Report from the regional workshops

Deliverable 3.3
Type: Report. Title: Final Report on AFF regional workshops outcome.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement ID 101000496

Document Summary

Deliverable title: **Report from the regional workshops**

Version: **2**

Deliverable Lead: **Aarhus University**

Related Work package: **WP3**

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Communication level: **PU - Public**

Project Number: **101000496**

Grant Agreement Number: **101000496**

Programme: **AgroFossilFree**

Start date of Project: **October 1st, 2020**

Duration: **36 months**

Project coordinator: **Centre for Research and Technology (CERTH)**

Summary

This report collates the submission reports from the 8 regional hubs that each organised and conducted three regional innovation workshops (RIW). The submitted thematic RIW reports comprise the outcomes of workshops about FEFTS utilisation and research and policy needs. The themes were divided into open-field crop production, livestock facilities and greenhouse production. A workshop guideline was framed to define the workshop objectives, agenda, scheduling, and templates (appendix 1). This was done in order to elicit, document and synchronise the output from the thematic RIW workshops. The output from each workshop is in this report combined into individual lists of FEFTS of interests and feedback, energy status in agri- and horticulture and FEFTS positioning, needs and enablers for FEFTS adoption, conditions and barriers for transition to and adoption of FEFTS and finally mitigation and innovative uses of FEFTS solutions. The lists provides a structured walkthrough of the regional opinions about relevant categories of FEFTS, the identified problems regarding energy in existing production systems, the assessment of relevant FEFTS for solving the problems identified, extraction of ideas on how to solve such problems, the suggestions to research needs, and the recommendation to policies to be incorporated nationally as well as in EU and the new CAP and other policy instruments to assist on FEFTS integration in local agri- and horticulture. This report also gathers the input from the regional presentations of the digital platform of the project comprising FEFTS solutions (https://www.platform.agrofossilfree.eu/en).

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1. Introduction

Novel FEFTS have the potential to contribute to the wider goal of meeting the increasing demand for energy in agricultural production while ensuring the sustainability of primary production, based on a more resource-efficient approach to energy production and use.

Over the past year and a half, the regional hub organizers has been conducting innovation workshops as part of the AgroFossilFree project. At the end of 2021 the digital platform comprising FEFTS solutions was developed and shared to the public. A short video describing the use of the AgEnergy platform is provided at AgroFossilFree's YouTube channel.

This synopsis output was informed by regional innovation workshop comprising workshop series of 'theme deepening' sessions for livestock farming, open-field crop production and greenhouse crop production. In the first half of 2022 these themes, guidelines (appendix 1) and the AgEnergy platform have been used as a resource for reporting of the series of both online and face-to-face workshops held from November 2021 to the end of June 2022. The purpose of this series was to use the themes and AgEnergy platform as the framework for idea generation.

In the table below the regional focus, organization, location and duration of each workshop is listed.

Table 1: Details of the 24 regional innovation workshops

Workshop title	Theme	Country and Region	Implementation	Primary administrator	Date and duration (h:m)	Number of participants including facilitators and note takers
Workshop on fossil free open field agriculture	Open-field crop production	Denmark, Northern Europe	Online via Teams *(Physical workshop on May16th, 2022 was cancelled)*	Senior Researcher, Michael Nørremark, Aarhus University	May 16th, 2022 1:30	17
Introduction of Agro Fossil Free in the Netherlands	Open-field crop production	Netherlands, Western Europe	Online via Teams *(due to local Covid-19 restrictions)*	Projectmanager Joris Tielen Delphy	January 26th, 2022 N.a.	162
Future of agriculture: Field robots, electric tractors and other alternatives to diesel fuel	Open-field crop production	Germany, Western Europe	Online via Zoom *(due to local Covid-19 restrictions)*	Project Manager Chuan Ma and Veronika Hofmeier WIP Renewable Energies	February 4th, 2022 3:00	85
Fossil-Free-Energy solutions in open-field agriculture in Greece	Open-field crop production	Greece, Southern Europe	LAB40 infrastructures of Drama Center of Commerce and Industry, Lamprianidou Lambrou 40, Drama 661 00	Research Associate, Konstantinos Vaiopoulos, Center for Research and Technology Hellas (CERTH)	March 1st, 2022 2:30	40
Energy Efficiency and Solar PV technology in Agriculture	Open-field crop production	Ireland, Western Europe	Teagasc Ashtown Food Research Centre, Ashtown, Dublin 15, D15 DY05	Energy & Rural Development Specialist, Barry Caslin, Teagasc	March 23rd, 2022 3:00	33
Renewable energies and energy efficiency in open field	Open-field crop production	Italy, Southern Europe	Azienda Agricola Casazza Via Appia Nuova, 93, 82018, Calvi, Benevento	Project manager, Elisa Tomasi, ENAPRA - Ente Formazione Confagricoltura	February 21st, 2022 7:00	52
Energy-saving practices in agricultural field production	Open-field crop production	Poland, Central and Eastern Europe	Lublin Agricultural Advisory Center, Pożowska 8, 24-130 Końskowola	Senior specialist, Martyna Próchniak, LODR	January 20th, 2022 5:00	36

Efficient nutrient management in field crops.	Open-field crop production	Poland, Central and Eastern Europe	Lublin Agricultural Advisory Center, Pożowska 8, 24-130 Końskowola	Senior specialist, Martyna Próchniak, LODR	February 24th, 2022 5:00	35
Third AFF Spanish Hub Regional Workshop	Open-field crop production	Spain, Southern Europe	Online via Google Meet	Consultant, Jorge Sneij, Trama Tecnoambiental and Consultant, Camino Fábregas, Iniciativas Innovadoras	May 11th, 2022 2:00	14
Farmers' response to questions about fossil free agriculture	Livestock farming	Denmark, Northern Europe	Questionnaire *(Physical workshop on May19th, 2022 was cancelled, follow up in autumn 2022)*	Senior Scientist, Frank Willem Oudshoorn, Innovation Center for Organic Farming	June 29th, 2022 N.a.	31
Integration and implementation of FEFTS in livestock farms	Livestock farming	Denmark, Northern Europe	Online via Teams	Senior Advisor, Arne Grønkjær Hansen, Innovation Center for Organic Farming	July 7th, 2022 N.a.	13
Electrical and hydrogen powered agricultural vehicles	Livestock farming	Netherlands, Western Europe	Proefboerderij Rusthoeve, Noordlangeweg 42, 4486 PR Colijnsplaat	Projectmanager Joris Tielen Delphy	May 18th, 2022 3:00	16
Energy saving, renewable energies and intelligent systems in livestock farming	Livestock farming	Germany, Western Europe	Online via Zoom *(due to local Covid-19 restrictions)*	Project Manager Chuan Ma and Veronika Hofmeier WIP Renewable Energies	March 11th, 2022 3:00	38
Technologies and strategies for sustainable livestock production	Livestock farming	Greece, Southern Europe	Arta Chamber of Commerce, K.Aitolou & N.Priovolou str., Arta, 47100	Project and Communications Manager, Mike Kaminiaris, AGENSO and Research Associate, Konstantinos Vaiopoulos, CERTH	May 22th, 2022 3:15	79
Heat Pumps in Agriculture	Livestock farming	Ireland, Western Europe	Teagasc Ashtown Food Research Centre, Ashtown, Dublin 15, D15 DY05	Energy & Rural Development Specialist, Barry Caslin, Teagasc	February 2nd, 2022 N.a.	25
Renewable energies and energy efficiency in livestock	Livestock farming	Italy, Southern Europe	Confagricoltura Mantova, Via Luca Fancelli, 4, 46100 Mantova MN	Project manager, Elisa Tomasi, ENAPRA - Ente Formazione Confagricoltura	March 29th, 2022 4:00	40
Innovative solutions for dairy farming.	Livestock farming	Poland, Central and Eastern Europe	Lublin Agricultural Advisory Center, Pożowska 8, 24-130 Końskowola	Senior specialist, Martyna Próchniak, LODR	March 23rd, 2022 4:00	23
Second AFF Spanish Hub Regional Workshop	Livestock farming	Spain, Southern Europe	Consell Comarcal d'Osona Carrer de l'Historiador Ramon d'Abadal i de Vinyals, 5, 3ª Planta, 08500 Vic, Barcelona	Consultant, Jorge Sneij, Trama Tecnoambiental and Consultant, Camino Fábregas, Iniciativas Innovadoras	May 9th, 2022 4:00	20
Sustainable energy production and storage on farm	Greenhouses	Netherlands, Western Europe	Proefboerderij Rusthoeve, Noordlangeweg 42, 4486 PR Colijnsplaat	Projectmanager Joris Tielen Delphy	May 24th, 2022 3:00	32

The future of covered horticulture: Renewable energies and energy efficiency in greenhouses	Greenhouses	Germany, Western Europe	Online via Zoom *(due to local Covid-19 restrictions)*	Project Manager Chuan Ma and Veronika Hofmeier WIP Renewable Energies	February 18th, 2022 3:00	100
Technologies and strategies for sustainable greenhouses	Greenhouses	Greece, Southern Europe	Agricultural University of Athens, Iera Odos 75, Athina 118 55	Research Associate, Konstantinos Vaiopoulos, CERTH and Project and Communications Manager, Mike Kaminiaris, AGENSO	April 8th, 2022 3:30	38
Using Carbon Neutral Biomass to Reduce Farm Fuel Costs	Greenhouses	Ireland, Western Europe	Teagasc Ashtown Food Research Centre, Ashtown, Dublin 15, D15 DY05	Energy & Rural Development Specialist, Barry Caslin, Teagasc	April 29th, 2022	19
Innovations and sustainability in greenhouses	Greenhouses	Italy, Southern Europe	Online via Teams	Project manager, Elisa Tomasi, ENAPRA - Ente Formazione Confagricoltura	May 25th, 2022 3:00	25
First AFF Spanish Hub Regional Workshop	Greenhouses	Spain, Southern Europe	Nave industrial Picassent Solar Cami de les Canyades, Picassent (Valencia), Diseminado Polígono 3, Parcela 229	Consultant, Marilena Lazopoulou, Trama Tecnoambiental and Consultant, Camino Fábregas, Iniciativas Innovadoras	November 24th, 2021 6:00	25

Participants were recruited to represent an array of stakeholders including agricultural and horticultural professionals, farmers/producers, researchers, agronomists, manufacturers, advisory services, local authorities, scientists, and managers.

Each workshop spent time discussion a few stakeholder presentations as a starting point for the workshop sessions. The presentations described a set of different conditions that could face FEFTS. They were planned to help stretch thinking towards new ideas for how best to prepare for an open innovation orientation. The idea of the workshops were to create new partnerships by bringing together all the stakeholders in the same thematic sector (e.g., all types of open-field crops, livestock farming and greenhouses), to take advantage of the multiplicity of expertise to identify innovations that are the most relevant to meet the fossil free challenges of the sector, to highlight these innovations in order to facilitate their adoption by the sector, to identify needs not covered by current available FEFTS solutions, and to define innovation priorities to feed into public policy in relation to FEFTS.

Each workshop progressed through a series of specific sessions chosen and arranged by the workshop organizers. According to the guidelines the compulsory presentation of the AgEnergy platform was done for all listed workshops in the above table.

1.1 Mandate

AgroFossilFree's Grant Agreement requests the preparation of a synthesis report, based on the reports of the regional workshops, highlighting common themes and issues as a way of providing broader insights into the results of the workshops, for later consideration.

1.2 Background

The guideline agreement in appendix 1 sets out the scope of activities related to regional workshops, and provides the basis for actions by presenting a list of activities that workshop organizers should undertake to the possible extent, taking into account national circumstances and priorities.

Three multi-actor workshops in each of AFF defined regional hubs, was planned to allow for the direct dissemination of novel FEFTS solutions and the capture of grassroots-level innovations and needs at a regional level. The central tool for interactive innovation in the hubs was the multi-actor workshops, bringing together research, extension, industry and farmers within and outside the project. The multi-actor workshops was organized by the AgroFossilFree regional partners, where their existing networks and consortiums was invited.

For all regions, each workshop was organized according to the following themes:

(i) Open-field crop production
(ii) Greenhouses and
(iii) Livestock Farming

However, in Poland and Denmark two open-field agriculture and livestock workshops were conducted, respectively. This was a possibility for the AgroFossilFree consortium to make these replacements, e.g. to replace 1 greenhouse theme by 2 livestock themes or 2 open-field agriculture themes.

In close collaboration with the relevant stakeholders, AgroFossilFree partners selected the most relevant FEFTS commercial solutions (6-10) from those assessed in WP2 according to the:

a) subject of each workshop,
b) results gathered in WP1 and
c) geographical and thematic scope of the manufactures, farmers, stakeholder, research/extension attendants.

An effort was made in order to ensure the participation of representatives of the respective national associations, RES industry, conservation agriculture, advisory services, smart farming industry, manufactures and of course farmers, in the workshops.

The selected commercial FEFTS solutions was presented in the workshops, allowing for:

(i) extracting feedback to the FEFTS research results to reach the farming community,
(ii) coming up with ideas for bringing the available FEFTS solutions into practice (adapted to specific regional conditions or different uses),
(iii) generating innovative uses for the existing FEFTS solutions.

In addition to the assessment of existing FEFTS solutions presented in the workshops, grassroots level ideas (or innovations) from all stakeholders was captured through identifying the pain points in the value chain which generate needs that could elicit an intervention with FEFTS solutions. During the workshops, the needs identified in the WP1 surveys (see D1.3) was to some extent validated, but new needs was also phrased, implementation and innovations was indeed captured. The lists and tables in this report synthesize the workshop outputs and enable the subsequent assessment of FEFTS for impact and feasibility. The structure and contents of this report supports the subsequent evaluation the FEFTS ideas' scalability, commercial value, resource requirements, etc. and for identifying the partner ecosystem, policies,

incentives, and the funding schemes needed for innovation-based collaborative projects. This is Task 3.4 where recommendations and policy guidelines will be defined.

This collective report of the hub workshop outcome is expected to include (Task 3.3):

(i) opportunities and specific needs in relation to FEFTS transition per region as identified
(ii) outputs issued from the workshops, collected under a well-defined common format/template in order to directly feed the AgEnergy Platform.

1.3 Scope of the RIW report

The present report is a synthesis of the outcomes, common themes and issues of the abovementioned regional workshops as presented in their respective reports and of the workshops' various presentations as made available.

In addition, the report outlines the key points raised by stakeholders in their views on advancing fossil free technologies in agri- and horticulture.

This report was prepared with a view to serving as one element to consider the status of task 3.3 deliverable, but in particular to advance the work on taking the pulse of the problems, needs and priorities in the framework of green transition for the agri- and horticultural sector.

Regional experiences shared and committed to paper during the workshops are represented in tables and lists. The structure of the report has been decided in order to make it possible for all RIW organizers to recognize their workshop output in this report. The tables and lists reports directly (or with minor rephrasing) the main findings from each of the 24 RIW, but divided into the following subjects: FEFTS of interests and feedback, Energy status in agri- and horticulture and FEFTS positioning, FEFTS needs and enablers, Conditions and barriers for transition to and adoption of FEFTS, and Mitigation and innovative uses of FEFTS solutions.

This Report provides a summary and synthesis of all findings from the workshops. The report collates 24 regional reports. The final section of the Report offers some brief reflections on how these findings might be considered and taken forward.

2. Priority action areas

Twenty-four multi-actor workshops were conducted covering the Northern, Western, Southern and Central/East regions of Europe. The workshops captured stakeholder's innovation ideas and needs on a regional level.

2.1 Overview

The central tool for information exchange in the regional hubs was the three multi-actor workshops, bringing together research, extension, industry and farmers within and outside the AFF project. The workshop guidelines and templates (appendix 1) were used before, during and after each workshop. Due to COVID-19 some workshops were done on-line with breakout rooms for group discussions of questions.

2.2 FEFTS of interests and feedback

Based on the guidelines, the workshop organizers were encouraged to prepare a number of FEFTS as presentations for discussion at the workshops (appendix 2). Below, for each of the three themes, the FEFTS that were highlighted and discussed at the workshops are listed. The main division of the list is aligned to the categories under the field 'Agricultural application' on the AgEnergy platform (see D2.1 for more details regarding the taxonomy and categorization applied on the platform's items). The individual technologies in brackets for each sub category can be found on the AgEnergy platform. The list is not exhaustive but reflects the specific FEFTS that were presented or discussed across the regional workshops.

The below FEFTS list reflects across themes that there is a great focus on the electrification of vehicles and the use of biomass, wind energy, geothermal energy, and solar energy as renewable energy sources for open-field arable and horticultural crop production and livestock farming.

There is also great interest in storing excess energy, either as fuel or as heat, or directly as electricity. Tools to measure and guide operations, as well as management tools which are constantly based on the latest knowledge, are also common topics across the three themes. It can also be immediately read in the workshop discussions that there is a need for combined or complete systems for efficient heating/cooling, lightning, and ventilation etc. for greenhouse crop production and livestock farming, which can be adapted to the individual farms in order to achieve large energy savings and shift the use of energy to renewable energy sources to the largest extent possible. It is evident from the workshop discussions that many FEFTS can be combined to form complete solutions.

1) Open-field crop production (FEFTS obtained from AgEnergy platform directly and translated from RIW reporting of FEFTS discussed):

Vehicles

Electrical

- Electric tractors (e.g. FT25G Farmtrac, Fendt e100 Vario compact tractor, John Deere tractors on renewable energy, eTrac, etc.)

Biogas/Biomethane

- New Holland T6 Methane Power Tractor

Hydrogen/Fuel-cell

- *Fuel cell technology, e.g. 400 kW Cummins fuel cell stack*

Energy efficiency

- Logistics for reduced fossil free use and machinery fleet optimisation

Agricultural field practices

Planting/seeding/weed control/Pesticide reduction

- *Electric powered autonomous vehicles*
- *AGRAS T16 - Crop Protection Spraying Drone*
- *Intelligent and connected orchard sprayer (e.g. Smartomizer H3O Sprayer)*

Precision agriculture

- Crop Sensor Isaria
- Mapping and satellite software platform for precision agriculture (e.g. MyDataPlant, AgDNA precision software, Farmer Core Software, InterNAV, etc.)

Fertilizer

- Production and performance of bio-based mineral fertilizers from agricultural waste
- Rational fertilisation and use of natural fertilisers, use of manure standards versus measurement of nutrient contents

Conservation agriculture

- No-till drill machines (e.g. Horizon DSX, CARBON-FARM 2, WEAVER - TRAILED GD Drill, Kings Agriseeds Monoshox NX M, etc.)

Irrigation

- Hydropower turbines (e.g. SMART Irrigation System, HyPump)

Soil organic matter

- Cover Crop Mixes and Individual Species
- Crop rotation management tool
- Increased crop diversification

Energy provision

Energy production and storage

- Performance evaluation of a geothermal and windmill based integrated systems for power and hydrogen production
- Hydrogen power plants, empowered by RES only
- Sustainable energy storage
- Biogas/biomethane production plant (e.g. Agriselect Biogas Plant, H2AD, EnviThan Gas Upgrading, etc.)

Wind energy

- Vertical wind turbine ECOROTE

Photovoltaics

- Brite Solar Glass

Training

- PLANET EU project - e-learning platform
- EU project SAGRI – “Skills Alliance for Sustainable Agriculture"

2) Livestock farming (FEFTS obtained from AgEnergy platform directly and translated from RIW reporting of FEFTS discussed):

Energy provision

Energy production and storage

- Biogas/biomethane production plant (e.g. Agriselect Biogas Plant, H2AD, Lundsby Biogas, etc.)
- Biomethane upgrading technologies (e.g. Sulfuric Acid Slurry Acidification, EnviThan Gas Upgrading, etc.)
- Industrial scale electricity storage and controlling (e.g. FENECON Energy Storage Systems)
- Geothermal heat pumps (e.g. Alternative Heating and Cooling Ltd., ELFOEnergy, Volker Energy Solutions, VATRA, etc.)
- Biomass pyrolysis (thermochemical) (e.g. BioGreen, SkyClean)

Wind energy
- Wind turbine (e.g. E70 PRO, ECOROTE, etc.)

Photovoltaics
- Solarwatt PV solar panels

Training
- PLANET EU project - e-learning platform

Heating and cooling of agricultural constructions *Biomass conversion*
- Biomass boilers (e.g. VIMEP biomass boiler, LINKA, Woodco Multifuel Boiler, etc.)

Energy efficient ventilation technology
- Air inlet fan (e.g. CoronaD air inlet)

Building management systems
- Automation (e.g. Hotraco Agri B.V.)

Heat/cooling for agricultural processes
- Heat pump (e.g. Clade CO2 heat pump, Hydro Royal Aquaculture Heat Pumps, Arwego e.K., Aspen, EcoHeat, etc.)
- Co- and trigeneration combined heat and power units (CHPs) for electricity provision while heating and/or cooling based on biomethane or other natural gases (e.g. UPB 924TC-B-I – CHP, TEDOM CHP units, etc.)
- Underfloor heating (e.g. Alternative Heating and Cooling Ltd.)
- Energy efficient cold storage (e.g. Milkplan)

Vehicles

Electrical
- Electric tractors (e.g. FT25G Farmtrac, Fendt e100 Vario compact tractor, John Deere tractors on renewable energy, eTrac
- Energy efficient machinery for saving fossil fuel

Biogas/Biomethane
- New Holland T6 Methane Power Tractor

Hydrogen/Fuel-cell
- Fuel cell technology, e.g. EOX175 electric and hydrogen tractor

Tools

Climate impact calculation tool
- DSS ESGreen digital tool for climate impact reduction
- Best-practice guidelines for farms and businesses on agricultural waste management (e.g. No-Agricultural Waste (NoAW) Horizon 2020 project)

Automatic management
- Complete control system for: milling, weighing, mixing and feed handling (e.g. Sobmetal Bracia Sobańscy)
- Automatic slurry handling (e.g. AgriManure)

3) Greenhouse crop production (FEFTS obtained from AgEnergy platform directly and translated from RIW reporting of FEFTS discussed):

Energy provision

Energy production and storage
- Geothermal heat pumps energy (e.g. ELFOEnergy ground medium)
- Battery storage (e.g. CEGASA eBrick 180 Pro)

Photovoltaics
- Solar panels (e.g. Atersa PV Panel Optimum GS Line)
- Transparent Solar Panel Technology (e.g. Brite Solar Glass)
- Solar thermal heat and cooling systems (e.g. SOLHO SPRHOUT)

Wind energy

- Wind turbine (e.g. E70 PRO, ECOROTE, etc.)

Heating and cooling of horticultural constructions

Biomass conversion

- Biomass boilers (e.g. VIMEP biomass boiler, LINKA, Woodco Multifuel Boiler, Halmfyr model 2815 BAL etc.)
- Wood pellet silos (e.g. A.B.S. silos)
- Co- and trigeneration combined heat and power units (CHPs) for electricity provision while heating and/or cooling based on biomethane or other natural gases (e.g. UPB 924TC-B-I – CHP, TEDOM CHP units, 2G Energietechnik GmbH, GTK 35 B - CHP Module etc.)

Irrigation for horticultural processes

- Solar water pump (e.g. LORENTZ PSk3)

Heat/cooling for horticultural processes

- Heat pump (e.g. Clade CO2 heat pump, Hydro Royal Aquaculture Heat Pumps, Arwego e.K., Aspen, EcoHeat, etc.)

Lightning

Energy saving

- LED and LED Chip on Board (COB) lamps (e.g. Pro Series LED Lightning Systems, Plantalux, etc.)

Vehicles

Electrical

- Electric tractors (e.g. FT25G Farmtrac, Fendt e100 Vario compact tractor, HV-100 Robots, etc.)

Tools

Climate impact calculation tool

- Digital tool for climate impact reduction (e.g. InfoGrow 2.0)
- Energy crop supply chains

Automatic management

- Complete measure, control and building management system for greenhouses (e.g. Argus Titan, RAM GmbH Mess- und Regeltechnik)
- Virtual greenhouse software

2.3 Energy status in agri- and horticulture and FEFTS positioning

The below Table 2 is collecting first the level of importance that energy consumption has on farm business and secondly providing information about current FEFTS integration where available/discussed at the 24 RIWs. Information is sorted by the themes open-field crop production, greenhouses, and livestock farming. The table collects the answers to the specific questions listed below and in the guidelines for RIW (appendix 1).

- Levelling the pain of energy consumption for local farms.
- FEFTS integration within local farms.

Table 2: Reporting from the RIW's on status on energy consumption and current FEFTS integration

DE	Open-field crop production	The actual agricultural and energy policies are not suitable to make the agriculture in Germany carbon neutral.
DK	Open-field crop production	Discussion directed to the unit of fossil fuel per product unit (kg grain, feed unit (e.g. silage), joule or other) and a demarcation of operations and input that belongs to crop production and fossil fuel consumption from presentation of FEFTS (arable field practices, vehicles, tools, and energy sales to external consumers using RES). Do not know the potential of alternatives to diesel. No doubt that farmers must comply with the CO_2 impact in the supply/value chain, there is no other choice. Acceptable that energy reduction measures cost. Farmers and machine manufactures are positive about reducing fossil fuel use, but the financing/funding scheme is an issue to reach common/public goals. Energy input is a "pain". Diesel consumption, it's obvious, but nobody is really doing something about it. Implementation of alternative energy sources becomes a pain.
ES	Open-field crop production	Energy consumption is a pain for ordinary agriculture, which is why conservation agriculture has been particularly appealing over the last two years due to the increased profitability caused by the rise in the cost of fossil fuels. Also, energy consumption is mostly related to irrigation. Farmers and cooperatives are integrating and using photovoltaic systems and biomass power generation to reduce electricity expenses generated mainly in crop drying processes or heating water for industrial processes. Also, the use of purines and bio-digesters for biogas production.
EL	Open-field crop production	Indeed, the energy consumption is a serious pain to the local farms. Highlighted the current increase of the energy cost, the reduction of the production as a side effect, and the deterrent effect to new possible farmers that may want to undertake new or even existing farms. Highlighted the significance of energy consumption pain in remote infrastructures that are not located close to cities or villages, where the transport to the location of the farm is accumulated to the total energy costs. Meaning that the fuel cost is a remarkable cost for them, as the farms are quite scattered/fragmented. Significant energy costs for plant protection applications and daily agricultural practices such as irrigation (e.g. water extraction by water wells), fertilization, tillage, and agricultural supplies (such as pest and disease control products). Energy costs in general, constitute one of the biggest pains and its confrontation is a matter of philosophy and attitude towards the issue.

		Bureaucracy problems act as limiting factors in adoption of innovative solutions to reduce energy consumption. There is a general Feeling that they are helpless against the increase of costs of nowadays' situations and circumstances. Highlighted the lack of FEFTS integration in the existing production units. Characterized the exploitation of FEFTS as one-way road towards the future modern type of large farms, and maybe also for smaller farms. A few participants stated that they already make use of the discussed FEFTS but they need further details and guidance for upcoming solutions such as mapping systems and smart tools. In conclusion, participants inclined positively towards the integration of FEFTS, despite their fear and uncertainty mainly for the small farms. Foresee it difficult but mandatory to integrate and implement FEFTS on the farms. Participants were mainly familiar with FEFTS about energy efficiency improvement, but also very interested in FEFTS presented regarding clean energy supply and soil carbon sequestration. Precision agriculture was introduced as a main FEFTS category based on the interests of the participants, with its integration still being performed. The use of several technologies and systems related to FEFTS such as the use of photovoltaics, the use of drones for crop monitoring, and the use of sensors for weed monitoring, the use of meteorological stations for measuring useful parameters are seen as solutions that farmers would like to use in the near future. These are already part of the agricultural practices that only few farmers have adopted so far in the region. Most of the stakeholders believe that they are necessary, but it is a matter of politics to promote them better and help farmers to adopt them faster. In addition, practices such as minimum tillage approaches, and the use of sensors for monitoring the soil inclination for proper machine setting were among the ones that the audience focused and discussed about a lot.
IE	Open-field crop production	Farmers generally felt that energy consumption is a big challenge on local farms. The uptake of e.g., RES, biogas, biomass boilers, and heat pumps will depend on access to capital for investment. The on-farm resources available and the amount of risk someone is willing to take will also influence the decision to adopt such technologies. Various incentives are now currently available to encourage the use of renewables on-farm. All respondents felt that energy consumption was a huge challenge on farms. This challenge was two-fold in that the embedded energy of many inputs are also severely impacted by the energy requirements for such inputs. There was a general view that almost every farm has the potential to generate renewable energy for its own use and ultimately to generate power for the national grid. However, the focus of the Government has been on large-scale projects.
IT	Open-field crop production	Awareness of FEFTS is present, but farmers desire to expand knowledge to find out more and to figure out if something is applicable to their farm FEFTS implementation blocked by a sense of frustration both regarding costs and the uncertainty of future benefits. In some large farms of the area, there's already a utilitarian approach to what we call FEFTS, such as biomass, photovoltaics, drones for fertigation and monitoring,

		sensors for weed monitoring, the use of meteorological stations for measuring useful parameters are already part of the agricultural practices of the region. Efficient vehicles, efficient tools, and precision agriculture, soil organic matter and tillage (soil carbon sequestration) were applauded unanimously.
PL	Open-field crop production (1st and 2nd)	A further increase in the price of fossil fuels was cited as a motivating factor for the wider implementation of renewable sources - economics is the strongest argument for introducing changes. Not all farmers are ready to develop at the same pace. There is also a large diversity of farms - the structure is quite fragmented, it is difficult to implement revolutionary solutions, it is difficult to find a uniform approach. Precision farming, no-till practices, crop rotation management tools, can help to solve the energy consumption problem. However, it requires promotional activities, dissemination. High and constantly increasing prices of fertilisers and energy were mentioned as a problem, which also translates into increased interest of farmers in rational fertilisation. Fuel prices have risen significantly which could influence the search for new, more economical solutions, however, the fear of uncertain future limits the actions, especially of smaller farmers. An additional factor is the European crisis, which also arouses many fears, including increases in energy prices, or even the lack of energy sources.
DE	Livestock farming	Primarily, there is a major need to reduce energy consumption. FEFTS examples in milk production farms are the use of vacuum pumps, pipe heat exchangers for cooling, efficient pumps for slurry management, and lighting. In swine farms the main FEFTS is for air conditioning (aeration) and infrared lamps with reduced energy requirements.
DK	Livestock farming	Quite a few farmers had already invested in FEFTS (i.e., electric machines, biogas plants, manure treatment, fuel saving technologies, heat pumps, heat recovery, carbon sequestration, planting forest and hedges), however, high electricity prices will probably slow down the investment rate. Energy production using solar PV has also gained increased interest. High energy costs due to energy crisis in Europe was mentioned as a main driver for increasing investments in photovoltaics, while biogas production was already peaking before that. Use of DSS ESgreen tool for climate impact reduction was also proposed.
ES	Livestock farming	Farms and livestock buildings have a substantial energy consumption. In addition, there is the need to adapt these buildings to the climate change outcomes adding cooling systems in general and heating systems especially for animal breeding all year. In addition, the food production for animals have a high energy consumption that needs to be factored in the equation or problem analysis (i.e., heat, steam, mixing etc.). Fossil fuel price is a major problem. Solar panels and systems based on biomass are very important. Lots of boilers have transition from diesel oil to biomass. Ventilation, heat pumps, milk cooling, RES and biogas based applications are slowly adapted. Animal food production has a high energy consumption. Increasing fossil fuel and energy costs will become a pain. Climate change will increase temperatures and add problems to livestock production.

EL	Livestock farming	The majority of the big-scale farmers use some innovative technologies in their production. FEFTS currently in use are photovoltaics, biomass boilers/CHP, biogas, wind turbines, smart control and automation unit systems, complete hardware and management solutions for livestock farms, LED lighting systems, relative humidity and temperature sensors, and ventilation systems. Integration and implementation of FEFTS in livestock farms considered as very significant for shaping the future agriculture of EU. Energy costs for heating and cooling are among the most significant production costs of livestock units, together with the animal feed costs that have increased recently. Participants were equally aware of the existence of clean energy supply FEFTS and energy efficiency FEFTS, with a slight lack observed in clean energy supply category. In several FEFTS the level of awareness exceeded the percentage of 80% and reached 100%. Only for Combined Heat and Power units (CHP), less than 1 out of 2 participants was aware about their commercial existence. So this indicates a quite sufficient level of awareness. Additionally, less that 2 out of 10 participants appeared to not be interested in any of the FEFTS presented during the workshop. Complete solutions and management systems were the most interesting FEFTS based on the participants' opinion. All participants unanimously declared that indeed, the energy consumption is a serious pain to the local livestock farms. They highlighted the significance of energy costs for heating and cooling, and the lack of awareness on novel technologies and systems. They also mentioned the elevated energy costs of nowadays that highly affect the final income deriving by the production. Some farmers mentioned that the energy costs constitute one of the major production costs, and together with the animal feed, are the two most prominent costs. Indicatively, since November 2021, they face more than doubled production costs due to increased energy costs.
IE	Livestock farming	There was wide agreement that energy consumption is a challenge for local farms and that energy costs are rising. Concerns: changing the social 'norm' of fossil fuel in agriculture, need to decarbonise, need to increase energy efficiencies on farms, insecurity of energy supply, dependency on imported gas for generation of electricity. Energy management challenges will be present when using RES. FEFTS currently in use were heat pumps for hot water production and heating for private homes, heat recovery of ventilated air. Less than 2% of dairy farms in Ireland have connected up a solar panel on their farm. Systems are driven by margins – costs vs outputs. Local farms often require a large amount of energy which cuts into tight profit margins.
IT	Livestock farming	In the agricultural sector, the issue of energy, its consumption and supply is becoming increasingly important. The livestock sector in particular was characterized, especially in the regions with a strong vocation, by a process of intense productive and technological restructuring. Interest in quantifying the direct energy needs of the national and regional livestock sector, which is anything but simple due to heterogenicity in terms of

		basic structure and production orientations. The technologies applied to the production process, on which the extent of energy consumption largely depends, vary significantly depending on the structural and production characteristics of the farms. The energy cost of farms still represents a small fraction of the total cost of production, about 5.5% in the dairy cattle sector and about 3.3% in the heavy pig sector. A total energy consumption of approximately 1,460 kWh per cow per year was detected, with reference only to activities related to farming, including the spreading of organic fertilizers. The most relevant electricity item is that of ventilation, with 20% of consumption, followed by the treatment of manure and fertilization (25.2%) and milking with 16.2% of consumption. The distribution of manure on arable land is also of great importance (26%). The other items of heat consumption have a decidedly lower weight, with litter distribution (6.8%) and milking (6.4%) in the lead. Ventilation and lighting, precision feeding and machinery (in general) and efficient buildings were applauded unanimously.
PL	Livestock farming	With energy prices currently on the rise, the problem is the high cost and low scale of use of renewable energy sources on farms. The costs of such installations are also currently high, and with unstable milk prices, such investments seem to farmers to be highly risky.
DE	Greenhouses	The actual agricultural and energy policies are not suitable in Germany to make the agriculture in Germany carbon neutral. Energy sources applied today was heating oil, natural gas, other fuels, wood chips, coal, biogas/biomethane, pellets, solar energy, sorted by highest share. No geothermal and hydrogen users.
ES	Greenhouses	All responded that energy consumption is a pain for local farms. Main reasons are the high prices of energy and the high energy consumption. In addition, the schedule of energy consumption is not in favour of the farmers. Farmers dealing with irrigation (and lack of rain) feel this pain. Overall, high energy prices affect the production costs and the final margin/revenue of the farmers. One participant pointed out that in his view, the farmers who have transitioned to renewable energy are those with low energy consumption. Foresee FEFTS integration within local farms as not easy. High initial investment, lack of incentives, tedious bureaucracy and permits. Also due to lack of knowledge and perceived risks. One participant pointed out the traditional culture of the agricultural sector as a factor that may generate distrust, resistance to change. Last but not least, small farmers feel very difficult accessing to incentives Photovoltaics was the most mentioned FEFTS. Also, wind power, biomass, biogas (from animal waste) for heating. Lightning was the most mentioned FEFTS. Also, temperature control, better irrigation management, energy storage, ventilation, insulating systems, hydroponics, LED lights, pump management. The majority of participants said these FEFTS are available. Few of them stated lack of knowledge about it.
EL	Greenhouses	FEFTS in use was basically photovoltaics, heat pumps, and vertical LED lighting systems.

		Pay much attention to the life span of the purchased FEFTS, aiming to balance the costs and profits, in order to achieve the optimum benefit from the investment. Most of the participants mentioned that they do not use many FEFTS. Farmers who use FEFTS, mostly invest in photovoltaics, heat pumps, and LED lighting systems, with a small percentage opting for biomass boilers for the unit's heating. All participants unanimously declared that indeed, the energy consumption is a serious pain to the local greenhouses. Energy costs for heating and cooling are among the most significant production costs of their units. They highlighted the significance of energy costs for heating and cooling, and the lack of awareness on novel technologies and systems. They also highlighted the lack of agricultural cooperatives as a significant factor regarding the final energy cost. Meaning that cooperatives' existence could lead to settlements with energy suppliers for lower energy prices. In addition to that, they mentioned the huge gap regarding technological equipment among the various greenhouses in Greece, as well as the differentiating weather conditions in the different regions of the country where greenhouses are located (Attica (central Greece) vs Crete (southern Greece)).
NL	Greenhouses	Limited business models for investments in renewable energy, and there is no business model for agricultural entrepreneurs to produce energy for other end users. RES is often a way to reduce costs of own production rather than earning money from energy production. FEFTS efforts are not rewarded in the price of the products.
IE	Greenhouses	There was wide agreement that energy consumption is a challenge for local farms because of the high usage. Mushroom sector consists of high users of thermal energy and electrical energy and increased costs are affecting margins. Energy costs are rising and are a huge challenge for producers. Spotlight has shone on consumption. Renewable energy incentives are important to drive conversion. Alternative energy sources are becoming more necessary because of energy costs and carbon emission reduction challenges. Need to increase energy efficiencies on farms. Insecurity of energy supply. Challenging national climate and sustainability targets.
IT	Greenhouses	Energy consumption is a pain for greenhouse industry. The thermal regulation of greenhouses requires a large amount of energy compared to open-field cultivations. With following higher production costs and greenhouse gas emissions. In recent months, the price of natural gas has increased exponentially, becoming unsustainable for many companies. Participants were mainly familiar with energy efficiency improvement FEFTS, but also very interested in FEFTS presented regarding clean energy supply. Precision agriculture was introduced as a main FEFTS category based on the interests of the participants.

2.4 Needs and enablers for FEFTS adoption

The below Table 3 is collecting the needs and enablers for FEFTS adoption that was discussed at the 24 RIWs. Information is sorted by the themes open-field crop production, greenhouses, and livestock farming. The table collects the answers to the specific questions listed below and in the guidelines for RIW (appendix 1).

- Feedback to FEFTS industry for improving the FEFTS or adjusting them to the specific regional conditions to bring them into practice.
- New uses for the FEFTS presented (i.e., FEFTS presented for arable crops that can be adapted for vineyard)
- Users' needs identified and everyday practices
- Needs regarding FEFTS
- Ideas regarding the use of FEFTS in the agri- or horticultural system you work on

Table 3: Reporting from the RIW's on needs and enablers for FEFTS adoption

DE	Open-field crop production	Make the availability of RES at affordable prices. Battery technology, as well as PV modules on the machines/robots. Hydrogen, as a product of temporary overproduction of PV electricity. Emission reductions of fertilizer production. Finding the right processing equipment and the right fuel for the size of the farm in question. Most participants claimed that (when they had a single choice) GHG emissions could be reduced the fastest by renewable energies (51%), energy efficiency (25%), and carbon sequestration (24%). When asked about the dominating fuels technology for tractors, in 20 years, the participants answered: diesel engine fuelled by plant oils and hydrated plant oils (28%), hydrogen technologies (18%), diesel engine fuelled by biodiesel (16%), bio-methane engine (14%), diesel engine for fossil fuels (8%), electric engines (8%), and others (8%). Allow also GHG reduction accounting for electric tractors, similar to electric cars. This accounting and the sale of GHG quotas for cars could generate about 250€ per year and per car.
DK	Open-field crop production	The use of nitrification inhibitors and impact on CO_2 compared to the impact of fossil fuel alternatives/green energy for open field agriculture. Reduced tillage. Smart arable land distribution. Infrastructure for alternative energy sources to obtain maximum operating time while minimizing operational disruptions. Doubts about energy efficiency in liquid alternative fuels. Intelligence in the conversion of biomass or sun/wind into fuel, so that loss of energy is avoided. Alternatives must be distributable. Energy-intensive liquid fuel that can be used in existing engines hydrogen and hydrogen/fuel cell vehicles. Engine manufacturers are looking at the hydrogen route, either hydrogen combustion engines or hydrogen and fuel cells in combination. Own production of electricity, as it is consumed and produced in the same place, and thus does not burden the wiring network. Local energy production on the farms (wind, biogas, possibly electrolysis) or several farmers join forces. Wet pyrolysis for bio-oil. GTL from biogas to existing diesel engines, production of NH_3 for fertiliser, and sees potential in recycling biomass for fuels. Need for support tools for machine analysis and decision support systems. Idle effects and consumption (electronic control unit data analysis showed that 20% of tractor uptime is idle). Need for data analysis of machine data. Tools for driving

		patterns and field/road transport, logistics. Implement and test existing. Use of robotics Express/calculate potential for savings. Make comparison between different technologies possible. Implementation important. Important to study the whole value chain and where to make the highest impacts/whole energy circle, find individual elements. “The hen and the egg”. Look at the entire system/energy cycle, not so much on individual technologies. Remember the rating on the AgEnergy platform and include the energy cycle.
ES	Open-field crop production	Need to reduce the electricity consumption (e.g. irrigation), water management, self-consumption, pumping, mobility, farm drying processes, heating water for industrial processes, emission reduction, minimize production costs, and increase sustainability. Technical support is needed for farmers because the day to day in the field occupies full time attention. Make things easier for them and show the benefits with practical cases and advising. Use cooperatives as a driver of knowledge transfer and provide them with the necessary support for all issues of technology adoption and bureaucratic issues. Do not want to stay only in the investigation phase, if a good practice is profitable, activate incentives so that other farmers can start down that path. Pilot tests for crop diversification and adaptation to climate change, and food sovereignty. There are many varieties that could have potential. Intercrop crops. Have crops all year round to keep the soil covered. This requires advice, dissemination but also technology. Training and financial support to implement conservation agriculture practices are needed.
EL	Open-field crop production	Development of energy communities for the optimum exploitation of existing energy sources is needed. The potential of RES when exploited by groups (“umbrella” type for assisting all farmers with the same cultivations, aiming to further reduce the final cost). Targeted and horizontal imposition and enforcement were introduced as an effective solution. Need for training, financial aid, advisory services and networking establishment for transition to FEFTS. Need to organise and act in groups for an effective transition, along with knowledge transfer in to order to be supported and national plan for this process. Use of photovoltaics, the use of drones for crop monitoring, and the use of sensors for weed monitoring, the use of meteorological stations for measuring useful parameters, as well as the minimum tillage approach and the use of sensors for monitoring the soil inclination for proper machine calibration. Finally, the use of solar radiation for pest control in cotton cultivation, along with the use of models for early detection of pests and diseases.
NL	Open-field crop production	Sustainable energy production on farm cannot go without energy storage on site, i.e. manufacturers should provide both solutions. Electrical or hydrogen powered tractors are too expensive and unsure expenses at the moment, i.e. doubts about market acceptance and reliability. The limited time of batteries on electrical vehicles severely hampers the usability and convenience of electrically powered tractors and thus technological innovations are needed.
PL	Open-field crop production	Farmers believe that precision farming solutions and no-till practices can reduce the use of fossil fuels, but from their perspective these are risky investments in such uncertain times and when there is no guarantee of the sale of agricultural products. In the case of expensive equipment, it is increasingly common for farmers, together with friendly forms, to adapt and design the equipment

		themselves to suit their needs and farm conditions. There are many modern technologies, applications and programmes available on the market, but often the data held by the farmer are not coherent - this causes chaos and confusion - the data format from one application does not always fit into another. There is no synchronized system of data processing. The topic of high equipment prices and modern technology was raised. An interesting solution may be a gradual adaptation of a farm by introducing elements of modern technology step by step - e.g. smartphone applications. A good thing is that farms are being taken over by young people who are better able to cope with modern technologies and will be able to better adapt to the current conditions, additionally they are more willing to use innovative solutions. Farmers are left without support after receiving aid or purchasing new equipment. They require assistance to operate the equipment and new technologies. Financial bonuses do not solve the problem, because farmers are often not able to cope with the use of their technologies on their own. There are solutions, where private companies take care of the equipment or there is a person employed on the farm, who takes care of the use of new technologies, but this concerns very large farms. Also the state consultancy is not sufficiently prepared for the transfer of innovative solutions - there is a need for specialised units dealing with precision farming and modern technologies. Problems with renting equipment to try it out on their own farm. There are also problems with crop rotation: availability of seeds, lack of market possibilities for certain groups of crops, or the exclusion of fields for the cultivation of certain species, e.g. for green manure. The role of crop rotation was emphasised as a comprehensive approach allowing savings through restoration of soil fertility and humus content (soil cover, appropriate crop sequence, use of intercrops, manure) which results in better use of nutrients, lower production costs, lower fuel and fertiliser consumption, higher yields. Mulching, leaving the soil under cover allows water to be retained in the soil and increases the humus content in the top soil layers, which is very desirable in Polish conditions. The market for biogas production is still underdeveloped - it has great potential for exploitation, but there is a lack of support and favourable regulations for its development. Farmers underline the lack of valuable studies and access to reliable information on FEFTS. They point out the need to prepare a compendium of knowledge. Farmers indicate the need for workshops to show machines at work, good examples of FEFTS application on demonstration farms. There is a lack of opportunities for farmers to go to demonstration farms abroad. Currently, there are a lot of different types of applications and internet platforms related to agricultural production. Not all farmers are able to navigate in it, and if they have to log in and enter data, they are less willing to use such tools. An untapped potential in Poland is biogas plants, which could solve the problem of surplus natural fertilisers, manage the organic waste market and contribute to an increase in farmers' incomes. Farmers could sell part of their production or its by-products as a substrate and in return use the digestate as fertiliser. Need to become independent in terms of energy and of raw materials. This is an opportunity to develop RES. Solar energy, wind energy or hydropower (pumped storage plants) should be used as much as possible.

		Another opportunity for farmers is green certificates, the implementation of which can also contribute to the application of good carbon sequestration practices by farmers, which will also contribute to reducing the negative effect of fertilisation through better use of fertilisers and maintaining their surplus in the sorption complex at the application site.
IE	Open-field crop production	Participants felt that with increasing energy prices that they will see increased payback on FEFT technologies but are concerned about the rising costs of these FEFT technologies also. Solar PV and energy efficient technologies will future proof their businesses, They found it difficult to acquire independent information regarding certain technologies such as PV and other energy efficient equipment which relates to their business. Solar PV and energy efficient technologies will future proof their businesses. The current opportunities for farmers are to lease their land to solar, wind and energy storage developers. Dedicated educational and training programs around the various FEFTS available. Enforcement of advisory and extension services for farmers, in order to facilitate support to farmers and producers.
IT	Open-field crop production	Familiar with energy efficiency improvement FEFTS, but also very interested in FEFTS presented regarding clean energy supply. Precision agriculture was introduced as a main FEFTS category based on the interests of the participants, especially by the fact that some major wineries and olive oil mills in the area are starting to adopt these technologies. Suggested to implement technologies regarding the transportation of waste produced by the biomass plants, which in Italy are almost non-existing. Many of the technologies shown were applauded unanimously: this reflects the fact that not only the need of competences is clear, but that the chosen FEFTS were really useful. Virtuous behaviour is the best way to show directly the benefits to peers, due to the upcoming generation of farmers which are less resistant to change.
DE	Livestock farming	Agricultural machinery can contribute to reducing GHG emissions. Realised that engine and agricultural machinery manufacturers do not yet favour a specific common solution, but rather rely on different technologies. Most participants claimed that (when they had a multiple choice) GHG emissions could be reduced the fastest by renewable energies (70%), energy efficiency (70%), and carbon sequestration (10%). Grid energy systems are essential components in order to implement decentralized and intelligent energy distribution, especially with regard to improved integration of RES. In addition, decentralized power generation and use increases security of supply and added value for the farmer. With increasing automation and electrification of machines and systems, the use of self-produced energy from RES will make an important contribution to the environmentally friendly design of agricultural production processes in the future.
DK	Livestock farming	Better practical advisory on solar power (agrivoltaics). More arable land distribution among farmers. ESG GREEN tool for Danish agriculture could be further developed and used in other countries and collaboration would make it possible to compare technologies from different countries and between application areas regarding the CO_2 impact. More research into use of pyrolysis as a manure treatment technology, especially the effect on soil and nutrient utilization after treatment. More work on biogas

		and side products. More support to insect production as new livestock and for feed production (alternative to fish meal and soya). More energy saving machinery and test results. More marketed machines powered by electricity, hydrogen, or methane. Machine using alternative fuel or power should be developed. More farm-scale wind energy. More work on robotics in agriculture. More low energy building materials. High interest and need for the AgEnergy platform, but a key criticism was the lack of economic information. Only 3 participants could imagine contacting foreign dealers. The required investment on individual improvement is too large.
ES	Livestock farming	If we factor in the cost equation the energy cost related to food production that is what sums up the bigger percentage and becomes the bigger problem. Approximately 70% of production cost is related to feeding. With focus just on the farm or livestock building domain, the more important problem is related to the cost of heating and cooling during the whole year. Filtering systems have a high energy consumption. The agriculture sector is quite atomized in the territory (at least in Spain) and there is a lack of grid interconnection to transfer your surplus of energy. In terms of energy management or energy trading, the sector has no opportunities a priori. Solar photovoltaic can be applied for many reasons but does not enable to use the full potential due to the lack of possibilities to sell the surplus of energy back into the grid. "Transfer centres" are key to foster knowledge dissemination and innovation adoption. The agriculture sector is eager to adopt changes. New technologies are not an issue. Information websites are valued. Support the word of mouth (practical experience) and demonstrations.
EL	Livestock farming	Photovoltaics, heat pumps and biogas production units could be the solutions to their problem, together with expansion of the energy producing units for sales to the external consumers. In addition to that, participants also mentioned the lack of proper buildings' insulation for reducing energy consumption.
NL	Livestock farming	For the FEFTS that were discussed in this workshop, there are always pioneer users who seek for these innovations out of personal interest and motivations. In market share, they represent roughly 5 to 10 percent of all customers. The rest follows after the technology or practice becomes economically and operationally viable and sometimes there is a last percentage that has to be forced to switch to new innovations. The FEFTS discussed are still in the pioneering phase. Enforcing these innovations through policy is not desirable according to the participants, as often local circumstances and finances are not sufficient yet. Therefore, it would be good whenever there would be support for pioneering farmers, guidance in the use of this new innovation and some financial support or acknowledgement or reward for their intention to start producing more sustainably. Hydrogen needs more research or extension services to farmers, e.g. about container storage on farm, how containers of hydrogen can be managed and what policies are there for the ownership and use of hydrogen containers.
PL	Livestock farming	A way out of necessary large scale and labour demanding situation are precise solutions, which, however, require large financial disbursement. All of these precision solutions have a significant impact on reducing energy, labour and therefore financial resources spent on milk production. Herd management based on precision technology optimises feeding, reproduction, early detection of health problems and electronic identification of animals. All these solutions are

		perceived by farmers as tools which are very helpful in increasing the economic and energy efficiency of the farm. Water retention based on aboveground and underground tanks storing rainwater from the roofs of livestock buildings is a good solution to the high demand for water from cattle and the current meteorological conditions.
IE	Livestock farming	Heat pumps need to be combined with solar PV and battery capacity. Heat pumps have many uses on farms, including in milk cooling process and with PV. Heat pumps have been successful on pig farms and continue deploy heat pumps on pig farms to heat houses and for heating of water for washing purposes, hot water and steam sterilisation systems. Integration with an entire energy management system including battery and PV. Potential discussed for use of heat pumps on swine, poultry, horticulture sector and on dairy farms. Encourage the utilisation of heat pumps, and more projects are needed showcasing the use of heat pumps. E.g. 5 steps to installing a heat pump' and show cases. Systems for cooling and heating at the same time. Reduce electricity costs for heat pumps. Potential for integrating heat pumps with PV panels could be better explained and sold as an integrated system on farms. Remove grid connection costs for heat pumps. Geothermal suitability maps exist that cover the entire country of Ireland and the potential is there to assess ground source heat pumps (GSHPs) resource for any farm or location. Enhance training of farmers, advisory services and installers. Technical assistance needed. Provide standard solutions as much as possible. Need simple communication on how and why, what costs and savings achievable. Feedback for improving the FEFTs or adjusting them. Integration is possible with the right supports and place for loans. Universal potentials of FEFTS from dairy to horticulture, but there is a need to encourage more practical approaches to encourage uptake of grants regarding the requirements of approval to make it more feasible. Need for free consultation. Dissemination of information through farm organisations. It is all there but not being applied. Case studies needed in simple language. Promotion of FEFTs pitched on cost savings. As a unique selling point (USP), could have products based on geothermal energy sources e.g. 'geothermal brewing products' or geothermal cheese. There is a need for electrical upgrades – three-phase should be promoted and grant-aided Mixed view whether technologies are at market stage or still under development. Solar panels (PVs) are deemed very popular in the market but there is lack of awareness or understanding for their operation. Dairy stakeholders cited lack of knowledge of suitable systems as a key reason as to why they did not install solar. There are RES objectives that need to be identified for each farming sector.
IT	Livestock farming	Need to identify alternative sources of income (production diversification) and/or the possibility of reducing production costs, in order to cope with the recurring crises of the agricultural product market and, in the current situation, the global economic crisis. Availability of agricultural products and by-products that can be conveniently used in the production cycles of energy from certain renewable sources. Large availability of agricultural land and roof surfaces of rural buildings suitable for the installation of systems that use solar energy.

		No interest in selling energy to others, but they were more focused on the circular economy on the farm: reuse of by products to gain energy for the functionality of the livestock production and the efficiency of the buildings. The FEFTS that is found valuable for livestock farming are the ones related to: adoption of electrically operated automatic systems for the distribution of fodder (rail distribution wagons, wheeled wagons with floor guide-line) in combination with a photovoltaic system, pre-cooling of the milk with production of lukewarm water (about 18 ° C), which can result in a saving of 40-50% on the consumption of the collection tank in the case of a farm that produces drinking milk, heat recovery from the milk refrigeration tank, with production of pre-heated water at 55 ° C which can then be sent to an insulated storage tank and, if necessary, to a boiler for a further increase in temperature (65 ° C). Savings of 70-80% can be achieved on the energy required for heating water locally, production of domestic hot water using a solar thermal system, always in conjunction with a complementary water heating system. Additionally, adequate design of the milk room is also important, in particular with regard to good internal ventilation: a low internal temperature in fact reduces the energy consumption of the milk tank (5 ° C less saves 18% of electricity). There is also need for adoption of automatic mechanical fodder and manure lane cleaning systems, such as rigid rod or rope scrapers, less demanding in terms of energy than the scraping blades carried by a tractor or wheel loader. Correct use of tractors, limiting their idle time as much as possible and adopting a low consumption/fuel efficient driving mode. Good internal organization of the building and storage facilities and arable fields, with limitation of non-productive routes of mechanical means.
DE	Greenhouses	Agri PV or greenhouses with transparent solar modules are a solution. Most participants claimed that (when they had a single choice) GHG emissions could be reduced the fastest by renewable energies (49%), energy efficiency (43%), and carbon sequestration (7%). When asked about the dominating fuels technology for greenhouses, in 20 years, the participants answered: hydrogen (37%), solar energy (24%), geothermal (11%), wood chips (10%), natural gas (10%), biogas/biomethane (3%), others (3%), pellets (2%), heating oil (0%), coal (0%). Need for technical assistance (i.e. several comments were related to technical questions).
ES	Greenhouses	Reduce the electricity consumption, water management, self-consumption, pumping, mobility, farm temperature and lightning, emission reduction, minimize production costs, sustainability and climate friendly. New uses for the FEFTS presented: Poultry farms, energy storage through battery, humidity extraction from greenhouses, use of waste for electricity. A group of participants stated not to have more ideas about it. Enhance knowledge on digitalisation, they don’t know anything about it Change PAC to include compatibility with other land uses More knowledge on pros and cons between different kinds on pellets The energy communities are key, where energy is distributed among users within a radius of 50 km, can help with the use of energy when someone does not need to self-consume. For example, agricultural activity is daytime and at night the energy can be used by houses. More workshops like this one

EL	Greenhouses	Integration and implementation of FEFTS in greenhouses is considered as very significant for shaping the future agriculture of EU. The FEFTS presented covered the topics of heating and cooling of buildings, process heat/cold, lighting, agricultural field practices, and vehicles, providing RES by solar, aerothermal, and biomass energy types, for mainly exploiting electricity and heating by photovoltaics, heat pumps, and solid biomass conversion technologies. Regarding energy efficiency improvement, efficient buildings, efficient vehicles, and efficient tools constituted the core FEFTS topics Need for advisory services as greenhouse producers are aware of the technological progress made in the sector. Thus, they are in need of proper guidance for achieving the optimum FEFTS.
NL	Greenhouses	Cooperation between agricultural entrepreneurs on FEFTS topics could also create new opportunities to invest in sustainable energy production and storage (overcome occasional societal resistance and difficult policy structures). Currently, farmers try to find ways on their own to create energy self-sufficiency and opportunities to do something with this subject on their company, whereas when much entrepreneurs would bundle their effort, they would form a stronger voice regarding society and policy makers. Example of four farmers that invested together in wind turbines and there was a little need for governmental support to make their efforts financially sound because there was an economy of scale behind it. Additionally, it formed a stronger opposition regarding all the objections of other citizens regarding their new land use. Another enabler are new technologies that make energy storage more worthwhile, especially hydrogen powered energy storage. These technologies are more accessible, with less risks on depreciation and malfunctioning in comparison to conventional battery systems, when they are more developed in the near future. Much hope is concentrated on energy storage technologies. Energy companies cannot guarantee reasonable energy prices throughout the whole year which makes production of energy a financially sound option, if competitive and compatible.
IE	Greenhouses	More geothermal heat pumps for climate control to extend growing season in greenhouses – great potential. Attach to current geothermal boreholes for localised crop heating to start the season earlier in tunnel or cold glass horticulture. Integrate with solar adoption and use reverse metering. New technology for CO_2 extraction from the atmosphere for crops could blend with heat pumps where both heat and CO_2 are needed. RES based glasshouse heating solutions needed. Underfloor heating for production nursery and plant propagation. Need solutions for efficient heat production. Need for energy efficiency. Relevance and interest on adoption and transfer of other FEFTs: solar PV, solid biomass conversion, heat pumps, energy efficient technologies, solar thermal, wind power, carbon sequestration, district heating, geothermal. Replace some gas heating of glasshouses. The horticulture felt they had sufficient supports to invest in the relevant FEFTS for their business. Good fit for mushroom farms. Local supply chains needed. More training desirable for greenhouse producers. Need a good awareness and communication campaign. Integration is possible with the right supports and place for loans. Streamline and promote the support mechanisms. Favour the emergence of least cost solutions. Consensus that the technologies for bioenergy are generally well advanced but also scope for continued improvement and

		increased efficiencies. Feedback setup for improving the FEFTs or adjusting them. Communication and awareness. Case studies as part of promotion. Dissemination of information through farm organisations. Promotion of FEFTs pitched on cost savings. Green labelling. Integrating of biomass technologies on suitable farms provide an option to decarbonise the heat sector in a rural context. It can integrate well if the right incentives are in place for farmers to grow biomass, but e.g. Miscanthus was a negative experience for some farmers. Biomass energy is very attractive for producers especially with the Support Scheme for Renewable Heat (SSRH). Anyone using fossil fuels for heat can use biomass to both save money and reduce their carbon footprint. Biomass should, in theory integrate very well with high energy use farms- the major constrain currently is the input costs crippling business activity. Can help communities implement a circular economy. Increase security of energy supply. Ideas re use of Biomass energy on farms. The mushroom sector has embraced biomass energy with over 70% using biomass as a primary heat source. Burning of straw for energy needs more promotion. Potential for pyrolysis and bio char as well as heat production.
IT	Greenhouses	Requests regarding bioplastics or, in general, technologies capable of helping reduce the impact of plastics for soil cover and the surroundings of the farm. This is crucial in the south of Italy, were most of the greenhouses are still tunnels and the contaminations of plastic residues on the soil can impact its productivity, even because of the bad (and illegal) habit of some farmers to get rid of the waste by burning plastic residues. The incentives for moving to FEFTS adoption are not sufficient, mainly because the income from greenhouses is very low and does not justify the expanse. Requesting enhanced knowledge on digitalization and automation, provide more FEFTS education to greenhouse owners and managers, but also to advisors and the financial sector. The technologies (photovoltaics, wind, biomass, etc.) work satisfactorily. Photovoltaics and biogas are the most used FEFTS in greenhouses in Italy, but the farmers need advisors to guide them in all the phases. Training is the key.

2.5 Conditions and barriers for transition to and adoption of FEFTS

The below Table 4 is collecting the conditions and barriers for transition to and adoption of FEFTS that was derived from the 24 RIW, sorted by the themes open-field crop production, greenhouses, and livestock facilities. The table collects the answers to the specific questions listed below and in the guidelines for RIW (appendix 1).

- Relevant barriers identified in relation to the agri- or horticultural system you work on (i.e., farm size, cropping system, farmers' age and education/training, etc.)
- Barriers for FEFTS adoption identified that are specific to the region

Table 4: Reporting from the RIW's on conditions and barriers for transition to and adoption of FEFTS

DE	Open-field crop production	The constant change of politics related to the sector and the permanent scarcity of raw materials/operating materials for this sector. Doubt about the political directions for focus on available FEFTS more instead of continue waiting for 2nd generation biofuels. There has been a political hope in the last 15 years for the introduction of 2nd generation biofuels, but it is still not yet available. Decision process of politicians regarding the promotion of energy. Risk of open up new horizons of thought and application structures - away from business as usual. The provision of sustainable drivetrain energy One participant claimed that the limit of 4.4% biofuels from energy crops is a barrier to the further development of the sector. Hesitant consideration to apply renewable energy drive trains, automation, carbon sequestration, in the near future, and few apply them already today. Missing and/or need of adjustment to policies and framework conditions.
DK	Open-field crop production	Desire for the same or uniform starting point for fossil consumption Change cultivation practices, but the transition must be done in stages and with soft transitions Don't know the potential for alternatives to diesel Niche arable productions typically have higher energy consumption than conventional cultivation of grain, grass, etc. Obscure value of some "soft" national incentives/initiatives.
ES	Open-field crop production	Farmers do not have enough time to spend on learning or investigating financing channels or grants in the sector. The agricultural sector is dramatically ageing, the older farmers are not interested in make big efforts to implement new technologies or practices. On the opposite side, young farmers need information and training to afford them. Advisors are not sufficiently knowledgeable in terms of technology: they are not well trained. In case of conservation agriculture practices implementation, it takes time and resources (financial and time) to learn the way to do successfully. The lack of time of the small farmers. Lack of financial incentives (or knowledge about it) Complicated bureaucracy. Lack of trust towards regulations (volatility)
EL	Open-field crop production	Olds-school and elderly famers, the lack of financial support and subsidies, the lack of subsidies associated/linked to the production, and the lack of advisory and extension services as well as guidance regarding the use of the solutions, along with the fragmentation of land into small production units with small plots, the lack of awareness and familiarization with novel innovative technologies, and the insufficiently structured policies. Additionally, proper function of collaborative

		schemes and the previous (not satisfactory) experience by cooperatives were identified as further barriers. It is a problem for an individual farmer to change his/her practices by adopting novel technologies and strategies, due to the high initial investment costs for many of them and the overall uncertainty about the expected results. Distant attitude of the majority of farmers towards FEFTS.
NL	Open-field crop production	Sustainable energy production on farm cannot go without energy storage on site. Electrical or hydrogen powered tractors are too expensive and unsure expenses at the moment Suitable alternatives to mineral fertilizers, e.g. knowledge gap
PL	Open-field crop production	Growing prices and uncertainty of energy and means of production: fuel, electricity, fertilisers, plant protection agents. Low profitability of production and uncertainty about the sales of agricultural products, which makes it impossible to make costly investments. High prices of energy-efficient machines and innovative solutions were mentioned. High prices of machinery and equipment and maintaining employees. Unfavourable legal regulations and strict procedures related to renewable energy sources are also a big problem - many farmers emphasised that they would be more courageous to invest in green transition technologies if they had a guarantee of stable regulations and return on investment. Legal regulations hinder the production and use of energy. The priorities of agricultural policy are not always in line with the real needs of agriculture, they are often imposed, not adapted to local needs. Very often changing regulations, to the disadvantage of the prosumer, leading to uncertainty of investments, longer payback time. Lack of targeted policy on development of renewable energy sources. Outdated and inefficient equipment and the attraction of some farmers to traditional farming methods. This applies especially to older people. Farmers often do not believe in the reliability of the data compiled and are too attached to traditional farming methods that have existed in families for generations. The problem is a lack of awareness of the interconnectedness of the economic and environmental aspects of field crops. Farmers often carry out soil sampling for the purposes of their obligations under EU programmes, but do not see the need for such action. Soil sampling, which is often outsourced, is also problematic. During the workshop, the representatives of the Chemical-Agricultural Station provided details on the principles of taking soil samples, which turned out to be still little known to farmers. Young farmers are more willing to invest and implement modern technologies. Polish farmers are increasingly well educated and are looking for information about energy-saving solutions and are interested in innovation. The interest is very high, especially in the context of solutions reducing labour input. Lack of labour for the farming sector, which also determines technological development. Fewer and fewer people are professionally involved in agriculture, many people work in the city and treat farm work as a hobby. Also young people are moving to the cities. Therefore, farmers are very interested in solutions which reduce labour input. Lack of FEFTS awareness among farmers, and the fact that they do not use the potential of modern solutions, even if they have expensive equipment. Lack of availability of knowledge on the subject. Farmers are often reluctant to test new solutions, despite the lack of costs involved. Lack of awareness among farmers

		about the profitability of production and the solutions that can be applied. Unwillingness to implement or even test new technologies. Lack of time to learn new things. Lack of use of basic cost-saving elements by farmers - e.g. soil sampling The problem is inefficient use of mineral fertilizers and wasting of nutrients and energy in the process of fertilization. An additional adverse effect is the poisoning of the environment. The cause is often an unregulated soil reaction, low humus content, but also a lack of knowledge of soil fertility.
IE	Open-field crop production	Hesitating attitude from old school and elderly famers, the lack of financial support and subsidies. Grid connection and local authority planning restrictions were also seen as key barriers for Solar PV. Most respondents put financial barriers as the main reason for not adopting FEFTS. The scale of the challenge in meeting emission reduction targets in agriculture and other sectors was a very strong point by participants and that none of the solutions being proposed today will get us to where we need to be by 2030 or 2050 to remove fossil fuels from agriculture. The transition to a low-carbon society is challenging. Many stakeholders acknowledged that Irish policy and regulatory landscape is seen as an impediment to the development of bioenergy and solar PV technology. Economic recession had an impact supporting renewable energy
IT	Open-field crop production	The lack of certainty of the market, the increasing costs of production, the insane bureaucracy in general and for public funds Commonly consideration that fossil free agriculture as an unreachable mirage. Prerogative of bigger companies and unbearable for a lower income reality. Resistance to change for the oldest generations. Lack of financial support and subsidies Lack of familiarization with new innovations and technologies Volatility of national policies
DE	Livestock facilities	For the majority of farmers, the actual agricultural and energy policies are not suitable in Germany to make the agriculture in Germany carbon neutral. The energy policies alone are suitable to minor extent. Frustrations on the challenges to make open field agriculture climate neutral. For many livestock farming branches, the meat prices remained rather stable in the last 30 years, whereas prices or electricity increased significantly (about 4% per year). This is a large challenge for many farmers. The same applies to milk. One of the rather stable energy sources is so far wood chips.
DK	Livestock facilities	High animal feed prices reduce the income and that might delay the implementation. Implementation of alternative energy sources becomes a pain. The incentives for moving to FEFTS adoption are sufficient and in some cases premature meaning that more research is actually needed but this is neglected. Verification of technologies i.e. under e.g. Environmental Technology Verification (ETV) programme, certification of integration of FEFTS. In addition to that, stimulation of awareness, and simplification of legislation for adoption of RES would enable FEFTS integration in Danish livestock farms. There is a barrier against PV integration in buildings, because of rules on construction of buildings. It is too difficult to integrate on existing buildings and often farmers chose to build solar farms on good farmland instead. This is driven by high fees for land use for that purpose, however, it is only a matter of time before that has to change because of competition on land for more purposes.

ES	Livestock facilities	There's a sense that the agriculture sector is eager to adapt quickly to any new technology or trend providing good outcomes. However the third-party support is not adequate to foster the implementation, maintenance, and exploitation. Lack of specific FEFTS knowledge from (local) installer. Lack of third-party specialized knowledge for maintenance. Transferring the knowledge to the whole collective of farmers is also something difficult and time-consuming. There are bottlenecks in the knowledge transfer chain. The simplified chain of knowledge transfer is national institution >> transfer centre >> specialist farmer/technologist >> group of farmers. The livestock sector is really work intensive on their farms, but sometimes it is "disconnected" from the technicians, the government, and other livestock farmers. Opportunities might be lost due to the lack of information about how to proceed. No direction for providing/approaching livestock farmers with initiatives that serve their needs for adoption of FEFTS, and the time they can spend/spare from their production management. Time-intensive work and business Generational change in the sector but still seems to be a correlation between old people and reluctance to connect to social media. There's an existing correlation between age and social media involvement. Young farmers are more prone to be connected to social media, get information, and better assess which event is worth assisting. The obstacles also depend on the type of technology we are dealing with. For example, in the region of Catalonia there are low subsidies for biogas, when the reality is that livestock farms could produce it, in comparison to the subsidies for solar photovoltaic or wind. Small farmers miss the presence of more structured or bigger farms in the events for knowledge-sharing. Techno-scientific research programs are designed regarding insights leverage, which may be created upon the hypothesis that farmers will be free of burden to attend, respond, or collaborate with research organizations. Research becomes burdensome for farmers. Real issues are doubts about maintenance and optimization, as well as the lifecycle costs and the options to get a better return on investment. Livestock farmers operate in tight profit margins. Investment uncertainty.
EL	Livestock facilities	Lack of guiding advisory services is one of the most significant problems, even though there is a high awareness of the technological progress made in the sector. Missing proper guidance for achieving the optimum FEFTS integration, and of simplification of bureaucratic procedures related to FEFTS licensing based on the existing legislation. Missing the formation of small groups (energy communities, cooperatives etc.) for FEFTS adoption Lack of network infrastructures/power grid, lack of awareness on behalf of the producers, lack of financial aid, as well as the long bureaucracy, in conjunction with lack of central policies, lack of incentives for FEFTS adopters, and lack of cooperation between farmers (e.g., for waste management process). Furthermore, animal feed costs have increased significantly, constituting probably the major cost in their farms. However, this price fluctuation is inevitable due to the current global instability observed in global markets during the first half of 2022, and cannot be easily addressed in the framework of FEFTS adoption. Lack of regional industrial symbiosis (e.g. Arta, Greece), meaning that there is a lack of cooperation between the farms of the region. Most significant problems are the bureaucracy and legislation related issues, the financial aid/incentives, and the lack of awareness on behalf of several farmers.

NL	Livestock facilities	Financial situation, appreciation and available capital to invest: for the current farming economically situation in the Netherlands, there is not much investment capital for pioneering FEFTS, such as with an electrical or hydrogen powered tractor. Some also pointed out that there is no financial appreciation or rewards for these sustainable investments for their businesses. Infrastructure: sometimes the current infrastructure is not sufficient enough to fuel vehicles accordingly to all their uses, both for hydrogen and electrical powered tractors. Both infrastructure on farm, such as energy storage facilities, but in other occasions also bigger infrastructure such as the local energy grid. Farmers do not feel confident to invest in unique hardware for which current mechanical workshop services would be far away. For example, one farmer was located in the southwest of the Netherlands whereas the dealer of H2Trac is only located with one office and mechanics around Arnhem in the east. When something breaks down, farmers fear that farming activities are postponed for long times and their planning fails. Depreciation and availability of current machinery is also a reason why farmers do not want to invest in hydrogen or electrical powered tractors yet. There is a lot uncertainty around this topic for new types of vehicles and when their current machinery is operational and reliable, they do not see much reason to change only for sustainability reasons considering all the financial uncertainties and costs. The right equipment may be purchasable, however for an operational farm in workable situations, the timely services and maintenance is more needed than nice concepts and models according to farmers. Doubt that the current infrastructure and local energy grid are suitable and appropriate for the new high demands of electrical agricultural vehicles Unclear infrastructure for hydrogen powered vehicles. The above cannot be answered yet by all industry organisations or governments concretely.
PL	Livestock facilities	The basic barrier limiting development on farms with dairy production is high investment costs. As has been noted, production is only profitable on a large scale, which generates high labour expenditure. With energy prices currently on the rise, the problem is the high cost and low scale of use of renewable energy sources on farms. The costs of such installations are also currently high, and with unstable milk prices, such investments seem to farmers to be highly risky. The use of renewable energy sources is hampered by unfavourable legislation, its instability and insufficient financial support. Farmers also report barriers in using computer applications, which in the case of herd monitoring systems is a necessary condition for using these tools. In the current situation of ever-increasing input prices, a major constraint will be the production of sufficient feed, which will adversely affect herd productivity. Farmers report difficulties in adapting to the constraints of high and restrictive milk quality standards. The low price of milk and the ever-increasing financial outlay result in low economic profitability. Semi-subsistence farms are not profitable and do not provide liquidity, and there is also the problem of organising the collection of milk from smaller, dispersed farms. On the other hand, on a larger scale, there is a problem with labour (there is a large deficit on the market). Other problems relate to the numerous inspections, both sanitary and administrative. This is due to the need to comply with environmental and animal welfare legislation. Furthermore, milk production is burdened with high sanitary requirements regarding the quality of the raw material, which often hinders sales processes. Farmers see very restrictive requirements for the withdrawal period of

		milk after the use of antibiotics or the permissible content of certain microorganisms. An important regional issue is the water requirements of dairy cows and ensuring adequate housing conditions that meet welfare criteria. Significant heat emission from dairy cows makes it necessary to ensure adequate ventilation. With changing climatic conditions, ensuring constant access to water in pastures (drying up of water reservoirs) becomes a problem. All these problems reported by the participants are related to the constantly changing environmental, legal and management conditions that can be observed in recent times.
IE	Livestock facilities	There are large gaps in the system of policy, grant aid and implementation at farm level. Dairy, poultry and pigs sector felt that Targeted Agricultural Modernisation Scheme (TAMS) upper ceiling limits on expenditure was limiting their potential investment in such technologies. Complete lack of awareness and farmers don't want to know unless there is a rise in costs or they can get a grant. Lack of information/expertise. Cost of equipment and labour. High capital expenditure needs to be overcome and economic and environmental benefits can be achieve after payback period. No insurance against failure of projects, could be Government support like in the Netherlands. Missing awareness of ground source heat pumps as a solution and more training of installers particularly around groundwater and GSHP. Heat pumps in domestic situation appear to be restrictive in their uptake. Lack of social proof – maps suggest only certain areas have the requisite underground heat for large projects. Grid connection capacity needs to be developed. No real solution for off-season heat storage Electricity costs. Grid connection costs. Three phase electricity. ESB network not able to cope. Supply chain challenges. Farmer age and farm size. Not sufficient training and education of farmers, advisors and installers. Level of paperwork for grant purposes considered excessive and off-putting. For instance heat pumps poorly understood by farmers. Lack of proactive farmer participation on this issue – more input from farm organisations. Access to skilled labour for specs and installation.
IT	Livestock facilities	Resistance to change for the oldest generations. Lack of financial support and subsidies. Lack of familiarization with new innovations and technologies Volatility of national policies. Bureaucracy. Workforce in this field is mainly composed by workers whose knowledge of technologies and IT is still quite low.
DE	Greenhouses	Missing intensives to combine the advantages of inter-regional, central generation (e.g. use of deep geothermal energy, substitution of crop failures at regional level, high synergy effects) with the advantages of regional, decentralized generation (e.g. short distances, high self-efficacy of regional consumers, use of individual location advantages). Uncertainty of future energy costs and fluctuations To implement everything in an economic way Get costs under control and get the investments back through the products sold. Regulations of energy source and energy efficiency and to choose the right source of energy. Choice of energy source, bureaucratic hurdles versus speed

		Differences in the structure of horticulture and farms, funding options are too complicated and lacking, especially for smaller farms, will small structures and special operations be accounted for when it comes to funding opportunities. The demands from regional consumers about products that do not fit into regional climate. Future prospect and transformation time
ES	Greenhouses	Costs and tax changes, high initial investment, permits, lack of knowledge on technologies and available mechanisms, financial security, adaptation of FEFTS to the local agricultural system, bureaucracy, theft insurance, legal delays and authorizations, fossil fuel lobbies, agenda of big energy players. There is a feeling that there is an energy monopoly and the farming community is helpless. The main issue to develop solar PV in Spain is the change of land use that is required. The Valencian community helps with development by offering advice but does not give capital expenditure grants. Lack of financial incentives (or knowledge about it) Complicated bureaucracy Lack of trust towards regulations (volatility) Advisors are not sufficiently knowledgeable in terms of technology, they are not well trained. In greenhouses, income is low. That is why it makes sense to install solar PV with the production of expensive products like pitaya - not apple trees. The technologies (PV, wind turbines, biomass, etc) work. However, operating expenses are high, and probably so high tech that a farmer will have to hire a maintenance company.
EL	Greenhouses	Hesitation to undergo vast changes and adopt innovative solutions due to the elevated cost that might be unbearable for their production units. Lack of financial incentives (due to the increased cost for performing the investment), the lack of expert agronomists to guide them and show them in practice the real benefits of adopting FEFTS, as well as the bureaucracy (simplification of licensing procedures). Product prices are relatively low with respect to the production costs, which leaves them small profit opportunities, always depending on the production unit's scale size. Fear about the constantly increasing cost of fertilizers due to the global economic instability. Lack of awareness was the most prominent response, accompanied by the lack of financial incentives, the lack of expert agronomists to guide them, and the bureaucracy. Fear of cost of investment, as well as the lack of results' demonstrations and efficiency proofs. The incentives for moving to FEFTS adoption are not sufficient.
NL	Greenhouses	There is a lot of unknowns associated with decision making regarding all the different options for RES energy production and storage. This situation would significantly be improved when there was more knowledge and support regarding what options would be appropriate to go for in the context of their company and environment. Policies and bureaucracy: The first and major point is the existence of many subsidy policies by different government bodies, but the lack of clarity on which policies and subsidies are best for the farmers circumstances. Farmers feel they have to invest a lot of time besides their regular farming business in figuring out

		which policy opportunities there are for their questions and needs and feel like they do not have this time besides their main effort, namely producing food. The investing in FEFTS would also be much more attractive when there would be some way in which self-sufficiency in energy use would financially be stimulated besides only a reduction in costs of production. However, the question immediately raised after this argument was; who should pay/stimulate this development? Government bodies or food industry? Limitations from the government: there exists an unclear situation regarding the perspective, support and course of action from different government institutions regarding FEFTS related subjects. There are several subsidy policies available, but interested entrepreneurs all point out that they do not know how to find their way for the best solution and options for their farms and greenhouses. Production/storage/return to the energy grid puzzle: the experienced problem is what to do and at what time of the year for produced energy. Lack of the optimal choices financially, but also regarding their later demands for energy and fluctuations in production due to weather conditions There is a need for advice/training on this subject. In additions, with regard to which options for renewable energy production are most suitable for what circumstances and for which types of farms or greenhouses. Financial situation, appreciation and available capital to invest: the current economic farming situation in the Netherlands, but also in the greenhouse sector, that there are sometimes not so much room to invest capital in pioneering adventures or risky investments with much uncertainty. The participants then feel that other priorities regarding the regular business operations are more important on the short term. There are limited business models for investments in renewable energy. Most of the time it is a way to reduce costs of production rather than earning money from producing energy.
IE	Greenhouses	The identified barriers for adoption was farm type and size, farmer age, lack of education and training, inefficient administration of supports, enterprise system, what is the right planning, underdeveloped grid connection capacity, bureaucratic obstacles to actions on FEFTS adoption. Lack of understanding and education in management Lack of diversity in energy sources. Costs high – when compared with returns from market There are gaps in the system of policy, grant aid and implementation at farm level Reluctance on the allowance to burn straw –emissions tight to achieve in this area Base system rollout on UK system Funding models extended to large scale users
IT	Greenhouses	The schedule of energy consumption is not in favour of the greenhouse industry in relation to the currently variable energy costs. Small farmers feel very difficult accessing to incentives A change of land use is required for solar PVs to gain ground, but there is no national support. For each hectare of greenhouse 13 hectares of solar PV system are needed, so farmers are often unable to meet their needs or resell the energy. Lack of financial incentives (or knowledge about it) Complicated bureaucracy Lack of trust towards regulations (volatility) In greenhouses, the income is too low to justify the expenses of a FEFTS.

2.6 Mitigation and innovative uses of FEFTS solutions

The below Table 5 is collecting the 24 RIW discussion on mitigation and innovative uses of FEFTS solution. The discussions concerned research topics, changes to policies (nationally and well as for EU and CAP), types of incentives, and sharing/utilisation of knowledge. Information is sorted by the themes open field agriculture, greenhouses, and livestock. The table collects the answers to the specific questions listed below and in the guidelines for RIW (appendix 1).

- Specific needs that can be addressed through research (it can be basic research on i.e., development of an advanced building management system, but also applied research on, i.e., application of a specific FEFTS to a new environment)
- Specific research and development requests regarding one or more FEFTS
- Adequate incentives for shifting to FEFTS adoption
- Types of incentives for fast adoption (subsidies, investment assistance, reduced interest rates, certification of FEFTS integration to increase agricultural product price, etc.)
- CAP to assist on FEFTS adoption and how
- The above can be technological needs, but also others, such as need for training, need for improved advisory, etc. Needs to be addressed by setting up collaborations (for example, by a collaboration project) or are there to be addressed at the political level (for example, by setting up a subsidy for FEFTS)

Table 5: Reporting from the RIW's on mitigation and innovative uses of FEFTS solutions

DE	Open-field crop production	Need that politics is finally moving and that the manufacturers are able to deliver. Rapid implementation of climate-neutral fuels. A lack of long-term reliability of the political framework leads to a loss of trust and thus prevents investments in alternative business (see German example of rapeseed oil fuel), and to avoid that FEFTS corresponding technologies will not be brought into series production because there is no demand. Political will (for the energy transition) with reliably constant funding conditions over longer periods of time (instead of a quick stop at the end of the promised funding). No green nuclear power, no green natural gas - progressively tax all fossil energy sources and building materials and thus promote domestic production of food, renewable raw materials and renewable energy sources until we are energetically, materially and food self-sufficient in Germany by 2050 - at least 100% degree of self-sufficiency in all areas. Every entrepreneur, such as a farmer, must be able to plan reliably for the long term. Enable long-term and plannable decisions in order to be able to invest properly. In addition: campaigns or other initiatives to improve willingness of each individual citizen to flexibly adapt their own (consumer) behaviour in the direction of ecology/green transition. Clear, unambiguous and long-term specifications (derived from the goals to be achieved, broken down into practical fields of application) with clearly defined target values. Regular monitoring of these target values and evaluation with a positive / negative reward system. Creation of reliable framework conditions Reliable framework conditions - alignment of politics with scientific and factual knowledge. Reliable framework conditions in production and marketing both at EU level and in imports. Politicians are required to create clear guidelines for the climate-neutral orientation. Clear long-term, reliable guidelines and, if necessary, a remuneration model for ecological services instead of a compensation model for lost profits. Reliable framework conditions (min. 10 years). Alternatively, setting incentives to promote new sales channels, e.g. for crops in an extended crop

		rotation, such as oats as a healing crop or legumes as protein plants when livestock is in decline. Appreciation and remuneration of the climate-friendly contributions of agriculture. Need cost-benefit calculations for technologies for farm sizes up to 100 ha. Change in the settlement account system for wheat, away from crude protein content. Tax exemption for biofuels. Purchase support for new vehicles like for e-cars. Planning security and developments that are not only designed for large companies. It must also remain affordable for small businesses. Financial compensation for carbon sequestration in agriculture, e.g. humus build-up, use of bio char. Create financial parameters to secure the use of renewable energies in the long term. Need quantification of carbon sequestration through photosynthesis, how carbon farming can sustainable, distortion of local markets (MERCOSUR), promotion of agro-photovoltaics, promotion of domestic biofuels (e.g. rapeseed oil). Promotion of regenerative fuel. Securing the domestic supply of high-quality food without leakage effects and a simultaneous focus on climate change adaptation. In other words, to produce additional energy with less space, regardless of whether it is agri-PV, wind or energy crops, and this without just outsourcing the negative effects. A clear, long-term commitment to tax-free vegetable oil fuel in agriculture, because of the simple fuel production with very little energy consumption and the short transport routes, no other fuel offers more regionality and CO_2 savings and adding value to agriculture. Abolition of the EEG levy on electricity for self-sufficient business. To develop and find suitable alternative fertilization methods and drive systems. Investigate if ecological/organic farming is counterproductive in the GHG impact due to management, yield and field operations. A niche would be, for example, soil cultivation or sub-vine cultivation in viticulture, also adapted to different soil structures. Promotion of alternative cultivation methods and drives, support for research. Promotion of biogas (base load, storable energy, organic fertilizer production/distribution, etc.).
DK	Open-field crop production	Need for speed in terms of politics and influence in the right directions. Subsidies and other financial incentives should be based on the use of 'hard' measures, e.g. from enterprise data (general on enterprise levels or specific on individual enterprise). Very important with validation of the effect of different measures. For example, a clear answer in the question whether niche productions in the open-field agriculture typically have higher energy consumption than normal cultivation of grain, grass, etc. Important to study the whole value chain and where to make the highest impacts/whole energy circle, find individual elements. Support schemes for the usage of the technology – not the investment. Subsidies should instead be given to the use of technologies and scale at farm level and based on baselines for the technologies. Danish example of exchange hectares of precision farming for hectare catch-crops, reductions or changes in the farm as the goal of the grant or initiative. Need EU offices that can help projects get started. Collaboration between Danish EnergyUDP and GreenUDP research programmes Need for political statements on climate labelling. There must be a different way of thinking for agribusiness companies regarding the settlement of accounts of products. CO_2 accounting must pay for itself. Doubt that a CO_2 tax will provide the green transition towards FEFTS adoption. Needs validation of impact of measures and implementation is of importance. Review

		and collect research in the area, create an overview of research. Difficult to find out where to/can start with projects, need advice to the starting point. Need for infrastructure for alternative energy sources out to the field, maximum operating time, min. operational disturbances. Need studies of the importance of land/field location distribution with regard to all parameters for saving fuel/transport/logistics. Create good data, effect and size in relation to consumption of fossil fuel - where can you achieve the greatest reduction by doing something for the few but largest players. Document consumption of fossil and non-fossil fuels. Need studies of different machinery technologies GHG impact. In the field, the use of nitrification inhibitors will be far more important for CO2 than green energy. Avoid one-sidedness regarding alternatives to fossil fuels. Cultivate the land according to other principles. Change cultivation practices, but the transition must be done in stages and with soft transitions. The market/mechanisms for carbon credits may well be opaque, but it can be the financial incentive to initiate, for example, cultivation measures. Need to increase energy intensity (energy used to produce a given level of output). Govern farmers own energy production. Foresee potential in recycling biomass for fuels (GTL (gas to liquid), but research and implementation are needed. Bio-char costs, but if the settlement of account is made for carbon sequestration, then it can become sustainable. Agriculture can/will/must produce fuels itself, as an exchange with diesel, e.g. biogas in exchange for diesel. Accounts for production and consumption and terms of trade. Producing hydrogen locally, possible, but distribution or practical application and studies are lacking.
ES	Open-field crop production	The link between cooperatives and research centres must be closer and more extensive so that cooperatives can transmit knowledge. Also, cooperatives generate their own information and investigations to help farmers. The public administration is providing resources through the lines of the rural development plan, through training courses, project generation, advisory areas and other research areas. But this depends on whether the state or region has such resources, which are often limited or may not exist at all. Some cooperatives or associations work directly with the ministries on the drafts of various regulations to contemplate measures to favour conservation agriculture, but most of the time there is a problem with the applicability to farmers and they are not very encouraging either. Energy communities, cooperatives, joint ventures, participation in European projects generate interest in the agriculture sector, they generate improvement, participation, knowledge, and transfer for the sector, from the perspective of a cooperative, but for a farmer who does not have time outside of his daily work in the field, it is much more complicated to find value in this type of activity. Adopt regulations to be more applicable to farmers and make them truthfully incentivize depending on the type of adoption. The CAP should support the practices of CA to promote its use. The Regional Rural Development Plans in the framework of the EAFDR should include measures to support activities contributing to the Green Deal. It seems there is a missing link between Green Deal and CAP. Research on the soil with focus on soil living entity to generate knowledge about the biological fertility of the soil and how to use microbiology to work for crop cultivation without destroying the soil. Also, to do more research on efficient irrigation systems, machinery digitalization, precision farming. Design research programs that take into account how to compensate farmers from a time dedication perspective.

EL	Open-field crop production	It is of paramount importance that training, financial aid, advisory and extension services, and networking establishment for this transition, will be provided to the local farmers. Enforcement of advisory and extension services for farmers, in order to facilitate support to farmers and producers. Strengthening of local agricultural cooperatives and associations, aiming to create secure robust links and stable contact with governmental stakeholders and commercial representatives for the adoption and implementation of FEFTS. Current incentives are not sufficient. Forming small groups and integrating central governmental policies is essential for achieving the best possible FEFTS integration and implementation that leads to fossil free energy use in the agricultural sector. Needs may be addressed by central policies coming as a result of governmental derivatives for advisory and extension services in the agricultural domain. Could be formed as small cooperative groups, or by central policies, however unanimous view on which of these directions. That financial aid such as subsidies and investment support; together with proper guidance, advisory and extension services are needed for achieving the best possible FEFTS integration and implementation. Unanimous view on the contribution of the new CAP in the implementation process of FEFTS. Supply of financial aid and structured general policies for the adoption of FEFTS and innovative technologies, strategies and tools in general, allowing the smooth modernization of the agricultural domain and mitigating/reducing simultaneously any possible negative economic side effect for the farmers, which may derive by the transition. Integration of precision agriculture after further research, along with the development of energy community for the optimum exploitation of existing energy sources and their willing to contribute in soil carbon sequestration in case of more knowledge available.
NL	Open-field crop production	Common attitude that public policy can best stimulate energy production per unit production (energy intensity) with subsidies instead of subsidising hardware like solar panels or wind turbines, consequently, requires new public policy.
PL	Open-field crop production	Good idea to offer subsidies to farms that achieve a positive balance of organic matter on their farms through the use of appropriate crop rotation and balanced fertilisation. Improve farmers' awareness and interest, where the key to the cooperation between science and practice is a better understanding of farmers, their views and needs which are very often not taken into account when designing legal regulations or technological solutions. State policy and the distribution of financial resources should better meet the needs of the Polish countryside. According to the participants, it is very unjustified for small farms to buy expensive technologies just because it is a requirement for receiving subsidies - there is no premium for basic equipment, while expensive equipment is not used well enough - it is also a form of wasting money and energy. As an example of workable support for sustainable agriculture and rational fertilisation practices, an obligation to carry out fertiliser plans was established in the measures implemented under the Rural Development Programme. A national "Nationwide programme for environmental regeneration of soils through their liming" was also introduced, which co-finances fertiliser limes applied to the most acidified soils in Poland. The "Programme of measures to reduce water pollution by nitrates from agricultural sources" was implemented. It sets out a number of guidelines and conditions on fertilisation, which should be met in order to

		minimise the risk of nitrogen losses from agricultural fields and pollution of the Baltic Sea. It is necessary to integrate available programmes and applications, to standardise the format of data on a farm so that they can be used in various applications available on the market. Looking for small solutions to improve work in a farm and to save energy, which are not associated with large financial outlays, are not too complicated and labour intensive. Availability of solutions for smaller farms that are more versatile, use the available data in different ways, and allow for gradual adaptation of the farm. High hopes are attached to the introduction of modern technologies, elements of precision agriculture - it is the future, however, the importance of tradition was emphasised - sustainable development should be introduced, preferably in two directions: the implementation of innovative technologies, but also the cultivation of tradition, so as not to lose the knowledge. It is also necessary to continue work and research on decision-support systems, programmes and applications that allow rational use of fertilisers, and research on varieties adapted to local conditions, better able to adapt to changing climatic conditions. Fear of adverse phenomena - e.g. weed infestation, accumulation of pests and diseases in the case of no-till technologies. As an idea for solving the concentration of natural fertilisers and the problem with their distribution, technologies for drying fertilisers or processing them, which later facilitates their transport over long distances, were indicated. There is a lack of systemic solutions for the development of RES in rural areas, where a lot of raw materials for energy purposes are unused. There are still a lot of reserves: green certificates, raw materials for energy purposes, solar and wind energy. Food goals are already assured, food waste must be reduced. Precision farming solutions are appreciated by large farmers but effort should be made to reach small farms.
IE	Open-field crop production	Improve incentives for moving to FEFTS adoption. Incentivise sustainable energy technologies and practices by developing an ongoing policy action. Deployment of renewable energy technologies and energy efficiency must be stimulated through ongoing energy policy. Government and public must engage to achieve energy efficiency, renewable energy, and emissions reduction targets, so the benefits of a sustainable energy system can be reaped by agriculture. Needs to be a clear Government strategy to facilitate grid connections for farmers and to properly support the installation of rooftop solar and other key infrastructure. Specific priorities for future public policies: enforcement of advisory and extension services for farmers, in order to facilitate support to farmers and producers, enablers such as subsidies, investment assistance, zero interest loans in order to encourage the adoption of FEFTS on farms, the new CAP should assist on FEFTS adoption. Supply of financial aid and structured general policies for the adoption of FEFTS and innovative technologies, strategies and tools in general, allowing the smooth modernization of the agricultural domain and mitigating/reducing simultaneously any possible negative economic side effect for the farmers, which may derive by the transition. Let farmers be central players in the national energy transition. Establishment of energy communities for the optimum exploitation of existing energy sources is needed. Actions in relation to energy efficiency could help to balance some energy demand growth. Training of both public and private

		advisors. Strengthening of local agricultural cooperatives and associations, aiming to create secure robust links and stable contact with governmental stakeholders and commercial representatives for the adoption and implementation of FEFTS. Farm independent auditing services which should be made available by Government in order to tell them what they should be doing in their business. They would like to see dedicated educational and training programs around the various FEFTS available. Research needed for the crucial issue of replacing fossil fuels with renewable energy for making progress towards decarbonisation. There is an urgent need for private and public investment in energy infrastructure, including energy storage, smart distribution, and management systems. It was recognised that agriculture will play a major role in the decarbonisation strategy. Need for carbon audit services.
IT	Open-field crop production	Green transition require that local entrepreneurs are provided with basic training, financial aid, advisory and extension services and networking. Clear policies and national as well as EU communication that is not volatile nor subject to misleading interpretations. Need innovation brokers, a consultant who is able to carve out tailor-made technological solutions for farms. Specific priorities for future public policies: prepared consultants who support farmers and producers, policies aimed at the development of virtuous farms, bureaucratic simplification and greater opportunities for access to credit. Improve incentives for moving to FEFTS adoption. Additionally, the development of energy communities for the optimum exploitation of existing energy sources is needed.
DE	Livestock farming	Avoid the frustrations on the challenges to make livestock farming climate neutral. Promote and understand best practice examples at political level.
DK	Livestock farming	Desire for the same or uniform starting point for fossil consumption. Financing for young farmers could be improved. Higher prices on product from farms that produce with low carbon footprint is a key to future success. FEFTS integration certification was seen as a new possibility for financing. Subsides should be more targeted towards climate. There is a need to close old subsidy programs and move finances to new areas.
ES	Livestock farming	Farmers and related organizations are participating in energy communities, cooperatives and European projects. In the case of the workshop participants, biogas management and collective schemes where highlighted as collaborations that should be pursued. There is a lack of connection from prestigious academic institutions with the agriculture sector; the role of “transfer centre” as a dedicated organization to bridge the gap between farmers and research is very much needed (or increased support to these organizations). It is specific farmers who provide insights about interesting technologies to the transfer centre, and it is the transfer centre that helps to clarify doubts about schemes and methods to obtain funding or incentives. Design research programs that take into account how to compensate farmers from a time dedication perspective. Investment assistance: clear understanding about the return on investment is fundamental. Livestock farmers do accounting and financial planning as a core activity in their business. Therefore it is a must to always present the financials of any solution. Livestock businesses operate on tight profit margins and this

		knowledge is fundamental. The industrial sector can operate on large profit margins, but not the average farmer. Plug and play energy systems with low maintenance and very easy to operate are a preference for FEFTS adoption. It's a matter of "time": farmers are really busy managing their exploitation and cannot dedicate a lot of time to FEFTS implementation. When something works, when a FEFTS is adopted by someone it will spread quickly through word of mouth. Also, a demonstration or pilot project is a good way to spread the benefits of FEFTS and foster their adoption. Investments are investments. Meaning, farmers dedicate capital to solutions that have to provide benefits right away. They want to be sure that they are not improvising or incurring in high risks. A protection framework is necessary against the uncertainty that some policies or plans bring to the farmers. Adequate national policies without inadequate level of detail. Overlapping in Spain between national policies and local policies. One friction point are the competencies, from the policy point of view. When national governments legislate in deep level of detail, the frictions will appear due to the lack of knowledge about the reality in the local dimension or because the national legislation in detail cancel the competencies that local governments have. Thus, local governments cannot implement the adequate local policies due to the frictions with the national level. The incentive would be a good cascade definition of policies caring about EU, national, and regional/local levels, empowering the local governments and being sufficient for the policies' scope. The land is diverse and the reality of different regions cannot fit into a detailed policy "for all".
EL	Livestock farming	Opted in general for choices that were mostly related to advisory services, simplification of licensing procedures with energy contractors, and raise of awareness and training in new technologies. Improve incentives for moving to FEFTS adoption to be regarded as sufficient. Reduce interest rates, certification of integration of FEFTS, and finally, benefit from advisory service. In addition to that, stimulation of awareness, and simplification of legislation for adoption of RES would enable FEFTS integration in Greek livestock farms. Promote, in terms of practical, financial and bureaucratic issues, low interest rate in loans, certification of FEFTS integration, and simplification of licensing procedures with energy contractors would allow even smoother integration of FEFTS in the diverse local farms. Simplification of licensing procedures regarding the adoption of RES and several FEFTS in order to provide end-users with the ability to easily adopt FEFTS. Need for central governmental policies for the proper organization of the entire sector, as well as the need of personal aspirations for amelioration of the situation in personal level. Highly ranked the need for financial aid in general, the stimulation of awareness, and the simplification of legislation for adoption of RES. Formation of energy communities as well as cooperatives is very significant. Furthermore, stimulation of awareness and training together with assistance by advisory services would also help in mitigating the problems faced. In addition to that, the need of promoting energy saving technologies could be addressed, by increasing participation of various stakeholders in EU projects. Highly ranked energy communities and participation in EU projects, but also a need for such actions regarding waste management. Need simplification of licensing procedures, need training in new technologies, new governmental policies, policies in EU level (probably through CAP), consulting, and awareness campaigns.

		Enforcement of advisory and extension services for farmers, in order to facilitate support to farmers. Strengthening of local agricultural cooperatives and associations, aiming to create secure robust links and stable contact with governmental stakeholders and commercial representatives for the adoption and implementation of FEFTS. In this framework industrial symbiosis could also be strengthened in the area. Furthermore, the need for central governmental policies was also introduced. Supply of financial aid and structured general policies for the adoption of FEFTS and innovative technologies, strategies and tools in general, allowing the smooth modernization of the agricultural domain and mitigating/reducing simultaneously any possible negative economic side effect for the farmers, which may derive by the transition. Farmers would highly appreciate research targeted to quality of animal feed, energy production (biogas) through the use of animal faeces (in the framework of circular management of farm waste), and new hybrids of animals (DNA improvement) for allowing higher production. Minor need for research in energy saving technologies. Positive towards general policies' implementation regarding FEFTS integration, together with the participation in EU research projects. Simplification of procedures for energy sales in external users.
NL	Livestock farming	Subsidy schemes for big investments in sustainable hardware, such as the FEFTS discussed, by government bodies or industry. Labelling for food produced in more sustainable way, or a reduction in the prices of leasing farmland. Farmers feel a lack of financial and societal appreciation in the Netherlands when they invest in sustainable equipment or practices. Financial assets to make big investments in sustainable hardware, equipment and strategies. A sort of generic scheme could be developed to work towards the right circumstances for the implementation of this FEFTS. Demonstrations of pioneer technologies that lift them up to a more mainstream accessible technology for farmers. There is a need for policies to support pilot projects wherein the offset, storage, delivery, economically sound and safe use of selected FEFTS tested and presented to the agricultural sector and society. Research to elaborate the local circumstances and financial situation appropriate for a customer/farmer to invest in an electrical or hydrogen powered vehicle.
PL	Livestock farming	Among the opportunities for the development of precise on-farm systems reducing labour and energy inputs and using renewable sources, the current financial support systems such as investment subsidies from the Rural Development Programme, the Agroenergy Programme (subsidies for heat pumps and photovoltaics for farms from the Provincial Fund for Environmental Protection) and the Moja Woda Programme (subsidies for the construction of water tanks).
IE	Livestock farming	There is a need for focused FEFTS awareness-raising in agriculture and for the general public. Need for grants and initial financial supports. Inform Government of the tonnes of CO_2 saved and get grants in place to install the technologies. Avoid bureaucratic obstacles to green transition actions. More collaborative projects are also needed and the subsidies requirements need to be addressed at Government level - subsidies for FEFTS. Insurance against project failure. Mixed opinion about how adequate the incentives for shifting to FEFTs are. More incentives to encourage heat pump technologies and fast adoption. Subsidies, investment assistance, reduced interest rates, and certification of FEFTs integration to increase agricultural product prices. Remove grid charges and connection costs and provide lower electricity tariffs for heat pump technologies. Insurance against

		project failure. Subsidies and grants towards capital costs. Funding means Government is supporting. Consensus that new CAP could assist on the adoption of FEFTS, but insufficient subsidies in CAP on FEFTS - farmers see elements like tree planning or hedgerows more quickly /easily integrated with farm business. Trusted funding stream could be another step in CAP evolution. Special funding schemes for early adopters. Incentives across all agricultural sectors. FEFTs could be used in an agri-environmental scheme (e.g. Similar to low emission slurry spreading as an option in IRL GLAS initiative). Identify best systems of operation in terms of energy efficiency. Need real data to inform decisions on what's happening on farms. Communication, awareness, and advisory support. Coordination of community projects, especially in relation to large scale community projects. Get farmers talking and communicating with other farmers. Need for centre of excellence. Coordinated approach to farms with multiple opportunities. Use centres of excellence, demo farms and universities/third level colleges. Study existing setups and cherry-pick the good aspects. Assess how farmers are using the technologies to best effect Deploy pilot projects for awareness. Training is needed. Enhanced advisory provision is needed. There is a need for proper backup in terms of servicing the equipment over the years after system installations. Need incentives for more training. Need for more research and innovation. Identify how to increase supply temperature to heat pumps. Identify how to improve Coefficient of Performance (COP) of heat pumps. Need studies of how heat pump performs under different flow temperatures and outside temperatures (air to water heat pumps) and its potential cooling. Need de-steaming industrial applications. Need demonstrations of environmentally friendly case studies for heat pump application in new pig buildings. Real life installation matched with the correct heat pump technology. There is also a need for 'proof of concept' flagship projects to demonstrate the different applications of geothermal/heat pump technologies and their benefits in agriculture sectors such as dairy, pig and poultry farming. How to combine heating and cooling to cut the cost of production. Research on developing simple control systems and off-season storage options. Research on the combination of GSHP with other renewables from an agricultural perspective. Quantify the relative benefits of different sources of heat (including health, environmental and socio-economic benefits). Need engineering solutions involving combined heat and power, solar, heat pumps, gas boiler, water storage, ground thermal, CO_2 extraction and seasonal storage options. Identify new ways to reduce the cost of renewable energy. Need a joined up policy to meet target of 400.000 heat pumps by 2030 in IRL. Need recognition of the benefits of heat pumps for lowering demand on the grid, perhaps tax breaks. Deploy smart grid.
IT	Livestock farming	This area is not very interested in energy storage or in selling. The aim would be self-sufficiency and efficiency for their farms. More subsidies from EU would be praised, not only for machineries but for training and education of famers and their employees. For the green transition to be achievable, it is of paramount importance that local entrepreneurs are provided with basic training, financial aid, advisory and extension services and networking for this transition. Need of clear national as well as EU policies and communication that is not volatile nor subject to misleading interpretations.

		Need innovation brokers, a consultant who is able to carve out tailor-made technological solutions for farms. Specific priorities for future public policies: prepared consultants who support farmers and producers, policies aimed at the development of virtuous farms, bureaucratic simplification and greater opportunities for access to credit, subsidies for technologies and for training of farmers and employees.
DE	Greenhouses	Where possible, let political decisions be taken at regional level and make long term plans (for business security reasons). The resulting experiences should then be bundled with suitable tools. Then they should be mirrored back into the regions to make adjustments at the inter-regional level. More reliability of politics - currently changing directions constantly. Remember that FEFTS which are good today maybe will be out/replaced by new technology tomorrow. Show ways that are feasible and protect climate-neutral pioneers from the ever changing opinions from the outside. Accelerate the development and not to beat around the bush. Promotion of improvements to existing greenhouse production sites with targeted and simple funding/incentive/support solutions. Also take into account small structures and niche farms when it comes to funding opportunities. Let entrepreneurs be entrepreneurs. Regionally produced products should have a higher value or the import of products that can also be produced in the country should be taxed higher. Priority for geothermal energy and heat networks Agri PV problem for EU arable land subsidy can be lost, this must be changed politically. To inject exhaust gases (CO2) economically into greenhouses and to get permits for it.
ES	Greenhouses	Development of energy communities, better subsidy, clusters of innovative solutions, better support from the local government, demonstrative pilot projects, training, collaboration among farmers, government, and financial institutions, better involvement of research centres, development of organizations for producers and consumers and collaboration among neighbouring farmers. Lacking a common/standard criteria among the different governmental departments. Need to simplify the administrative requirements for implementation. Financial incentives to FEFTS, better alignment and harmonization between local governments and European policies. Need knowledge and training on the technical side in relation to FEFTS. Lowering costs and enhancing subsidy implementation were highlighted as the crucial items. Other topics mentioned were differentiation between large and small production units, implement plug and play solutions, useful energy audits, easy to learn operation and maintenance, development of experimental farms, and thorough feasibility studies. Specific needs that can be addressed through research: understand energy consumption for agricultural vehicles, open-field crops, how to reduce costs of production, anaerobic digestion of agricultural by products, demonstration of general applications of FEFTS and research results. Improvements to existing incentives for shifting to FEFTS are needed. Lack of knowledge, insufficient, bureaucracy, lack of good political leadership, not financially strong for their needs. Need support to technology transition, reduce bureaucracy, cash injection, long-term subsidy, credits, financial support. Components of the CAP of more interest for the FEFTS adoption:

		green deal, operative funds, uses compatibility, subsidies, but knowledge about CAP needs to be improved. Improvements to CAP to make FEFTS adoption more interesting: Less bureaucracy. A specific line for agrivoltaics development. More information to farmers. The main drawbacks of the CAP is that it does not allow compatibility with other land uses, it does not allow land use change. This is problematic in the case of Andalusia for example where they do not fill the farms with PV but they put rules, that more than 50% of the land has to be occupied by agricultural activities Changes to existing policy mechanism in which FEFTS should be included: Give more weight to ecological agriculture and green policies. Merge energy efficiency and agri-food policies. Give more training on farmers but also advisors and financial sector on technologies
EL	Greenhouses	Forming of small groups (energy communities, cooperatives etc.) for FEFTS adoption, and promote general policies' implementation regarding FEFTS integration, together with the participation in EU research projects. The vast majority of the participants stated that the incentives for moving to FEFTS adoption are considered to be insufficient. They would like to receive reduction of farmers' taxes, reduced interest rates and assistance in repayment of the investment generally. Removal of bureaucracy that follows anything related to innovative changes, such as authorization licenses and legislation in general. Need for help in repayment of the investment, the investment aid, the reduction of farmers' taxes, the increase of their products' prices, the reduced interest rates, and the branding of their products for achieving optimum market placement. Supply of financial aid and structured general policies for the adoption of FEFTS and innovative technologies, strategies and tools in general, allowing the smooth modernization of the agricultural domain and mitigating/reducing simultaneously any possible negative economic side effect for the farmers, which may derive by the transition. Additionally, the development of national advisory service will allow achieving maximum engagement and lead to knowledge transfer from research to the field and further incorporation of FEFTS in the daily agricultural practices. It is of paramount importance that training, financial aid, advisory and extension services, and networking establishment for this transition, will be provided to the local farmers. Forming small groups and integrating central governmental policies is essential for achieving the best possible FEFTS integration and implementation that leads to fossil free energy use in the agricultural sector. Significant need for an effective national advisory service system that would have fast reflexes. In addition, the lack of awareness regarding energy use was also put in the discussion as a minor aspect. To their point of view, farmers' specialized education with further orientation to innovative practices, was considered as part of the advisory service system activities. Lack of advisory service system is the most significant problem. Enforcement of advisory and extension services for farmers, in order to facilitate support to farmers and producers. Strengthening of local agricultural cooperatives and associations, aiming to create secure robust links and stable contact with governmental stakeholders and commercial representatives for the adoption and implementation of FEFTS. Participation in future EU projects appears to be a great opportunity for several farmers, in order to simplify the knowledge transfer from established research

		outcomes, or even contribute in reaching new research findings that could assist in the formation of future agriculture. Integration and simplification of bureaucratic procedures related to FEFTS licensing based on the existing legislation. More research and demonstrations of precision agriculture, biogas exploitations, automations for the agricultural production, IoT technologies, energy production is the site of the production unit, agrivoltaics, biomass use, as well as ionic fertilization. In addition to that, participants stated that a need for further research might not be as significant as raising awareness of the existing solutions and their potential. This comes to reassure the need for stimulation of the involved stakeholders for achieving the optimum exploitation of available knowledge and technology developed. . Opted for choices that were mostly related to advisory services, raise of awareness for new technologies and simplification of licensing procedures.
NL	Greenhouses	Research on the financial possibilities of different technologies would also be a suitable topic with regard to clean energy production and storage on farm. Look into existing business cases and what business cases can be created in the future with the infrastructure and technologies that are available. The government should do more to encourage pioneering entrepreneurs and offer to them services, advisory services, and opportunities to become a pioneer in sustainable energy production and storage. Mitigate the shortcoming of knowledge and advice on FEFTS for agricultural entrepreneurs. Even when farmers would have their own production facilities and storage systems, there would exist a need for advice on the management of these systems (energy production expectations, need of storage capacity, moment to sell energy to customers, need to store energy for peak moments for use with own greenhouse production). New opportunities for commercial advisory companies to incorporate these subjects in their services besides the regular advice regarding the crop production. New or improved technologies like energy management systems could also form a solution to these needs
IE	Greenhouses	Improve incentives to encourage the use of bioenergy on farms. Incentives for fast adoption. Focused supports to encourage the utilisation of bioenergy. Subsidies needed with simplified supports system. Need for strong promotion and awareness of the Support Scheme for Renewable Heat (SSRH) needs to increase and it should be promoted more. Need for financial supports. More collaborative projects are also needed and the subsidies requirements need to be addressed at Government level - subsidies for FEFTS. Funding means Government is supporting. Avoid bureaucratic obstacles to green transition actions. Need for explicit rule set in funding mechanisms to remove any uncertainties. Ease of application and fast response for financial supports. Mixed opinion about how adequate the incentives for shifting to FEFTs are. More incentives to encourage biomass technologies and incentives for more training. Reduced interest rates, certification of FEFTs integration to increase agricultural product prices, remove grid connection costs and Reduce Value Added Tax on renewables. Targeted Agricultural Modernisation Scheme (TAMS) rules need to change to be more favourable for users. Mixed opinion on whether the new CAP could assist on the adoption of FEFTS. Budget of CAP already under pressure to address existing priorities without adding more new/alternative funding needed. There are currently insufficient subsidies in CAP on FEFTS.

		Need more knowledge and training. Biomass energy training is needed for farmers, especially mushroom producers. Enhanced advisory. Advisory services and others in regular contact with farmers can play a role in identifying energy needs and opportunities. Need to develop broad awareness of FEFTS solutions. Marketing of concepts needed across the agricultural sector by all organisations. Need for farm energy audits. Need for carbon audits. Need for coordination of potential community projects, especially in relation to large scale community projects. Enhanced advisory provision is needed. Investment assistance needed. Need for more research and innovation. Develop net metering system. Investigate the use of poultry manure (dried) as a fuel in woodchip boilers. Consistent supply of suitable biomass resource is essential. Broaden the base for additional sources of wood fuel and develop supply chains. Simple boiler systems – must be reliable. Local service and energy supply needs to be available. Demonstrate how biomass energy systems fit in with older farm buildings and existing technologies. Increase knowledge of capacity for broad deployment as in other EU countries. Identify best systems of operation in terms of energy efficiency. Coordinated approach to farms with multiple opportunities/as part of district heating. Avoid having a narrow focus on heat pumps and electrification and should be more open to other options such as biomass. Use the metered data now available from the Support Scheme for Renewable Heat (SSRH) installations to demonstrate actual volume. Trials of biomass energy technology on different farm types. Investigate applications for bio char. Develop sustainable pricing models and markets for energy crops. New technologies such as bioenergy with carbon capture and storage –securing geological storage sites. Identify new ways to reduce the cost of renewable energy.
IT	Greenhouses	For the green transition, it is of paramount importance that local entrepreneurs are provided with basic training, financial aid, advisory and extension services and networking. Need clear national as well as EU policies and communication that is not volatile nor subject to misleading interpretations. Need innovation brokers, a consultant who is able to carve out tailor-made technological solutions for farms. To save resources, incentives should no longer be sent to simple photovoltaics, but to agrivoltaics. Lowering costs and enhancing subsidy implementation Merge energy efficiency and agri-food policies Subsidies to support technology transition Improve existing incentives for shifting to FEFTS Specific priorities for future public policies: prepared consultants who support farmers and producers, policies aimed at the development of virtuous farms, bureaucratic simplification and greater opportunities for access to credit.

3. Regional similarities and dissimilarities

This section is a summary of action areas that the 698 workshop participants saw as critical to address in relation to FEFTS. The first sub section analyses the similarities and dissimilarities between regions in relation to needs and expectations to existing and/or most demanded FEFTS. The sub section 3.2 provides a summary of the conversations that preceded the barriers for adoption of FEFTS, i.e., across regional and stakeholder specific implications of each of the three themes, in response to the questions explored in the session 2.2 of the workshop guidelines (Appendix 1). The final sub section offers reflections on how these findings might be considered and taken forward in relation to public and private incentives and other instruments, research topics, and tools for supporting multi-actor collaboration. The analysis that follows aims to give a thorough view regarding FEFTS adoption, in terms of commonalities and differences identified between the 8 hubs of the project.

3.1 Business and profession group needs and expectations to existing FEFTS and/or most demanded FEFTS

For the open-field crop production theme, the participants focus was overall on fossil free machinery, changes to agricultural field practices (in relation to more adoption of precision agriculture), crop rotation and diversification, no or minimum tillage approaches (no-till) and conservation agriculture (CA) based cultivation of crops. There was also focus on RES production possibilities, where Central and Northern regions were primarily focused on biomass-based energy and fuel production, geothermal heat pumps and wind energy for both own consumption and electricity sale to the electricity grid. In southern parts of Europe, the focus was on agrivoltaics for primary increasing the degree of energy self-sufficiency. The open-field agriculture activities as an energy user/consumer category, the issues of fuel consumption per hectare and available FEFTS related to fossil free machinery/equipment were discussed in detail and evaluated both in Greece and Italy (in the South), and in Netherland, Denmark and Germany (in Central/North Europe). However, FEFTS as substitutions for diesel fuelled tractors and machinery was not of obvious business interest in Poland, Spain and Ireland. Especially for Ireland, the discussion at the workshop was very much focussed on existing RES, where wind, solar and geothermal energy were highlighted as novel agricultural activities in terms of strong potential for energy sales to external consumers. The implementation of agrivoltaics for energy self-sufficiency was the one of the most interesting business cases explored by the farmers in the workshops of Greece and Italy. In Denmark, Netherlands, Germany and Ireland, the idea of energy sales from RES provided by arable farmers to external consumers was most propagated. Precision farming (especially fertilization) was discussed and evaluated as a big player in Poland for reducing fossil energy through reduction/better utilisation of fertilizers and local production of fertilizers from biomass. Changes to crop cultivation, crop rotation schemes, and increase in crop diversity was a general topic raised at all workshops and regions, where participants came up with ideas of reduction in energy costs by no or minimum tillage, conservation agriculture practices, and CO_2 sequestration techniques. In Italy, training based on European knowledge was mentioned as a main FEFTS tool (mostly related to S - strategy) to change from conventional to more energy efficient arable farming.

For the livestock theme the participants focus was in general on energy provision from various RES, both from the inside as well as from the outside of livestock buildings. Especially heat pumps and ventilation systems converting livestock buildings to more energy efficient facilities were discussed throughout the regional innovation workshops. Increase in energy self-sufficiency was the main target for many regions dealing with livestock production. In Germany, there was also a certain focus on ways to store energy produced by RES. Regarding direct reduction of fossil fuel consumption, electrical and methane powered machinery were mentioned as business applicable solutions to reduce the livestock sector dependency on

fossil fuel mainly in Germany, Denmark and Netherlands. In Southern Europe, the conversion of biomass to energy was the general FEFTS discussed among livestock producers. At the same time, in common with Poland and Denmark, a great desire was observed in southern countries regarding the implementation of smart control and management systems to guide feeding operation, manure treatment alternatives, biomass conversion to energy and business models to identify where energy consumption could be reduced on individual farms.

For the greenhouse sector, there was throughout the regions a business interest in RES for clean energy production, ranging over solutions such as agrivoltaics, geothermal energy applications, heat pumps and wind energy. In the southern Europe, there was also a focus on solar powered water pumping/irrigation systems, whereas in Central and Northern Europe there was more focus on local energy supply from biomass boilers. Energy control and management systems for greenhouses and overview of CO_2 reduction means for greenhouses was debated as well in all regions, except for Ireland. Ireland greenhouse regional workshop was mainly focusing on mushroom production, where the other regions were having a broad approach to greenhouse production diversity on the workshops.

3.2 Identification of barriers for adoption of FEFTS

All regional participants concurred that energy consumption and costs were becoming more and more critical across all three agricultural sectors investigated. The European 2022 crisis was evolving during the workshops during spring 2022, which influenced the workshop discussions in relation to energy consumption and alternatives to fossil fuel-based energy sources.

For all the workshops conducted in each hub, there was consistency of several identified barriers for FEFTS adoption as well as clear opinions regarding existing RES across all regions. The following barrier statements were recognized at all workshops and independent of the three themes.

The constant changes of political decisions related to the agri- and horticultural sectors and the permanent scarcity and prices of raw materials/operating materials in relation to the sectors were highlighted. Obscure national regulations hinder the production, sale and use of energy from RES. However, economic recession has also an impact on supporting use of renewable energy by the agri- and horticultural sectors. Other important barriers identified were the lack of certainty of the relevant markets, the increasing costs of production, the boundless bureaucracy in relation to subsidies, public funds and in general for running an agri- and horticultural business. Subsidy schemes for reduction of 20-40% of the direct investments in sustainable technologies was criticised, as the subsidies are not associated/linked to the production of crops or livestock. That leaves no financial appreciation or rewards for sustainable investments for an agri- or horticultural business. An example of how bureaucracy reduces the incentives for adoption of FEFTS was given by the workshops in Germany, where it was highlighted that the actual agricultural and energy policies are not suitable to make the agriculture carbon neutral. Another example was given by the Danish workshops, where photovoltaics integration in buildings, is not possible due to regulations to construction of buildings. It was pointed out that currently the most significant problems are the existing bureaucracy and legislation related issues, followed by the financial aid/incentives.

When the agri- and horticultural sector looked inwards, the common barriers for adoption of FEFTS across regions were the diversity of farm type and size, lack of education and training, inefficient administration of supports, enterprise systems, and lack of advisory services to guide for the right planning in order to take actions on FEFTS investments. In additions, a concern is that farmers probably do not have the sufficient time to spend on learning or investigating financing channels or grants in the sector. Additionally, it is a

problem for an individual farmer to change his/her practices by adopting novel technologies and strategies, due to the high initial investment costs for many of them and the overall uncertainty about the expected results. Regarding financial barriers identified the most common ones were low profitability of production and uncertainty about the sales of agricultural products. Moreover, agricultural stakeholders do not always see much reason to change only for sustainability reasons, considering all the financial uncertainties and costs. It was also observed that there is lack of knowledge on installing specific FEFTS in a local level, as farms are in large distance from the main installers due to their remoteness. In addition, decision making is executed in most cases far away from farming areas, being a drawback in faster adoption of FEFTS in farms. In general, there are important bottlenecks in the knowledge transfer chain. In addition, aging of farmers is a limiting factor.

In Ireland the concern of a potential dramatic increase in electrification and RES was the risk of underdeveloped grid connection capacity, which was then observed as a technical barrier. There were doubts that the current infrastructure and local energy grid are suitable and appropriate for the new high demands to 'all electric' concept. For each hectare of greenhouse 13 hectares of standard performance PV system are needed, so farmers are often unable to meet their needs or resell the energy. Another, but common, technical barrier to replace fossil fuel was the obvious lack of knowledge about the potential for alternatives to e.g. diesel for vehicles. Especially for crop production, it was also common that there is lack of awareness of the interconnectedness of the economic and environmental aspects of field crops, e.g. specific effects on CO_2 sequestration in different crop rotation systems.

Dissimilarities were observed for one group of countries: Greece, Spain, Ireland, Italy and Poland, where the aging of farmers and their reluctance to use information technologies and internet are seen as barriers. These issues were on the contrary not mentioned at workshops in Denmark, Netherlands and Germany.

3.3 Identification of incentives and other instruments, research and tools for supporting multi-actor collaboration, aiming to increase FEFTS adoption

The conversations at the final stages of the workshops dealt with priority actions in relation to incentives, research topics and tools for supporting multi-actor collaboration in order to promote FEFTS adoption. During the study of the workshops, a picture emerged of five categories into which the topics discussed can be divided. All regions referred to policies and other mitigations for the implementation of FEFTS, need of cost-benefit analyses, need for labelling and changes to tax schemes, needs for research, innovation and advisory services, as well as possibilities of multi-actor collaboration. These five categories traverse the three themes of the project (e.g., open-field crop production, livestock facilities and greenhouses). There was not one of the themes that had more focus on a single one of the categories than other themes, i.e. the categories' respective areas of effort were obviously significant for the participants of all three themes. The following is a summary of the similarities within each of the five categories. The study showed that there were only a few dissimilarities.

Policies

For the first category in relation to policies there was a concurrent and specific request from the Netherlands and Denmark that subsidies and other financial incentives should be based on the use of 'hard' measures, e.g. from enterprise data (general on enterprise levels or specific on individual enterprise). Support schemes for the usage of the technology – not the investment. Subsidies should instead be correlated to the use of technologies and scale at farm level and based on baselines for the technologies. Subsides should be more targeted towards positive climate effects. Public policy can best stimulate energy production per unit

production (energy intensity) with subsidies instead of subsidising hardware like solar panels or wind turbines, which consequently, requires new public policy. These two countries also stated a need to close old subsidy programs and move finances to new areas.

There was a common agreement between all regions on the paramount issue of credibility of political incentives and subsidy schemes. In this context more long-term and reliable policies were requested by the regions Germany and Italy. These regions mentioned the demand of long-term reliability of the political framework, long-term and plannable decisions in order for farmers to be able to invest properly. Aspects that are also deemed as very important suggest to be payed attention on:

- Letting political decisions be taken at regional level and make long term plans (for business security reasons).
- Need for reliable framework conditions, which is the alignment of politics with scientific and factual knowledge.
- Clear policies and national as well as EU communication that is not volatile nor subject to misleading interpretations.
- Supply of financial aid and structured general policies for the adoption of FEFTS and innovative technologies, strategies and tools in general, allowing the smooth modernization of the agricultural domain and mitigating/reducing simultaneously any possible negative economic side effect for the farmers, which may derive by the transition.

All the workshops' stakeholders focused a lot on minimizing the bureaucracy and avoiding gaps between subsidy schemes and practical agri- and horticulture, which were commonly suggested by the regions Germany, Greece, Spain and Ireland. Promotion and understanding of the best practice examples at political level were also suggested. In addition, it was agreed that the adoption of regulations should be more applicable to farmers and make them truthfully incentivize depending on the type of adoption. When national governments legislate in deep level of detail, the frictions will appear due to the lack of knowledge about the reality in the local dimension or because the national legislation in detail cancel the competencies that local governments have. Stimulation of awareness, and simplification of legislation for adoption of RES would enable smoother FEFTS integration. Removal of bureaucracy that follows anything related to innovative changes was suggested, such as authorization licenses and legislation in general that sets bureaucratic obstacles to green transition actions. A practical example was given by the Netherlands, where it was highlighted that EU subsidies for arable land have not changed/modified yet when agrivoltaics are established on arable land as alternative to grow crops. FEFTS related to RES could be used in an agri-environmental scheme. It was recommended to let the agri- and horticultural sector be the central players in the national energy transition while avoiding having a narrow focus on a few FEFTS and specific RES, but be more open to other options. Policies should also work for smooth modernization of the agri- and horticultural sectors and mitigating/reducing simultaneously any possible negative economic side effect for the farmers, which may derive from the transition towards FEFTS and RES as such.

In Poland and Spain there were concerns about the differentiation of financial resources to better meet the needs for small farms as well as for big farms. A differentiation between large and small production units are needed, which means improvements to existing incentives are needed as well in order to support the FEFTS transition at both small and large scale arable and livestock farms. It was stated that the small- and large-scale farms have different needs of FEFTS and different economics of scale.

The regions Greece, Italy, Ireland, and Netherlands were all recommending that policies should also concern subsidising consultancy services and pioneering entrepreneurs. Financial aid such as subsidies and

investment support, together with proper guidance, advisory and extension services, are needed for achieving the best possible FEFTS integration and implementation. The policies should do more to encourage pioneering entrepreneurs and offer certain services to them, enhance access to advisory services, and provide opportunities to producers to become pioneers in sustainable energy production and FEFTS adoption. Enforcement of advisory and extension services for farmers in order to facilitate support to farmers and producers, together with enablers such as subsidies, investment assistance, zero interest loans will encourage the adoption of FEFTS on farms. There could be special funding schemes for early adopters/pioneers. Policies and advisory should also aim at the development of model farms.

Cost-benefit

It was Germany and Spain that clearly stated that farmers requests cost-benefit calculations for FEFTS and a must to always present the financials of any solution, especially for smaller farm sizes up to 100 ha. However, all regions expressed concerns about cost-benefit uncertainty of investments in FEFTS. There was a request to show ways that are feasible and protect pioneers in sustainable food production from the ever-changing opinions from the outside. If an incentive is to change field cultivation practices, the transition must be done in stages and with soft transitions while controlling costs. The farmers want to be sure that they are not improvising or incurring in high risks. For instance, in Denmark, the workshop highlighted doubts that a CO_2 tax will provide the green transition towards FEFTS adoption. Germany workshop suggested a tax exemption for biofuels and the creation of financial parameters to secure the use of renewable energies in the long term. A clear, long-term commitment to tax-free bio-oil fuel in agriculture is necessary, given the simple fuel production with very little energy consumption and the short transport routes (no other fuel offers more regionality and CO2 savings and adding value to agriculture). Abolition of levies on electricity for self-sufficient business is also commonly identified as important. A protection framework is necessary against the uncertainty that some policies or plans bring to the farmers. In addition, there is a major need for help in repayment of the investment and some sort of investment aid or insurance against project failure. A clear understanding about the return on investment is always fundamental. That also includes the validation of the effect of different FEFTS (both RES and measures that improve energy efficiency), study of the whole value chain and identification of where to make the highest impacts/whole energy circle, in order to find the individual elements that increase cost-benefit. In this regard, also avoid one-sidedness regarding alternatives to fossil fuels.

Possibilities for better balancing of cost-benefit was proposed by the workshops. Firstly, supply of reduced interest rates in connection with FEFTS and sustainable energy production investments. Secondly, reduced taxes on produced sustainable energy which are lowering the demand on the grid, as well as FEFTS integration certification or branding, e.g. by higher prices on product from farms that produce with low carbon footprint. In Greece only, there was a demand for simplification of procedures for energy sales to external users. Ireland raised the importance of proper backup in terms of servicing the equipment over the years after system installations which also has impact on running cost levels after FEFTS implementation.

Labelling

Labelling or certification of products produced by use of FEFTS, RES and low carbon foot print was only mentioned at workshops in Germany, Denmark, Greece, Netherlands and Ireland.

In common, the mentioned regions requested political statements on climate/CO_2 labelling. There were common suggestions for labelling food that is produced in more sustainable way and need for certification of integration of FEFTS in the food production value chain, in order to increase agricultural product prices. Ireland was requesting the development of sustainable pricing models and markets for products produced

by use of FEFTS and RES especially. Regionally produced products should have a higher value or the import of products that can also be produced in the country should be taxed higher. There was also suggestions to radical change the settlement price of agri- and horticultural products. An example was mentioned that suggests changing the settlement price system for wheat, away from crude protein content to e.g. carbon footprint or carbon sequestration. If a CO_2 tax will be imposed to agri- and horticulture, there will indeed be a need for a CO_2 accounting system that can pay for itself. A simplification of the licensing procedures with energy contractors was mentioned in order to obtain a better accounting system for the sustainable energy produced. Financial compensation and labelling for carbon sequestration in agriculture, e.g. humus build-up, use of bio-char etc. For bio-char specifically, it was mentioned at the Danish workshop that bio-char can only become sustainable if the settlement of account is made for carbon sequestration.

Research, innovation, and consultancy

There was a common interest in research that leads to demonstrations and promotions of pioneer FEFTS that boost them up to a more mainstream accessible technology for farmers and advisers. Several regions pointed out the necessary research overview first, in order to pinpoint the best FEFTS at the regional level. Also, there was a common need of defining the correct or best measures of energy efficiency, and whole energy circle approach to reduce GHG emissions and to make the right decisions on FEFTS and combinations of FEFTS on regional, local and farm level. Research should first look at the entire system/energy cycle, not so much on improving individual technologies in the first place. There were, however, differences on research topics from region to region. Research project objectives are listed in Table 3.1. In general there was a demand for both research for recording more data and knowledge to base decisions on. Secondly, there was a general interest in research that supports the farm level adaptation of renewable energy, and local production of energy, fuel, fertilizer, and storage of energy (and carbon). Research on intelligence in the conversion of biomass or geothermal/solar/wind into fuel, so that loss of energy is avoided. Also research on infrastructure for distribution and sale of renewable energy sources to obtain maximum GHG reduction impact, while minimizing operational disruptions and economical failures. More specifically on FEFTS categories, needs of research was highlighted on heat pumps, precision farming technologies, biochar and soil fertilization. Also, there is need for research that leads to “proof of concept” in general for FEFTS.

Italy (IT) is not on the list of research projects in Table 6. However, in Italy there was a main focus on the need of innovation brokers, which was defined as a consultant who is able to carve out tailor-made technological solutions for farms. Local entrepreneurs and installers should be provided with basic training, financial aid, advisory and extension services and networking for this transition. All other regions was mentioning the need and role of innovation brokers in an advisory system setup that is obviously not existing in any of the hub regions. For example, development of independent national advisory service to achieve more engagement and lead to knowledge transfer from research to the field and further incorporation of FEFTS in the daily crop/livestock production practices. General demand for demonstrations and tests for showing the benefits of FEFTS with practical cases and advising.

Table 6: Specific research project objectives derived from the 24 regional workshops completed by the regional AFF hubs

Research project objectives	**Region**
Define production of food from renewable raw materials and renewable energy sources until the local farm/area/country are energetically, materially and food self-sufficient	DE
To produce sustainable regenerative fuel.	DE
To develop and find suitable alternative fertilization methods and drive systems.	DE

To investigate and develop inject exhaust gases (CO2) such that it can obtain permission and are economically sound (greenhouses)	DE
Collect research in the area, create an overview of research. Create good data such that the greatest GHG reduction can be achieved	DK
Investigate how to increase energy intensity (energy used to produce a given level of output).	DK
More research and implementation of systems for recycling biomass for fuels (GTL (gas to liquid)	DK
To producing hydrogen locally is possible, but distribution or practical application and studies are lacking.	DK
To generate knowledge about the biological fertility of the soil and how to use microbiology to work for crop cultivation without destroying the soil.	ES
To do more research on efficient irrigation systems, machinery digitalization, precision farming.	ES
Development of experimental farms, and thorough feasibility studies	ES
To increase quality of animal feed and animal breeding (DNA improvement) for allowing higher production and less GHG impact.	EL
Implementation of precision agriculture, IoT, automation, ionic fertilization/hydroponics (greenhouses)	EL
Energy production on-farm, e.g. biogas exploitations, agrivoltaics	EL
Research that leads to demonstrations of pioneer technologies that lift them up to a more mainstream accessible technology for farmers	NL
Research on the financial possibilities of different FEFTS for clean energy production and storage on farm, where the offset, storage, delivery, economically sound and safe use of selected FEFTS are tested and presented to the agricultural sector and society.	NL
Research on farmers' views and needs which are very often not taken into account when designing legal regulations or technological solutions.	PL
Standardisation of the format of data on a farm so that they can be used in various applications available on the market.	PL
Research on decision-support systems, programmes and applications that allow rational use of fertilisers, and research on crop varieties adapted to local conditions, better able to adapt to changing climatic conditions.	PL
The development of RES in rural areas, where a lot of raw materials/biomass for energy purposes are unused. There are still a lot of reserves: green certificates, raw materials for energy purposes, solar and wind energy. Food waste must be reduced.	PL
Precision farming solutions are appreciated by large farmers but effort should be made to reach small farms.	PL
The development of precise on-farm systems reducing labour and energy inputs and using renewable sources.	PL
Actions in relation to energy efficiency could help to balance some energy demand growth. Identify best systems of operation in terms of energy efficiency. Identify best systems of operation in terms of energy efficiency	IE
Replacing fossil fuels with renewable energy for making progress towards decarbonisation	IE
Need systems to record real data to inform decisions on what's happening on farms and what can be optimised/changed/replaced by FEFTS. Also to assess how (pioneer) farmers are using the FEFTS to best effect.	IE
Improve Coefficient of Performance (COP) of heat pumps, for instance how to increase supply temperature to heat pumps, how heat pump performs under different flow temperatures and outside temperatures (air to water heat pumps) and its potential for cooling.	IE
Geothermal/heat pump technologies and their benefits in agriculture sectors such as dairy, pig and poultry farming, especially for integration with new buildings. How to combine heating and	IE

cooling to cut the cost of production. Sustainable case studies. Quantify the relative benefits of different sources of heat (including health, environmental and socio-economic benefits).	
Research on developing simple control systems and off-season storage options. Research on the combination of GSHP with other renewables from an agricultural perspective.	IE
Need engineering solutions involving combined heat and power, solar, heat pumps, gas boiler, water storage, ground thermal, CO2 extraction and seasonal storage options. Identify new ways to reduce the cost of renewable energy.	IE
Develop net metering system and define local service and energy supply availability for RES. Identify new ways to reduce the cost of renewable energy.	IE
Investigate applications for bio char.	IE

Multi-actor collaboration

The previous sections dealing with enablers and mitigation of FEFTS was focussed on the perspectives seen from a farmer's point of view, and what can be done to support the adaptation and implementation of FEFTS for sustainability of future agri- and horticulture, for example by EU or national policies, i.e. what could the government do to make agri- and horticulture fossil free.

Multi-actor collaboration on the other hand, is a process through which multiple parties see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible. The section looks for workshop statements that suggest coordination of activities and management of the FEFTS awareness, adaptation, and implementation collectively rather than individually. It was the regions Greece, Italy, Ireland, Denmark and Spain that dominated the definition of relevant multi-actor collaboration.

The region and/or EU is diverse and the reality of different regions cannot fit into a detailed policy "for all". Some of the most important views on collaborations were:

- Collaboration among farmers, government, and financial institutions, better involvement of research centres, development of organizations for producers and consumers and collaboration among neighbouring farmers.
- Better alignment and harmonization between local governments and European policies.
- Components of the CAP of more interest for the FEFTS adoption: green deal, operative funds, uses compatibility, subsidies, but knowledge about CAP needs to be improved.
- Improvements to CAP to make FEFTS adoption more interesting (such as including a specific paragraph only for agrivoltaics adaptation and implementation).
- The main drawbacks of the CAP is that it does not allow compatibility with other land uses and it does not allow land use change, for instance agrivoltaics.

It was observed that there were a unanimous view on the contribution of the new CAP in the implementation process of FEFTS and it was identified that there is a missing link between Green Deal and CAP.

In general, according to the RIWs' feedback, subsidies from EU would be praised, not only for the sector directly, but also indirectly for training and education of farmers, their employees, and advisors. In a multi-actor context, a need of EU offices that can help multi-actor collaboration projects get started was highlighted. Also need for focused FEFTS awareness-raising in agriculture and for the general public. Need of forming small groups and integrating central governmental policies is essential for achieving the best possible FEFTS integration and implementation. Strengthening of local agricultural cooperatives and

associations, aiming to create secure robust links and stable contact with governmental stakeholders and commercial representatives for the adoption and implementation of FEFTS was also deemed as positives changes. For example, define regional centres of excellences and test beds that could consist of demo farms, research stations, technological institutes, universities/third level colleges, etc. During the construction of centres of excellence, it is necessary with lists of all relevant and important stakeholders, especially seek the industrial symbiosis and investors. Collaboration between national Energy incentives and Green incentives research programs such that agri- and horticulture becomes a part of the energy resource solutions support with research and development activities contributing to the overall Green Deal.

4. Concluding remarks and issues for further consideration

In general, the RIWs followed the workshop guidelines and committed to templates for reporting, which proved to ease the presented synthesis of workshop outcome and fulfil the report objectives. This report outputs 1:1 issued statements (with minor rephrasing) from the individual 24 RIW workshops, collected under a structure that will serve the subsequent step of fostering recommendations and policy guidelines (Task 3.4). It has been a high priority that the regional workshop organizers can recognize their respective reporting and workshop output.

It was possible from the synthesis to derive regional information about needs for future research on FEFTS, topics of interest for national as well as for EU agendas, and topics for incentives and incentives improvement. This report has summarised regional similarities and/or dissimilarities, for instance in relation to business and profession group needs and expectations, identification of incentives for adoption of FEFTS, identification of barriers for adoption of FEFTS, level of interest in existing FEFTS and/or most demanded FEFTS, sources of funding for project ideas, and other instruments and tools for supporting multi-actor collaboration and implementation of FEFTS.

In conclusion, the prevailing impression is that all regions declared unity in terms of barriers for adoption of FEFTS across all three themes. The needs for FEFTS were differentiated not only between themes, but also between regions. For instance, reduction of dependency on diesel for fuelling vehicles and crop cultivation (implicit carbon sequestration) was discussed most in Northern and Central part of Europe, whereas, in Southern Europe plus Ireland, the conversion of biomass to energy, agrivoltaics and heat pumps were the general FEFTS discussed. It is also important to point out that many of the results of the 24 RIWs were in alignment with the feedback gained by the farmers' survey conducted in the context of Task1.3.

Appendix 1 Regional Workshops Guidelines

Table of contents

1. General Information (Introduction)

Three multi-actor workshops in each of AFF defined "hubs", should allow for the direct dissemination of novel FEFTS solutions (WP2) and the capture of grassroots-level innovations and needs in regional level (WP1). The central tool for interactive innovation in the "hubs" will be the multi-actor workshops, bringing together research, extension, industry and farmers within and outside the project. The multi-actor workshops will be organized by the AgroFossilFree regional partners, where the existing networks and consortiums will be invited.

For all regions, the workshops will be organized based on the following **themes**:

(i) Open-field agriculture

(ii) Greenhouses and

(iii) Livestock farming.

However, in DK, PL and IR there is the possibility for the AgroFossilFree consortium to replace 1 greenhouse theme by 2 livestock building themes or 2 open-field agriculture theme.

In close collaboration with the relevant stakeholders, AgroFossilFree partners will **select the most relevant FEFTS commercial solutions** (6-10) from those assessed in WP2 according to the:

a) subject of each workshop,

b) results gathered in WP1 and

c) geographical and thematic scope of the manufactures, farmers, stakeholder, research/extension attendants.

An effort has to be made in order to ensure the participation of representatives of the respective national associations, RES industry, conservation agriculture, smart farming and of course farmers, in the workshops.

The selected commercial FEFTS solutions will be presented in the workshops, allowing for:

(i) extracting **feedback to the FEFTS research results** to reach the farming community,

(ii) coming up with **ideas for bringing the available FEFTS solutions into practice** (adapted to specific regional conditions or different uses),

(iii) generating **innovative uses for the existing FEFTS solutions**.

In addition to the assessment of existing FEFTS solutions presented in the workshops, **grassroots level ideas (or innovations)** from all stakeholders will be captured through **identifying the "Pain Points"** in the value chain which **generate needs** that could elicit an intervention with FEFTS solutions. During the hub workshops, the needs identified in the WP1 surveys (see D1.3) will initially be validated and new needs,

implementation and innovations could be captured. The workshop synthesis (report) will support the assessment of FEFTS for impact and feasibility. Research partners in AgroFossilFree will evaluate the ideas' scalability, commercial value, resource requirements, etc. and will identify the partner ecosystem and the funding needed for lean start-up of innovation-based collaborative projects.

The synthesis (report) of the hub workshops is expected to include:

(i) **opportunities** and **specific needs in FEFTS per region** as identified by work under WP1 and WP2

(ii) **outputs issued from the workshops**, collected under a well-defined common format/template in order to directly feed the AgEnergy Platform.

The final part for the successful completion of Task 3.3 will be the preparation of an overall report by AU, collating all 8 regional reports. Furthermore, important information and results from this Task will be used in Task 3.4 for recommendations and policy guidelines and will be made accessible on the AgEnergy Platform too.

In addition, we should have in mind that during the workshop, there is need to identify among the participants, the ones that are agile, useful, have a specific expertise, tend to express their opinion and are able to communicate in English. The reason for this is to find the ones that are appropriate and willing to participate in the transnational workshops that will follow (Task 3.4).

2. Scope and goals of regional workshops

(courtesy of Nolan Doesken)

2.1 Open innovation orientation

- Create new partnerships by bringing together all the stakeholders in the same the-matic sector (arable crops, livestock, viticulture, greenhouses, etc.),
- Take advantage of the multiplicity of expertise to identify among the pre-selected innovations from WP2 inventory the most relevant to meet the AgroFossil Fee challenges of the sector,
- Highlight these innovations in order to facilitate their adoption by the sector,
- Identify needs not covered by current available FEFTS solutions,
- Define innovation priorities to feed into public policy in relation to FEFTS.

2.2 Workshop specific objectives and proposed questions

The objectives of the whole process will be derived during the Working Group discussions and will be the following:

1. **Receive the general opinion of agricultural stakeholders** about all categories of FEFTS (RES/Energy Efficiency measures/Soil Carbon Sequestration) applied in local agriculture
2. **Identify problems** regarding energy in existing farming systems
3. **Assess** whether the presented FEFTS or other existing ones are adequate for solving the problems identified
4. **Extract ideas** of these stakeholders on how to solve such problems
5. **Create** collaborative **research project proposals** between different stakeholders (farmers, extension services, industry and researchers) taking into consideration the problems and the solving ideas received above.
6. **Recommend policies** to be incorporated in the new CAP and other policy instruments to assist on FEFTS integration in local agriculture.

Regarding the preparation of the questions that each hub will create in order to use them in the workshop (and the respective question categorization), aligned with the aforementioned objectives, the Guidelines propose some examples of questions to be discussed with the Workshops' attendants:

1. **General opinion about the energy status in agriculture and FEFTS positioning:**
   - Do you think that energy consumption is a "pain" for local farms?
   - How do you see FEFTS integration within local farms?
2. **Findings regarding the needs and ideas identified in WP1:**
   - Do you think that the users' needs identified in D1.3 are confirmed by your everyday practices?
   - What are your needs regarding FEFTS that were not mentioned in the presentation?
   - The above can be technological needs, but also others, such as need for training, need for improved advisory, etc. Can these needs be addressed by setting up collaborations (for example, by a collaboration project) or are there to be addressed at the political level (for example, by setting up a subsidy for FEFTS)?
   - Do you have ideas regarding the use of FEFTS in the agricultural system you work on?
3. **Identification of barriers and incentives for adoption of FEFTS:**
   - Do you find the barriers identified in D1.3 relevant to the agricultural system you work on (i.e., farm size, cropping system, farmers' age and education/training, etc.)? (By consulting D1.3, the facilitator can open the discussion about the barriers identified in the relevant country and production system!)
   - Can other barriers for FEFTS adoption be identified that are specific to your Hub?
4. **Relevance and interest on adoption and transfer of presented FEFTS, ranking of the highest scored FEFTS:**
   - Do attendees show a special interest towards specific FEFTS? Please put together a list with the FEFTS presented and then allow the attendants to rank them either by using pins/stickers on a physical board or by providing the list on a piece of paper where each attendant will rank the FEFTS with numbers.
   - Are these FEFTS in the market yet or are they being developed (TRL<9)?
   - Ask attendees to provide feedback to FEFTS industry for improving the FEFTS or adjusting them to the specific regional conditions so as to bring them into practice.
5. **Potential new uses for existing FEFTS:**
   - Can you propose new uses for the FEFTS presented (i.e., FEFTS presented for arable crops that can be adapted for vineyard)?

6. **Potential inputs for research:**
    - Are there specific needs that can be addressed through research (it can be basic research on i.e., development of an advanced building management system, but also applied research on, i.e., application of a specific FEFTS to a new environment)?
    - Do you have in mind specific research results regarding one or more FEFTS?
7. **Policy recommendations:**
    - Do you think that the existing incentives for shifting to FEFTS adoption are adequate?
    - What kind of incentives would you like to receive for fast adoption (subsidies, investment assistance, reduced interest rates, certification of FEFTS integration to increase agricultural product price, etc.)?
    - Do you think that the new CAP could assist on FEFTS adoption and how?)

2.3Target groups

In order to have the greatest possible diversity of expertise, a broad spectrum of stakeholders should be gathered:

- Farmers, farmers' unions and representatives of inter-professional organisations, associations
- Manufacturers of RES and RES associated and their representatives' organizations at national level,
- Governmental authorities,
- Agricultural advising structures/extension services (public and/or private advisors specialized in RES),
- Research and R&D institutes,
- Research and Technology Organisations (GTS institutes)
- Training representatives (engineering schools, universities, agricultural, etc…),
- Contractors.

In order to increase the impact of these workshops, recommendation is about **40 attendants per regional workshop**. Of course, we should take advantage of both the contacts that were made during the conducted interviews for Task 1.3 and the stakeholders' mapping contacts that gathered for Task 3.1 purposes.

3. Practical organization of workshops

- Remember to inform Iniciativas Innovadoras (INI, Camino Fabregas cfabregas@iniciativas-innovadoras.es) before and after workshops, send photos and information. INI is also able to support the setup of workshop invitations, roll-ups etc.
- Ask attendants for permission for using pictures.

- Ask attendants permission to send newsletter invitation.

3.1 Thematic facility/venue

Each workshop should draw on unique experiences of a farmer, or a manufacturer or others from implementing novel FEFTS technology/technologies. Thus, a recommendation is to place the venue on location, where one or more FEFTS technologies has been implemented or manufactured.

The format of the workshops should ideally **start with a short presentation of the project** and **a series of relative FEFTS** for the local agricultural systems, followed by **separation in 2 Working Groups** where discussion on **Clean Energy Supply FEFTS** and **Energy Efficiency FEFTS** will be carried out respectively (in the open field workshops, we should also discuss about **Soil Carbon Sequestration**). Finally, (if the time is adequate) short presentations of the discussion results in each Working Group by the facilitators to the full audience should be held. In the following section, a proposed workshop timeline is presented.

3.2 Global introduction, plenum [20 min]

This introduction presents the objectives of the AFF project and workshop to the participants (AFF intro ppt file available on Teams: AFF Teams→General channel→Files→AFF meetings→Kick-off meeting). It should also include a presentation of the AgEnergy online platform and its intended practical use and relevance for the workshop participants (https://platform.agrofossilfree.eu/en). Short/Initial/Indicative presentation of the summary of the WP1 conducted interviews of farmers and experts to give an overview of factors that influence the adoption of FEFTS (relevant input provided by the D1.3 report and at AFF Teams→General channel→Files→AFF meetings→ 3rd meeting).

3.3 (Optional) Introduction to venue and displayed FEFTS technology [20-30 min]

For instance an introduction tour, or presentation.

In the meanwhile, the workshop organizers are partitioning the participants into working groups for discussion of participant-relevant FEFTS.

3.4 Work in groups, plenum and breakout, two successive sessions including breaks [1-2 hours]

Participants are divided in 2 or more working groups (group size recommendation is 10-15) **Grouping by category:**

1. **Clean/renewable Energy Supply,**
2. **Energy and Natural Resource Efficiency Theme,**
3. **Carbon Sequestration (open field agriculture)**

As an option, the composition of the groups may also be previously defined by organisers, mixing in all of them representatives from all stakeholders' sectors (policy makers, farmers, advisors, manufacturers…) to ensure balanced composition of each group.

The number of working groups depends on the participants common interests in thematic FEFTS technologies. The number of people that will participate in each Working Group depends on how many participants will appear in the workshop in total.

Each working group is coordinated by a facilitator and a minute taker **(you can use a recording device with the consent of the attendants to debrief the conversation in a detailed way or systematic sampling of POST-ITS)**.

In this option, the facilitator guides the discussions while the minute taker takes note of the exchanges. This information and notes will be used to synthesize the workshop and write the workshop deliverable. A template (appendix 2) will be provided to workshop organizers in order to collect conclusions in a harmonized way and write the report.

There will be 2 sessions in order to give attendants the opportunity to work on more categories (see above). It is important to take advantage of this possibility since some participants have a transversal expertise.

One person among the workshop organizers will have to be responsible for 3.5 and should circulate around the groups for listening and making notes aiming to the plenum session in 3.5.

3.5 Feedback from participants and last inputs, plenum [20 min]

Explanation of the further process and immediate conclusions of the workshop (e.g. overview of FEFTS discussed and the organizers experiences from the working groups).

3.6 Workshop synthesis, post workshop [40 min]

The facilitators and minute takers of each working group synthesize the opinions expressed in their working group by making use of the workshop template (appendix 2).

Please, do this work ASAP after the workshop to avoid forgetting some of the important findings.

4. Expected outputs

4.1 Deliverables from each hub workshop

In order to facilitate the organization of transnational workshops, it is recommended to use a harmonized model for the synthesis (report) of each regional workshop. At the end of each workshop, a synthesis (report) will be requested from the local workshop organizers. For each of the FEFTS addressed in the workshop, the synthesis report will include the main points addressed during the workshop:

Workshop short note template (appendix 1):

1. Description of the context: Was the workshop organized during an event? Were some thematic groups gathered? List of the companies and organisations that participated in the workshop.
2. List of priorities/challenges for the thematic sector, following the FEFTS categories and sub-categories defined by AFF.
3. List of FEFTS selected for the workshop
4. Summary of thematic areas.

Workshop output template (appendix 2):

5. Summary of prepared questions asked by the workshop organizers (cf. guideline 2.2)
6. Results of workshop discussion on ways to support the development or implementation of relevant FEFTS.
7. Identification of other needs not addressed by the discussion/presented FEFTS
8. Identification of collaborations that could be set between attendants/stakeholders.
9. Priorities for future public policies on FEFTS implementation and/or further product development.
10. Attach in appendix a copy of the workshop program and call, as well as any media publicity.

This synthesis will act as the basis for the reflection prior the three transnational workshops (WP3, Task 3.4).

Guidelines' Appendix 1

(see examples of short note at the end of Appendix 1)

Workshop short note template

Workshop title:
Theme:
FEFTS: • •

(shade in green the level 2 sub-category that the workshop address)

FEFTS category	**Level 1 sub-category**	**Level 2 sub-category**
Energy User/Consumer	Agricultural technology applications	heating and cooling of buildings
		process heat/cold
		lighting
		agricultural field practices
		vehicles
		tools
		energy sales to external consumers
Clean Energy Supply	Renewable Energy Sources	solar
		wind
		hydro
		geothermal
		bioenergy
		free energy
	Energy types	heating
		cooling
		electricity
		mechanical energy
		chemical energy
	Energy Technologies	photovoltaics
		solar thermal
		wind mills
		hydropower
		heat pumps
		geothermal
		solid biomass conversion
		biogas / biomethane production
		liquid biofuels production
	Energy Storages	heat storage
		electricity storage
		cold storage
		intermediate bioenergy carriers

Energy Efficiency Improvement	Energy savings	efficient buildings
		efficient vehicles
		efficient tools
		precision agriculture
		precision livestock farming
		conservation agriculture
Carbon sequestration	Carbon sequestration	soil organic cover
		tillage (Conservation Agriculture + CTF)
		nutrient management
		crop diversification
		soil and water conservation techniques
		fire management
		grassland management

Workshop synopsis:
Venue/resources/supporting materials:
Workshop target audience:

Workshop short note template (Example 1)

Workshop title: Nitrogen Use Efficiency Optimization through Precision Farming
Theme: Open-field agriculture
FEFTS: • Precision agriculture technologies • Training precision agriculture • Bio-based mineral fertilizer • ……

(shade in green the level 2 sub-category that the workshop address)

FEFTS category	Level 1 sub-category	Level 2 sub-category
Energy User/Consumer	Agricultural technology applications	heating and cooling of buildings
		process heat/cold
		lighting
		agricultural field practices
		vehicles
		tools
		energy sales to external consumers
Clean Energy Supply	Renewable Energy Sources	solar
		wind
		hydro
		geothermal
		bioenergy
		free energy
	Energy types	heating
		cooling
		electricity
		mechanical energy
		chemical energy
	Energy Technologies	photovoltaics
		solar thermal
		wind mills
		hydropower
		heat pumps
		geothermal
		solid biomass conversion
		biogas / biomethane production
		liquid biofuels production
	Energy Storages	heat storage
		electricity storage
		cold storage
		intermediate bioenergy carriers

Energy Efficiency Improvement	Energy savings	efficient buildings
		efficient vehicles
		efficient tools
		precision agriculture
		precision livestock farming
		conservation agriculture
Carbon sequestration	Carbon sequestration	soil organic cover
		tillage (Conservation Agriculture + CTF)
		nutrient management
		crop diversification
		soil and water conservation techniques
		fire management
		grassland management

Workshop synopsis:

The workshop aims at advancing the adaption of several key enabling technologies in the field of precision agriculture (satellite imaging, radar monitoring, etc.) with potential for monitoring critical variables to optimize crop quality, availability, safety and crop growth in general at large spatial scales in order to achieve optimal management of the resources, improve productivity and yields, and, lest but not least, reduce the climate impacts of farming operations (mainly fuel and tillage). This will include:

- Enhanced data processing and machine learning algorithms
- Remote sensing-based quantitative and qualitative biomass and cereal grain remote monitoring system
- Machine Learning, hierarchical modelling and on-farm data applications for prediction of spatio-temporal correlated yield potential in grass and cereal grain
- Methodology based for use with decision support tools for bioindustry and agriculture
- The development and implementation of the building blocks for a novel methodology for cereal grain and grass protein production systems for improving nitrogen use efficiency (NUE), quality and quantity (yield potential estimation) and soil fertility and respiration management.

Thematic sessions with discussion of the adaption of FEFTS:

Increase in nutrient use efficiency (NUE). Optimum targets for N performance indicators would be those aiming for high utilisation of N input while minimising N loss risk and not compromising agricultural productivity (e.g. soil fertility, C:N ratio etc.). For example, a reduction of nitrogen leaching (i.e higher crop NUE) of 1 kg N/ha from nitrogen applied as organic as well as inorganic fertilizers will reduce emissions by **2.15 kg CO_2 eq./ha.** This number is based on the following calculations and emission factors: Nitrous oxide (N_2O) emissions from leaching of nitrate from the root zone. Calculations based on the Guidelines for National Greenhouse Gas Inventories (IPPC, 2006): Global Warming Potential (GWP) = 298 kg CO_2-eq./kg N_2O, and conversion of N_2O-N to N_2O is 44/(2·14) = 1.571. Emission factor: Indirect N_2O from nitrate leaching = 0.0046 kg N_2O-N/kg N (Eriksen et al., 2020).

Improved soil fertility. Historically, loss of carbon in soils through poor soil management has been a substantial contributor to CO_2 emissions, and is still estimated to be a net source of CO_2 (IPCC,

2013). Higher soil fertility can enhance yield, and consequently make more plant residues available for carbon sequestration in the soil. What seems to be decisive for the direction of SOC changes is the effect of tillage on net primary production (NPP). If NPP increases due to certain tillage practices, SOC stocks are more likely to increase and vice versa (Virto et al., 2012). Minimize GHGs emissions (reduced traffic and tillage and efficient use of organic and inorganic fertilizers). The soil properties and functions that are most important with regard to climate change are: soil structure and texture, organic matter content, nutrients, soil microorganisms, pH and cat-ion exchange capacity.

Increased crop quality and quantity: Increase protein and yield per unit. Studies have also shown that the use of integrated cropping systems coupled with the adoption of best agronomic practices to increase yield such as optimum plant establishment, optimised fertilization and proper crop sequencing can increase crop productivity without increasing production inputs (Kirkegaard et al. 2008). Wheat grain yield increase can reduce greenhouse gas emissions by ~ **50 kg CO_2 eq./tonne of grain** or by 8-15 % (Berry et al. 2008; Elsgaard et al. 2013). Cropping rotation, including legumes, grass, and the crop residues for carbon sequestration to soils are very important factors as well.

Venue/resources/supporting materials:

Research Center Foulum, auditorium

Workshop target audience:

Farmers, advisers, researchers, public authorities

Workshop short note template (Example 2)

Workshop title: Green hydrogen production and fuel cells for power generation to future agricultural machinery
Theme: Open-field agriculture
FEFTS: • Electric tractor on hydrogen • Electric Tractor FT25G Farmtrac • Fendt e100 Vario: The battery-powered compact tractor • New Holland T6 Methane Power Tractor • GridCON Autonomous Electric Tractor • Electrically powered mechanical weed control robots • Performance evaluation of a geothermal based integrated system for power, hydrogen and heat generation • Solar Energy • THEIA Agrivoltaics • Small wind power - Aerocraft AC 120

(shade in green the level 2 sub-category that the workshop address)

FEFTS category	Level 1 sub-category	Level 2 sub-category
Energy User/Consumer	Agricultural technology applications	heating and cooling of buildings
		process heat/cold
		lighting
		agricultural field practices
		vehicles
		tools
		energy sales to external consumers
Clean Energy Supply	Renewable Energy Sources	solar
		wind
		hydro
		geothermal
		bioenergy
		free energy
	Energy types	heating
		cooling
		electricity
		mechanical energy
		chemical energy
	Energy Technologies	photovoltaics
		solar thermal
		wind mills
		hydropower
		heat pumps
		geothermal

		solid biomass conversion
		biogas / biomethane production
		liquid biofuels production
	Energy Storages	heat storage
		electricity storage
		cold storage
		intermediate bioenergy carriers
Energy Efficiency Improvement	Energy savings	efficient buildings
		efficient vehicles
		efficient tools
		precision agriculture
		precision livestock farming
		conservation agriculture
Carbon sequestration	Carbon sequestration	soil organic cover
		tillage (Conservation Agriculture + CTF)
		nutrient management
		crop diversification
		soil and water conservation techniques
		fire management
		grassland management

Workshop synopsis:
Fossil fuel for direct power generation to machinery typically represents around 25% of the total energy consumption per hectare of open field cultivation of grain (Dalgaard et al., 2005). In Europe hydrogen produced from carbon-free sources is increasingly seen as one of the solutions that will help decarbonize the emissions from power generation to trucks, buses and construction industry. The objective of this workshop is to introduce the audience to the latest commercial developments of fuel cell technologies and hydrogen production, and discussion of how its infrastructure could be adapted to the agricultural machinery sector.

In this workshop event, experts from the EUDP funded HyBalance project will share the latest developments on public policies and industrial solutions to develop the use of hydrogen in several sectors of the economy. They will also open a discussion on possible cooperation between the agricultural sector and possibilities of providing energy to sustainable hydrogen plants. The latest developments by Ballard/MAN fuel cell and power generation will be presented as an example of projects using hydrogen and fuel cells as an alternative fuel are developing for companies manufacturing engines. The

Venue/resources/supporting materials:
CEMTEC Erhvervspark, Hydrogen Valley, with a visit to HyBalance test plant in Hobro, Denmark.
Hydrogen Valley, Hobro (Kristina Fløche Juelsgaard)
Exhibition of fuel cell from Ballard.

Workshop target audience:
Manufactures of off-road machinery, farmers and contractors organisations, policy makers, farmers, contractors, researchers, public authorities

Guidelines' Appendix 2

(see examples of workshop template at the end of Appendix 2)

Workshop output format

Please use the answers of the questions in guideline section 2.2 and fill in each category!

Executive summary of the workshop
Number of workshop participants: *Names and affiliation of workshop participants:* *Name(s) of person(s) identified for transnational workshop:* *Text here……* *Appendix: Attach copy of workshop program and call, as well as any media publicity*
Conditions (problems, what to solve, etc.)
Text here……..
Enablers (ideas, recommendations, who)
Text here……
Barriers (pain points)
Text here……
Mitigations (TODO's, policies, research, etc.)
Text here……..

Workshop output format (example 1)

You will have to be more elaborated in your outcomes, but an example is given below!

Executive summary of the workshop

Number of workshop participants: 23

Names and affiliation of workshop participants: NN1, NN2

Name(s) of person(s) identified for transnational workshop: NN1

Comments received from the AgEnergy Platform presentation: Presentation of AgEnergy platform was successful. An example based on attendant's specific question was demonstrated. Mrs. NN introduced the Power2X plant and the future plans of distributing hydrogen fuel…… Disruption to fossil fuel use in open field agriculture is depending on machine and engine manufactures choices. The individual farmer has less influence on the disruption. The conversion to alternative and fossil free investments should be followed up by subsidy schemes…… Etc……

Conditions (problems, what to solve, etc.)

Question addressed (according to guideline questions 2.2):
General opinion about the energy status in agriculture and FEFTS positioning

Answers:
The general opinion is that fuel consumption for plant production is high and can be reduced. Too much weight of 'iron' to move around, which occupies too many horsepower and thus too much inefficient fuel consumption.

Question addressed (according to guideline questions 2.2):
Do you think that energy consumption is a "pain" for local farms?

Answers:
Could be a future 'pain' as fuel costs seems to increase currently. Increased energy prices influences on the price of fertilizer, which will be the biggest 'pain' for farmers.

Enablers (ideas, recommendations, who)

Local produced biofuels, electricity, hydrogen. New trading possibilities in terms of local farmers being producers/associated producers of electricity and biofuels and hydrogen.
Robotics, many small machines, electrified, fuel cell
Fuel cell based power train for agricultural vehicles
Fertilizer production plants based on fossil free technologies.

Barriers (pain points)

Alternative solutions for local farmers not matured yet. The energy consumption 'pain' is not big enough to think alternatively in relation to new investments.

Mitigations (TODO's, policies, research, etc.)
Research on balancing the economics of local farm production of energy, i.e. hydrogen, electricity etc. Research on carbon sequestration on local farms to balance carbon emission from plant production. *Remember to include technology driven influence on EU subsidy ECO-schemes, national strategies for ECO-schemes*

Appendix 2 Complete list of FEFTS discussed at thematic RIW's

Table 7: FEFTS listed in RIW reports from each hub for open field crop production

Fuel cell technology, e.g. 400 kW Cummins fuel cell stack Electric Tractor FT25G Farmtrac Fendt e100 Vario: The battery-powered compact tractor New Holland T6 Methane Power Tractor GridCON Autonomous Electric Tractor Electrically powered mechanical weed control robots (e.g. FarmDroid) Performance evaluation of a geothermal and wind mill based integrated systems for power and hydrogen production Precision farming Hydrogen plants Crop cultivation methods Nutrient management Logistics of fossil free fuel and machinery optimisation	Denmark
Electrical tractors Autonomous electrical machines Sustainable storage units Sustainable energy production Sustainable energy storage Alternatives to mineral fertilizers	Netherlands
Fendt e100 Vario electric tractor tractors from John Deere for renewable fuels field robots Overview on different measures in open field agriculture	Germany
SMART Irrigation System (Agro Fossil Free - SMART Irrigation System) Vertical wind turbine ECOROTE (Agro Fossil Free - Vertical wind turbine ECOROTE) Brite Solar Glass (Agro Fossil Free - Brite Solar Glass) AGRAS T16 - Crop Protection Spraying Drone (Agro Fossil Free - AGRAS T16 - Crop Protection Spraying Drone) Smartomizer H3O Sprayer (Agro Fossil Free - Smartomizer H3O Sprayer) eTrac, a full electric light weight robot tractor (Agro Fossil Free - eTrac, a full electric light weight robot tractor) Cover Crop Mixes and Individual Species (Agro Fossil Free - Cover Crop Mixes and Individual Species) No-till planter (Agro Fossil Free - No-till planter	Greece
Wind energy Hydropower Anaerobic digestion/biogas Biomass Solar photovoltaic Heat pumps	Ireland
Solar pumping for irrigation with solar trackers (Agro Fossil Free - Solar pumping for irrigation with solar trackers) Agriselect Biogas Plant (Agro Fossil Free - Agriselect Biogas Plant)	Italy

AGRAS T16 - Crop Protection Spraying Drone (Agro Fossil Free - AGRAS T16 - Crop Protection Spraying Drone) Smartomizer H3O Sprayer (Agro Fossil Free - Smartomizer H3O Sprayer) eTrac, a full electric light weight robot tractor (Agro Fossil Free - eTrac, a full electric light weight robot tractor) Cover Crop Mixes and Individual Species (Agro Fossil Free - Cover Crop Mixes and Individual Species) *Training material:* PLANET EU project - e-learning platform (Agro Fossil Free - PLANET EU Project) EU project SAGRI – "Skills Alliance for Sustainable Agriculture" (Agro Fossil Free - SAGRI EU Project)	
Precision Farming Technologies - ACTRA GB Hybrid no-till machine My Data Plant - a tool for precision farming Crop rotation as a method of nutrient management and crop diversification control	Poland
Crop Sensor Isaria, Claas Application for preparing a fertiliser plan - Bogusław Kiedrowski InterNav – a tool for calculating fertiliser rates Manure Standards – rational fertilisation and use of natural fertilisers	Poland
Cover crop residues: Kings Agriseeds Monoshox NX M: pneumatic no-till planter Soil organic matter Tillage (conservation agriculture + CTF) Crop diversification Soil and water conservation techniques	Spain

Table 8: FEFTS listed in RIW reports from each hub for livestock facilities

Clean energy supply (and emission reduction) Air Unit Heater VIMEP biomass type (Agro Fossil Free - Air Unit Heater VIMEP biomass type) Wind turbine E70 PRO (Agro Fossil Free - Wind turbine E70 PRO) Agriselect Biogas Plant (Agro Fossil Free - Agriselect Biogas Plant) Lundsby Biogas Solarwatt PV solar panels Sulfuric Acid Slurry Acidification *Energy efficiency improvement* Corona Air inlet fan (Agro Fossil Free - Corona Air inlet fan) Complete solutions for livestock farmers (Agro Fossil Free - Complete solutions for livestock farmers)	Denmark
Electric vehicles Agrovoltaics Heat pumps/heat recovery Energy efficient machinery for saving fossil fuel More grass in the rotation DSS ESgreen tool for climate impact reduction	Denmark
EOX175 electrical and hydrogen powered tractor New Holland T6 Methane-powered tractor.	Netherlands

FENECON GmbH solar battery and controlling Arwego e.K. heat pumps for agriculture Overview on electric mobility in livestock farming Overview on energy efficiency, energy saving potentials and self-power-supply in livestock farming	Germany
Clean energy supply Air Unit Heater VIMEP biomass type (Agro Fossil Free - Air Unit Heater VIMEP biomass type) Wind turbine E70 PRO (Agro Fossil Free - Wind turbine E70 PRO) Agriselect Biogas Plant (Agro Fossil Free - Agriselect Biogas Plant) UPB 924TC-B-I - CHP Trigeneration Module (Agro Fossil Free - UPB 924TC-B-I - CHP Trigeneration Module) *Energy efficiency improvement* Aspen heat pump (Agro Fossil Free - Aspen heat pump) Corona Air inlet fan (Agro Fossil Free - Corona Air inlet fan) Complete solutions for livestock farmers (Agro Fossil Free - Complete solutions for livestock farmers) Control and management system for feed mixing plant (Agro Fossil Free - Control and management system for feed mixing plant)	Greece
Geothermal Heat Pumps Alternative heating and cooling (AHC)	Ireland
Clean energy supply Agriselect biogas plant (https://platform.agrofossilfree.eu/it/view/feft/935) Aspen Heat Pump (https://platform.agrofossilfree.eu/en/view/feft/795) Energy efficiency improvement Hotraco Agri (https://platform.agrofossilfree.eu/it/view/feft/349) Intesa Sanpaolo Impresa (https://platform.agrofossilfree.eu/it/view/feft/869) Corona Air inlet fan (https://platform.agrofossilfree.eu/en/view/feft/752) HEAT PUMP to increase the efficiency of the cogeneration unit (https://platform.agrofossilfree.eu/en/view/feft/647) *Soil carbon sequestration* Best-practice guidelines for farms and businesses on agricultural waste management (https://platform.agrofossilfree.eu/en/view/feft/867) *Training material* PLANET EU project - e-learning platform (Agro Fossil Free - PLANET EU Project)	Italy
Efficient farm buildings Precision animal feeding Efficient milking systems Herd Monitoring Systems	Poland
Clean energy generation FEFTS Linka Biomass Boiler Wind turbine E70 PRO Alcon Biomass boiler Halmfyr model 2815 BAL Biogreen - Pyrolysis Equipment *Energy efficiency FEFTS* Plate heat exchanger Milkplan Heat recovery unit MP EcoHeat	Spain

AgriManure - Automatic slurry handling	

Table 9: FEFTS listed in RIW reports from each hub for greenhouses

Solar panels by 'ABC zonnepanelen', Energy production by wind turbines by 'SwifterwinT' Energy storage systems by 'Centrica' Energy management systems	Netherlands
Measure and control technology by 'RAM GmbH Mess- und Regeltechnik' CHPs for greenhouses by '2G Energietechnik GmbH' Overview on different fuels for greenhouse acclimatization Overview on CO_2 reduction in greenhouses	Germany
Brite Solar Glass (Agro Fossil Free - Brite Solar Glass) Aspen heat pump (Agro Fossil Free - Aspen heat pump) PSk Hybrid Solar Water Pumping Solution (Agro Fossil Free - PSk Hybrid Solar Water Pumping Solution) Dragon Heat Biomass Boiler (Agro Fossil Free - Dragon Heat Biomass Boiler) Argus TITAN System -BMS for greenhouses (Agro Fossil Free - Argus TITAN System -BMS for greenhouses) Pro Series™ LED Lighting Systems (Agro Fossil Free - Pro Series™ LED Lighting Systems) Virtual Greenhouse Software (Agro Fossil Free - Virtual Greenhouse Software) Electric tractor FT25G Farmtrac (Agro Fossil Free - Electric tractor FT25G Farmtrac)	Greece
Sustainable Energy Crop Supply Chains by 'Shamrock Renewables' Biomass Boiler by 'Woodco Energy' Utilising Biomass with a Support Scheme for Renewable Heat (SSRH) by 'Sustainable Energy Authority of Ireland (SEAI)' Strategies for Sustainable Biomass Supply Chains by 'Irish Bioenergy Association' Biomass Heat in the Mushroom Industry by 'Codd Mushrooms'	Ireland
Low-Temperature Geothermal Energy (https://platform.agrofossilfree.eu/en/view/feft/450) Solar water pump LORENTZ PSk3 (https://platform.agrofossilfree.eu/en/view/feft/512) Heating greenhouses with geothermal energy (https://platform.agrofossilfree.eu/en/view/feft/837) Highly efficient, solar-powered irrigation pump (https://platform.agrofossilfree.eu/en/view/feft/90) Geothermal heat pumps – ELFOEnergy Ground Medium2 (https://platform.agrofossilfree.eu/en/view/feft/846) Transparent Solar Panel Technology for Energy Autonomous Greenhouses (https://platform.agrofossilfree.eu/en/view/feft/95) Horticulture LED COB/SMD lamp Plantalux (https://platform.agrofossilfree.eu/en/view/feft/648) Electronic tractor FT25G Farmtrac (https://platform.agrofossilfree.eu/en/view/feft/290) SPRHOUT (Solar PoweRed Horticultural Off-grid UniT) (https://platform.agrofossilfree.eu/en/view/feft/112) Pro Series LED Lightning Systems (https://platform.agrofossilfree.eu/en/view/feft/352) InfoGrow 2.0 (https://platform.agrofossilfree.eu/en/view/feft/746) Virtual Greenhouse (https://platform.agrofossilfree.eu/en/view/feft/749)	Italy
Low-Temperature Geothermal Energy	Spain

Solar water pump LORENTZ PSk3 Alcon Biomass boiler Halmfyr model 2815 BAL A.B.S. Silos for wood pellets CEGASA Lithium LFP batteries eBrick 180 Pro Atersa PV Panel Optimum GS Line Geothermal heat pumps – ELFOEnergy Ground Medium2 Horticulture LED COB/SMD lamp Plantalux Electronic tractor FT25G Farmtrac HV-100 Robots Pro Series LED Lightning Systems Fendt e100 Vario: The battery-powered compact tractor InfoGrow 2.0 Virtual Greenhouse	