (farmsize production)	40 - 72[29]	€53/MWh[30]	60 onshore, 105 offshore[31]	109.51 - 74.37 onshore[32]

9 ADEME, Coûts des énergies renouvelables et de récupération de données 2019 https://librairie.ademe.fr/energies-renouvelables-reseaux-et-stockage/765-couts-des-energies-renouvelables-et-de-recuperation-en-france-9791029713644.html

10 SDES, enquête transparence des prix du gaz et de l'électricité 2019 ; Eurostat Electricity prices for non-household consumers - bi - annual data (from 2007 to 2020) https://www.statistiques.developpement-durable.gouv.fr/sites/default/files/2020-01/questionnaire-2nd-semestre-electricite-2019.pdf

11 Eurostat Electricity prices for non-household consumers - bi - annual data (from 2007 to 2020) http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_pc_204&lang=en

12 Vlaams Energieagentschap, Rapport 2020/2 Deel 1 : Rapport OT/Bf voor projecten met een startdatum vanaf 1 januari 2021, page 37, Chapter7.3.2.1 https://www.energiesparen.be/sites/default/files/atoms/files/2020_2_deel1.pdf

13 Based on invoices we received from farmers

14 Ibid 10

15 Ibid 11

16 PWC, Vlaamse Regulator van de Elektriciteits en Gasmarkt, page 158, chart 97, https://www.vreg.be/sites/default/files/document/rapp-2019-03.pdf

17 Commissie voor de Regulering van de Elektriciteit en het Gas, CREG, p.10 https://www.creg.be/sites/default/files/assets/Prices/boordtabel.pdf

18 Vlaams Energieagentschap, Rapport 2020/2 Deel 1 : Rapport OT/Bf voor projecten met een startdatum vanaf 1 januari 2021, p.38, Ch. 7.3.3

19 Based on offers for PV installations received by farmers

20 ADEME, Solaire photovoltaïque, fiche technique, https://www.ademe.fr/sites/default/files/assets/documents/solaire-pv_fiche-technique-integration-dans-industrie-2020.pdf

21 Sustainable Energy Authority of Ireland SEAI, Electricity form Solar https://www.seai.ie/technologies/solar-energy/electricity-from-solar/

22 Planbureau voor de Leefomgeving, Eindadvies Basisbedragen SDE ++ 2020, p.36 https://www.pbl.nl/sites/default/files/downloads/pbl-2020-eindadvies-basisbedragen-sde-plus-plus-2020_3526_27-02-2020.pdf

23 based on offers received and calculations made by Innovatiesteunpunt

24 ADEME, Etude sur la compétitivité du solaire thermiqueen France, https://www.ademe.fr/node/14745

25 Planbureau voor de Leefomgeving, Eindadvies Basisbedragen SDE ++ 2020, p.46 https://www.pbl.nl/sites/default/files/downloads/pbl-2020-eindadvies-basisbedragen-sde-plus-plus-2020_3526_27-02-2020.pdf

26 NB : Biomass isn't considered in each country as RE

27 Wattvalue, Coût des énergies renouvelables en France 2017, https://www.wattvalue.fr/cout-des-energies-renouvelables-en-france-2017/

28 based on offers received and calculations made by Innovatiesteunpunt.

29 France Energie Eolienne, https://fee.asso.fr/comprendre-leolien/les-couts-de-leolien/

30 Wind Energy Ireland, How does wind energy affect Irish electricity prices?, 06 March 2020 https://windenergyireland.com/latest-news/3173-blog-how-does-wind-energy-affect-irish-electricity-prices

31 Fraunhofer Institute for Solar Energy Systems, Levelized Cost of Electricity Renewable Energy Technologies, March 2018, https://www.ise.fraunhofer.de/content/dam/ise/en/documents/publications/studies/EN2018_Fraunhofer-ISE_LCOE_Renewable_Energy_Technologies.pdf

32 Northern Ireland Business Info, Guide "How to switch to renewable energy" https://www.nibusinessinfo.co.uk/content/efficiency-and-environment

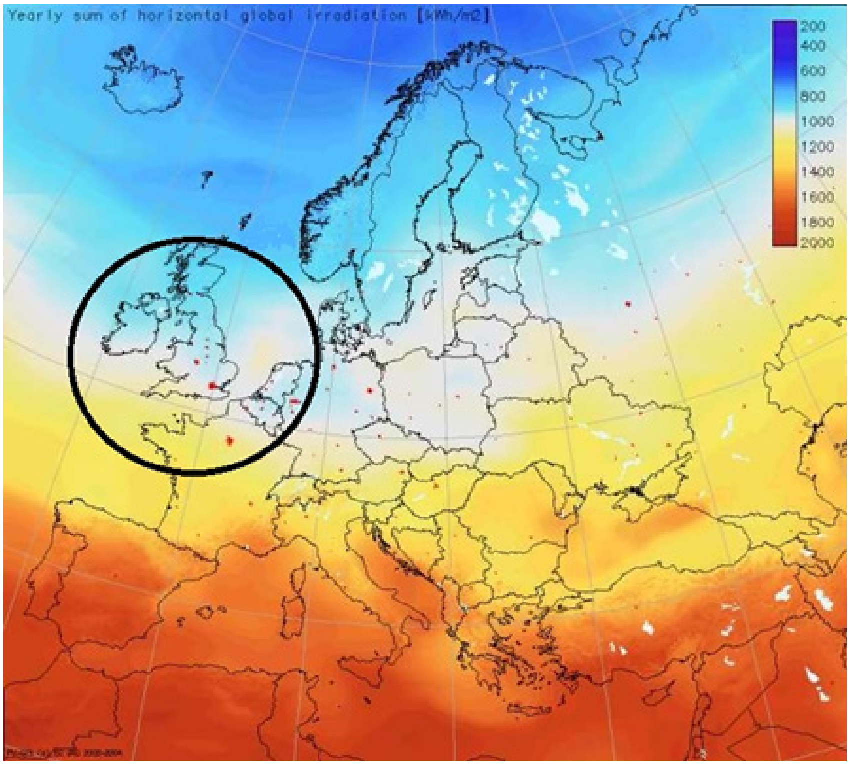
These differences between North-Western European states are found both in terms of agriculture (number of farms, average farm size, activities) and energy (prices, energy used, renewable energy equipment, energy policies).

An in-depth study of the sectors can therefore reveal disparities in the potential of STE between States according to these different factors.

2 Sectors adapted to STE

Agriculture in NWE is an important part of economic activity and an important actor regarding energy consumption but also its activity of renewable energy production. The purpose of this section is to identify sectors and their potential needs of hot water consumption, which is an important source of C02, through 5 countries of North-Western Europe. These sectors usually consume fossil fuels whereas other green energies can be available and appropriate. We will then draw up a profile of each type of farm which could be interested in using an STE application.

STE depends on solar irradiance: as the following map shows, the yearly global irradiance is between 800 and 1,200kWh/m² in the NWE zone.[33]



The emergence of new technologies offering better solar energy recovery yields could help to a better deployment in the NWE and be beneficial for farmers that use hot water.

The I4F project aims at verifying this hypothesis.

Each country and each region has its own agriculture policies and production systems. It is, therefore, necessary to understand and compare those sectors needing hot water to identify the key markets for an STE application in each country.

I. Success factors of Solar Thermal Energy (STE) in agriculture

To identify the different sectors that can be adapted to solar thermal energy, several criteria were taken into account:

- Heating systems that use water as a heat transfer fluid,
- Underfloor heating systems using low-temperature water (between 30 and 50°C)
- Energy needs all year round and especially during the summer when the sunshine is the most important.

This led us to identify 5 priority sectors of agricultural activity:

1. **Milk-fed calves breeding** that uses hot water for the production of feed (reconstituted milk)
2. **Pig farms and especially maternity** and post-weaning workshops
3. **Dairy farms** and especially those processing milk onsite
4. **Protected cropping** under heated glasshouses: market gardening and horticulture
5. **Meat poultry breeding**

[33] EF4, Irradiance annuelle globale (kWh/m²), 1995-2006 https://www.ef4.be/fr/pv/composants-dun-systeme/ensoleillement-belgique.html

II. Comparative Analysis of Energy Costs

For simplicity, we have taken as a reference a solar thermal system composed of 10 units of 4m² each, i.e., a nominal power of 25 KW recovering a capacity of production of 50,000kWh/year (Note: In fact, the energy saving is, for a veal farm in North West of France should be about 40 000 kWh /year) The cost of this system is estimated at €5,000 per unit, i.e., the total investment is €50,000 for a system of 10 units.

As the new generation thermal solar system (such as those produced by FengTech), the system will operate for a minimum of 20 years without maintenance costs and produce free energy, the average price per year of the kWh recovered can be known through the calculation “total energy production” / “system price”.

- Initial investment (for a system of 10 units) = €50,000
- Energy production during 20 years= 1,000,000 kWh
- Cost of energy produced= €50,000 / 1,000,000 = 0.05 €/kWh

This price per kWh will be compared with the price of other energies used in agriculture (electricity gas, biomass, photovoltaic). The size of the used STE system influences the cost of energy produced. And the use of solar thermal energy has an influence also on effective energy saving.

3 Global analysis and conclusion

I. Sectoral analysis[34]

The identification of the key success factors of solar thermal energy led us to select a priori five relevant fields of agricultural activity:

A. Milk-fed calves (calf) breeding:

Slaughter calves are young animals (5.5 months old and 142 Kg of average European weight in 2016[35]), from dairy breeds and whose white meat is appreciated by European consumers. They are fed mainly with a complete and balanced milk replacer, which is a mixture of milk powder, dairy products, fat and nutritional supplements diluted in hot water. This food in the form of a drink is gradually supplemented by the intake of cereals and other forages. These veal calves are reared for a period of 22 to 24 weeks, in 1 to 2 batches per year[36]. Each calf has 1 to 2 drinks per day and consumes about 7 litres of water per drink, of which 4 litres are heated to 70-80°C[37]. Among the various energy consumption related to calves, heating water for drinking represents on average 108 kWh/calf, i.e., 71% of direct energy consumption[38].

Based on its experience, FengTech estimates that solar thermal energy is suitable for farms with an energy consumption of 20,000 kWh/year for water heating, which represents an average of 185 calves per year for a period of 6 months (2 lots/year) or 164 calves over 8 months (1.5 lots/year, lot 123 calves)[39]

B. Dairy farms:

In those farms, the main hot water needs come from the washing of milking equipment: milking parlour, milk tank. This represents on average 120 kWh/dairy cow, i.e., about 14% of the total energy consumption. This daily consumption represents, depending on the size of the farm, 200 to 1000 litres of hot water per day, between 300 and 400 litres for 60-70 cows, 700-800 litres for 120 cows[40]. Dairy farms that process all or part of their milk production into finished products (cheese, fresh cheese, yogurt, butter, ice cream) also have significant hot water requirements for the production process (milk thermisation) and for cleaning the dairy.

34 When information is lacking at the European level, we have chosen to use the French data as references.

35 C.D., Veaux de boucherie : une production très européenne, 1 Juin 2017 https://www.reussir.fr/bovins-viande/une-production-tres-europeenne

36 IDELE/INOSYS, Repères techniques et économiques en élevage de veaux de boucherie, Campagne 2017-201 https://opera-connaissances.chambres-agriculture.fr/doc_num.php?explnum_id=150827

37 IDELE/ADEME, Consommation d'énergie en bâtiment de veaux de boucherie, 2010 http://idele.fr/fileadmin/medias/Documents/2-Energie_batiment_veaux_2010.pdf

38 Ibid 37

39 Ibid 37

40 IDELE/ADEME, Les consommations d'énergie dans les bâtiments laitiers, 2009 http://www.bretagne.synagri.com/ca1/PJ.nsf/TECHPJPARCLEF/19296/$File/CONSOMMATION%20BAT%20ELEVAGE%20LAITIER%20ADEME.pdf?

Although figures on the energy consumption of this transformation are not available, surveys of professionals have shown that this process requires 1 litre of hot water/litre of processed milk. It uses electricity, gas or biomass.

C. Pig farms especially maternity and post-weaning workshops:

The sector is organized according to three stages of production: Maternity, post-weaning and fattening. For farms specializing in maternity and post-weaning, the reference unit is the sow, which has an average litter of 23 piglets[41]. Energy needs are very important during the maternity (1st month after birth) and Post-weaning (6 to 8 weeks after maternity) phases. Heating is the first item of energy expenditure since it alone represents 46% of the consumption of a breeder-fattener type farm[42]. Piglets need a lot of heat during their first 4 weeks, with temperatures between 35°C (first week) and 24°C (3rd and 4th weeks)[43]. At the maternity stage, heating represents on average 729 kWh/place out of the total energy consumption of 900 kWh/place. At this stage, heating represents 80% of the energy needs per place. At the post-weaning stage, heating represents 67 kWh/place out of the total energy consumption of 85 kWh/place[44].

The main heating systems are of three types:

- Radiant heating: radiant heaters using electricity or gas are mainly used in maternity and post-weaning facilities.
- Conduction heating: this system uses a heated floor under which water with a temperature between 40 and 50°C circulates. Its advantage is that it heats in contact with the piglets.
- Convection heating: in this system, hot water (connected to a boiler) is transported to aerotherms that heat the room.

In the last two cases, the systems can be equipped with a water network (aerotherms, underfloor heating) and could be powered by a solar thermal system. The idea of substitution of oil-fired boilers seems the most relevant. Water needs for cleaning are important throughout the pig production cycle. Cumulative consumption amounts to 2095 litres of water per sow per year on average (500 litres in the maternity ward, 500 litres in post-weaning, 1,095 in fattening)[45].

The cleaning of the buildings is carried out after each batch of pigs with the emptying of the sanitary facilities and is done with cold water. The use of hot water could be more efficient and lead to water savings while improving the comfort of the staff dedicated to this task. This use of "free" hot water could be complementary to heating during periods of crawl space.

D. Protected cropping under heated glasshouses, market gardening and horticulture:

This sector includes two main production families: horticulture in the strict sense of the term (ornamental plants, cut flowers and production of young plants) and market gardening (vegetables).

The energy needs come from the heating of greenhouses all year round, particularly at night. In horticulture, the set temperatures are between 8 and 15°C and justify daily heating[46]. In market gardening, the heating of greenhouses is essential throughout the year for the production of tomatoes, cucumbers

41 IFIP, L'alimentation de la truie, 2007 https://www.ifip.asso.fr/sites/default/files/pdf-documentations/truiea3.pdf

42 IFIP, Bâtiment d'élevage à énergie positive, 2013 https://www.ifip.asso.fr/sites/default/files/pdf-documentations/fiche_bilan2013_30.pdf

43 IFIP, Le bâtiment d'élevage à basse consommation d'énergie (BEBC), 2013 http://www.bretagne.synagri.com/ca1/PJ.nsf/TECHPJPARCLEF/19309/$File/BEBC+%20SEPT%2012.pdf

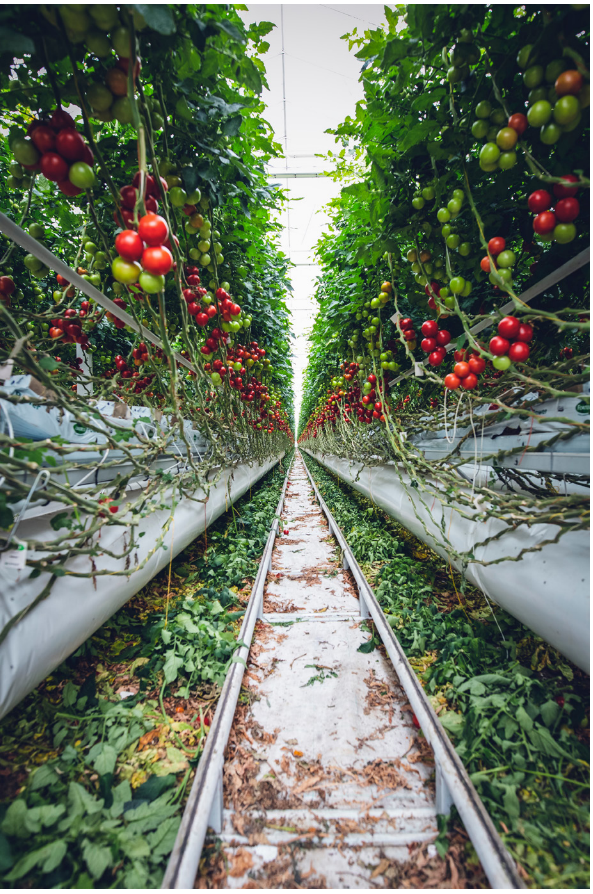
44 IFIP/ADEME, Les consommations d'énergie dans les bâtiments porcins, 2006 https://www.ifip.asso.fr/sites/default/files/pdf-documentations/tp4bartolomeu107.pdf https://www.ademe.fr/sites/default/files/assets/documents/46249_plaquette_ifip_20p.pdf

45 Ibid 43

46 Focus on energy, Ten easy ways to cut energy costs in existing greenhouse spaces - Wisconsin - USA - 2008 https://www.canr.msu.edu/floriculture/resources/energy/assets/TenEasyWaystoCutEnergyCostsInExistingGreenhousesbyWIFocusonEnergy.pdf

but also strawberries. Greenhouses need to be kept at a set temperature of 15 to 23°C all year round[47]. While these temperatures can be reached naturally during the day in summer, they are not reached at mid-season and in winter, especially at night. In market gardening, it is estimated that 80% of energy expenditure takes place at night.[48]

In practice, the heating requirements for the water can be reached through 3 techniques :



- The thermosiphon (pass heat exchange) which requires water heated to 60-80°C.
- A thermosiphon combined with a growth tube (mixed system) requires water at 30-50°C.
- Low-temperature heating (by the floor or under the cultivation tables): this system requires water at 30-50°C.

Among these three heating systems, it is clear that the most suitable for STE are the ones that use water at low temperatures. In addition, depending on the region, there are also specific energy requirements for greenhouses that need to be dehumidified throughout the year, tomatoes in particular.

Regarding market gardening under heated greenhouses, there are two characteristics to take into account that are not favourable to using solar energy:

1. The area of land required to install the solar panels uses approximately 1/3 of the overall area of the site on which the greenhouse is located.
2. Carbon dioxide (CO_2) must be injected frequently into the greenhouses to stimulate photosynthesis and plant production.

In this perspective, the use of natural gas boilers makes it possible to inject part of the combustion gases into the greenhouse.

E. Meat poultry breeding:

In this sector, the heating needs of the buildings are periodic because they are linked to the first month of life of the chicks. They also depend very largely on the state of insulation of the building. On average, the heating expense represents 95 kWh/m²/year, out of an estimated direct energy consumption of 120 kWh/m²/year (i.e., 80% of the energy consumption)[49]. The heating item represents nearly 3% of the production costs for the farmer, i.e., 30% of the variable costs. It is the second most important expense after feed for the farmers. It is directly linked to the heating of livestock buildings, particularly at the chick growth stage. Ambient temperatures are set between 32°C and 19°C for 3 to 4 weeks[50].
Solar thermal energy is not well developed in the poultry sector, despite the real potential for regular heating needs. This absence is linked to the lack of a water network equipment in livestock buildings, traditionally heated by gas-fired or electric radiant heaters.

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47 CTIFL, Evolution du parc chauffée en tomates et concombres, 2016 https://plateforme-documentaire.ctifl.fr/Record.htm?idlist=1&record=19502174124913203569

48 Focus on energy, Ten easy ways to cut energy costs in existing greenhouse spaces - Wisconsin - USA - 2008 https://www.canr.msu.edu/floriculture/resources/energy/assets/TenEasyWaystoCutEnergyCostsInExistingGreenhousesbyWIFocusonEnergy.pdf

49 IFIP, Bâtiment d'élevage à énergie positive, 2013 https://www.ifip.asso.fr/sites/default/files/pdf-documentations/fiche_bilan2013_30.pdf

50 ADEME- ITAVI, Les consommations d'énergie dans les bâtiments avicoles, 2008 http://www.agri72.fr/bibliotheque_pdf/Infos%20Conseils/Energies/economies%20denergies/conso%20energie%20bat%20avicoles.pdf

II. Different target sectors per country

A. France

According to our surveys, the use of STE is possible in all or part of the fields studied. It is already known and practised in veal calf rearing and dairy farms with on-farm processing, while it is almost absent in poultry, pig farms and the horticulture/market gardening sector. This is due to the low level of water supply in poultry and pig buildings and the lack of knowledge of this technology in horticulture/market gardening.

Taking this into account, we can select five target sectors in terms of interest:

1. **Milk-fed calves:** As the average size of a farm is 250 places, it can be estimated that solar thermal energy can be applied in all 2,222 farms with more than 50 calves per year. This sector uses mainly liquefied petroleum gas (LPG)[51].
2. **Dairy farms:** In dairy farming, hot water needs are necessary and daily: they are the second item of electrical energy consumption. However, they are marginal (300 to 500 litres of water per day, 14% of the total energy consumed) and occupy only a small part of the total operating costs (1.68% in 2009)[52]. However, they can be doubled in the case of farms with on-farm processing.
3. **Ornamental horticulture and nurseries:** medium-sized greenhouses (less than one hectare), kept frost-free and heated by the soil at low temperatures.
4. **Market gardening (tomatoes):** in small and medium-sized greenhouses (less than one hectare), heated by the soil at low temperature and dehumidified.
5. **Pig farms:** maternity workshops with underfloor heating.

Poultry farms are generally not suitable for STE for two major reasons: only the chicks should be heated for less than a month and the most used heating method is electric or gas radiant. This could change in the future if poultry farm buildings are fitted with heated floors.

B. Belgium (Flanders)

Dairy farms and calf farms both need hot water daily, regardless of the season. They, therefore, provide the most interesting potential markets for STE systems when proven economic. In the Region of Flanders, several STE systems have been installed on dairy farms and calf farms (the number of installations is not known). However, there is still some potential within the ICaRE4Farms project, we will mainly target those remaining farms.

The Flemish government wants to encourage measures on energy saving and the production of sustainable energy in agriculture. Regarding the installation of STE systems in agriculture, several funding mechanisms can be applied:

- the Flemish agricultural investment fund (Vlaams LandbouwinvesteringsFonds – VLIF),
- a premium from the distribution grid operator,
- and a tax investment allowance.

The Flemish partners consider that the main target sectors for STE are dairy farms and calf farms:

- **Milk Fed Calves:** In Belgium, 95% of the calf farms are located in the Region of Flanders (about 250 farms) and the average herd size is about 590 calves[53].
- **Dairy farms:** This is an important sector in the Region of Flanders. The Agriculture and Fisheries Report of December 2020 state that there are 5,606 dairy farms (28% of the total amount of farms with a total of 330,696 dairy cows, which includes 2,214 farms with a herd size of more than 60 cows.[54]

[51] GEB Institut de l'Elevage d'après PIE et Normabev, Chiffres-Clés Bovins 2018, via IDELE, 2018

[52] IDELE/ADEME, Les consommations d'énergie dans les bâtiments laitiers, 2009 http://www.bretagne.synagri.com/ca1/PJ.nsf/TECHPJPARCLEF/19296/$File/CONSOMMATION%20BAT%20ELEVAGE%20LAITIER%20ADEME.pdf?

[53] Rundveeloket: www.rundveeloket.be

[54] Vlaanderen,Rapport Emissie van broeikasgassen door de landbouw, 2020 www.milieurapport.be/sectoren/landbouw/emissies-afval/emissie-van-broeikasgassen

The other agricultural sectors that are less adapted to STE:

- **Pigs:** the number of sows is sharply decreasing over time (from more than 6 million in 2004 and less than 400,000 in 2018), whereas the total number of pigs stays more or less on the same level (between 5.5 and 6 million per year). This means that the majority of pig farms specialize in fattening.[55]
- **Horticulture:** greenhouses in Flanders are very often heated via CHP (combined heat and power) using natural gas which produces electricity simultaneously (and the CO_2 released during this process can also be used in the greenhouse itself for photosynthesis).

C. Netherlands

The Netherlands has a wide variety of agricultural companies. Combined, these companies produce much more than would be expected based on the size of the country. This is due to the innovative approach to the farming practices of Dutch farmers. Dutch farmers already employ renewable energy to power many of their processes and systems. The National Government provides various subsidies and tax incentives to make investments in renewable energy generation more appealing. The biggest driver of the installation of RE technologies has been the SDE subsidy (SDE stands for stimulation of the production of renewable energy).[56] Several interviews with farmers reveal that they are quite keen to apply the available subsidies to improve their profitability. However, the most used renewable energy sources are wind and biomass (especially fast-growing woody biomass and biogas from manure and slurry digestion).

In terms of sectors, the Dutch partners conclude that the most promising targets for STE technology are calves and dairy farms.

- **Milk Fed Calves:** Dutch production of veal constitutes a large proportion of the European production at about 31%. In 2019, the Netherlands was home to 1600 veal farms, with an average number of 663 calves. Veal farms already frequently adopt STE systems.[57]
- **Dairy farms:** The Dutch dairy sector is quite well developed. With a share of almost 5% of the global dairy trade, the Netherlands belongs in the top-5 of the largest dairy exporters globally.[58] 2,200 farms own 150 or more cows.[59] As a new sector, dairy farms with additional heat demanding processes, such as cheese production and manure digestion are interesting. Moreover, innovative products such as the specialized farm boiler make the application of STE possible for a broader agricultural audience.

Pig breeders and poultry companies could be interesting, but this is more on a case-by-case, depending on their exact situation.

In horticulture, the potential use of STE is low for three prominent reasons: the low cost of natural gas, the need for additional CO_2 in the greenhouses and the maturity of other (sustainable) technologies such as CHP and geothermal energy that appear to be more successful.

55 Vlaanderen, Landbouw & Visserij, Landbouwreport 2020, https://publicaties.vlaanderen.be/view-file/41555
56 Rijksdienst voor ondernemend Nederland, Zon SDE ++ Subsidie https://www.rvo.nl/subsidie-en-financieringswijzer/sde/aanvragen/zon
57 Wageningen, University & Research, Agrimatie, de Nederlandse kalfsvlees keten, https://www.agrimatie.nl/ThemaResultaat.aspx?subpubID=2232&themaID=3577&indicatorID=3591&sectorID=2257
58 ZuivelNL, Publicatie Zuivel in Cijfers, 2019 https://www.zuivelnl.org/nieuws/publicatie-zuivel-in-cijfers-2019#:~:text=Nederland%20telde%20begin%20april%202019,dan%204%25%20af%20tot%2016.260
59 Wageningen, University & Research, Agrimatie, Sectoren, Melkveehouderij https://www.agrimatie.nl/SectorResultaat.aspx?subpubID=2232&sectorID=2245

D. United Kingdom

UK agricultural policy has indicated that rules to increase farmers' provision of public goods will be used to fundamentally change farmers' attitudes to environmental sustainability. Against this background, UK farmers are primed for a technology such as STE to enhance their environmental credibility. Regarding the STE market it seems that the main target sectors are dairy farms and potentially horticulture:

- **Dairy farms:** The UK is the eleventh-largest milk producer in the world. Milk accounted for 16.9% of the total agricultural output in the UK in 2018 and was worth £4.5bn in market prices.[60] There are 1.86 million dairy cows in the UK and the average herd size is 148 cows.[61] Many herds are 500 cows with a significant number of 1000 cows. DEFRA's farm structure report shows that 2,800 holdings have between 100 and 150 dairy cattle. Additionally , the same report indicates that 4,300 holdings have herds of more than 150 dairy cattle.[62]
- **Horticulture:** British farmers produce 3.5m tonnes of fruit and vegetables every year – on 153,000 hectares of land. Also, British farmers grow 14,000 hectares of plants and flowers. The UK horticulture industry employs approximately 40,000 permanent workers, plus 70,000 seasonal workers each year.[63] The area of edible protected crops grown (under greenhouses) in the United Kingdom, 2,377 hectares, has increased by 9% since 2015 and by 20% since 2013.[64] The trend is towards larger, fewer units to supply a perceived market demand for fruit and vegetables. The potential for the use of STE solar energy could be greatest for small glasshouses which are many in the UK.

The rearing of veal calves is not very widespread in Great Britain due to the lack of domestic demand for this meat. Therefore, the calves are either exported alive to the Netherlands or euthanized in dairy cattle farms. However, recent changes in agricultural policy in the UK which includes the banning of euthanasia for newly born and very young calves together with limits on the age at which young animals can be exported may change this.

Finally, there is a possibility to use solar energy to heat the piglets' maternities. The main energy costs incurred in other stages of the management of the pigs (weaning, finishing for slaughter and sow management) are in providing good ventilation and home mixing of feed. Ventilation systems are usually powered by electricity and the equipment used to prepare pig feed is also powered in this way (hammer mills, etc.). A study by Quality Meat Scotland[65] (an executive non-departmental body of the Scottish government) estimated that 85% of pigs were fed on feed grown and mixed on the farm. There is therefore some incentive to reduce energy costs in the pig industry but solar panels have been the main route towards this objective.

E. Ireland

Ireland has similar farming methods to the UK and other regions in Northern Europe. Although compared to other European regions, there is no significant data or documentation of Irish farms which have trialled or piloted an STE system. To date, the majority of research and investment by both the public and private sector has been in Solar PV and Wind Energy.

Dairy farming is the largest sector of the agriculture industry in Ireland. On initial research, it would appear that the STE system would have a practical application in producing hot water for dairy parlours when combined with boilers and heat exchangers. According to the IFA (Irish Farmers Association)[66], 18,000 Dairy farmers milking 1.55 million dairy cows with an average herd of 90 cows. The number of farms owning more than 90 cows isn't known but probably high.

60 Department for Environment, Food and Rural Affairs, Report "Total Income from Farming in the United Kingdom, first estimate for 2019", 20 June 2020

61 House of Commons, Briefing Paper number 2721, 1 May 2020

62 Department for Environment, Food and Rural Affairs, Farm structure Report for June in UK, 01 October 2019

63 Department for Environment, Food and Rural Affairs, Horticultural Statistics, 2 July 2020 https://www.gov.uk/government/collections/horticultural-statistics

64 Ibid 63

65 Quality Meat Scotland, Efficient Energy Use in Pig Feed Production https://www.qmscotland.co.uk/sites/default/files/Efficient%20Energy%20Use%20in%20Pig%20Feed%20Production_0.pdf

66 Irish Farmers' Association, Dairy Factsheet: https://www.ifa.ie/dairy-factsheet/

III. Global conclusions

A. Particularly appropriate sectors

The analysis by country of the different agricultural sectors previously identified as being potentially the most suitable for the use of STE revealed important differences. For example, calf rearing, which consumes a lot of hot water for liquid animal feed, appears to be the most suitable sector in the short term. Moreover, FengTech, a partner of the project, found its first agricultural customers in this sector and over 10 years brought 30 solar installations into service. However, where this breeding sector is very present in France, Flanders and the Netherlands, it is almost absent in Great Britain and Ireland where there is no demand for veal and calves are exported alive to continental Europe and the Netherlands in particular. Raising dairy cows has also emerged as a suitable sector for the STE because of the significant hot water requirements for cleaning milking parlours. However, solar energy is only economically justified if the consumption of hot water exceeds 500 litres per day.[67] This consumption can be doubled where breeders process their milk on the farm (producing butter, cream, cheese, etc.). In these conditions, STE would be more suitable on farms with more than 100 cows, which represents only 15% of herds in France but much more in Flanders, the Netherlands, Ireland and the United Kingdom.

Horticulture and market gardening in heated greenhouses also seems suitable for STE, in particular for crops kept frost-free and heated at low temperatures: plants in pots, young plants of vegetables and trees, etc. However, solar thermal is not very suitable for greenhouses maintained all year round at 20 or 22°C (production of tomatoes, cucumbers, etc.), artificially lit, and enriched with carbon dioxide. Also, it is penalized by the significant amount of land required to install the solar collectors. There are, in particular in France and the United Kingdom, configurations of medium-sized greenhouses (less than 1 ha), heated at low temperatures. But most horticultural productions in northern Europe use very large heated and lighted greenhouses. These greenhouses mainly use a combination of heat and electricity produced by gas engines.

In the pig sector, STE is suitable for maternity and post-weaning piglet workshops, as long as the buildings are equipped with heated floors using hot water. However, the majority of piglet maternity workshops use gas or electricity radiant heaters. Finally, broiler rearing is rarely suitable for solar thermal energy because the heat requirements only concern the first month of the chicks life and mainly uses gas or electric heaters. However, underfloor heating of poultry houses could be developed in the future.

In conclusion, we can consider that the most relevant sectors in the short term to use STE are the breeding of milk-fed calves and dairy farms with more than 100 cows (less if the milk is processed on the farm). The use of solar energy is also to be considered in specific and less numerous cases of pig breeding (maternity homes with heated floors) and greenhouse horticulture. In the future, if STE were to be used more in these sectors of agriculture, this would require a more radical review of production systems: installation of heated floors in pig and chicken farms, lower temperature heating in greenhouses, etc.

B. Quantitative estimation of the different markets

While the qualitative targeting of the most promising applications for STE installations is possible, the quantitative assessment of market issues is more difficult to obtain. In one case, this involves crossing the technical constraints of solar use (local sunshine, recovery efficiency, thermal power delivered, etc.) with the energy needs of potential user sectors: distribution of needs throughout the year, required temperatures, heating systems currently in use, etc. The second step is to assess, in each of the 5 countries concerned, the number of farms that meet the conditions considered a priori to be optimal. And for that, statistical data is lacking. For example, if the number of dairy farmers and the number of total cows is known in all countries, the distribution of herds according to their size is more difficult to know. Likewise, for sow farms, the distribution of buildings between those which are heated by radiant heaters and those equipped with heated floors is never known. In each of these cases, to do well, it would be necessary to carry out sample surveys, which would represent a considerable amount of work.

[67] IDELE/ADEME, Les consommations d'énergie dans les bâtiments laitiers, 2009 http://www.bretagne.synagri.com/ca1/PJ.nsf/TECHPJPARCLEF/19296/$File/CONSOMMATION%20BAT%20ELEVAGE%20LAITIER%20ADEME.pdf?

Under these conditions, we can only estimate approximately and at a minimum, at 26,000 the number of solar thermal installations potentially conceivable in the medium term in the 5 countries of the ICare4Farms project. They are distributed according to the table below.

Table 4: Selection criteria of suitable farms for STE application per agricultural activity

Sector	Application	Selection Criteria	Belgium (region of Flanders)	France	Ireland	Netherlands	United Kingdom	Total
Milk fed Calves	warming of liquid food	≥ 250 places	250	2,200	0	1,600	0	4,070
Dairy farms	cleaning of milking parlours	≥ 100 cows	2,210	5,600	5,400	2,200	7,100	22,510
	cheese workshop cleaning	≥ 50 cows		1,000				1,000
Horticulture	low temperature underfloor heating, dehumidification	≤ 10000m²						
Pigs (maternity and post weaning)	floor heating and washing	≥ 200 sows		1,900				1,900
Total			2,460	10,720	5,400	3,800	7,100	29,480
			8.34%	36.36%	18.32%	12.89%	24.08%	

SECTION 2: Market Analysis per country

1 France

I. Methodology

The French partners of ICaRE4Farms (AC3A, Fengtech, LMT and Sub-partner ChPdL) conducted two approaches in parallel:

- **One, qualitative**, to discover and understand for each of the five sectors of activity identified as priorities, the energy needs, the heating systems used, the importance of energy costs in production costs, the technical environment and the investment decision processes, the debt capacity, etc. Two types of interlocutors were met and questioned for this purpose:
  - Farmers,
  - Representatives of interprofessional technical centres: ITAVI (technical institute of poultry farming), IFIP (French pork institute), Astredhor (technical centre of horticulture) and CTIFL (interprofessional technical centre for fruits and vegetables).
- **The other is quantitative,** allowing to assess the relative weight of the different target market segments for STE technology at the national level, the potential for installation of solar systems and the amount of substitutable energy. This consisted of collecting, analyzing and exploiting the sector studies provided by the agricultural technical centres.

II. Summary of results

STE could be developed in the context of the search for alternative solutions, a general increase of energy prices and the taxation of energy (gas, fuel oil, electricity).

A. Agriculture, Energy Consumption and Financial Aid

In France, solar thermal energy currently accounts for only 3% of renewable energy consumption in agriculture.
The average prices per kWh are as follows[68]:

- Grid electricity: 0.094 €/kWh (excluding VAT)[69]
- Self-consumed photovoltaic electricity: from 0.086 to 0.143 €/KWh
- Biomass: from 0.062 to 0.122 €/kWh
- Solar Thermal Energy: 0.047 to 0.280 (over 20 years)
- Natural gas: 0.036 €/kWh (excl. VAT)[70]

Additionally, there is a domestic consumption tax on natural gas (TIGCN)[71] that was €8.45/MWh in 2019, and dropped to €8.43/MWh since 1st January 2021, with some exemptions (reduced rates) for activities with a high/combined consumption.
Public schemes support individuals and professionals in their energy transition. This is notably the case of the ADEME (French Environment and Energy Management Agency) through calls for projects from the *Fonds Chaleur*[72], which can subsidize feasibility studies and works (between 20 and 40%) for biomass, solar thermal or other renewable energy projects.

[68] ADEME, Coûts des énergies renouvelables et de récupération de données 2019, 2020 https://librairie.ademe.fr/energies-renouvelables-reseaux-et-stockage/765-couts-des-energies-renouvelables-et-de-recuperation-en-france-9791029713644.html

[69] SDES, Prix de l'électricité en France et dans l'Union européenne en 2019, 2020 https://www.statistiques.developpement-durable.gouv.fr/prix-de-lelectricite-en-france-et-dans-lunion-europeenne-en-2019-0

[70] SDES, Prix de l'électricité en France et dans l'Union européenne en 2019, 2020 https://www.statistiques.developpement-durable.gouv.fr/prix-de-lelectricite-en-france-et-dans-lunion-europeenne-en-2019-0

[71] Ministère de la Transition écologique, Fiscalité des énergies, 4 Février 2021 https://www.ecologie.gouv.fr/fiscalite-des-energies

[72] ADEME, Présentation Fonds Chaleur, Période 2009-2020 https://fondschaleur.ademe.fr/?gclid=CjwKCAjw8cCGBhB6EiwAgORey1L47hW6BbXKvXfX-2Q3cqKmf8fXXH-T1-Hlvfw07198bPFzeEOWLhoCtykQAvD_BwE&gclsrc=aw.ds

Concerning solar thermal energy, this device conditions the aid for the certification of equipment: CSTBat, Solarkeymark or equivalent.[73] Likewise, the CEE (Energy Saving Certificate) system allows for assistance in the installation of renewable energy systems. Finally, the chambers of agriculture can organize, on a case-by-case basis at the local and regional level, schemes to accompany the ecological transition.

B. Sectoral analysis

1. Milk Fed Calves

a. Presentation of the sector

Slaughter calves are young animals (8 months old and 142 Kg of average European weight in 2016)[74] whose white meat is appreciated by European consumers. They are fed mainly with a complete and balanced milk replacer, which is a mixture of milk powder, dairy products, fat and nutritional supplements diluted in hot water. This food, in the form of a drink, is gradually supplemented by the intake of cereals and other forages. These veal calves are reared for a period of 22 to 24 weeks (= 153 to 166 days)[75], in 1 to 2 batches per year. In 2018, it is estimated that 1.27 million calves were reared on 2,222 farms, each one producing at least 50 calves per year.[76] The average size of a farm in Bretagne and Loire Atlantique is 250 places, these two regions are divided into 572 and 418 workshops (value of 2013)[77], or 38% of French production.[78] However, it should be noted that this sector is in a crisis of chronic overproduction due to the seasonality of production and a drop in consumption.

b. Energy needs

It is estimated that a calf has an average direct energy consumption of 152 kWh when reared over 22-weeks. This is a very high figure, which represents about 15% of the operating costs for farmers.[79] Among the various energy consumption costs related to rearing calves, heating water for drinking represents on average 108 kWh/calf, i.e., 71% of direct energy consumption. Important differences exist: it varies due to the structure of the farm and the equipment used to heat water. Each calf has 1 to 2 drinks per day, consuming about 7 litres of water per drink, of which 4 litres of water is heated to 70-80°C. 81% of farms use propane gas to heat water (ADEME figures)[80]. It is estimated that a farmer uses an average of 11 kilograms of gas per calf[81].

c. Potential for using solar thermal energy

Faced with rising gas prices and volatility, veal calf farmers are increasingly turning to systems such as biomass boilers and Solar Thermal Energy. This trend towards installing renewable energies is reflected in the INOSYS network's 2018-2019 survey, which showed that only 66% of farms use gas to heat water, with an increase in the use of biomass boiler systems (20%) and solar thermal energy (17%)[82]. Moreover, the use of hot water for drinking could be threatened in the coming years with the return to a more rapidly fibrous diet and the animal welfare requirements of consumers. The veal calf sector is well known to FengTech, which has installed 30 systems in this sector. The experience gained shows that the residual consumption of propane gas is 5kg per calf (compared to an average of 11kg), which represents a saving of 66%.

Based on its experience, FengTech estimates that solar thermal energy is suitable for farms with an energy consumption of 20,000 kWh/year for water heating, which represents an average of 185 calves per year for a period of 6 months (2 lots/year) or 164 calves over 8 months (1.5 lots/year, lot 123 calves).[83]

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73 ADEME, Le Fonds Chaleur en Bref, Updated in 2021 https://www.ademe.fr/expertises/energies-renouvelables-enr-production-reseaux-stockage/passer-a-laction/produire-chaleur/fonds-chaleur-bref

74 C.D., Veaux de boucherie : une production très européenne, 1 Juin 2017 https://www.reussir.fr/bovins-viande/une-production-tres-europeenne

75 IDELE/INOSYS, Repères techniques et économiques en élevage de veaux de boucherie, Campagne 2017-2018 https://opera-connaissances.chambres-agriculture.fr/doc_num.php?explnum_id=150827

76 GEB Institut de l'Elevage d'après PIE et Normabev, Chiffres-Clés Bovins 2018, via IDELE, 2018

77 Agricultures et territoires : L'observatoire technico-economique veaux de boucherie 2014

78 Ibid 76

79 IDELE/ADEME, Consommation d'énergie en bâtiment de veaux de boucherie, 2010 http://idele.fr/fileadmin/medias/Documents/2-Energie_batiment_veaux_2010.pdf

80 Ibid 79

81 Enquête Fengtech – Atelier de 368 places de veaux – ferme de M. et Mme. Broissin (Newspaper articles)

82 Inosys, Repères techniques et économiques en élevage de veaux de boucherie, Campagne 2018-2019 http://idele.fr/no_cache/recherche/publication/idelesolr/recommends/reperes-techniques-et-economiques-en-elevages-de-veaux-de-boucherie-1.html

83 Ibid 79

As the average size of a farm is 250 calves, it can be estimated that solar thermal energy can be applied in all 2222 farms producing more than 50 calves per year.[84]

2. Dairy farms

a. Presentation of the sector

France had a total herd of 3.6 million dairy cows in 2019 and produced 23,908,000 tons of milk in 2017.[85] Most of this production is distributed in the West of France (32%) and Normandy (14.2%).[86] This livestock is spread across 62000 farms, with an average of 59 dairy cows.[87]

b. Dairy farms with on-site processing

This sector refers to farms that process all or part of their milk production into finished products (cheese, fresh cheese, yogurt, butter, ice cream). The focus here is on farms that process cow's milk onsite. The figures on the state of the sector need to be updated and completed: the agricultural census conducted by the Agreste[88] in 2010 reported 2,623 dairy cow farms with on-farm processing, representing 42% of the total number of farms with on-farm processing. The "Bienvenue à la ferme" network, which brings together farmers who offer hospitality to the public (tables d'hôte, accommodation, and sale of farm products), has 1084 farms[89] selling dairy products (all types of farms combined). The IDELE (French Livestock Institute) estimates at 3,000 the number of dairy cattle farms processing on-farm.[90] The next census conducted in 2020 should include a significant increase in these figures related to the rise in the phenomena of short circuits and organic production.

c. Energy needs

On average, a cow uses 884 kWh per year: this consumption is divided between fuel oil and electricity (442 kWh/dairy cow/year), which represents 12% of the operating costs for livestock farmers.[91] The main energy requirements are from the equipment used: milk tank, water heater, milking machine.[92] They also include the heating of the water used to wash the milking parlour, which represents on average 120 kWh/dairy cow/year, i.e., about 14% of the total energy consumption. This daily consumption is, depending on the size of the farm, 200 to 500 litres of hot water per day for the washing station alone.[93] Dairy farms with on-farm processing also have significant hot water requirements for the production process (milk thermisation) and for cleaning the dairy. Although figures on the energy consumption of this transformation are not available, surveys of professionals have shown that this process requires 1 litre of hot water per litre of processed milk. Electricity, gas or biomass are the main sources used to heat water.

For example, the GAEC Arc-en-Ciel[94] (in Mayenne), which has a herd of 70 cows, produces 350,000 litres of milk per year, of which 300,000 litres are used to produce Gouda cheese. It uses 300,000 litres of hot water, heated to 50-70°C. The farmer estimates that the production consumes 254kWh/litre of milk. Using this figure, the energy requirement for heating water can be estimated at 76,200 kWh per 300,000 litres.

d. Potential for using solar thermal energy

In dairy farming, hot water is needed daily, and it is the second-largest source of electrical energy consumption. However, hot water usage is marginal (300 to 500 litres of water per day, 14% of the total energy consumed) and accounts for only a small share of total operating expenses (1.68% in 2009).[95]

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84 GEB Institut de l'Elevage d'après PIE et Normabev, Chiffres-Clés Bovins 2018, via IDELE, 2018

85 IDELE, Chiffres clés bovins, 2019 http://idele.fr/filieres/bovin-viande/publication/idelesolr/recommends/chiffres-cles-bovins-2019.html

86 France Agrimer, les filières de l'élevage français, 2014 https://www.franceagrimer.fr/content/download/33636/document/Les_fili%C3%A8res_de%20l_elevage_francais-sept-2014;pdf.pdf

87 Ibid 86

88 Agreste, Recensement agricole, 2010 https://agreste.agriculture.gouv.fr/agreste-web/methodon/S-RA%202010/methodon/

89 Site "Bienvenue à la Ferme", Moteur de recherche https://www.bienvenue-a-la-ferme.com/accueil/index/produits_fermiers/2651

90 IDELE/ADEME, Les consommations d'énergie dans les bâtiments laitiers, 2009 http://www.bretagne.synagri.com/ca1/PJ.nsf/TECHPJPARCLEF/19296/$File/CONSOMMATION%20BAT%20ELEVAGE%20LAITIER%20ADEME.pdf?

91 Ibid 90

92 Ibid 90

93 Ibid 90

94 LMT, Interview minutes GAEC Arc en ciel, 26/08/20

95 DELE/ADEME, Les consommations d'énergie dans les bâtiments laitiers, 2009 http://idele.fr/contact/publication/idelesolr/recommends/les-consommations-denergie-en-batiment-delevage-laitier.html

However, hot water usage can be doubled in the case of farms with on-farm processing. This sector appears to be one of the most suitable sectors for STE. The hot water needs are regular and significant (1 litre hot water per litre of milk), without depending on seasonality. In addition, farmers who practice processing and selling in short circuits are often aware of renewable energy and their activity should continue to expand. The use of solar thermal panels may be interesting in this case for farms processing at least 300,000 litres of milk per year, i.e., the production of 50 dairy cows. In this context, the potential market for solar thermal installations remains to be refined.

3. Pigs

a. Presentation of the sector

Pig farming is another major sector of French agriculture, particularly in the West of France (57% of farms in Bretagne and 12% in Pays de la Loire).[96] The IFIP (National Technical Institute for Pig breeders) counts 22,000 pig farms in 2020,[97] marked by a decline in medium-sized farms. The number of sows has also decreased by 21% between 2000 and 2010 (Techporc 2013):[98] it is estimated at 950,000 in 2020.[99] The sector has many stages of production, mainly maternity, post-weaning and fattening. For farms specializing in maternity and Post-Weaning, the reference unit is the sow, which has an average litter of 23 piglets.[100] It is estimated that 5,700 farms have 98% of the sows. On average, these farms have 190 sows.[101]

b. Energy requirements in pig buildings

Heating needs

Heating needs are very important during the maternity phase (1st month after birth) and post-weaning (6 to 8 weeks after maternity) phases. Heating is the top use of energy expenditure since it alone represents 46% of the consumption of a breeder-fattener type farm.[102] Piglets need a lot of heat during their first 4 weeks, with temperatures of 35°C (first week) reducing to 24°C (3rd and 4th weeks).[103]

- At the maternity stage, heating uses on average 729 kWh/place out of a total energy consumption of 900 kWh/place. This equates to 80% of the energy needs per place.
- At the post-weaning stage, heating represents 67 kWh/place out of a total energy consumption of 85 kWh/place, i.e., 79% of the energy needed at this stage.

Pig breeding has the particularity in the agricultural sector to use mainly electricity (75%). This energy is adapted to the different stations of the livestock building (heating, ventilation, lighting). Other energies such as gas or fuel oil can also be used.

There are three types of heating systems:

- Radiant heating: radiant heaters that use electricity or gas are mainly used in maternity and post-weaning facilities.
- Conduction heating: this system uses a heated floor under which water with a temperature between 40 and 50°C circulates. Its advantage is that it heats in contact with the piglets.
- Convection heating: in this system, hot water (connected to a boiler) is transported to aerotherms that heat the room.

In the last two cases, the systems can be equipped with a water network (aerotherms, underfloor heating) and could be powered by an STE that will replace the oil-fired boilers. According to the ADEME (URE study of 2007), there are differences in equipment depending on the orientation of the farm.[104]

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96 France Agrimer, les filières de l'élevage français, 2014 https://www.franceagrimer.fr/content/download/33636/document/Les_fili%C3%A8res_de%20l_elevage_francais-sept-2014;pdf.pdf

97 Institut du Porc (IFIP), Le porc par les chiffres, 2020-2021 https://www.ifip.asso.fr/fr/content/le-porc-par-les-chiffres-%C3%A9dition-2014

98 Tech Porc, 11500 élevages de porcs en France métropolitaine en 2010, 2013 https://www.ifip.asso.fr/sites/default/files/pdf-documentations/techporc_roguet_n12_2013.pdf

99 Communauté professionnelle porcine, Production porcine progresse malgré la diminution du cheptel, 04 Février 2021 https://www.3trois3.com/derniere_heure/france-production-porcine-progresse-malgre-la-diminution-du-cheptel_14939/

100 IFIP, L'alimentation de la truie, 2007 https://www.ifip.asso.fr/sites/default/files/pdf-documentations/truiea3.pdf

101 Ibid 98

102 IFIP, Bâtiment d'élevage à énergie positive, 2013 https://www.ifip.asso.fr/sites/default/files/pdf-documentations/fiche_bilan2013_30.pdf

103 IFIP, Le bâtiment d'élevage à basse consommation d'énergie (BEBC), 2013 http://www.bretagne.synagri.com/ca1/PJ.nsf/TECHPJPARCLEF/19309/$File/BEBC+%20SEPT%2012.pdf

104 IFIP/ADEME, Les consommations d'énergie dans les bâtiments porcins, 2006 https://www.ifip.asso.fr/sites/default/files/pdf-documentations/tp4bartolomeu107.pdf https://www.ademe.fr/sites/default/files/assets/documents/46249_plaquette_ifip_20p.pdf

- For Maternity farms: the breeders use generators (33%), oil-fired boilers (33%) or gas boilers (11%).
- For fattening breeder farms, generators are present in 74% of farms, 17% of oil boilers and 21% of gas boilers,
- The post-weaning and fattening workshops are 95% equipped with a generator and 5% with a gas boiler.

Water needs for cleaning

Hot Water needs for cleaning is important throughout the pig production cycle. Cumulative consumption amounts to 2,095 litres of water per sow per year on average (500 litres in the maternity ward, 500 litres in post-weaning, 1,095 in fattening).[105] The cleaning of the buildings is carried out after each batch of pigs by emptying of the manure storage facilities and is usually done with cold water. The use of hot water could be more efficient and lead to water savings, while improving the comfort of the staff dedicated to this task. This use of "free" hot water could be complementary to heating during periods of sanitary vacuum.

c. Potential for using solar thermal energy

According to the IFIP, an STE installation could cover between 40 and 55% of hot water needs.[106] For this, the presence of a hot water heating network is a prerequisite. The difficulty also stems from the fact that heating needs depend on the occupancy rate of the buildings. Only a third of the maternity workshops are equipped with generators[107] and 15% use oil-fired boilers.[108] These operations therefore seem to be particularly suitable. They represent a potential of 5,700 farms (with an average of 190 sows)[109] of which 19% employ oil-fired boiler,[110] i.e., 1,083 farms. Despite the absence of figures, an interview with Mr. Rousselière (IFIP)[111] informed us of a tendency for pig farmers to equip new buildings with water systems.

4. Poultries

a Presentation of the sector

In France, poultry farming comprises over 27,900 livestock buildings with a total surface area of 15,000,000m². This sector comprises two distinct sectors: meat poultry and eggs.[112] Meat poultry farming occupies 65% of the surface area of the buildings, 70% of which is concentrated in two regions: Brittany and Pays de la Loire.[113] The average size of a poultry building is 880m². The majority of the poultry buildings are heated by gas.

b. Energy consumption and heating needs

In 2006, the whole sector consumed 1.8 TWh, of which 1.6 TWh for meat sector.[114] In this sector, the heating needs of the buildings are periodic because they are linked to the first month of life of the chicks. They also depend very largely on the state of insulation of the buildings. On average, the heating expenses represents 95 kWh/m²/year, out of an estimated direct energy consumption of 120 kWh/m²/year (i.e., 80% of the energy consumption).[115] Heating accounts for nearly 3% of the production costs for the farmer, i.e., 30% of the variable costs. It is the second most important expense after purchasing feed for the farmers. It is directly linked to the heating of livestock buildings, particularly at the chick growth

105 Ibid 103

106 IFIP, Le bâtiment d'élevage à basse consommation d'énergie (BEBC), 2013 http://www.bretagne.synagri.com/ca1/PJ.nsf/TECHPJPARCLEF/19309/$File/BEBC+%20SEPT%2012.pdf

107 IFIP : Consommations d'énergie en bâtiments porcins : comment les réduire ?, 2008 https://ifip.asso.fr/sites/default/files/pdf-documentations/energie_batiment1.pdf

108 Ibid 107

109 Institut du Porc (IFIP), Le porc par les chiffres, 2020-2021 https://www.ifip.asso.fr/fr/content/le-porc-par-les-chiffres-%C3%A9dition-2014

110 Tech Porc, 11500 élevages de porcs en France métropolitaine en 2010, 2013 https://www.ifip.asso.fr/sites/default/files/pdf-documentations/techporc_roguet_n12_2013.pdf

111 LMT, Interview minutes IFIP, 22/09/2020

112 ADEME- ITAVI, Les consommations d'énergie dans les bâtiments avicoles, 2008 http://www.agri72.fr/bibliotheque_pdf/Infos%20Conseils/Energies/economies%20denergies/conso%20energie%20bat%20avicoles.pdf

113 France Agrimer, les filières de l'élevage français, 2014 https://www.franceagrimer.fr/content/download/33636/document/Les_fili%C3%A8res_de%20l_elevage_francais-sept-2014;pdf.pdf

114 Ibid 112

115 IFIP, Bâtiment d'élevage à énergie positive, 2013 https://www.ifip.asso.fr/sites/default/files/pdf-documentations/fiche_bilan2013_30.pdf

stage. Ambient temperatures are set between 32°C and 19°C for 3 to 4 weeks.[116]

c. Potential for using solar thermal energy

Solar thermal energy is not well developed in the poultry sector, despite the real potential of regular heating needs. This absence is linked to the lack of a water heating network in livestock buildings, which are traditionally heated by gas-fired radiant heaters. In the absence of buildings equipped with underfloor heating, the deployment of STE has a very limited potential market share.

5. Protected cropping

a. Presentation of the sector

Horticulture: There were 3,308 companies in 2017 representing a total surface area of 16,152 hectares,[117] including 1,105 hectares of glass greenhouses and 466 hectares of plastic tunnels. Production is mainly oriented towards young vegetable plants and nursery plants (34%), potted plants (20.5%) and bedding plants (17%).

Market Gardening: We are only interested in productions under heated greenhouses, i.e., the production of tomatoes and cucumbers. In 2016, this represented 1,081.6 hectares of which 88% were tomatoes and 12% cucumbers. According to Ariane Grisey (CTIFL),[118] these 951 hectares of heated greenhouses devoted to tomato cultivation represent 20% of the total surface area devoted to tomatoes, but 80% of production. In terms of distribution across France, Brittany and the Loire Valley have 771.3 hectares of heated tomato and cucumber greenhouses (467.6 for Brittany and 204.3 for the Loire Valley).[119] These two regions have seen a clear change between 2011 and 2016 (+9.3% and +12%). Cucumber production is spread over 81 farms, 43 of which are in the north of France. The average surface area of heated farms was 3.9 hectares in 2016, with disparities: 2.7 hectares in Brittany (Bretagne) compared with 4.8 in the Loire Valley (Val de Loire)

b. Energy consumption and heating needs

Horticulture: According to the ADEME study (2007), 88% of farms producing potted plants were heated, while this share represented only 66% of cut flower farms. These farms have significant heating needs, which is one of the main consumption items. The sector consumed 2 TWh in 2005, i.e., an average of 160 kWh/m²/year.[120]

These needs come from the necessity to heat the greenhouses all year round, particularly at night. In horticulture, the set temperatures are between 8 and 15°C and justify daily heating. This heating takes place throughout the year, and mainly at night (80% of energy consumption).[121] Most of this heating is done with gas: greenhouse operators have advantageous rates for this type of heating. The cogeneration technique (electricity + heat) is widely used in the greenhouse sector (55%), with 16% of greenhouse operators using only gas.[122]

Market Gardening: The sector is a major energy consumer: according to the 2016 study,[123] the consumption of all heated greenhouses excluding lighting represents 3.3 TWh, or 283 ktoe (KgTOE). On average, these costs represent 23% of direct production costs. Energy consumption per greenhouse is 1.2 MWh/ha on average but can vary between 0.2 and 2 MWh/ha.

- Energy uses: In 2016, 50% of the greenhouse fleet was co-generated using natural gas engines. This explains why gas is the main source of energy used (77%). But the market gardening sector also uses biomass (14.5%) and industrial hot water (5.9%). In addition, 45% of the greenhouses use an

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116 ADEME- ITAVI, Les consommations d'énergie dans les bâtiments avicoles, 2008 http://www.agri72.fr/bibliotheque_pdf/Infos%20Conseils/Energies/economies%20denergies/conso%20energie%20bat%20avicoles.pdf

117 Agrimer – Observatoire des données structurelles des entreprises de production de l'horticulture et de la pépinière ornementale 2018 p. 8 https://www.franceagrimer.fr/fam/content/download/57218/document/SYN-HOR%20R%C3%A9sultats%20Obs%20Struturel%202017.pdf?version=4

118 LMT, Interview minutes CTIFL, 17/11/2020

119 France Agrimer, les filières de l'élevage français, 2014 https://www.franceagrimer.fr/content/download/33636/document/Les_fili%C3%A8res_de%20l_elevage_francais-sept-2014;pdf.pdf

120 ADEME, Utilisation rationnelle de l'énergie dans les serres, 2007 https://bois-energie.ofme.org/documents/Energie/B-Synthese-3p-serre2007.pdf

121 Focus on energy, Ten easy ways to cut energy costs in existing greenhouse spaces - Wisconsin - USA - 2008 https://www.canr.msu.edu/floriculture/resources/energy/assets/TenEasyWaystoCutEnergyCostsInExistingGreenhousesbyWIFocusonEnergy.pdf

122 CTIFL, Evolution du parc chauffée en tomates et concombres, 2016 https://plateforme-documentaire.ctifl.fr/Record.htm?idlist=1&record=19502174124913203569

123 Ibid 122

auxiliary energy source, mainly gas and biomass boilers.[124] On average, the energy consumption of a tomato greenhouse is 317 kWh/m² but varies according to region: 346 kW/H in Brittany, 404 kWh/m² in the Loire Valley.[125]

- Needs and processes used: The heating of greenhouses is essential throughout the year to produce tomatoes, cucumbers and strawberries. Greenhouses need to be kept at a set temperature of 15 to 23°C all year round.[126] While these temperatures can be reached naturally during the day in summer, they are not reached at mid-season and in winter, especially at night. In market gardening, it is estimated that 80% of energy expenditure takes place at night.

In practice, these heating instructions require water to be heated to high temperatures: there are 3 techniques:

- The thermosiphon (present in 22% of the park): this system requires water heated to 60-80°C.
- Thermosiphon combined with a growth tube (71% of the park): this mixed system requires water at 30-50°C.
- Low-temperature heating (4.5% of the park): this system requires water at 30-50°C.

In addition, 93% of farms in Bretagne have hot water storage (mainly open buffer), while only 73% in the *Val de Loire*.[127] In addition, there are also specificities linked to the climate depending on the region: in Bretagne (temperate region), energy needs are even more important as tomato greenhouses need to be dehumidified throughout the year. According to the Agrithermic design office,[128] these factors contribute to high energy consumption even in the summer period (2/3 of winter needs).

c. Potential for using solar thermal energy

In the future, new greenhouses in market gardening production (tomato and cucumber) will have to integrate renewable energies. Indeed, the rise in gas prices and taxation (TICGN) and the end of aid for co-generation, scheduled for 2021, should lead greenhouse growers in this direction. Half of the farms using co-generation should have to change their system with the end of aid in 2021. However, the sector's financial difficulties could be a brake, as only 58% of the companies in the sector are considered financially sound. In this context, the tomato/cucumber market gardening sector is of interest for solar thermal energy: the energy used for heating is a major need for greenhouse operators (317 kWh/m²), who have needs throughout the year and are generally equipped with a water network.[129] This need is even greater in oceanic climates such as North-Western Europe where 2/3 of the energy needs are still met in summer for dehumidification.

The major problem with solar thermal energy is the land constraint: the surface area required for the solar panel's installation represents about 1/3 of the total surface area of the greenhouse. According to Mr. Stauffer (from the Agrithermic design office),[130] equipping small greenhouses (<1 hectare) with a reasonable and regular share of their energy consumption (about 10-20%) such as dehumidification would be one of the most suitable strategies for Solar Thermal Energy.

In the horticultural sector (production of potted plants and market garden seedlings), solar energy can be adapted to medium-sized greenhouses, kept frost-free or below 15°C and heated by the soil at low temperatures.

124 Agrimer – Observatoire des données structurelles des entreprises de production de l'horticulture et de la pépinière ornementale 2018 https://www.franceagrimer.fr/fam/content/download/57218/document/SYN-HOR%20R%C3%A9sultats%20Obs%20Struturel%202017.pdf?version=4

125 Ibid 124

126 Ibid 122

127 Agrimer – Observatoire des données structurelles des entreprises de production de l'horticulture et de la pépinière ornementale 2018 https://www.franceagrimer.fr/fam/content/download/57218/document/SYN-HOR%20R%C3%A9sultats%20Obs%20Struturel%202017.pdf?version=4

128 LMT, Interview minutes Agrithermic, 14/12/2020

129 Ibid 127

130 Ibid 128

III. Conclusion on French agricultural markets: Identification of the target segments

French agriculture has significant energy needs for heating buildings, animal feed and hot water production. These needs are covered by different heating systems, some of which use hot water and others not (poultry farming). The sectors of activity studied, use different energy sources with a predominance for natural gas.
The choice of solar thermal energy will depend in part, on the overall energy consumption and related to the heating of water, the size of the farm and the price of energy, as well as available subsidies (including the Heat Fund in particular). In France, electricity cost around €104/MWh and gas €35.80/MWh.131 However, these prices tend to vary.
The price of electricity depends on the proposed tariff (peak/off-peak hours, Peak Day Effacement, etc.) as well as the mode of consumption (photovoltaic production or not). Natural gas is a fuel whose price has risen sharply in recent years, fluctuates within the same year and is increasingly taxed (TICGN).
Public policies and the State's decision to integrate renewable energies into the French mix will have an impact on the potential use of solar thermal energy.
The example of horticulture and market gardening particularly illustrates the impact of the State in energy choices. By abolishing aid for co-generation and increasing the tax, the State is opening up alternatives to gas such as Solar Thermal Energy.
According to our surveys, the use of solar thermal energy is possible in all or part of the fields studied. It is already known and practiced in veal calf rearing and dairy farms with on-farm processing, while it is almost absent in poultry, pig farms and in the horticulture/market gardening sector. This is due to the low level of water supply in poultry and pig buildings and the lack of knowledge of this technology in horticulture/market gardening.

Taking this into account, we can classify the sectors in terms of interest:

1. Particularly appropriate sectors:
   - Milk-fed calves: production of a heated liquid feed (reconstituted milk).
   - Dairy cow rearing with on-farm processing: Use of hot water for cleaning milking parlours and dairy workshops.
   - Ornamental horticulture and nurseries: medium-sized greenhouses (less than one hectare), kept frost-free and heated by the soil at low temperatures.

2. Other sectors of interest:
   - Market gardening (tomatoes): in the case of small to medium sized greenhouses (less than one hectare), heated by the soil at low temperature and dehumidified.
   - Pig farms: maternity workshops with underfloor heating.

3. Some sectors are not suitable for the time being:
   - Poultry farms (broiler chickens).
   - Pig farms: post-weaning and fattening workshops.

131 SDES, Prix de l'électricité en France et dans l'Union européenne en 2019, 2020 https://www.statistiques.developpement-durable.gouv.fr/prix-de-lelectricite-en-france-et-dans-lunion-europeenne-en-2019-0

2 Belgium (Flanders)

I. Methodology

The Flemish project partner of ICaRE4Farms, Innovatiesteunpunt (ISP), has collected the data and statistics in this document from various sources:

1. Extensive use has been made of the figures of the Department of Agriculture and Fisheries (Flanders Region):[132] The national overviews provide a handy insight in figures of the current situation and the most recent evolutions of the Flemish primary sector. In addition to a general overview of all agriculture, horticulture and fisheries, they also present insight into the main sub-sectors: pigs, cattle, poultry, arable farming and horticulture. The Agriculture and Fisheries Report is a biennial report that provides a general description of agriculture, horticulture and fishing. The figures are divided into four pillars:
   - Structural characteristics: number of companies, livestock, land use, company size, specialization.
   - Economic characteristics: production/supply quantity, production value/supply value, fishing quota, fish prices, trade, operating result, consumption, agriculture in the chain.
   - Social characteristics: employment, age, education and succession.
   - Environmental characteristics: use of energy, water, crop protection products and fertilizers.
2. ISP has a broad network of farmers. The figures from the Agriculture and Fisheries Report have been supplemented with the data obtained by the energy consultants of ISP from the numerous energy advice they have given to farms in recent years, in particular: the need for hot water in different agricultural sectors (quantity, temperature level and other daily and annual needs), the way in which this hot water is produced.
3. ISP is part of the Enerpedia consortium, which also includes experimental farms in Flanders, the agricultural research institute ILVO and university college Thomas More. This consortium conducts applied research into measures for energy saving and sustainable energy production in agriculture in Flanders. Within Enerpedia there is a lot of knowledge exchange between the different partners. All knowledge is bundled on their website.[133]
4. We also consulted other websites for data on energy and water use in agriculture.[134]

II. Summary of results

A. Agriculture, Energy Consumption and Financial Aid

The emission profile of Flemish agriculture differs greatly from other sectors, with methane and nitrous oxide being the dominating pollutants. It is biological, non-energetic processes that are the basis of these emissions. Methane is produced by the digestion of feed in the rumen (stomach) of ruminants such as cattle and is also released from manure. Nitrous oxide is released either from the storage and use of (animal) manure or indirectly, as a result of nitrogen losses through atmospheric deposition and leaching. The main energy sources of greenhouse gas emissions in agriculture are fossil fuels (e.g. for heating greenhouses and stables) and off-road vehicles.

In 2018, greenhouse gas emissions from agriculture amounted to 7 497 kton CO_2-equivalent which is 9.6% of the total Flemish greenhouse gas emissions. The share of agriculture is comparable to that of households (12%), and smaller than that of industry (30%), energy (22%) and transport (20%).[135]

132 Vlaanderen, Departement Landbouw & Visserij, Landbouwcijfers https://lv.vlaanderen.be/nl/voorlichting-info/publicaties-cijfers/landbouwcijfers#overzichtsrapporten

133 Enerpedia - de agrarische-energie encyclopedie www.enerpedia.be

134 Instituut voor Landbouw-, Visserij- en Voedingsonderzoek - Rundveeloket https://www.rundveeloket.be/,

Vlaanderen, Departement Omgeving www.milieurapport.be

Waterportaal www.waterportaal.be

Vlaanderen, Departement Landbouw & Visserij www.lv.vlaanderen.be

135 Vlaanderen,Rapport Emissie van broeikasgassen door de landbouw, 2020 www.milieurapport.be/sectoren/landbouw/emissies-afval/emissie-van-broeikasgassen

In agriculture, 26% of greenhouse gas emissions in 2018 are from energy sources. The heating and ventilation of greenhouses and stables in greenhouse horticulture and intensive livestock farming are the main causes for this.

Table 5: Energy use by agriculture and horticulture in the Region of Flanders, per sector[136]

	2011	2012	2013	2014	2015	2016	2017	2018
arable land	1,062	1,150	1,212	1,161	1,291	1,411	1,549	1,520
dairy	1,709	1,935	2,256	2,433	2,449	2,537	2,724	2,627
beef cattle	1,121	1,291	1,447	1,603	1,674	1,686	1,436	1,573
pigs	2,473	2,664	2,668	2,604	2,746	2,709	2,370	2,340
vegetables in open air	321	366	402	364	424	280	369	149
vegetables under glass	9,443	10,219	9,748	8,797	10,509	11,766	11,890	13,015
floriculture under glass	1,588	1,709	2,427	1,275	1,702	1,593	2,187	1,961
fruits	633	641	707	751	753	735	738	717
other, agriculture	4,500	4,467	4,668	4,301	4,793	4,637	4,054	4,094
other, horticulture	881	616	831	550	584	590	760	911
Total net use	23,732	25,059	26,366	23,840	26,925	27,944	28,076	28,906

Table 6: Energy use by agriculture and horticulture in the Region of Flanders, per energy source[137]

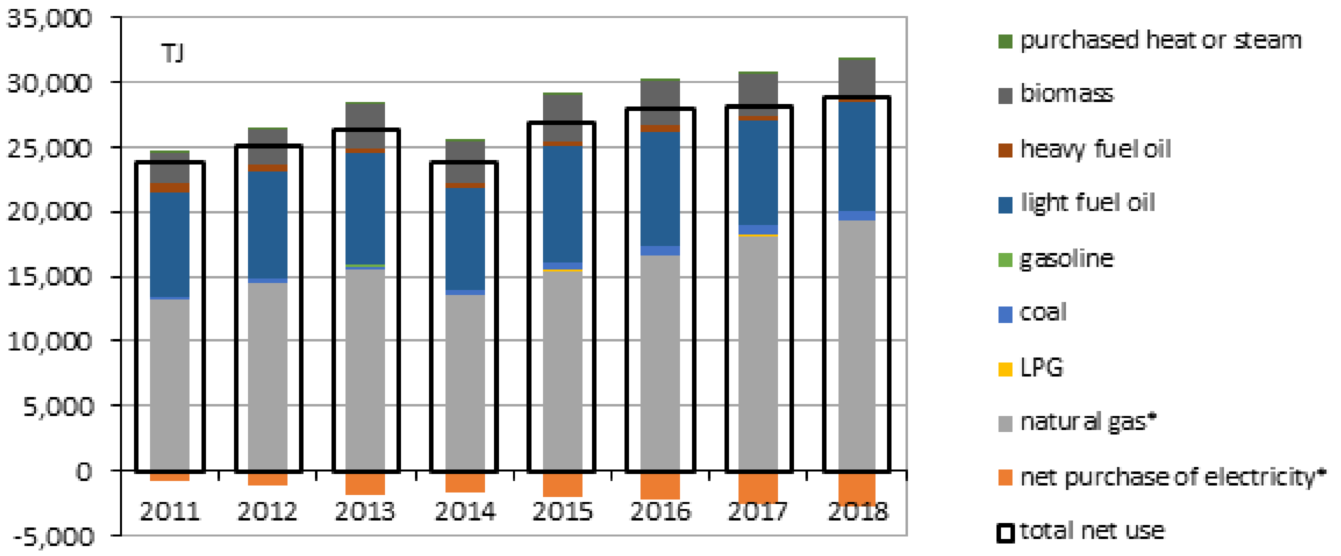
[TJ]	2011	2012	2013	2014	2015	2016	2017	2018
net purchase of electricity*	-879	-1,227	-1,903	-1,662	-2,061	-2,174	-2,529	-2,795
natural gas*	13,122	14,497	15,459	13,603	15,448	16,580	18,104	19,322
LPG	21	26	54	54	49	82	98	77
coal	237	265	296	244	606	667	688	661
gasoline	9	8	8	8	10	9	9	12
light fuel oil	8,038	8,299	8,726	7,955	8,998	8,865	8,147	8,332
heavy fuel oil	716	562	386	248	302	484	410	268
biomass	2,362	2,600	3,286	3,345	3,525	3,392	3,116	2,991
purchased heat or steam	107	28	55	45	46	38	33	38
Total net use	23,732	25,059	26,366	23,840	26,925	27,944	28,076	28,906

*mainly because of CHP systems

136 Vlaanderen, Landbouw & Visserij, Landbouw, Energiebalans https://landbouwcijfers.vlaanderen.be/landbouw/totale-landbouw/energiebalans

137 Vlaanderen, Landbouw & Visserij, Landbouw, Energiebalans https://landbouwcijfers.vlaanderen.be/landbouw/totale-landbouw/energiebalans

Figure 3: Energy use by agriculture and horticulture in the Region of Flanders, per energy sources



Financial aid: policy measures in the Region of Flanders

The Flemish Climate Policy Plan 2021-2030 is working hard on climate-smarter agriculture and fisheries, including appropriate measures in the field of climate mitigation, adaptation and sustainable land use. The Flemish government wants to encourage measures on energy saving and the production of sustainable energy in agriculture. Regarding the installation of STE systems in agriculture, several funding mechanisms can be applied. All of them are investment support mechanisms:

- Flemish agricultural investment fund (Vlaams LandbouwinvesteringsFonds – VLIF):[138]
  - Renovation: 40% of the investment .
  - New buildings: 30% of the investment.
  - This support cannot be combined with other premiums.
- Premium from the distribution grid operator:[139]
  - 200 €/m² aperture surface with a maximum of 40% of the invoice amounts and with a maximum of €10,000.
- Tax investment allowance:[140]
  - This is a tax benefit whereby a certain percentage of the investments may be deducted from the taxable profit.
  - Energy-saving investments and investments in renewable energy carried out by medium and large companies were eligible for an increased investment allowance of 13.5% in 2020. This way, the government stimulates energy-saving investments and investments in renewable energy at companies.

Those who want to apply for an investment for an STE system must have the system installed by an installer with a certificate of competence. Either the installer is self-certified, or the installation is checked by a certified inspection body. With the 'certificate of competence' for installers of green energy systems (solar panels, solar boilers, heat pumps, ...), the Flemish government, together with the other regions, wants to increase the yield, safety and lifespan of installed installations.

138 Vlaanderen, Landbouw & Visserij, VLIF-investeringssteun voor land- en tuinbouwers https://lv.vlaanderen.be/nl/subsidies/vlif-steun/vlif-investeringssteun-voor-land-en-tuinbouwers

139 Fluvius, premie voor zonneboiler https://www.fluvius.be/nl/thema/premies/premies-voor-bedrijven/premie-zonneboiler

140 Vlaanderen, investeringsaftrek voor energiebesparende investeringen door bedrijven www.vlaanderen.be/verhoogde-investeringsaftrek-voor-energiebesparende-investeringen-door-bedrijven

B. Sectoral Analysis

1. Milk Fed Calves

a. Presentation of the sector

In Belgium, 95% of the veal calf farms are located in the Region of Flanders (about 250 farms). The average herd size is about 590 calves.[141]

b. Energy consumption and heating requirement

On calf farms, a lot of hot water is needed daily. In 2005, the Flemish calf sector used 1.3% of the total water use in the Flemish agriculture and horticulture sector.[142] At the veal farms, the production of milk replacer and the water for cleaning stables, machines and equipment make up the largest share of the total water requirement.

On arrival at the farm, the calves are given 2 litres of milk 2 times per day at +/- 42°C. This is systematically built up to 8.5 litres of milk 2 times per day. At an average farm, the daily need for hot water (80°C) per calf is about 10 litres.[143] This means that a farm with 590 calves will need about 5,900 litres of hot water (80°C) on a daily basis.

This water is heated in many ways, often using fuel oil or natural gas. But STE installations are becoming more common, which are supplemented with fossil fuels.

c. Potential for the use of solar energy

This daily need for hot water makes this sector very appealing to use STE systems. This is certainly already the case in Flanders, although no exact figures are known.

2. Dairy farms

a. Presentation of the sector

The dairy sector is important in the Region of Flanders. The Agriculture and Fisheries Report of December 2020 states that there are 5,606 dairy farms (accounting for 28% of the total amount of farms) with a total of 330,696 dairy cows. The average herd size is 59 cows, but with a wide spread of farm sizes.[144]

Table 7: Number and size of Dairy Farms in Flanders

Size of herd	Number of farms	Percentage share
1 - 14 dairy cows	1,432 farms	25.5%
15 - 29 dairy cows	547 farms	9.8%
30 - 44 dairy cows	676 farms	12.1%
45 - 59 dairy cows	737 farms	13.1%
More than 60 dairy cows	2,214 farms	39.5%

Below we will only discuss the dairy farms with 60 or more dairy cows. In this category, the average herd size is about 113 milk cows.

b. Energy consumption and heating requirement

In the Region of Flanders, electric boilers are the most common method of heating water (to 80-90°C) that is needed for cleaning the milk machines and the milk tanks. This heating accounts for about 22% of the electricity used on the farm.[145] For the average farm of 113 dairy cows, this means that about 11,000 kWh/year is needed for heating the water. Many farms have implemented heat recovery on the milk tank. In those farms, less electricity is needed for heating the water.

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141 Instituut voor Landbouw-, Visserij- en Voedingsonderzoek - Rundveeloket https://www.rundveeloket.be/

142 Waterportaal, Waterverbruik vleesvee-en kalverhouderij https://www.waterportaal.be/WATERBRONNEN/Alternatievewaterbronnenpersector/Vleesvee-enkalverhouderij/Waterverbruik.aspx

143 This data is based on energy audits by Innovatiesteunpunt.

144 Vlaanderen, Landbouw & Visserij, Landbouwreport 2020, https://publicaties.vlaanderen.be/view-file/41555

145 Enerpedia - de agrarische-energie encyclopedie www.enerpedia.be

c. Potential for the use of solar energy

Since several hundred litres of hot water are needed in a dairy farm daily (without depending on seasonality), this sector appears to be one of the most suitable sectors to apply STE systems. Several dairy farms in Flanders have already installed an STE system, but no precise figures are available on this. STE systems can also be used in farms that have implemented heat recovery on the milk cooling tank but will have to heat the water over temperatures of about 45 ° C. This means that the annual yield will be somewhat lower because it is difficult to achieve higher temperatures in winter.

On dairy farms that also process milk for the preparation of cheese, rice pudding, yogurt, etc, the potential for STE systems is even greater. Hot water is also needed at these farms for cleaning the processing equipment and in some cases also for the preparations themselves.

3. Pigs

a. Presentation of the sector

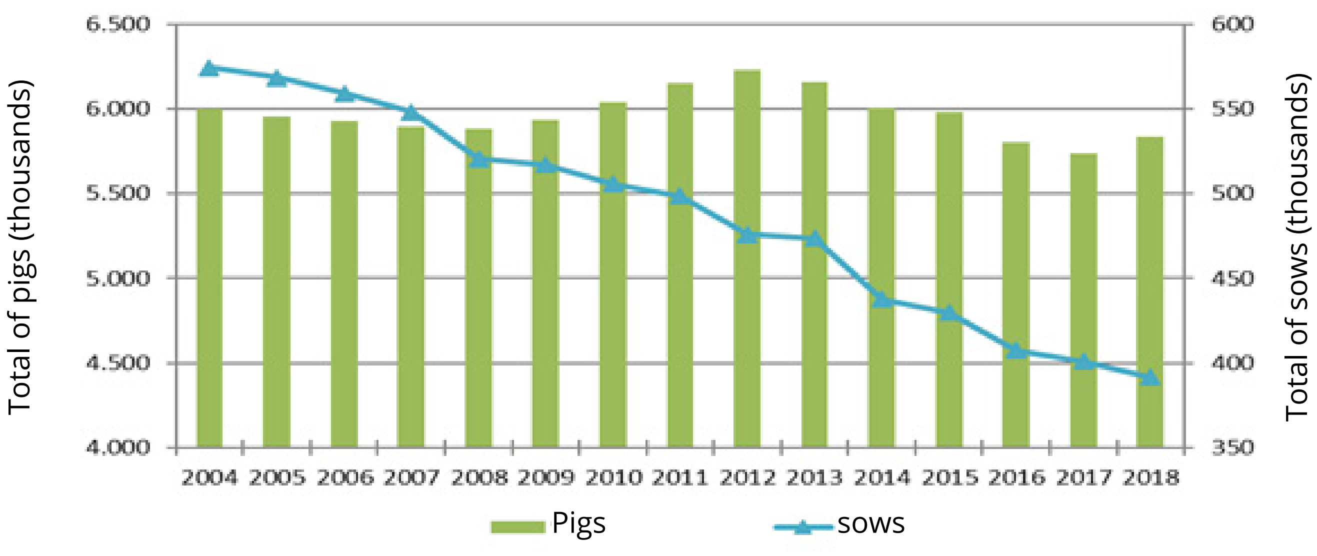
The pig sector is also very important in Flanders. The Agriculture and Fisheries Report of December 2020 states that there are 3,731 pig farms (16% of the total amount of farms) with a total of 5.8 million pigs, of which 392,000 sows. The average herd size is 1,563 pigs, but with a wide spread of farm sizes.[146]

Table 8: Size and Number of pig farms in Flanders

Size of herd	Number of farms	Percentage share
1 – 249 pigs	906 farms	24.3 %
500 – 999 pigs	949 farms	25.4 %
1000 – 1499 pigs	576 farms	14.4 %
1500 – 1999 pigs	385 farms	10.3 %
2000 – 2499 pigs	267 farms	7.2 %
2500 – 2999 pigs	194 farms	5.2 %
More than 3000 pigs	454 farms	12.2 %

The number of sows is sharply decreasing over time, whereas the total number of pigs stays more or less at a constant level (blue line = number of sows, green bars = number of pigs in total):

Figure 4: Number of pigs and sows in Flanders



b. Energy consumption and heating requirement

In the Region of Flanders, only pig farms with sows and piglets need hot water to heat the stables. The energy use for these farms is between 260-520 kWh per sow berth.[147] There are no detailed figures of the

[146] Vlaanderen, Landbouw & Visserij, Landbouwreport 2020, https://publicaties.vlaanderen.be/view-file/41555

[147] This data is based on energy audits by Innovatiesteunpunt.

amount of hot water that is needed, this will vary on the way the heating system is built (via underfloor heating or delta pipes, the size of the houses, the degree to which the houses are insulated, etc.).In most pig farms, heating takes place via a fuel oil boiler, occasionally also via natural gas (boiler or combined heat and power). More and more it can be observed in Flanders that the stables are heated by a heat pump. Heat pumps can get their heat from the air, from the ground or the central air duct.

c. Potential for the use of solar energy
Currently STE systems are rarely used in pig farms, mainly because the heating of the stables is only needed during the winter months. Another reason is that fuel oil and natural gas are relatively cheap. When pig farms want to change the heating system from fossil fuel sources, they usually opt for the installation of a heat pump.

4. Poultry – broiler chickens

a. Presentation of the sector
In the Region of Flanders, there are 474 farms with more than 100 broiler chickens (in total about 27 billion broiler chickens). The average herd size is about 50,000 broiler chickens.[148]

b. Energy consumption and heating requirement
In this sector, the heating needs of the buildings are periodic because they are linked to the first month of life of the chicks. They also depend very largely on the state of insulation of the building.

c. Potential for the use of solar energy
Since the heating needs of the broiler chicken farms are periodic, there is not much interest for adapting STE systems. Another reason is that fuel oil and natural gas are relatively cheap, so there is no price incentive to change towards other systems.

5. Horticulture

a. Presentation of the sector
In the Region of Flanders, there are 6,883 horticultural businesses (growing vegetables, fruit and floriculture).[149] This includes companies that grow outdoors as well as companies that grow under glass (greenhouses). There are no detailed figures regarding the number of greenhouses.

Figure 5: Energy consumption from greenhouses in Flanders[150]

[TJ]	2015	2016	2017	2018
net purchase of electricity*	-4,890	-4,867	-5,235	-5,439
natural gas*	14,905	15,965	17,258	18,561
LPG	6	8	14	8
coal	579	628	655	661
gasoline	3	3	3	5
light fuel oil	912	815	640	620
heavy fuel oil	278	452	405	268
biomass	372	316	303	254
purchased heat or steam	46	38	33	38
Total net use	12,211	13,359	14,077	14,976

*mainly because of CHP systems

148 Departement Landbouw & Visserij, ublicaties & Cijfers, Landbouwcijfers https://lv.vlaanderen.be/nl/voorlichting-info/publicaties-cijfers/landbouwcijfers#overzichtsrapporten

149 Departement Landbouw & Visserij, ublicaties & Cijfers, Landbouwcijfers https://lv.vlaanderen.be/nl/voorlichting-info/publicaties-cijfers/landbouwcijfers#overzichtsrapporten

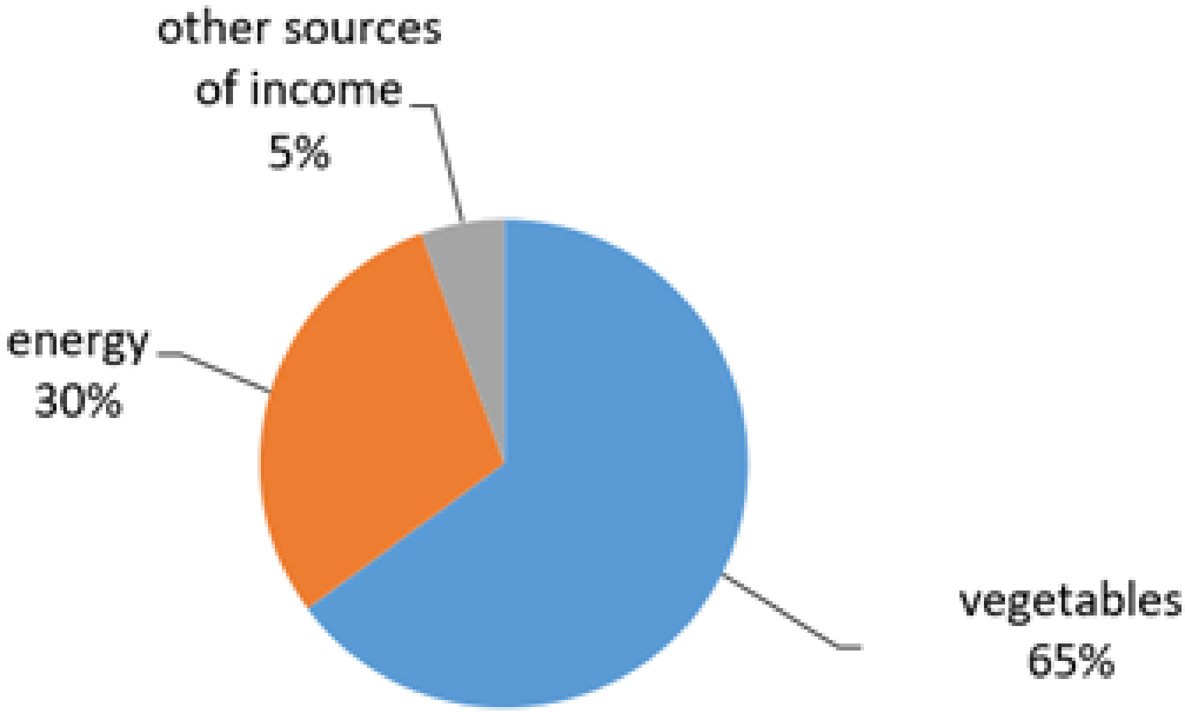
150 Vlaanderen, Sector Barometer tuinbouw https://lv.vlaanderen.be/sites/default/files/attachments/wd_20190920_sectorbarometertuinbouw_0.xlsx

b. Energy consumption and heating requirement
Greenhouses in the Region of Flanders are big consumers of energy The main use for energy is heating and lighting. The heated area (as well as the temperature level) is highly dependent on the product that is being grown. There are no detailed figures of the amount of hot water that is needed in greenhouses.

c. Potential for the use of solar energy
In greenhouses, heating is mainly required during the winter months, which is less favourable for STE systems. Moreover, greenhouses in Flanders are very often heated via a CHP system (combined heat and power) because in this way electricity can also be produced simultaneously (and the CO_2 released during this process can also be used in the greenhouse itself). Additionally, it is possible to sell the surplus electricity generated from the CHP installations. This accounts for 30% of the income of specialized greenhouse vegetable companies.[151]

When considering sustainable solutions for heating greenhouses, in Flanders we mainly look at heat networks where the 'waste heat' from nearby industrial operations is used to heat the greenhouses.

Figure 6: Income for owners of greenhouses in 2019



III. Conclusion on Belgian agricultural markets: Identification of the target segments

Dairy farms and calf farms both need hot water daily, regardless of the seasons. Therefore, they represent the most interesting potential markets for STE systems when the latters are economically efficient.
In the Region of Flanders, several STE systems have been installed on dairy farms and calf farms (no details are known about the number of installations). However, there is still some potential. Within the ICaRE4Farms project, we will mainly target those remaining farms.

[151] Departement Landbouw & Visserij, ublicaties & Cijfers, Landbouwcijfers https://lv.vlaanderen.be/nl/voorlichting-info/publicaties-cijfers/landbouwcijfers#overzichtsrapporten

3 Netherlands

I. Methodology

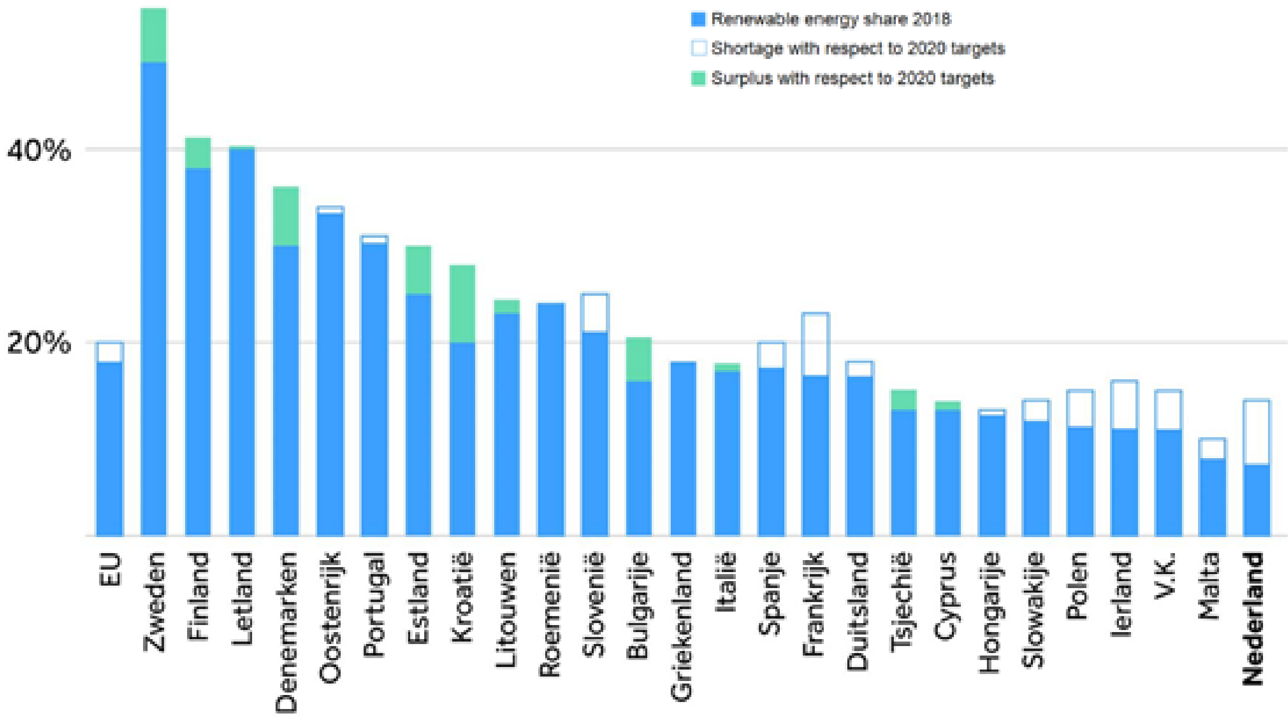
This study is mostly based on aggregated statistical research by several of the Dutch national research institutes and universities, such as the Wageningen University of Agriculture (WUR) and the Central Bureau of Statistics (CBS). We have further supplemented the provided data with information supplied by farmer's organizations (LTO) and interviews with farmers. In these concrete cases we have provided advice to existing agricultural companies concerning their Renewable Energy Strategy. The interaction with the companies has provided much-needed insight into the working and installations of real-life farms.

II. Summary of results

A. Agriculture, energy Consumption and Financial Aid

The Netherlands is not a leader in terms of renewable energy production in Europe. In 2018, the Netherlands was last in class in terms of the share of renewable energy in the total net energy usage. The graph[152] below shows that they fall short of the target set for 2020 at 14%. This means they still have a lot of work to do in a short time.

Figure 7: Shares of renewable energy in the EU Member States in 2018. The Netherlands is last in class, falling well short of the target set for 2020.



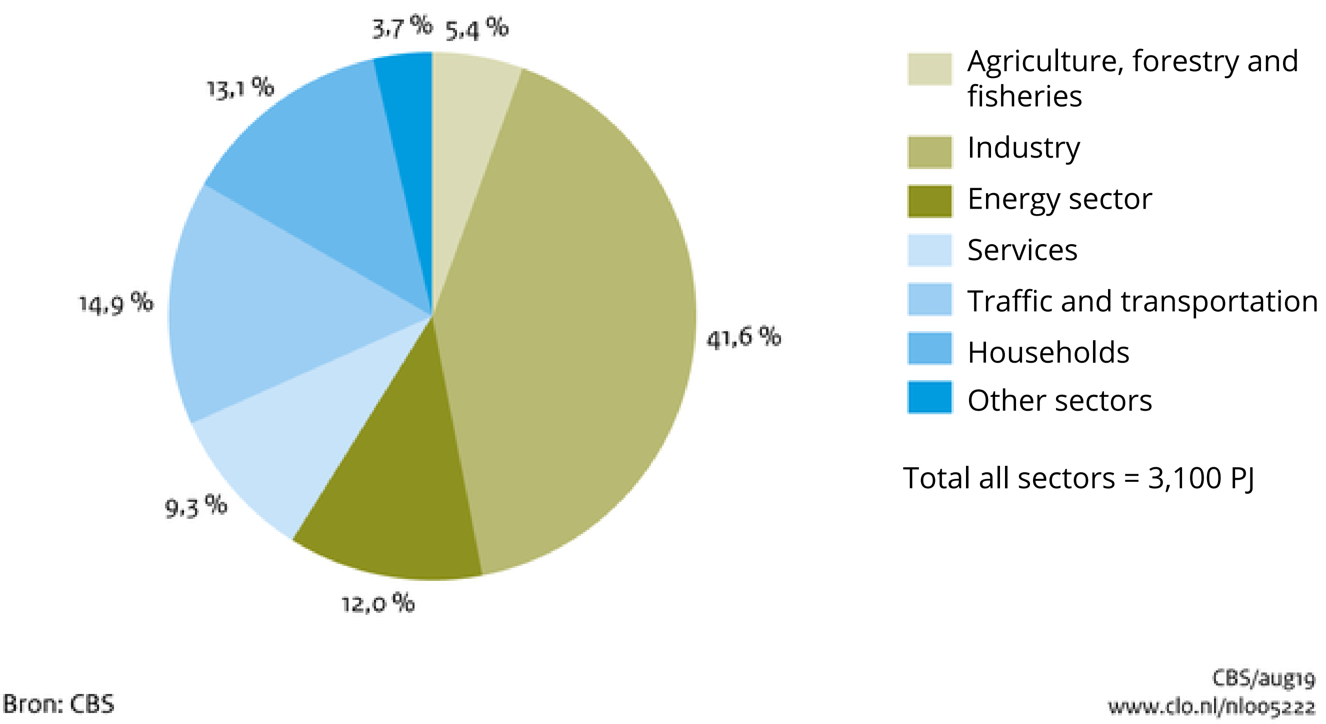
Looking at the distribution of energy usage over the different sectors, we see that agriculture and fishery take up 5,4% of the total domestic energy consumption.[153] The distribution of energy use over the different sectors is displayed in Figure 2. Although the Netherlands isn't performing that well in terms of Renewable Energy, farmers show a much higher level of ambition. According to ZLTO[154] over 45% of the energy used in the primary agricultural sectors is currently renewable energy generated within the sector.

[152] Eurostat, Shares of renewable energy in the EU Member States in 2018 https://ec.europa.eu/eurostat/documents/2995521/10335438/8-23012020-AP-EN.pdf/292cf2e5-8870-4525-7ad7-188864ba0c29

[153] Rijksoverheid, Compendium voor de Leefomgeving, Energy use per sector, 2018 https://www.clo.nl/sites/default/files/styles/clo_infographic/public/infographics/0052_003g_clo_22_nl.png?itok=4-uzCITq

[154] ZLTO, Energie, https://www.zlto.nl/energie

Figure 8: Energy use per sector of the Netherlands in 2018. The agriculture and fishery sectors take up 5,4% of the total domestic energy usage.



The main renewable energy sources that are used are wind and biomass. Additionally, innovative horticultural companies make use of combined heat and power (CHP), generating electricity on-site using natural gas and using the residual heat and CO_2 in their production processes. Another great example is farmers getting rid of their natural gas connection altogether and instead opting to use biomass boilers. Instead of importing woody biomass, these farmers involve their neighbourhoods, municipalities and local site managers to harvest fast-growing woody biomass resulting from maintenance and roadside grasses.

The National Government provides various subsidies and tax incentives to make investments in renewable energy generation more appealing. The biggest driver of the installation of RE technologies has been the SDE subsidy[155] (SDE stands for stimulation of the production of renewable energy). This subsidy is no “simple” investment subsidy provided upfront, but a production subsidy that is paid per unit of energy produced. The installations that qualify for SDE have a minimum production capacity (for STE, the minimum power requirement is 140 kW, which corresponds to a 200m^2 aperture surface according to the models).[156] The idea is that the SDE subsidy covers the unprofitable top of the investments, making an attractive business case for the RE market. In 2021, the SDE subsidy is going to be gradually decreased for wind turbine and solar PV technologies, while newer and more innovative solutions were included, such as harvesting residual heat from sewage and surface water and carbon capture and storage. STE systems that are not big enough to qualify for SDE can be financed partially with the national ISDE investment subsidy. The ISDE subsidy[157] covers approximately one-third of the investment, provided that the installation is listed on the pre-approved list of technologies.

On top of the national subsidy scheme several provinces or municipalities provide their own subsidies for energy-saving schemes or the production of renewable energy. These local arrangements are beyond the scope of this report. Most farmers that we have met for the interviews were very interested in subsidies and tax benefits to make their business more sustainable.

[155] Rijksdienst voor ondernemend Nederland, Zon SDE ++ Subsidie https://www.rvo.nl/subsidie-en-financieringswijzer/stimulering-duurzame-energieproductie-en-klimaattransitie-sde/aanvragen-sde/zon

[156] Rijksdienst voor ondernemend Nederland, Zon SDE ++ Subsidie https://www.rvo.nl/subsidie-en-financieringswijzer/stimulering-duurzame-energieproductie-en-klimaattransitie-sde/aanvragen-sde/zon

[157] Rijksdienst voor ondernemend Nederland, Investeringssubsidie duurzame energie en energiebesparing (ISDE) https://www.rvo.nl/subsidie-en-financieringswijzer/isde

B. Sectoral Analysis

1. Milk Fed Calves

a. Presentation of the sector
In 2019, the Netherlands had 1,599 meat calves' farms.[158] With an average number of 663 calves, the total population of calves in the farms amounts to 1,060,592 animals. This count includes both white and rose meat calves. Based on an extrapolation of the turnover reported for a representative sample by the central bureau of statistics, the total turnover of the sector is approximately €1 billion. The Dutch production of veal constitutes a large fraction of the European production at about 31%.[159]

b. Energy consumption and heating requirement
The total electricity usage of the sector is 0.2 PJ[160],[161],[162] corresponding to 56 GWh. This makes the average electricity use per farm is 35 MWh. The energy content of the natural gas that is consumed by the sector is the same as the electricity usage, also 0.2 PJ. In addition to the electricity usage and natural gas usage, the veal sector also makes use of other fuels and energy sources (e.g. propane, diesel, biomass), for an additional 0.4 PJ of energy consumption. The energy consumption for heating water is not known. Based on the use cases that we have studied during this project we conservatively estimate that heat demand makes up 25% of the total energy demand in veal farms.

c. Potential for the use of solar energy
Veal farms are one of the most well-known opportunities for STE. Looking at the project portfolio of most STE installers, they show almost exclusively veal farms in their client list. Since the hot water demand is largely for feeding calves, which happens all year-round, the overlap between production and consumption of heat can be quite good. Despite the relative popularity of STE in the sector, the vast majority of companies could still benefit from STE.

2. Dairy farms

a. Presentation of the sector
The Dutch dairy sector is quite well developed. With a share of almost 5% in the global dairy trade, the Netherlands belongs to the top-5 of the largest dairy exporters globally. Most Dutch milk is exported to countries in the EU. The most important export product is cheese, which represents €3.7 billion of annual exports, nearly half of the total dairy export of €7.8 billion.[163]

The Netherlands is home to almost 17,000 dairy companies, who in total host 1.6 million cows and 0.4 million goats. The total average yearly milk production of these companies is 835 tons of milk. 2200 of the companies in the sector own 150 or more cows.[164]

b. Energy consumption and heating requirement
The yearly energy usage within the entire dairy sector is 2.8 PJ of electricity (45,750 kWh per company), 0.6 PJ of natural gas and 4.7 PJ of fuels and other energy sources.[165] The share of hot water production in the energy use is not known as far as was found in this study. A complicating factor is the usage of gas-fired blowers for space heating, so that no hot water is used as a medium for the heating application.

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158 Wageningen, University & Research, Agrimatie, de Nederlandse kalfsvleesketen, https://www.agrimatie.nl/ThemaResultaat.aspx?subpubID=2232&themaID=3577&indicatorID=3591&sectorID=2257

159 Ibid 158

160 Sectorrapportage duurzame zuivelketen: prestaties; Wageningen university and research ; reference number 508871

161 Energiemonitor van de nederlandse glastuinbouw; Wageningen university and research; reference number 505786

162 Wageningen, University & Research, Agrimatie, Energie https://www.agrimatie.nl/ThemaResultaat.aspx?subpubID=2232&themaID=2273

163 ZuivelNL, Publicatie Zuivel in Cijfers, 2019 https://www.zuivelnl.org/nieuws/publicatie-zuivel-in-cijfers-2019#:~:text=Nederland%20telde%20begin%20april%202019,dan%204%25%20af%20tot%2016.260

164 Wageningen, University & Research, Agrimatie, Sectoren, Melkveehouderij https://www.agrimatie.nl/SectorResultaat.aspx?subpubID=2232&sectorID=2245

165 Ibid 163

c. Potential for the use of solar energy
Dairy farms in general use a modest amount of hot water based on information shared orally by Friesland Campina[166] concerning their member farms. The chief application of hot water is cleaning of stables and milking robots. A novel technology that includes STE panels was identified by Friesland Campina that has a high potential for the use on dairy farms. The "farm boiler" is a specially programmed boiler designed to match the hot water demand on a dairy farm. Two STE panels are used to provide a part of the heat on sunny days. The relatively low power of the STE makes sure that the overlap between production and demand is quite good, making the business case for adding the panels quite profitable. This technology is currently being piloted by Friesland Campina.

Several specific installations can sharply increase or decrease the heat demand of a dairy farm. This makes it very difficult to make generalized statements concerning the suitability of the sector for STE applications. Several examples are mentioned here based on our case studies. One of these technologies is specifically mentioned in the ICaRE4Farms project bundle: the anaerobic manure digester. The digester itself needs to be maintained at an elevated temperature year-round, which represents a considerable additional heat demand for the farm. Biogas produced in the plant could be used to heat the digester, however, each Nm^3 of biogas that can be saved by applying a secondary RE technology can be used towards the useful production of the digester. Supplementary technologies for manure processing can add an additional heat demand: a nitrogen stripper, a biogas converter (to green gas) and manure dryer.

An installation that can reduce the heat demand is heat recovery from milk cooling tanks. Using the residual heat to preheat water is an efficient energy saving measure. Farms that have taken this measure are less attractive for STE applications, especially since the cooling demand of the milk tanks and the resulting heat production are increased in summer.

Another sub sector of dairy farms, cheese farms, is also worth mentioning as a possible target industry. Cheese farms use technology that increases the heat demand. We have studied several cheese farms in our case studies. The Pasteur used by cheese farms represents the biggest additional hot water consumption, with the goal of pasteurizing the milk prior to producing cheese. A Pasteur can consume thousands of litres of hot water per hour at relatively high temperature (72°C). Moreover, the curd bath is heated to moderate temperatures. This all leads to an increased heat demands year-round, making cheese production farms interesting for STE applications.

3. Pigs

a. Presentation of the sector
The Netherlands is a home to 1.007 million female breeding pigs and 11,855 million fattening pigs according to CBS in 2020.[167] According to Agrimatie there were 4,056 pig farms, with an average of 2,992 pigs in the Netherlands in 2019. The pig industry in the Netherlands is worth about €8 billion.[168]

b. Energy consumption and heating requirement
The average energy use on pig farms in terms of electricity is 147,000 kWh and in terms of gas 10,000 Nm^3 in the year 2018. In that same year pig farms used an average of 2,430 m^3 water. How much of the gas and water consumption amount to the production of hot water is not known. We do however have a case study of a pig farm. It's a farm with 7,500 pigs and it uses 9.25 m^3 of hot water (70 degrees) daily for fermentation. The corresponding energy used to heat the 9.25 m^3 of water is 650 kWh, the equivalent of 74 Nm^3 of natural gas daily.[169]

c. Potential for the use of solar energy
There is opportunity for solar energy to heat the water that the farmers use for the food as well as cleaning. Especially the hot water usage for fermentation has potential for using STE, since the required

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[166] CCS, Interview minutes Friesland Campina, October 2020

[167] CBS, Statlne, Livestock pigs, 1981-2020 https://opendata.cbs.nl/#/CBS/en/dataset/7373eng/table

[168] Wageningen University& Research,Agrimatie, Varkenshouderij, Economisch resultaat https://www.agrimatie.nl/SectorResultaat.aspx?themaID=2272&indicatorID=2046&subpubID=2232&sectorID=2255

[169] Wageningen University& Research, Agrimatie, Varkenshouderij, Energie, https://www.agrimatie.nl/SectorResultaat.aspx?subpubID=2232&sectorID=2255&themaID=2273

temperature levels are lower, and the energy usage is year-round.[170]

4. Poultry

a. Presentation of the sector

In 2019 the Dutch egg production sector owned a total of 33,355,261 chickens within 749 farms, which results in an average of 44,533 chickens per farm. To produce chicken meat, there were 48,079,037 chickens within 629 farms with an average of 76,437 chickens each in 2019. The total value of the poultry industry was €51 million in 2017.[171]

b. Energy consumption and heating requirement [172]

The average energy use on farms that produce eggs in terms of electricity is 110,700 kWh and in terms of gas is 2,300 Nm^3 in the year 2018. The water use amounts to 1,580 m^3. It is not known how much of the gas and water used on the farms is intended for hot water production. We do know that a significant fraction of heat used on these farms is to keep the poultry housing warm because the chickens need to stay in optimal shape to lay their eggs. This indicates that the heat demand will be highest in the cold months, providing a bad match with the production profile of STE systems.

The average energy use in 2018 on chicken farms for meat production in terms of electricity is 114,000 kWh, in terms of gas 5,800Nm^3. The average water use amounts to 1,970m^3. We do not know how much of the water is heated. What we do know is that the main application for heat on the farms is for space heating because that plays an important role in optimizing the growth of the chickens.

c. Potential for the use of solar energy

There is a potential use for solar energy, however we do not know how much exactly, since this will also be different for each farm. We can say however that space heating is not a high potential application for heat generated by STE, since the heat demand profile does not match the heat production profile.

5. Horticulture

a. Presentation of the sector

There are 10,535 companies active in the Dutch horticulture sector as of 2019. The sector can be further divided in the subsectors: fruits, floriculture, vegetables and glasshouses.

Table 9: Subdivision horticulture sector (source: agrimatie.nl)[173]

Activity	Companies	Area
Fruit	2,651 farms	20,322 ha
Floriculture	1,561 farms	27,217 ha
Vegetables	2,823 farms	25,610 ha
Glasshouses	3,500 farms	9,778 ha
Total	10,535 farms	82,927 ha

General characteristics of horticultural holdings in the Netherlands

A general trend can be observed within all subsectors over the past 10 years indicating a decrease in the total number of farms but an increase in the size of farms. This is most noticeable in the glasshouse industry, where the farm sizes have doubled since 2010 and the total number of farms has decrease from 5,700 to 3,500 farms.[174]

170 Journal of animal Science and Biology, Fermented liquid feed for pigs: an ancient technique for the future, Joris AM Missotten & al. 2015 https://jasbsci.biomedcentral.com/articles/10.1186/2049-1891-6-4#:~:text=Fermented%20liquid%20feed%20is%20feed,the%20pH%20of%20the%20mixture

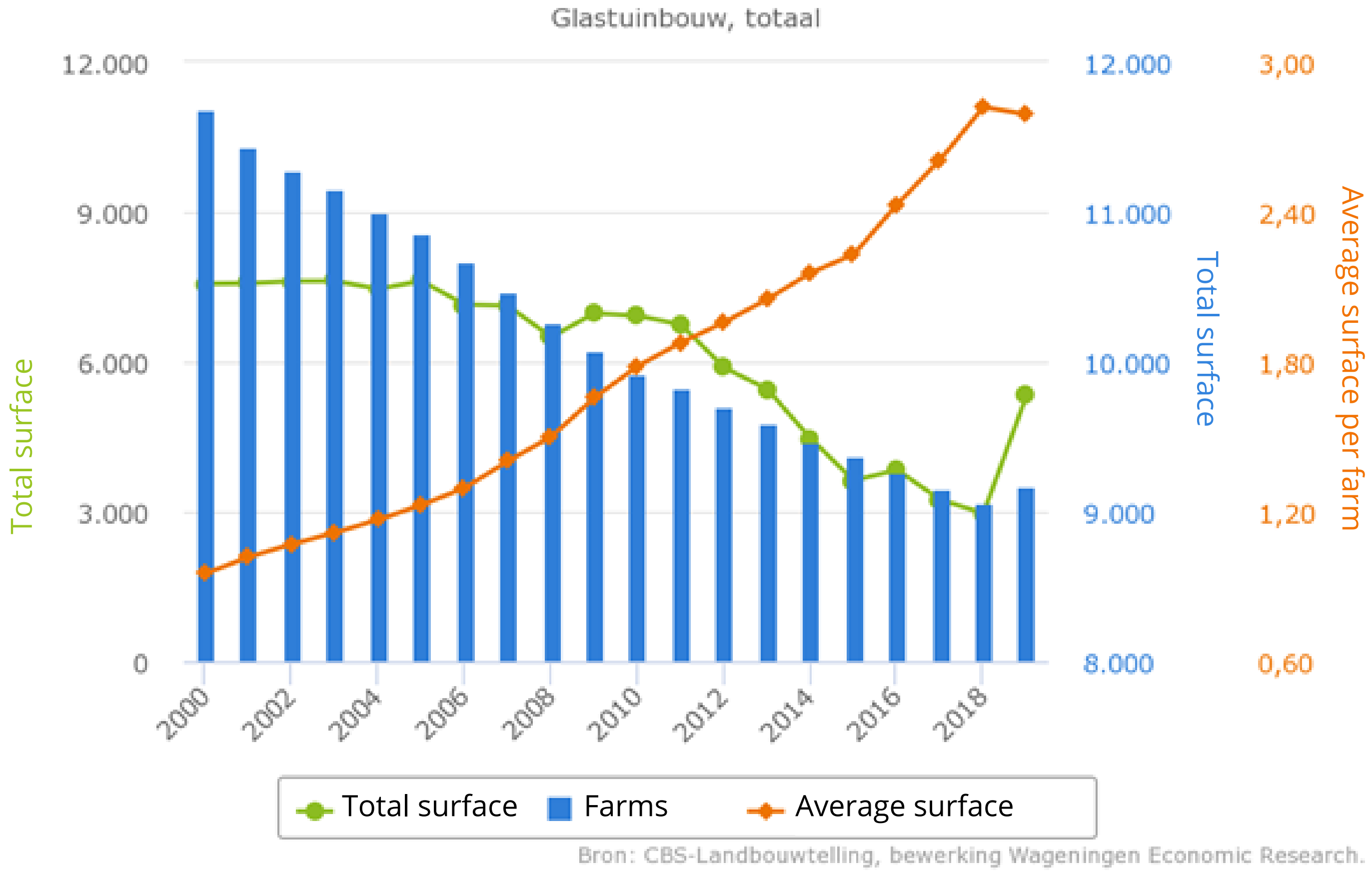
171 Wageningen University& Research,Agrimatie, Pluimveehouderij https://www.agrimatie.nl/SectorResultaat.aspx?subpubID=2232&sectorID=2249

172 Wageningen University& Research,Agrimatie, https://www.agrimatie.nl/Binternet.aspx?ID=11&Lang=0

173 Wageningen University& Research,Agrimatie, Fruitteelt, Economische resultaat, https://www.agrimatie.nl/sectorResultaat.aspx?subpubID=2232&sectorID=2237&themaID=2272&indicatorID=2052

174 Wageningen University& Research,Agrimatie, Glastuinbouw, https://www.agrimatie.nl/SectorResultaat.aspx?subpubID=2232&sectorID=2240

Figure 9: Total number of Farms, total surface and surface per farm in glasshouse sector



b. Energy consumption and heating requirement

The energy requirement of unprotected cropping is negligible. For fruiting the annual cost of energy is only 2% of the total annual cost of an average farm. Which leaves little space to invest in renewable energy.[175]

The share of energy cost for an average glasshouse is 15% of the annual cost. As mentioned in other regions, the main use of energy for glasshouses is heating and lighting. In 2018, the share of natural gas in the total energy supply for the sector was 81%. In comparison 7,3% of the total energy supply came from renewable sources. The glasshouse sector is a net exporter of electricity, due to the sale of electricity from Combined Heat and Power generation (CHP) fueled by natural gas.[176]

c. Potential for the use of solar energy

The potential use of STE in this sector is low for three prominent reasons:

1. Low cost of natural gas,
2. The need for additional CO_2,
3. The maturity of other (sustainable) technologies.

To address the first obstacle, the tax on natural gas in the Netherlands is related to the volume of gas a company consumes through tax brackets. In the second bracket, which applies to most glasshouses, the tax is 35% lower than the first bracket.[177] Consequently, energy savings resulting from STE are less economic when compared to the 'cheaper' natural gas price. In addition, for natural gas used in CHP installations it is possible to receive full return on the natural gas tax as compensation for the generated

175 Wageningen University& Research,Agrimatie, fruitteelt, https://www.agrimatie.nl/sectorResultaat.aspx?subpubID=2232&sectorID=2237&themaID=2272&indicatorID=2052

176 Wageningen University& Research,Agrimatie, Energie verbruik, glastuinbouw totaal, https://www.agrimatie.nl/Binternet.aspx?ID=11&Lang=0

177 Rijksoverheid, Belastingplan 2021, Belastingwijzigingen woor ons klimaat, https://www.rijksoverheid.nl/onderwerpen/belastingplan/belastingwijzigingen-voor-ons-klimaat/energiebelasting-ode

electricity.[178] Heavy subsidizing of natural gas reduces the potential for investments in other sustainable energy solutions.

The second obstacle is that there is an independent need for CO_2 in the glasshouse industry. When natural gas is fully replaced by renewable energy sources CO_2 needs to be imported. This is an opportunity for an overall more sustainable supply chain. However, it can also be considered a technological barrier because it requires a holistic solution that goes beyond just energy savings.

This also touches on the last obstacle, other renewable energy technologies are more mature in glasshouse industry and are able to supply a holistic solution, whereas STE is not yet at that level of maturity. Because of the complexity and size of glasshouses, subsidies to promote renewable energy in this branch will favour technologies that integrate well and have a high valorization potential. With the prime example of CHP, and in lesser degree geothermal energy or solar-PV.

Overall, STE has the best potential in small glasshouses that do not receive tax benefits and are not valorizing their energy production through CHP or solar-PV. This is only a small segment of the market.

III. Conclusion on Dutch agricultural markets: Identification of the target segments

The Netherlands has a wide variety of agricultural companies. Combined, these companies produce much more that most would expect based on the size of the country. This is due to the innovative approach to farming of Dutch farmers. Contrary to the country itself, Dutch farmers already employ renewable energy to power many of their processes and systems. Various national and local subsidies are in place to support (agricultural) companies if they choose to reduce their CO_2 emissions. Based on the informal interviews we have conducted during the use cases; we have concluded that farmers are quite keen to apply the available subsidies to improve their profitability.

In terms of sectors in the Netherlands, we conclude that veal and dairy farms are the most promising targets for STE technology. Veal farms already frequently adopt STE systems. As a new sector, we conclude that dairy farms with additional heat demanding processes, such as cheese production and manure digestion are interesting. Moreover, innovative products such as the specialized farm boiler make the application of STE possible for a broader agricultural audience. Pig breeders and poultry companies can be interesting, but this is more case-by-case, depending on their exact situation. In horticulture the match with STE seems not great. Other technologies, such as CHP and geothermal energy appear to be more successful.

[178] Belastingdienst, Belastingen op milieugrondslag, Teruggaag energiebelasting of kolenbelasting https://www.belastingdienst.nl/wps/wcm/connect/bldcontentnl/belastingdienst/zakelijk/overige_belastingen/belastingen_op_milieugrondslag/teruggaafregelingen/teruggaafregeling_energiebelasting_of_kolenbelasting

4 United Kingdom

I. Methodology

Extensive use of statistics from the Department of Food and Rural Affairs has been made to obtain statistics concerning agriculture in the UK. This information has been augmented by technical publications by the National Farmers Union and the other farming organisations. Commercial journals that provide farmers with the latest advice and research findings have been accessed and a longstanding source of farm management information 'The John Nix Pocketbook for farm management' a compendium of technical and financial information for farm managers (established in 1966 and is a continuous annual publication) has been used. The Institute of Agricultural Management has also helped make these assessments. Personal knowledge and personal contacts with practising farmers have also been used.

II. Summary of results

A. Agriculture, Energy Consumption and Financial Aid

The Renewable Energy industry in the UK is a response to incentives to cut greenhouse gases. Agriculture is reckoned to contribute around 10% of GHG. Almost 50% of UK electricity generation came from renewable sources in 2020.[179] Most renewable energy production comes from solar panels, wind turbines, anaerobic digestion, or hydropower; farmers in the UK have therefore recognized the potential of their farms to produce renewable energy either to reduce their reliance on purchased energy or to provide renewable energy into the supply chain of electricity generation organisations.

Government incentives to produce renewable energy have been steadily reduced and some systems are now viable without financial support ("the direction of travel is that projects in the future will have to be viable without long term subsidy").[180]

In the UK farmers regard the production of renewable energy as a potentially lucrative enterprise on the farm, feeding surplus energy into the national power grid or as augmentation or replacement for energy used on the farm.

The outcome for this market analysis is that farmers will consider the adoption of STE as a purely commercial decision with no subsidies involved.

B. Sectoral Analysis

1. Milk Fed Calves

The description of the market contained in the French analysis concludes that the market for veal calves in Europe is oversupplied and that there is low demand is also mirrored in the UK. There are only a few veal producers in the UK therefore it is not a good market sector for STE use because veal production is so limited.

However, recent changes in agricultural policy in the UK which includes the banning of euthanasia for newly born and very young calves together with limits on the age at which young animal scan be exported may change this.

2. Dairy farms

a. Presentation of the sector

The UK is the eleventh-largest milk producer in the world. Milk accounted for 16.9% of total agricultural output in the UK in 2018 and was worth £4.5bn in market prices.[181] The total number of UK dairy cows has fallen from 2.6 million in 1996 to 1.9 million in 2018, a 27% reduction.[182] The UK produced 15.0 billion litres of milk in 2018, the highest annual figure since 1990. In 2019, the UK recorded a trade surplus in volume terms for dairy for the first time since records began (1997). In 2018, the UK had a negative trade

179 Redman, Graham, John Nix Pocketbook for Farm Management, 51th edition, 2021

180 Ibid 179

181 Department for Environment, Food and Rural Affairs, Report "Total Income from Farming in the United Kingdom, first estimate for 2019", 20 Juin 2020

182 Department for Environment, Food and Rural Affairs, Annual Statistics on Livestock Numbers in England and the UK, 25 Mars 2021 https://www.gov.uk/government/statistical-data-sets/structure-of-the-livestock-industry-in-england-at-december

balance in butter and cheese, but a positive trade balance in milk and cream. Farm-gate milk prices for August 2019 were 28.6 pence per litre (ppl), up from a low of 21.5 ppl in August 2016. In February 2020, the farm-gate price was 28.6 ppl. Between 1995 and today, doorstep milk delivery has declined from 45% to 3% of the retail market. Supply chains were disrupted following the lockdown imposed to suppress the coronavirus outbreak in March 2020.
DEFRA reports that there are 1.86 million dairy cows in the UK with an average yield of 8,122 litres per cow. The average herd size is 148 cows.[183] Many herd sizes have 500 cows with a significant number having more than or up to 1000 cows. Most are specialist dairy units supplying milk to large milk processors.[184] DEFRA's farm structure report (01 Oct 19) shows that 2,800 holdings have between 100 and 150 dairy cattle. Additionally, the same report indicates that 4,300 holdings have more than 150 dairy cattle. Note that a business may have more than 1 holding although for this market assessment of scale and distribution it is sufficient to consider 'holding' and 'farm' as equivalent. There is little on-farm milk processing.

b. Energy consumption and heating requirement

Dairy farming techniques in France and the UK are similar. There is no easily accessed data on energy use per cow in the UK but hot water is required for raising dairy calves on milk supplement and washing dairy equipment.
Solar hot water systems have the most application in the high energy use agricultural sectors. For example, a dairy cow uses 350 kilowatt-hours (kWh) of electricity per year, of which around 40% is used for heating water.[185] Northern Ireland has less direct sunlight than many parts of Europe. The combination of direct and diffused sunlight which can be harnessed for use is between 1,000 and 1,100kWh per square meter each year.[186]

c. Potential for the use of solar energy

A dairy farm will produce 1 calf per cow per year so the average herd will produce 148 calves per year with 500 or 1000 not uncommon.[187] A high proportion of the female calves will be retained on the farm to replace older cows when no longer able to produce milk economically and the bull calves will be either euthanized or a small proportion sold, to be raised for beef. This will need to change because of recent agricultural policy so even more calves will need to be raised on dairy farms. Raising female calves to join the milking herd is the second largest cost of dairy farming on many farms so any reduction in cost, e.g. costs for rearing, would be welcomed. This makes dairy farming a potential market for STE.

3. Pigs

a. Presentation of the sector

In the UK there are 433,000 female breeding pigs and 4.5 million fattening pigs according to DEFRA in 2020.[188] Most pig farming is on an industrial scale and all costs are monitored carefully. Most pigs are housed although there are significant numbers kept outdoors. The pig industry is worth about £1.3 million.[189] Feed costs are about 10 times the cost of all other variable costs so cost reduction by farmers is targeted at optimizing feed costs.[190]

b. Energy consumption and heating requirement

Heating the housing for pigs is a cost that is not widely reported. However, one source of data available is from 59 pig farms recording on the Teagasc ePM records dated from 2015 The energy cost (heat, power and light) is €3.49 per pig produced (or €87/sow /year based upon 24.8 pigs produced/sow/

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183 House of Commons, Briefing Paper number 2721, 1 May 2020

184 Department for Environment, Food and Rural Affairs, Farm structure Report for June in UK, 01 October 2019

185 Ibid 184

186 Northern Ireland Business Info, Guide "How to switch to renewable energy" https://www.nibusinessinfo.co.uk/content/efficiency-and-environment [consulted on 21/06/2021]

187 FairvueFarms, Facts about calves, 2008: http://www.fairvuefarms.com/factscalves.htm

188 Department for Environment, Food and Rural Affairs, Report "Total Income from Farming in the United Kingdom, first estimate for 2019", 20 Juin 2020

189 Department for Environment, Food and Rural Affairs, Farming Statistics – Crop areas and cattle, sheep and pig populations at 1 June 2020 - England, 22 October 2020 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/928464/structure-june20-eng-21oct20.pdf

190 Quality Meat Scotland, Efficient Energy Use in Pig Feed Production https://www.qmscotland.co.uk/sites/default/files/Efficient%20Energy%20Use%20in%20Pig%20Feed%20Production_0.pdf

year). Most heating is restricted to young pigs and supplied by radiant lamps, pads, ducts or underfloor heating. Controlled environment systems are in place on some farms.[191]

c. Potential for the use of solar energy

There is some opportunity for solar energy to heat the farrowing operation to about 24°C The main energy costs incurred in other stages of the management of the pigs (weaning, finishing for slaughter and sow management) are in providing good ventilation and home mixing of feed. Ventilation systems are usually powered by electricity and the equipment used to prepare pig feed is also powered in this way (hammer mills, etc). A study by Quality Meat Scotland (an executive non-departmental body of the Scottish government) estimated that 85% of pigs were fed on feed grown and mixed on the farm.[192] There is therefore some incentive to reduce energy costs in the pig industry, but solar panels have been the main route towards this objective.

4. Poultry

a. Presentation of the sector

In 2018, the UK production value of poultry and poultry meat was over 2.6 billion British pounds. This translated to an output of 1.94 million metric tons that year. The overwhelming majority of slaughtered animals were broiler chickens, followed by turkeys (2 Dec 2020). Chicken is our most popular meat, with 20 million birds slaughtered every week in the UK. The vast majority (86%) of industrial-sized farms are in the poultry sector, with 1,534 industrial-sized farms. Previous research from 2017 found seven out of the 10 largest farms in the UK housed more than 1 million birds.[193]

b. Energy consumption and heating requirement

Temperature controls are important as temperature demands vary based on bird age and weather conditions, mature birds require much less heat than young birds (22°C compared to around 30°C).[194] Thermostats need to be in the correct locations to avoid overheating, away from draughts or doors.

c. Potential for the use of solar energy

Maintaining the optimum temperature of 22 to 30 degrees is important although STE is not widely used currently.

5. Horticulture

a. Presentation of the sector

British farmers produce 3.5m tonnes of fruit and vegetables every year – on 153,000 hectares of land. In addition, British farmers grow 14,000 hectares of plants and flowers. The UK horticulture industry employs approximately 40,000 permanent workers, plus 70,000 seasonal workers each year.[195] Protected cropping is the term used to describe glasshouse production. The area of edible protected crops grown in the United Kingdom, 2,377 hectares, has increased by 9% since 2015 and by 20% since 2013.[196] The trend is towards larger, fewer units to supply a perceived market demand for fruit and vegetables. The potential for the use of STE solar energy could be greatest for small glasshouses, which are many in the UK.

b. Energy consumption and heating requirement

The main use of energy is for heating and lighting. Almost all glasshouses require some form of heating. Traditionally they have been heated by gas or electricity. New huge glasshouses are being built. These often use 'waste heat' from nearby industrial operations and/or ground heat pumps. A 6 hectare

191 TEAGASC, National Pig Herd Performance Report 2015, 2015 https://www.teagasc.ie/media/website/publications/2016/Teagasc_National_Pig_Herd_Performance_Report_2015.pdf

192 Ibid 192

193 The Guardian, Industrial-sized pig and chicken continuing to rise in UK, 07 April 2020 https://www.theguardian.com/environment/2020/apr/07/industrial-sized-pig-and-chicken-farming-continuing-to-rise-in-uk

194 Charles, D.R, Temperature for Broilers, Cambridge University Press, 07 September 2007 https://www.cambridge.org/core/journals/world-s-poultry-science-journal/article/abs/temperature-for-broilers/A839C9F602F009BB78C555441BE9117E

195 Department for Environment, Food and Rural Affairs, Horticultural Statistics, 2 July 2020 https://www.gov.uk/government/collections/horticultural-statistics

196 Ibid 195

glasshouse using these heating methods is being built in Lincolnshire currently.

c. Potential for the use of solar energy

Solar energy has potential in this sector particularly if it could be used to cool overheating glasshouses and use any captured energy in other ways; although small greenhouses may exhibit the greatest demand, the cost of heat production can be shown to be economic.

III. Conclusion on British agricultural markets: Identification of the target segments

UK agriculture shares many similarities with French agriculture. This is not a surprise as we have shared the same agricultural policy (CAP) for 50 years. However, UK agricultural policy has now changed and from 1st January 2021 we will see some increased divergence. The practice of managing agricultural businesses in the 2 countries, as far as the farmer/manager is concerned is very similar, with a concentration on economic goals that have driven intensification, growth of farm size and a reduction in the numbers of farms throughout Europe.

Interest in reducing GHG emissions has prompted farmers and policymakers to incentivize their reduction. UK agricultural policy has indicated that rules to increase farmers' provision of public goods will be used to fundamentally change farmers' attitudes to environmental sustainability.

Against this background, UK farmers are primed for a technology such as STE to enhance their environmental credibility.

The UK's large dairy farms and relatively high use of water should provide a potential market for STE when proven economic.

The elements of the UK dairy farming as a potential market for STE are:

- The scale of the businesses - an average and growing dairy herd size of 148 cows.
- With 500 and 1000 cow herds common.
- Agricultural policy changes - new rules to ensure dairy bull calves are not slaughtered or exported shortly after birth.
- Potentially many more calves on dairy farms - many more calves on dairy farms implies high cost for rearing dairy replacement. This should provide sufficient scale and policy environment to begin a marketing campaign. Currently, veal production in the UK is at too small a scale to be considered but this might change as farmers are forced to keep or sell male dairy calves in the UK:
- Poultry is a highly specialized and integrated industry with a requirement for heating and could be considered as a market in due course.
- The pig industry is in the same category as the poultry industry.
- The protected crop industry has scale and the glasshouse units are becoming larger. A new 6 hectare glasshouse in Lincolnshire includes many environmental features e.g. waste heat and CO_2 from industrial processes are being used as heat pumps.

In the UK there are very few STE units in agriculture. A demonstration system is required and the results from ICaRE4Farms technical investigations are needed to begin providing data and examples to underpin a marketing campaign.

5 Ireland

I. Methodology

Data and statistics were sourced from various public sector, semi-state bodies and third-level institutes working in the agriculture or renewable energy sector. Teagasc, associate partner in the ICaRE4Farms project was the main source of information and have expert knowledge of farms and energy requirements in an agriculture setting.

An online Energy Decision Support Tool which is a collaborative initiative between Teagasc, Sustainable Energy Authority of Ireland (SEAI) and Cork Institute of Technology was also used as a source of data. The online tool demonstrates that energy needs/consumption varies greatly depending on the location and size of the farm.

II. Summary of results

A. Agriculture, energy Consumption and Financial Aid

According to the EPA (Environmental Protection Agency), agriculture is the single largest contributor to Ireland's overall Greenhouse Gas emissions, accounting for 35.3% of greenhouse gases emissions in Ireland.[197] However, only 3.2% of all greenhouse gases from agriculture are caused by fuel consumption. All government bodies and semi-state bodies which support the agriculture sector in Ireland are working on initiatives and research to reduce carbon emissions on farming including investment in renewable energy systems.

The main grant initiative to incentivise investment in renewable energy systems on farms is The Targeted Agricultural Modernisation Schemes II (TAMS II). However, the eligible projects for renewable energy include Solar PV and LED lighting but do not include STE systems. Larger farms can also claim 30% grant funding through the SEAI's Better Energy Communities (BEC) scheme. Farms could also apply for an STE system under the Support Scheme for Renewable Heat (SSRH) which is administered by the Sustainable Energy Authority of Ireland (SEAI).

Analysis from data and research in Ireland suggests that Solar Thermal systems are ideal for use in process heating, food processing or production, as well as for heating glasshouses. In the Republic of Ireland, the typical payback on a solar thermal system is highly dependent on utilisation volumes of hot water as there is neither a Renewable Heat Incentive (RHI) nor any other kind of subsidy at present to support solar thermal systems.

B. Sectoral Analysis

1. Milk Fed Calves

Ireland has a large surplus of calves from the dairy industry that are finding their way to the continental veal market in the Netherlands and other European markets. In 2018, according to Bord Bia figures, there was a 6,035 head or 15% jump in the number of calves exported to the Netherlands – bringing the[198] total number to 47,585 cattle: the majority of these going into veal production. Up until October 2019, the figure has jumped to 83,240 head – a rise of 35,655 or 75% on 2018 levels.

There are very few veal farms in Ireland and therefore it has been difficult to get data on farm and herd numbers. There is no data or information to suggest that STE systems would be applicable for this type of agriculture in Ireland due to lack of demand or opportunity to test.

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[197] Environmental Protection Agency Website: https://www.epa.ie/our-services/monitoring--assessment/climate-change/ghg/agriculture/

[198] Bord Bia, Irish Food Board, Dairy from Ireland, 2020: https://www.bordbia.info/dairy/

2. Dairy farms

a. Presentation of the sector

Over 18,000 dairy farmers milk Ireland's 1.55 million dairy cows. In 2019, Ireland produced 7.9 billion litres of milk, it was a 5% increase in milk production compared with 2018 figures. Data from IFA (Irish Farmers Association) state that the average herd size on Irish farms is 90 cows with an average production of 450,000 litres.[199] There are 11 milk processing and 13 milk purchasing cooperatives located across rural Ireland.[200]

b. Energy consumption and heating requirement

Energy consumption varies between dairy farms depending on the size of the farm, the heating systems used and the type of milking parlours. Data from Teagasc and Cork IT show that electricity usage on dairy farms contributes on average, 0.60 cent/litre to milk production costs.[201] In terms of electricity consumption per dairy cow milked, the figures vary from 4 kWh/cow/week to 7.3 kWh/cow/week. This is equivalent to €0.60/cow/week to €1.10/cow/week.

According to Teagasc, Electrical boilers are the most common method of heating water. Generally, the night rate of electricity is half the price of day time rate and farmers utilise this lower rate to heat water overnight. Oil and LPG systems reduce heating-related CO_2 emissions by 30%. Heat recovery uses waste heat to reduce water heating related to CO_2 emissions by up to 50%.[202]

Costs of electricity on Irish Dairy Farms:[203]

- Average costs are €5 per 1,000 litres of milk produced – there is a large variation in energy costs on dairy farms from €2.60 to €8.70 per 1,000 litres of milk, or from €1,500 to €4,500 on a 100-cow farm.
- The main drivers of energy consumption on dairy farms are milk cooling (31%), the milking machine (20%), and water heating (23%).
- The average farm could save €1,800 per year through a combination of altered management strategies and energy-efficient technology.

Figure 10: Results from an energy efficiency audit on 22 dairy farms in Ireland

	Percentage consumed Wh per litre[1]	Cost of electricity €c/kWh[2]	Percentage day tariff[3]
Milk cooling	13.02	0.16	60
Water heating	9.83	0.11	45
Milking	8.44	0.11	71
Lighting	1.37	0.02	89
Other	7.54	0.10	69
Pumping	2.13	0.03	38
Total	42.34	0.51	62

[1] Wh/L = watt hours/litre. [2] €c/L = Euro cent per litre of milk. [3] Percentage of electricity consumed from 9.00am to 12 midnight.

Most of the hot water required on dairy farms is used for washing milk parlours and cows before and after milking. Milking typically occurs twice a day, early in the morning and in the evening. Teagasc and Cork IT tested an STE system in 2010 for a dairy farm application but the results showed that the

199 Irish Farmers' Association, Dairy Factsheet: https://www.ifa.ie/dairy-factsheet/

200 Irish Cooperative Organisation Society, Brexit: Potential impact for Irish cooperatives, Preparation measures being undertaken & Priorities for the Irish Government, October 2018 https://data.oireachtas.ie/ie/oireachtas/committee/dail/32/joint_committee_on_agriculture_food_and_the_marine/submissions/2018/2018-12-12_submission-irish-cooperative-organisation-society-icos_en.pdf

201 TEAGASC, Dairy Farm Energy Consumption, at TEAGASC National Dairy Conference 2010, 2010 https://www.teagasc.ie/media/website/rural-economy/farm-management/DairyFarmEnergyCoonsumption.pdf

202 Ibid 201

203 TEAGASC, Factsheet Energy 05: Dairy farm Energy, 2020 https://www.teagasc.ie/media/website/rural-economy/rural-development/diversification/Energy-5-Dairy-Farm-Energy.pdf

STE system did not provide sufficient hot water for washing milk parlours in the morning. The results suggest, at the time of the test, that an STE system was not financially viable for dairy farms; however, the technology and efficiency of STE systems has significantly advanced since 2010.

c. Potential for the use of solar energy

The most common form of renewable energy on farms in Ireland is Solar PV. STE systems may be applicable as a form of Renewable Energy, but as part of this research exercise, it was not possible to find any dairy farms using STE in Ireland. At the time of writing this report, there are no financial grants for farmers to invest in STE systems as grant programmes are only available for renewable energy systems which generate electricity. This may explain why Solar PV and wind turbines are the most common for RE on Irish farms.

3. Pigs

a. Presentation of the sector

The pig industry is the third most important Irish agri-food sector, after dairy and beef, accounting for 8% of gross agricultural output.[204] The 2020 National Pig Census published by the Department of Agriculture and the Marine (DAFM) indicate that the national herd consisted of 1,675 active herds containing 1,702,921 pigs, The average number of pigs kept on an active pig herd was 1,017 which shows a slight increase on the average of 1,008 pigs per active herd in 2019.[205]

b. Energy consumption and heating requirement

Audits done by Teagasc on 23 pig farms show a huge variation in the energy usage ranging from 18 up to 45kWh /pig produced with an average figure of 28kWh/pig produced. The energy cost (heat, power and light) is €3.49 per pig produced (or €87/sow /year based upon 24.8 pig's produced/sow/year) [data from 2015].[206]

Energy on pig farms is mainly used for:

- Heating the farrowing and first stage weaner houses,
- Ventilation systems and fans,
- Feed delivery and mixing, power-washing,
- Manure pumps to mix and agitate slurry tanks.

c. Potential for the use of solar energy

For most pig units, the three biggest energy consumers are heating, lighting, and ventilation, so it is these areas that offer the greatest scope for efficiency savings. Teagasc provides guidance and advice to farms on energy-saving investments in the first instance to reduce costs and carbon emissions. Measuring, recording and benchmarking energy use across the business is the first step to improving energy efficiency, which is often expressed in kilowatt-hours (kWh) per pig or kg live-weight basis. A lot of the savings are greatly influenced by management which is the most important aspect of energy efficiency.

Solar Thermal Energy could have some potential application on pig farms, but it would have to be coupled with an existing regulated heating system. STE may have application for maintaining temperatures on pig farms.

4. Poultry

a. Presentation of the sector

There are an estimated 350 poultry farms in Ireland with 70 million chickens produced annually, 4 million turkeys and eggs from 2 million hens. The poultry industry is divided into 2 separate sections – poultry meat and egg production.[207] Over half of these are kept in enriched cages; the rest are in alternative

[204] Department of Agriculture, Food and the Marine, National Pig Census 2019, 2020 https://www.agriculture.gov.ie/media/migration/animalhealthwelfare/animalidentificationandmovement/nationalpigcensus/2019PigCensusReport190220.pdf

[205] Department of Agriculture, Food and the Marine, National Pig Census 2019, 2020 https://www.gov.ie/en/publication/5b140b-national-pig-census-2019/

[206] TEAGASC, National Pig Herd Performance Report 2015, 2015 https://www.teagasc.ie/media/website/publications/2016/Teagasc_National_Pig_Herd_Performance_Report_2015.pdf

[207] TEAGASC, Poultry Industry in Ireland, 2018 https://www.teagasc.ie/rural-economy/rural-development/poultry/

systems, mainly free-range. In each sector, production can be either highly intensive e.g., battery cage eggs, free-range or organic.

b. Energy consumption and heating requirement

Energy consumption and heating requirements vary greatly depending on the type of farm and whether it is an egg-production farm or producing broilers. Data from Teagasc[208] estimates that if 0.71 kWh corresponds to the total energy needs for one bird, then the heating cost represents a consumption share of 84%, i.e. 0.59 kWh/bird.

Example - A standard 73m x 18m 27,000 bird broiler house (without renewable energy installed) on average consumes between 240-266 Megawatt hours (MWh) of heat energy.

c. Potential for the use of solar energy

There is a potential for an STE system to maintain the required heat temperature on Poultry farms, but there does not appear to be any current sites using STE. The majority of heat and lighting required is used by LEDs which are powered with either Solar PV, Wind Turbines or conventional fossil fuel burning boilers, or a combination of both.

The Department of Agriculture, Food and Marine operates TAMS (Targeted Agricultural Modernisation Scheme) II which provides grant aid for a number of investments specifically aimed at improving energy efficiency in the farming sector. Examples of these include Plate coolers, Heat Transfer Units and Internal Ice Builders for the Dairy Sector. The Pigs and Poultry Scheme and the Young Farmer Capital Investment Scheme provides grant aid for biomass boilers, electrical heat pads, energy efficient LED lighting, indirect heating systems, solar panels for water heating and electricity production, ventilation fans and control systems, insulation for doors, roofs and walls, air source heat pumps and heat recovery units.[209]

At present (2021) the Rural Development Programme (RDP)-funded Targeted Agricultural Modernisation Scheme (TAMS) will cover 40% of the cost of many upgrades and 60% for young trained farmers up to a maximum spend of €80,000. The allocated budget for TAMS II over the full course of the RDP is €395 million. The budget for 2019 was €70 million.[210]

5. Horticulture

a. Presentation of the sector

The Department of Agriculture, Food & the Marine (DAFM) sources[211] estimate that the Horticulture Industry was worth €477m (farm gate value) in 2019, which is the 4th highest sector in terms of gross agricultural commodity output value – only Beef, Dairy and Pigs are larger.

Figures from Teagasc[212] state that there are estimated to be 180 nurseries and 212 commercial field vegetable producers growing around 4,600ha of crops. Horticulture in Ireland has two sectors: food and amenity produce. The key crops in the sector are mushrooms, potatoes, field vegetables, fruit, nursery stock, cut foliage, Christmas trees and bulbs. Mushroom production is the largest sub-sector of the horticulture industry. The mushroom industry (34 growers, [40 farms]) is the largest horticultural sector in Ireland followed in second place by potatoes.

b. Energy consumption and heating requirement

Horticulture in Ireland refers to both field-grown crops and indoor crops such as fruit, vegetables and herbs grown or glasshouses or polytunnels. The main use of energy is for heating and lighting in an indoor setting with the heating being provided by gas or oil burners although several large-scale farms have invested in Solar PV systems.

c. Potential for the use of solar energy

Solar energy has potential in this sector particularly if it could be used to cool overheating glasshouses and use any captured energy in other ways, although small greenhouses may exhibit the greatest demand as the cost of heat production can be shown to be economic.

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208 TEAGASC, Fact Sheet No 6: Energy efficiency on Poultry Farm, August 2018 https://www.teagasc.ie/media/website/publications/2018/Teagasc-A4-Energy-Fact-Sheet-No.-06-Energy-Efficiency-on-Poultry-Farms_2pp.pdf

209 https://www.teagasc.ie/rural-economy/rural-development/diversification/energy-efficiency-in-poultry-units/

210 https://smartfarming.ie/wp-content/uploads/2019/05/Michael-ODonoghue-Accessing-the-TAMS-II-On-Farm-Renewables-Fund-.pdf

211 Bord Bia/Irish Food Board, Irish Horticulture Industry https://www.bordbia.ie/industry/irish-sector-profiles/irish-horticulture-industry/

212 TEAGASC, Fact Sheet Horticulture 05: Production of nursery stock and ornemental plants, 2020 https://www.teagasc.ie/media/website/crops/horticulture/horticulture-factsheets/5-Production-of-Nursery-Stock-and-Ornamental-Plants.pdf

III. Conclusion on Irish agricultural markets: Identification of the target segments

Ireland has similar farming methods to the UK and other farms in Northern Europe. Although compared to other European regions, there is no significant data or documentation of Irish farms which have trialled or piloted an STE system. To date, the majority of research and investment by both public and private sector has been in Solar PV and Wind Energy.

Dairy farming is the largest sector of the agriculture industry in Ireland. On initial research, it would appear that the STE system would have a practical application in producing hot water for dairy parlours when combined with boilers and heat exchangers. The majority of hot water required on dairy farms is for washing milk parlours and cows before and after milking. Milking typically occurs twice a day, early in the morning and in the evening. Teagasc and Cork IT tested an STE system in 2010 for a dairy farm application but the results showed that STE systems did not provide sufficient hot water for washing milk parlours in the morning.[213]

In 2019, the Department of Agriculture, Food and Marine allocated an additional €10 million Renewable Energy Grants for Farms through the Targeted Agricultural Measures Scheme (TAMS). The amendments to the scheme were for the inclusion of Solar PV Installation on farms (to extend current availability under the scheme to all sectors). Grant aid in the pilot phase will be available for 40% or up to 60% in the case of qualified young farmers to fund the cost of a solar system of 6kWp.[214] TAMS II first opened in June 2015 and is set to expire in December 2020. This scheme is co-funded by the EU and the national exchequer under the Rural Development Programme (2014-2020) with a total allocation of over €395m over its duration.[215]

To date, the majority of STE systems in Ireland have been installed in a domestic setting with no documented investments or installations on farms. Solar Thermal Energy Systems requires more research and trials on farm sites in Ireland with the newer and more efficient technologies to give the agriculture sector confidence to invest in such systems. Furthermore, the grant assistance to invest in Renewable Energy are focused on electricity generation (Solar PV and Wind Turbines) and policy would need to change or be updated to incentivise investment in STE systems

213 Breen, M., Murphy, M.D., Upton, J., Development of a dairy multi-objective optimization (DAIRYMOO) method for economic and environmental optimization of dairy farms, Applied Energy, Volume 242, 2019, Pages 1697-1711 https://www.sciencedirect.com/science/article/abs/pii/S0306261919304647

214 Department of Agriculture, Food and the Marine, Minister Creed confirms opening of €10 Millions Renewable Energy Grants for Farms, 5 April 2019 https://www.gov.ie/en/press-release/25b833-minister-creed-confirms-opening-of-10-million-renewable-energy-grant/?referrer=http://www.agriculture.gov.ie/press/pressreleases/2019/april/title,125828,en.html

215 Agriland, What is TAMS II?, 2015 https://www.agriland.ie/tams-ii-what-it-is-and-how-to-apply

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- https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Agri-environmental_indicator_-_greenhouse_gas_emissions&oldid=374989
- Eurostat, Agricultural turnover in EU, 2018
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Annex

Interviews

1. Fengtech – Atelier de 368 places de veaux – ferme de M. et Mme. Broissin (Newspaper articles)

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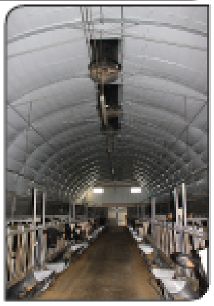
Des bâtiments performants pour une production sécurisante

Agriculteurs à Saint-Pierre-de-Chevillé, Patrick Broissin et Isabelle Berty ont agrandi leur atelier veaux de boucherie. Leurs tunnels, bien ventilés et éclairés, contribuent à la performance de leur production.

Dans les bâtiments tunnels de Patrick Broissin et Isabelle Berty, les veaux bénéficient de plus de clarté et d'une bonne ventilation.



Les deux premiers bâtiments ont été construits en 2015 sur l'exploitation de l'EARL de la pépinière, à Saint-Pierre-de-Chevillé. Des tunnels de 45 m de long sur 8,1 m de large pour accueillir une nouvelle production hors-sol : un atelier veaux de boucherie de 243 places. « *Ce choix a été mûrement réfléchi*, raconte Patrick Broissin, *c'est la production qui nous permettait le meilleur retour sur investissement, dans le cadre de l'arrivée de mon associée* ». Une stratégie gagnante puisque les agriculteurs ont agrandi dès 2016 leur atelier avec un troisième bâtiment, portant à 363 le nombre total de places. « *Et cet atelier est aujourd'hui la première source de revenu de l'exploitation qui regroupe, par ailleurs, 3 poulaillers de chair label rouge et 449 places d'engraissement porc* », constatent-ils.

Engagés auprès de l'intégrateur Denkavit (640 éleveurs en France, dont 19 en Sarthe), Patrick Broissin et Isabelle Berty ont signé un premier contrat de 10 bandes à prix fixe par veau, selon une grille forfaitaire. « *C'est vraiment sécurisant*, reconnaît Patrick Broissin, *le prix est connu. Et il est basé sur nos résultats techniques* ». Des résultats qui découlent du bon suivi des veaux par les éleveurs –avec une importance particulière pour les quinze premiers jours de démarrage–, et de la performance des bâtiments.

Ventilation et luminosité

Pour un coût de 1 200 € la place, les tunnels bénéficient d'équipements améliorés. « *La ventilation est assurée par des entrées d'air, situées sur chaque pignon, et par des sorties via trois cheminées au plafond*, décrit le producteur. *Les grilles perforées placées devant les entrées d'air, au Nord, ralentissent efficacement les flux sur le dernier bâtiment* ». Avec une isolation à la laine de verre de 25 mm d'épaisseur entre les deux bâches du plafond, l'ambiance intérieure est idéale pour les veaux. En ce qui concerne la luminosité, le troisième bâtiment dispose de deux fenêtres –au lieu d'une pour les autres– et d'entrées d'air plus grandes, augmentant la clarté intérieure.

Outre les bâtiments, les frais d'électricité et d'eau sont à la charge des producteurs. « *Nous avons besoin de 3 600 L d'eau chaude tous les jours pendant la phase maximum lactée*, rappelle Isabelle Berty, *le gaz représente donc une charge importante de l'atelier* ». Pour gagner en rentabilité –et en autonomie énergétique– les producteurs ont investi l'an dernier 40 000 € dans 12 panneaux thermiques Fengtech. L'eau du réseau, qui passe dans les tubes photosensibles, se réchauffe. Selon la saison, le gaz prend le relais pour atteindre une température optimale de 70 à 80°C. « *En un an, nous avons baissé de 60 % notre facture de gaz, en passant de 11 à 5 kg par veau* », soulignent-ils.

DELPHINE GROSBOIS

L'eau du réseau, qui passe dans les tubes photosensibles, se réchauffe. Selon la saison, le gaz prend le relais pour atteindre une température optimale de 70 à 80°C.

agri Tourainergies

Communiqué de presse porte ouverte 4 décembre 2019

62 % d'économies d'énergies dans un atelier de veaux de boucherie de 364 places en Sarthe (72) !

Grâce à la centrale solaire thermique brevetée par Fengtech

Dans un atelier de veaux de boucherie, le premier poste de charges pour l'éleveur – hors bâtiment - c'est l'énergie pour chauffer l'eau de buvée.

Mme BERTY et M BROISSIN, cherchaient une solution durable et économique pour chauffer de l'eau de buvée de leur 364 places de veaux de boucherie en intégration avec Denkavit. Leurs objectifs étaient de réduire leur facture d'énergie de façon significative et de participer à la protection de l'environnement avec naturellement une rentabilité économique. Ils ont choisi la centrale solaire thermique type ETF brevetée par FENGTECH (voir la photo ci-dessus). Ce système a été installé par Elevance, filiale du groupe Agrial en septembre 2018.

Depuis un ans de fonctionnement de la centrale solaire, Mme BERTY et M BROISSIN ont consommés 4 kg de propane par veau par an au lieu de 10.5 kg veau par an avant l'installation de la centrale solaire. C'est 62% d'économies d'énergies et environ 13 tonnes d'émissions de CO_2 en moins par an.

D'autre part, il faut signaler que l'installation est autofinancée, c'est-à-dire que l'économie d'énergie réalisée permet de couvrir le remboursement bancaire et de générer des revenus, ce dès la première année.

Fengtech, société basée à Laval en Mayenne, innove dans le domaine des équipements de centrales solaires thermiques pour les professionnels. La société a déposé 6 brevets et dispose aujourd'hui de plus de 35 sites installés dans le Grand-Ouest et le Nord de la France.

ELEVANCE — FENGTECH Energie Solaire Thermique — DENKAVIT

FENG TECHNOLOGIES SAS 14 rue Eugène JAMIN 53000 Laval Mail: contact@fengtech.fr

Tél: 02 43 49 75 45 / 06 76 21 25 28 www.fengtech.fr R.C.S. LAVAL 524 198 389 SIRET 524 198 389 00016

2. LMT, Interview minutes Agrithermic, 14/12/2020

Echange avec Agrithermic
Compte rendu
Date : 14 décembre 2020

I. Ordre du jour

- Présentation du programme ICaRE4Farms,
- Discussion sur le solaire thermique en horticulture et maraichage

II. Liste des participants

- Vincent Stauffer Agrithermic
- Nicolas Chomel Laval Mayenne Technopole
- Antoine Pinson Laval Mayenne Technopole

III. Synthèse

1 Agrithermic

Agrithermic est un bureau d'études de référence sur les questions thermiques en serres. C'est un des seuls acteurs européens spécialisés sur ces questions : il est présent sur d'autres pays européens (Royaume Uni, Pays-Bas).
Son activité est d'accompagner les acteurs de l'horticulture et du maraichage à travers 2 types de prestations :

- Diagnostic énergétique des serres,
- Conception de serres à hautes performances énergétiques et bioclimatiques.

Le bureau d'études a développé un logiciel destiné à calculer les consommations énergétiques : Hortinergy
Hortinergy intégre les spécificités des serres en utilisant notamment leur position géographique et leur productible solaire. Il permet de calculer avec précision les besoins énergétiques (consommation, puissance) et de dimensionner les équipements.
Agrithermic participe aux travaux réalisés sur le solaire thermique en horticulture et maraichage : il a ainsi participé aux études du CTIFL (centre technique légumes et fruits) sur le solaire thermique en serre en 2016 et 2020. Il a ainsi pu travailler sur 4-5 projets sur le STE.
Ce contact nous a été recommandé par d'autres responsables de centre techniques interviewés auparavant : David Vuillermet (station d'experimentation RATHO en horticulture) et Ariane Grisey (chargé de mission énergie CTIFL)

2 Chiffres et part du STE dans les besoins

Selon M. Stauffer, l'équipement occupe en moyenne 1/3 de la superficie de la serre (1 hectare de panneaux solaire pour une serre de 3 hectares), ce qui permet d'assurer 30% des besoins annuels, dont 90% en été.
Au niveau de l'installation, il estime qu'une attention particulière doit être portée au circuit hydraulique. L'eau des panneaux solaires étant reliée à un ballon tampon d'eau chaude, il n'y a pas de difficultés particulières pour apporter une source d'énergie complémentaire au réseau.
Dans les réseaux de chauffage à basse température (40-45°C), le solaire pourrait assurer 10% des besoins toute l'année sur les petites exploitations. C'est un marché de niches qui serait le plus adapté au STE, malgré la difficulté d'obtention d'aides de l'ADEME.

M. Stauffer insiste sur la déshumidification qui occupe une part importante de la consommation énergétique des serres maraichères. Cette problématique de l'humidité matinale est très présente dans les régions océaniques (Bretagne) : elle justifie un chauffage jusqu'en été (2/3 des besoins énergétiques d'hiver). Ce besoin de déshumidifier est estimé à 10% des consommations énergétiques annuels.

3 Le secteur maraicher

M. Stauffer estime cependant que la principale difficulté est liée au foncier disponible du fait que la surface des capteurs solaires est de l'ordre du tiers de la surface de serre. Cette contrainte foncière est encore plus forte aux Pays Bas.
M. Stauffer nous conseille de nous orienter vers des coopératives comme Saveol en Bretagne. Fleuron d'Anjou aurait peu de serres chauffées.

4 Horticulture

M. Stauffer estime que l'horticulture, qui a des besoins plus faibles en chaleur (eau 40°C), serait aussi un secteur intéressant pour le STE. Les serres étant plus petites que les serres de maraichage, elles seraient plus adaptées au solaire thermique. Il pense notamment aux producteurs indépendants de jeunes plants dont les serres font entre 800 et 1000m².

5 Les contacts potentiels

- NEWHEAT : développeur de projets énergétiques (serres maraichères incluses). Toutefois, Newheat se positionne comme vendeur de chaleur et investit dans des champs de capteurs. Il privilégie donc les champs de capteurs de grande dimension.
- BHR (bureau horticole régional) : situé à Angers, interlocuteur des horticulteurs et des pépiniéristes.

De plus, Agrithermic étant présent sur 2 des pays partenaires du projet (UK, Pays Bas), il pourra être utile pour trouver des sites dans ces pays..

3. LMT, Interview minutes CTIFL, 17/11/2020

Exchange wtih CTIFL
Report
Date : 17 November 2020

I. Agenda of the meeting

- Presentation of ICaRE4Farms programme,
- Identification of the structure of the market gardening sector and compatibility with Solar Thermal Energy

II. Liste des participants

- Ariane Grisey CTIFL
- Nicolas Chomel Laval Mayenne Technopole
- Antoine Pinson Laval Mayenne Technopole

III. Synthesis

1 CTIFL

The CTIFL (Centree Technique Interprofessionel des Fruits et Légumes) is a professional technical body is a professional technical body dedicated to the market gardening sector. It carries out research for market gardeners and supports companies with their expertise in the field. This structure studies fresh fruit and vegetables on a French scale. Established in the heart of the main French fruit and vegetable production basins, the four centers of the CTIFL constitute, in partnership or association with the regional experimentation stations, one of the main experimentation networks in Europe. The structure is composed of around 300 people spread across France, including two stations in the northern part of the country and in Carquefoe, near Nantes (44) and in Paris.
Within the CTIFL, Ariane Grisey is an engineer in charge of the "Environment - Energy Unit" at the CTIFL operational center in Saint-Rémy-de-Provence.

2 The market gardening sector return.

Mrs Grisey shared information on market gardening on its trends. Currently, 80% of the greenhouses in the market gardening are heated with gas at temperatures around 20°C, all year round. They have an average consumption of 300 kWh/m²/year. According to Ms Grisey, one of the next trends in the sector foreseen by the multiannual energy programming [MEP] is to slow down the production of co-generation energy in the coming years. Co-generation installations will cease to be subsidized by the French date from February 2021.

Within the sector, several factsheets will be published on the different types of energy in 2021. ADEME is currently testing solar power plant project in Nimes. This plant will focus on the issue of drying.

In the marketing in the market gardening sector, France has a park of approximately properly 1300 hectares of heated green houses and 6100 hectares of unheated crops. Most of the production comes from heated greenhouses (about eight out of 10 tomatoes).

3 Solar Thermal Energy in market gardening

In market gardening, the temperature requirements are high (greenhouses of several hectares heated by gas at high set points between 18 and 22°C for tomato production). Greenhouse growers have high water needs, and generally have water natural stations to 70-80°C (40 - 50°C in horticulture). Using fatal energy, the water needed to heat it to matter greenhouse is about 40°C, enough to reach the green houses target temperatures. Mrs Grisey has already carried out studies on solar thermal energy in market gardening. She has planned to produce factsheets on the various energies (including solar thermal) in 2021. For her, one of the main difficulties of solar thermal in market gardening is land: greenhouses generally lack space, and the installation of panels would require about 30% of the surface area.

She also give us some indications about energy tools in the Netherlands: the use of water from market gardening is centered around geothermal energy (advantage of flat ground) and heat pumps.

4 Contacts

Ms. Grisey was very interested in the use of solar thermal energy in greenhouses and asked for the contact details of the partners at the university of Lincoln to discuss the sizing of the green houses.
It also proposes to collaborate in more specific research is needed on TSE in horticulture.

4. LMT, Interview minutes GAEC Arc en ciel, 26/08/20

Interreg North-West Europe ICARE4FARMS

European Regional Development Fund

LAVAL MAYENNE TECHNOPOLE LMT INNOVER & RÉUSSIR

Meeting with the GAEC Arc en Ciel
Report
Location: Bazougers (Mayenne dept)
Date: 26 August 2020

I. Agenda of the meeting

- Presentation of the company,
- Presentation of LMT and the ICaRE4Farms programme,
- Identification of energy needs and attitudes towards solar thermal energy (STE).

II. List of participants

- Willem de Kam GAEC Rainbow
- Nicolas Chomel Laval Mayenne Technopole
- Antoine Pinson Laval Mayenne Technopole

I. Synthesis

1) About the company

- Willem and Marieke de Kam, Dutch citizens, have been living in Bazougers for 25 years,
- GAEC (Legal form of agricultural grouping) formed in 2018 with the arrival of their son-in-law,
- Activities: raising dairy cows (organic), processing and sale of Gouda cheese, pig breeding (fattening), recent bakery activity, camping on the farm, Hosting seminars.
- 105 ha of land and 70 dairy cows,
- 350,000 litres of milk per year, of which 300,000 are processed into cheese and sold directly.
- 2 full-time employees and 1 part-time employee (24 hours/week),

2) Energy needs and current systems

- Hot water consumption (65°C) is concentrated on milk production and processing:
  - Milking parlour: approx. 200 liters per day,
  - Cheese dairy: approximately 1 liter of water per liter of milk, i.e. 300,000 liters.
- Needs are covered both by flat solar collectors (6 panels of 2m2 each) and a wood shredded boiler. Both devices are connected in a boiler room to a 1500 litre hot water buffer tank. Thermal energy consumption is not measured.
- Electricity needs are covered by photovoltaic panels on the roof: 1550 m2. The production is 180,000 kWh per year, of which 20,000 are consumed by the company itself and 60,000 sold to EDF. In relation to this production, the total consumption of the farm (including housing) is between 50 and 60,000 kwh/year.
- The GAEC has received subsidies from Ademe (French agency for environment and energy saving) for solar and wood equipments up to about 20% of the investments.

3) Opinions and attitudes towards Solar thermal energy (STE)

- Willem de Kam met Liqun Feng a few years ago and found his solar system interesting. However, at the time, he did not choose it for technical reasons: the system had to operate in open circuit (without heat exchanger) which posed a problem in keeping it frost-free in the winter. He therefore opted for flat plate collectors installed on the roof.
- STE seems simpler to use than wood heating, which requires more maintenance: 2 days per year of technical shutdown, 2 days per year of shredding, feeding the wood silo, decentering, etc.

- Today, most milk cooling tanks (those of Serap industrie in particular) operate with heat recovery on the refrigeration unit.
- According to Willem de Kam, all dairy farmers producing cheese on the farm should be energy self-sufficient by mixing STE + wood + photovoltaics.
- Profitability and credit financing are not a major obstacle.

5. LMT, Interview minutes IFIP, 22/09/2020

Rencontre avec l'IFIP
Compte rendu
Lieu : Le Rheu (35650)
Date : 22 septembre 2020

I. Ordre du jour

- Présentation de l'entreprise,
- Présentation de LMT et du programme ICaRE4Farms,
- Identification des besoins en énergie et attitudes vis-à-vis de l'énergie solaire thermique (EST).

II. Liste des participants

- Rousseliere Yvonnick IFIP
- Nicolas Chomel Laval Mayenne Technopole
- Antoine Pinson Laval Mayenne Technopole

III. Synthèse

1) L'entreprise

L'IFIP est le centre technique professionnel du secteur porcin. Association type 1901, il regroupe 80 salariés, dont 50 sur son site du Rheu, et est organisé selon plusieurs pôles : pôle technique d'élevage, pôle bâtiment d'élevage, pôle économique. L'IFIP est également annexé à un bâtiment de recherche en agronomie (INRAE).
M. Rousselière est conseiller porcin bâtiment et équipement, au sein du pôle bâtiment d'élevage.

2) Le secteur porcin et les consommations d'énergie

M. Rousselière nous a présenté l'étude de 2013 « Guide du bâtiment à énergie positive » réalisé par l'IFIP avec l'aide de l'Ademe. L'IFIP envisage de mettre à jour cette étude en actualisant les retours sur investissement des équipements. Ceux-ci ont changé devant la hausse des prix de l'électricité tandis certaines technologies énergétiques se sont démocratisées.
La production porcine est divisée en 3 étapes, souvent réalisées par des éleveurs différents :

- Maternité
- Post-sevrage
- Engraissement

Les besoins énergétiques sont notamment présents durant la phase de maternité : cette période est étalée sur 28 à 35 jours. Durant cette phase, la consommation de référence est de 900 kWh/place ; la consommation de référence en termes de chauffage est de 729 kWh/place.
A titre de comparaison, les autres phases (Post sevrage, engraissement et gestation) ont une consommation de référence tous types confondus d'environ 300 kWh/place dont 67 kWh/place destinés au chauffage en Post-sevrage.
Les porcelets nécessitent des températures élevées de 35°C pendant leurs premiers jours à 25°C à la fin de cette période.
Les éleveurs mettent donc en place un chauffage : soit par radiants (lampes chauffantes) soit par plancher chauffant.au sol. Ils utilisent donc principalement l'électricité (radiant), mais aussi d'autres sources d'énergie pour le chauffage au sol. Il semble que le plancher chauffant soit encore minoritaire bien que plus économique.
Concernant l'eau chauffée, elle circule sous les places par un réseau de plaques au sol (en général 6 ou 8). On utilise en général 310 litres d'eau par place de maternité.

Il est fréquent qu'il y ait une perte calorique d'environ 2°C entre chaque plaque (la première étant généralement chauffée autour de 36-38°C).

3) Le potentiel de l'énergie solaire thermique

- Alimentaire : l'usage d'eau pour les soupes destinées aux porcs existe, mais l'utilisation d'eau chaude ne présente pas d'utilité.
- Chauffage : Au stade de la maternité et accessoirement du post sevrage, les éleveurs ont des besoins importants en chauffage. Cette consommation représente selon l'étude de 2013 environ 729 et 67 KWH par place en maternité et post sevrage.

Le souci est ici la saisonnalité. La saison estivale est la période où l'eau est le plus chaude mais aussi la période où les besoins en chauffage sont les plus faibles. Il y a également une perte importante calorique entre les plaques de chauffage au sol.

- Lavage des ateliers : cette tache (nettoyage des excréments porcins) se fait en général 1 fois toutes les toutes les 2 semaines en maternité. Elle nécessite des besoins importants en eau et en détergents. On utilise classiquement de l'eau froide associée à du détergent. Selon M. Rousselière, le lavage à l'eau chaude pourrait permettre des économies en eau et en détergent, tout en améliorant le confort du personnel dédié à une tâche ingrate. Cette utilisation de l'eau chaude pourrait être un supplément à l'utilisation principale pour l'eau de chauffage.

4) Suites

M. Rousselière est très intéressé par la technologie ETF et par les températures qu'elle arrive à atteindre. Il aurait souhaité visiter une exploitation porcine pour voir l'application de l'EST.

Il se pose aussi la question de la compatibilité entre la place accordée aux panneaux solaires au sol et les contraintes foncières, importantes en élevage porcin.

Afin de rencontrer des éleveurs pour les interroger sur leurs propres besoins en énergie thermique et leur attitude vis-à-vis du solaire, il faut contacter les conseillers des services « bâtiment » des groupements de producteurs. Les deux principaux sont Cooperl à Lamballe et Evelup à Landivisiau.

6. CCS, Interview minutes Friesland Campina, October 2020

Last year October we had contact with Nathalie Puijn from Friesland Campina. We exchanged some ideas regarding solar thermal energy to generate heat for nitrogen stripping (stikstofstripper), based on a business case we calculated for Anton Stokman. We see that we did not write much about it but we also talk on the phone about the combination of solar thermal energy and smart boilers (de boerderijboiler). This is an initiative from Friesland Campina to introduce small STE systems (2 STE panels + smart boiler) for dairy farmers.

They concluded from their own sample set of 80 pilot farms that small dairy farms in the Netherlands do not have a large enough heat demand to invest in large STE and storage systems (they only need hot water for cleaning if they don't pasteurize their own milk). The idea of the combination between STE and a small boiler is that the boiler does not heat to 90 degree all the time but keeps the water at 60 degree with a program to start heating when hot water is needed for cleaning. This saves gas, the STE panels further save gas by producing heat that is used to preheat the boiler.

vergister opwarmen naar 40 graden met een lucht warmtepomp (COP van 3:1 aangenomen). Voor de benodigde warmte is een kerntal gebruikt van 1,9Mj per cube groengas (bron ECN 2009). De electrische energie daarvoor wordt met zonnepanelen (220.000 kwh opwek per jaar) aangeleverd.

Opwekking en verbruik

Opwekking zon PV	220.000	kWh
Basisverbruik	180.000	kWh
Overig verbruik	-	kWh
Dagelijkse warm water vraag	506,7	kWh
jaarverbruik warm water	184.933	kWh
jaarverbruik totaal	364.933	kWh

Installatie parameters

Aantal zonthermische panelen	22	
STE productie jaartotaal	66.000	kWh
Gebruik gasketel?	0	Boolean
gebruik PV voor elektrisch verwarmen	1	Boolean
COP warmtepomp	3	factor
Aantal jaren tbv total cost of ownership (TCC	15	jaar

Energieprijzen en subsidies

NET toevoervergoeding elektriciteit	€	0,047	euro per kWh
NET leveringskosten elektriciteit	€	0,064	euro per kWh
NET energiebelasting en ODE (0-10.000)	€	0,151	euro per kWh
NET energiebelasting en ODE (10.000-50.000)	€	0,107	euro per kWh
NET energiebelasting en ODE (>50.000)	€	0,041	euro per kWh
Subsidie (Fasebedrag) SDE+ toekenning 2017	€	0,090	euro per kWh
Verwachte basiselektriciteitsprijs 2020 SDE+	€	0,047	euro per kWh
gasprijs (inclusief belastingen, excl BTW)	€	0,065	euro per kWh

Resulterend energiegebruik

Netto vraag en levering	Energie [kWh]	Kosten / baten	
Netlevering ELEK (elektriciteitsverkoop)	-115.123	€	-15.824
Warmtepomp winst	40.872	€	-
Eigenverbruik ELEK	104.877	€	-4.510
Nuttig gebruik zonthermische opwekking	65.924	€	-
Netvraag ELEK (elektriciteitsinkoop)	153.260	€	19.869
Netvraag GAS (gasinkoop)	-	€	-
TOTAAL verbruik	364.933	€	-465

Kosten elementen installatie (schatting)

Opwekking energie			
*Zonthermisch paneel all inclusive	€	44.000	euro
Opslag water			
Buffervaten 5x 2000 liter en 1x 1500 liter (tapwater)	€	5.261	euro
Randapparatuur, leidingen, appendages			
Afsluiters, mengventiel, circulatiepomp, keerklepper	€	1.575	euro
Isolatie	€	945	euro
Leidingen, beugels (koper)	€	1.943	euro

**grote variatie in materiaal- en installatiekosten 2000 tot 3500 euro per paneel all incl*

Associate Partners

Communauté d'agglomération du Cotentin (CAC)

deENet Kompetenznetzwerk dezentrale Energietechnologien e.V. (deENet)

Teagasc

Ebtech Glasshouse Systems

Lincolnshire County Council

Kamphuis Konstruktie BV

Ontwikkelingsmaatschappij Oost-Nederland NV (Oost NL)

Institut Technique de l'AVIculture (ITAVI)

Boerenbond

ICaRE4Farms - Increase the capacity of Renewable Energies (RE) in Farms in the North West Europe Region by using Solar Thermal Energy

www.nweurope.eu/icare4farms

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