KNR 2.3

Fossil-energy-free technologies and strategies for EU farmers and solutions in the management of the farm

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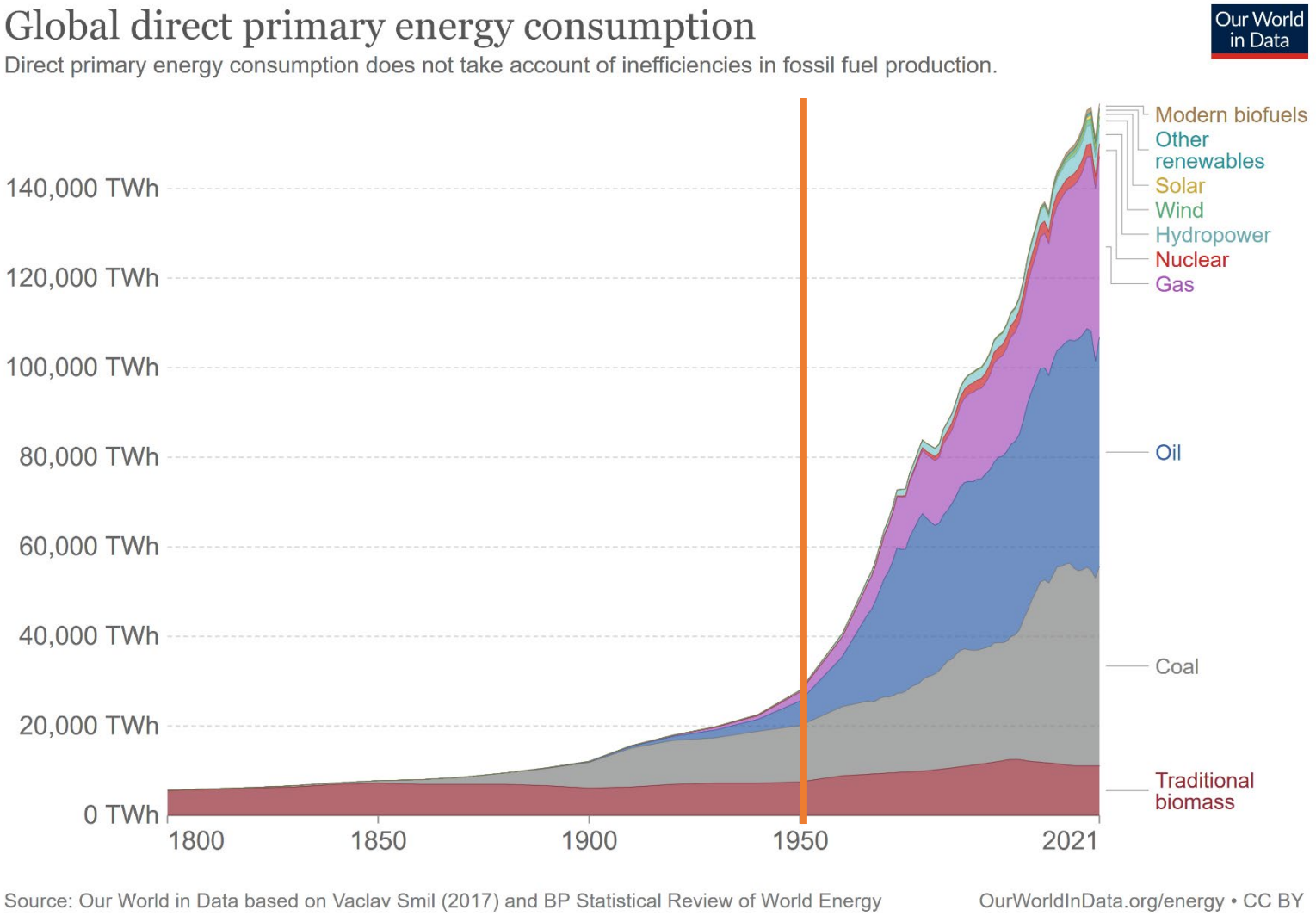
Outline

- Introduction
- **Overview** of energy use in European agriculture today
- **EU-wide survey** to farmers about their perspectives regarding Renewable Energy Sources (RES) and energy efficiency solutions (EES) influencing FEFTS **adoption** rates in European farms
- Specific **FEFTS solutions proposition** for each type of the major agricultural production systems (open-field agriculture, greenhouses).

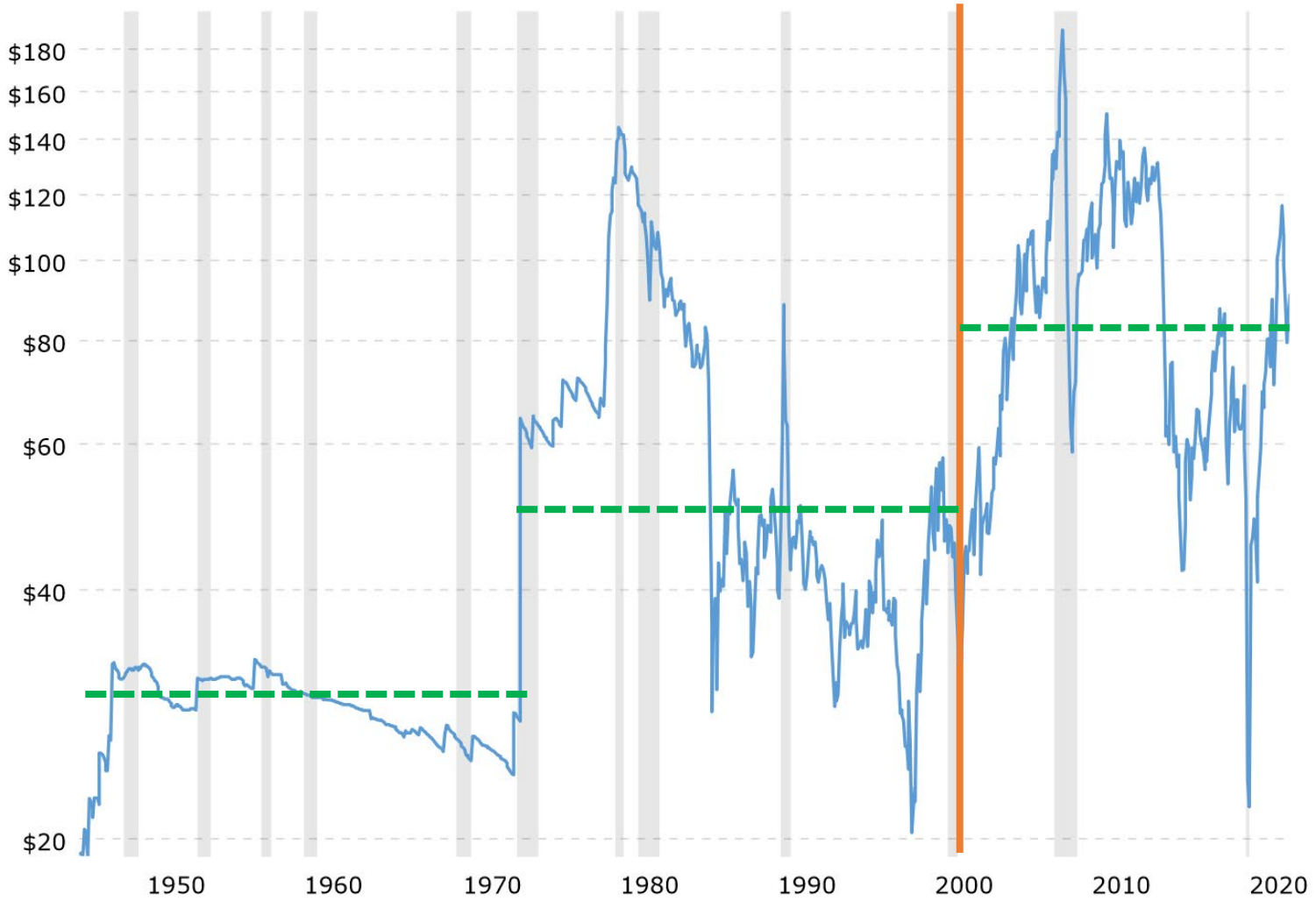
Energy Consumption Increment

Agriculture has followed the same route after the green revolution:

- Significantly increased **mechanisation** of agricultural practices (**main consumer of direct energy**)
- Simultaneous increase of agricultural **inputs** applied in field (**main indirect energy carriers**).



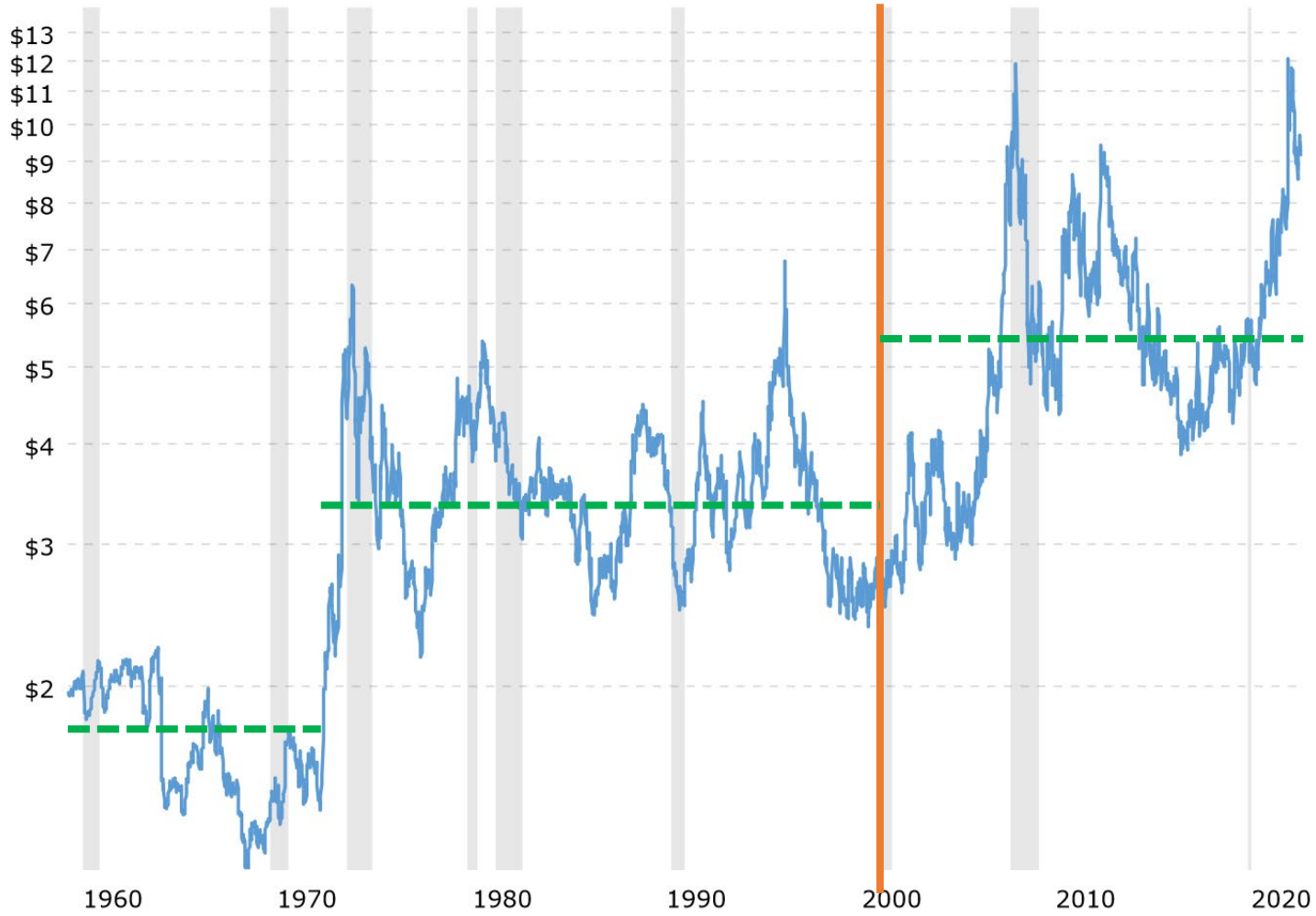
Crude Oil price history ($/barrel)



Notes: Gray areas show global recessions; the graph is in Log Scale; the graph is inflation-adjusted

Source https://www.macrotrends.net/1369/crude-oil-price-history-chart

Wheat price history ($/bushel or 27.216kg)



Notes: Gray areas show global recessions; the graph is in Log Scale

Source https://www.macrotrends.net/2534/wheat-prices-historical-chart-data

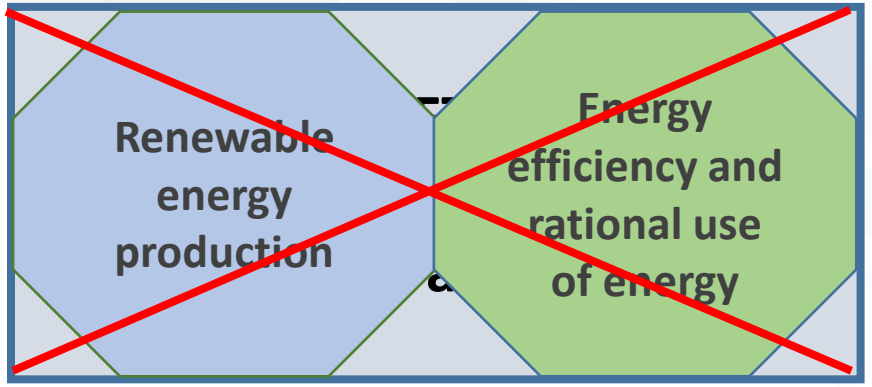
Fossil-Energy-Free Technologies and Strategies

Oil Crisis

New technologies and strategies appear as partial or full solutions of fossil energy dependency

Reduced Oil Price

Conventional fossil-based solutions recover in a high extent



Market growth allowed optimisation and lower prices

+

Energy Efficiency and rational use of energy

Intelligent control systems complemented with Best Energy Management Practices

→

More appealing for all sectors **including AGRICULTURE**!

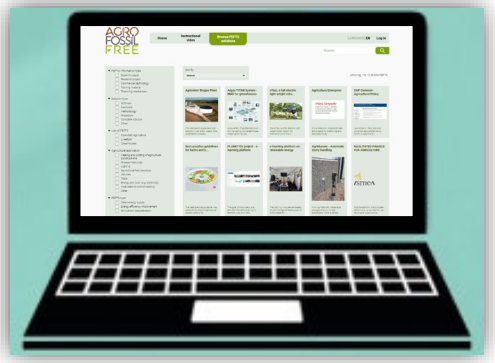
What AgroFossilFree is all about?

POLICY
Policy Guidelines and dissemination

INNOVATION
Multi-actor networking:
Innovation Workshops in 8 countries and 3 International Workshops for integrating national results in an EU context

KNOWLEDGE
Inventory of Papers, Projects, Products, Training material, Financial tools

PLATFORM

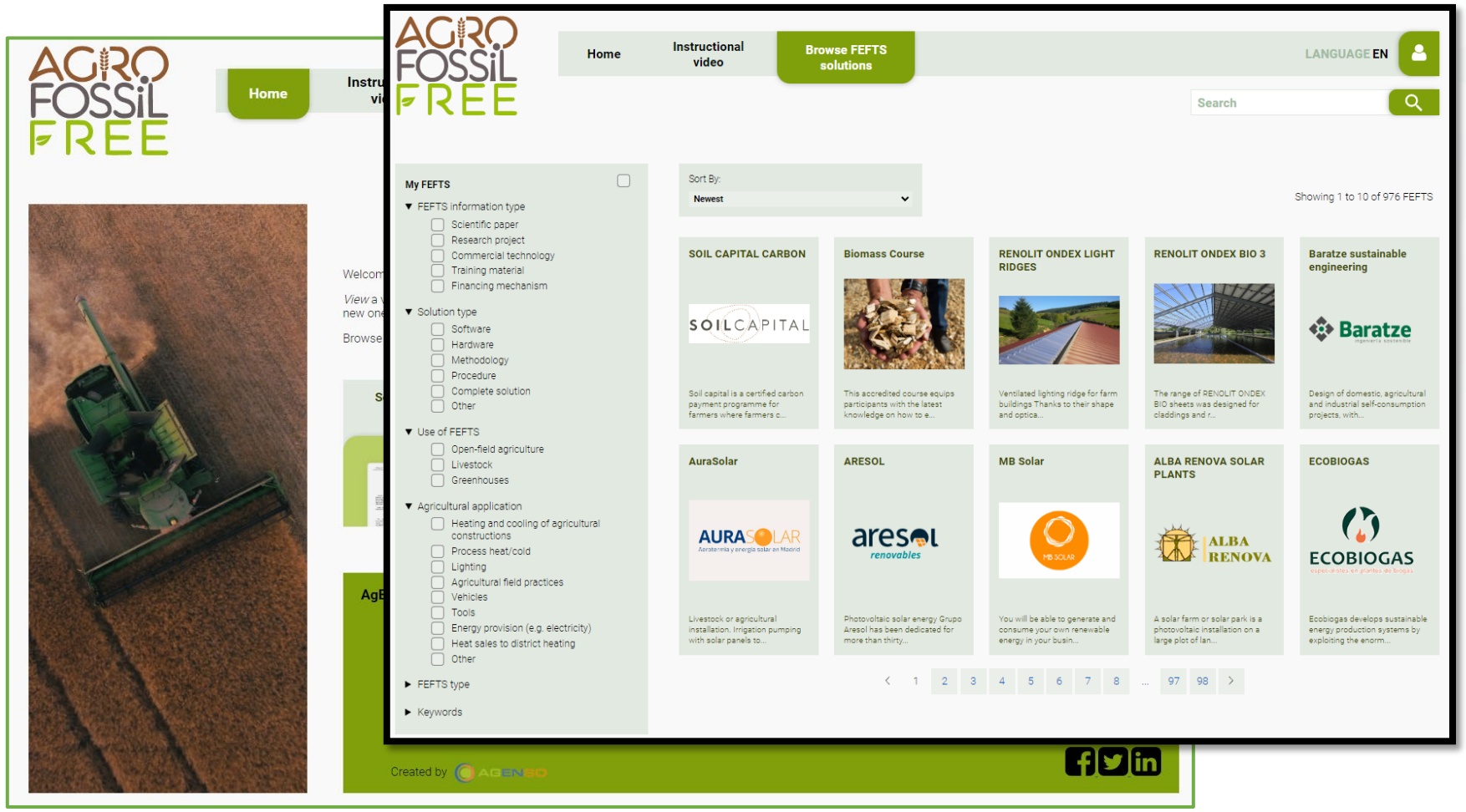


RESEARCH
Assessment of EU agriculture energy status and farmers' needs

AgEnergy Platform - Permanent networking tool

https://platform.agrofossilfree.eu/en

- 976 FEFTS (>500 upcoming)
- Around **130** fields related to FEFTS
- Around 25 dynamic lists
- Translations in all 8 EU languages
- Multilingual function offers higher **farmers' engagement** in local national level



Methodology Energy Status assessment

- **Operational definition of energy use** in agriculture, covering all agricultural activities and uses(direct/indirect)
- System boundary: **cradle to farm-gate**
- A **meta-analysis**, which combines the results from multiple scientific studies, is used to estimate energy use in agricultural systems
- Data was drawn mostly from **LCAs, reports and national data** provided by AgroFossilFree H2020 project partners for 8 EU countries (Greece, Italy, Spain, Ireland, the Netherlands, Germany, Denmark, and Poland)
- Results are combined, allowing to **calculate EU averages** in terms of energy per category as well as total energy use per system
- Data on direct energy use was also drawn from **Eurostat and national surveys**
- Aggregate figures on indirect energy were calculated by **multiplying** EU consumption levels of each input drawn from EUROSTAT and national surveys to the energy embodied in each agricultural input presented in the literature and databases

Current Energy Status in European Agriculture

Direct Energy

Agriculture
(Eurostat)

3.2% of total energy consumption in EU

56%: oil and petroleum products
17%: electricity
14%: gas
9%: from renewables and biofuels

Indirect Energy

62% increase by including production and transport of fertilisers and pesticides

Nitrogen fertilizers account for **78%** of all the energy associated with fertilizers and pesticides in the EU

[1]Agricultural System		Indirect ()[2]		Direct		Other/ unclassified		Total	
Open field	Arable	63%	(769)	31%	(380)	6%	(78)	100%	(1227)
	Orchards and vineyards	51%	(106)	31%	(64)	18%	(38)	100%	(208)
[3]Greenhouse	High intensity	1%		99%				100%	
	Low Intensity	23%		27%		50%		100%	

[1] Only crops and systems covered in this study are included
[2] Data in brackets are total energy consumption figures in PJ
[3] The data for greenhouses are simple averages based on studies that provided data on tomatoes, cucumbers and greenhouses and therefore should solely be seen as indicative

Energy use in open-field agriculture

- This review indicates that annual energy use in EU open-field agriculture is at least 1431 PJ, equivalent to **around 3.7% of total EU annual energy consumption**, with the majority of energy sourced from non-renewable energy sources.
- Our meta-analysis finds that the production/transport of fertilizer is the largest energy consuming activity in EU agriculture, accounting for **around 50% of all energy inputs**.
- On-farm diesel use accounts for **31% of total energy inputs**
- The production of pesticides and seeds accounts for **5% and 6%** respectively of total energy inputs.
- Other energy uses, mainly irrigation, storage and drying, account for 8% of total energy inputs.

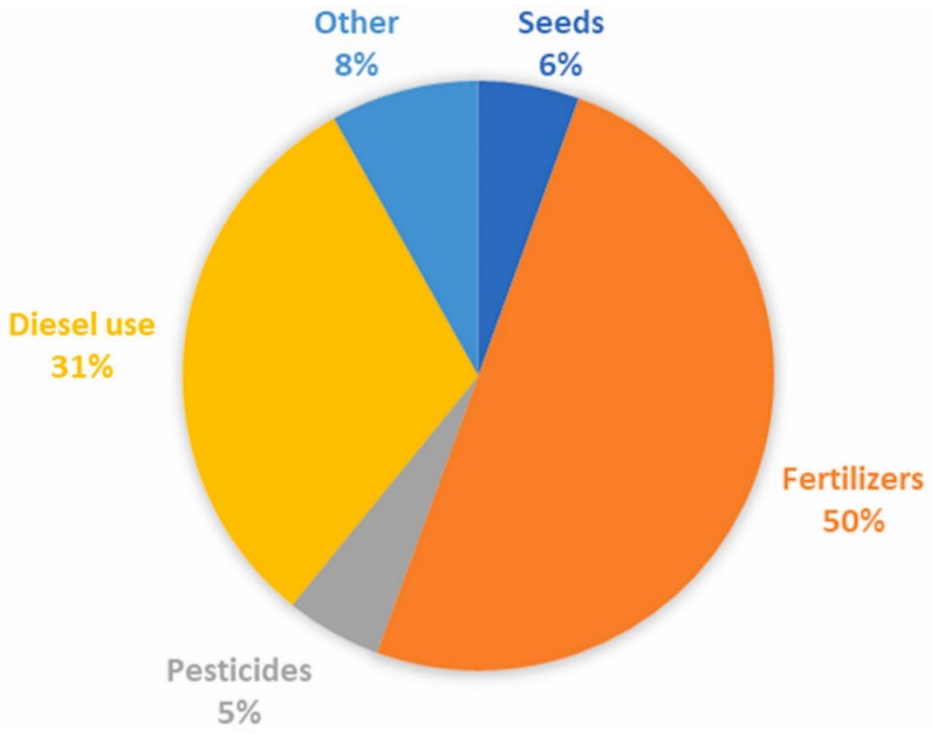


Figure - Energy inputs open-field agriculture EU-27 (%) *[Paris et al, 2022a]*

Paris, B et al. Energy use in open-field agriculture in the EU: A critical review recommending energy efficiency measures and renewable energy sources adoption. Renew. Sustain. Energy Rev. 2022, 158, 112098, doi:10.1016/J.RSER.2022.112098./

Energy use in open-field agriculture

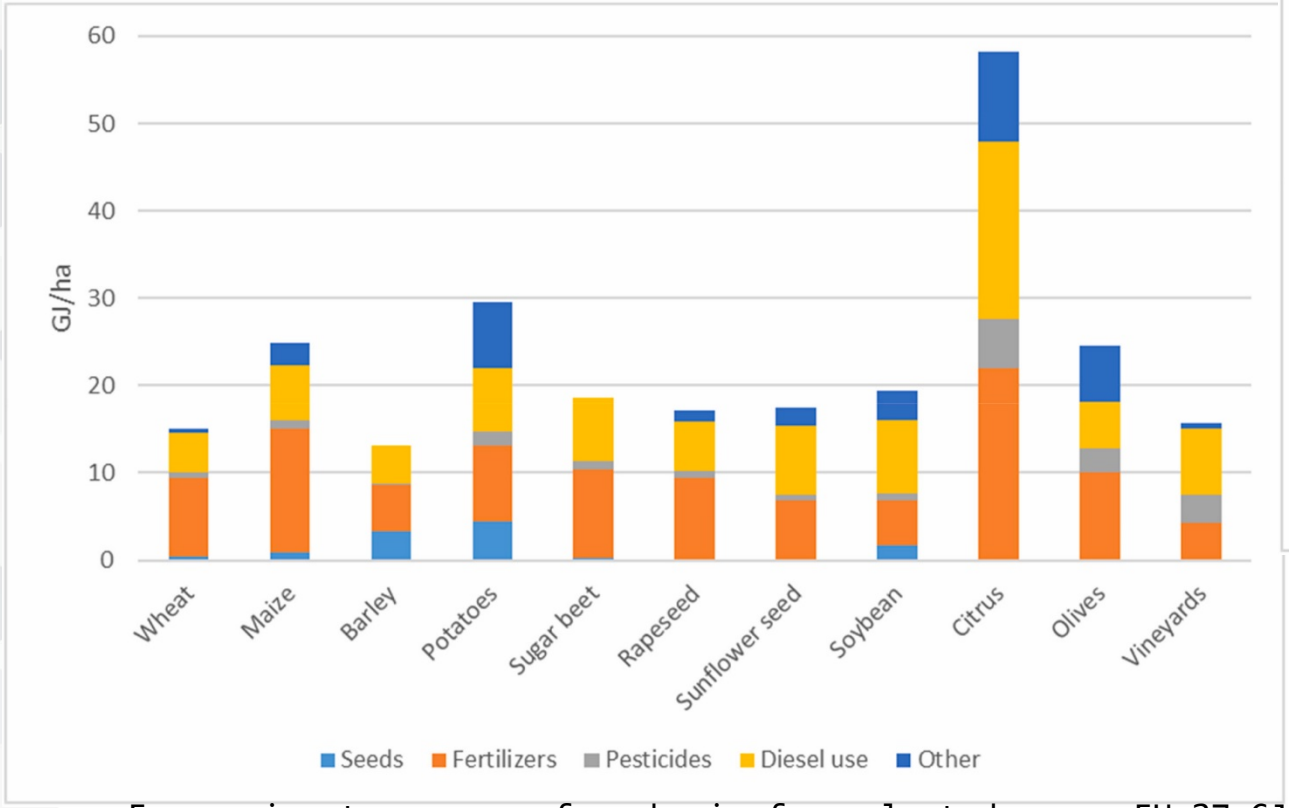


Figure - Energy inputs on a surface basis for selected crops EU-27 GJ/ha *[Paris et al, 2022a]*

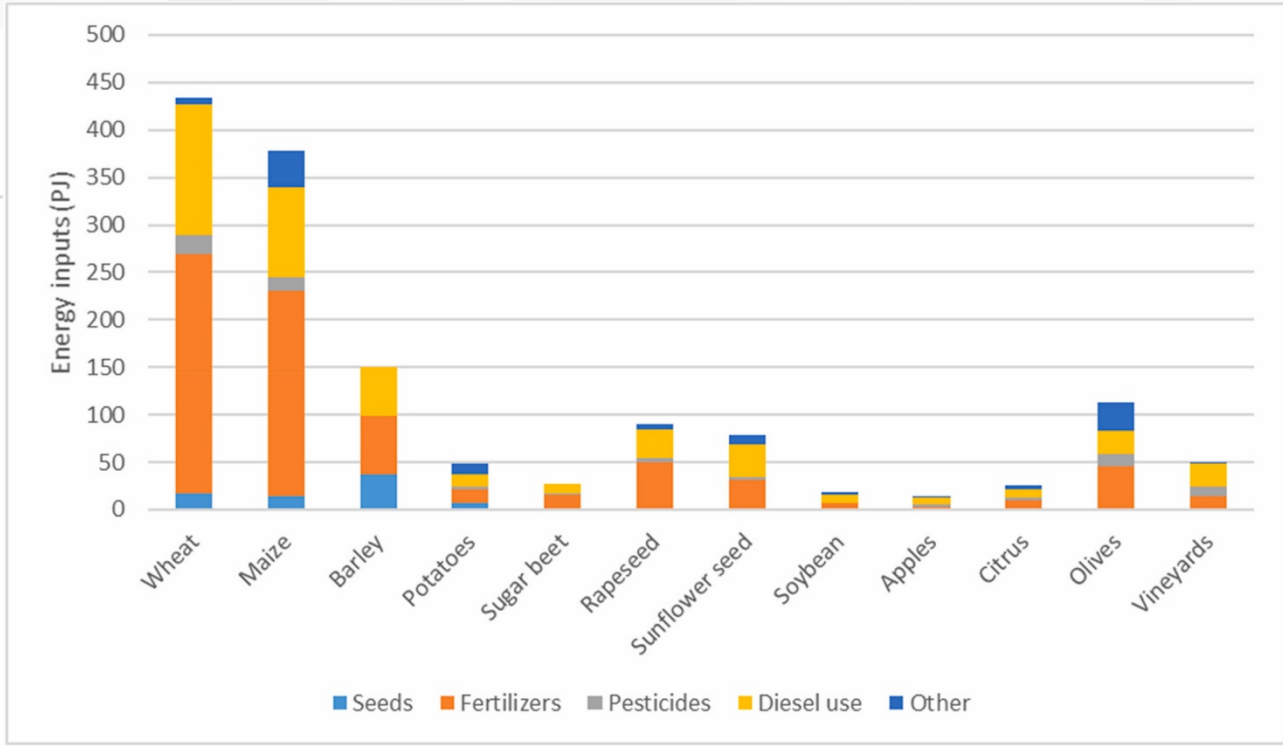


Figure - Total energy inputs for selected open-field crops EU-27 *[Paris et al, 2022a]*

The energy inputs for most crops range between **15 GJ/ha to 25 GJ/ha**

Paris, B et al. Energy use in open-field agriculture in the EU: A critical review recommending energy efficiency measures and renewable energy sources adoption. Renew. Sustain. Energy Rev. 2022, 158, 112098, doi:10.1016/J.RSER.2022.112098.

Energy use in greenhouse systems

- High energy systems (northern Europe) are generally **heavily climate controlled** and energy use is dominated by **heating and cooling** processes
- Heating in some studies reaches 99% of all energy inputs

- Low energy systems (southern Europe) show a mixture of energy uses including **heating, cooling, irrigation, lighting, fertilisers, and pesticides**.
- Overall energy requirements per hectare are significantly less (**50–70 times less energy per hectare**) as compared to high energy systems, but generally **still multiple times higher** than the energy requirements of open-field agriculture

Table - Energy consumption per category in EU greenhouses (%) *[Paris et al, 2022b]*

Energy Consumption per Category	Range of Total Energy Consumption
Heating and cooling	0–99%
Irrigation	1–19%
Fertilizers	1–27%
Pesticides	0–6%
Lighting	1%

Paris, et al. Energy Use in Greenhouses in the EU: A Review Recommending Energy Efficiency Measures and Renewable Energy Sources Adoption. Appl. Sci. 2022, Vol. 12, Page 5150 2022, 12, 5150, doi:10.3390/APP12105150.

Perspectives on FEFTS adoption in European farms

Methodology

- The prepared survey and interview questions went through an **extensive round of testing** in eight countries.
- This process was followed by the development of a **sampling structure based around country specific production systems** allowing for a proportionate sample based on the agricultural systems of each country.
- In total, **470 farmer surveys** were conducted across 8 different European countries.
- These comprised around **50% FEFTS adopters and around 50% non-adopters** per country.

The characteristics of adopters and non-adopters of FEFTS differ

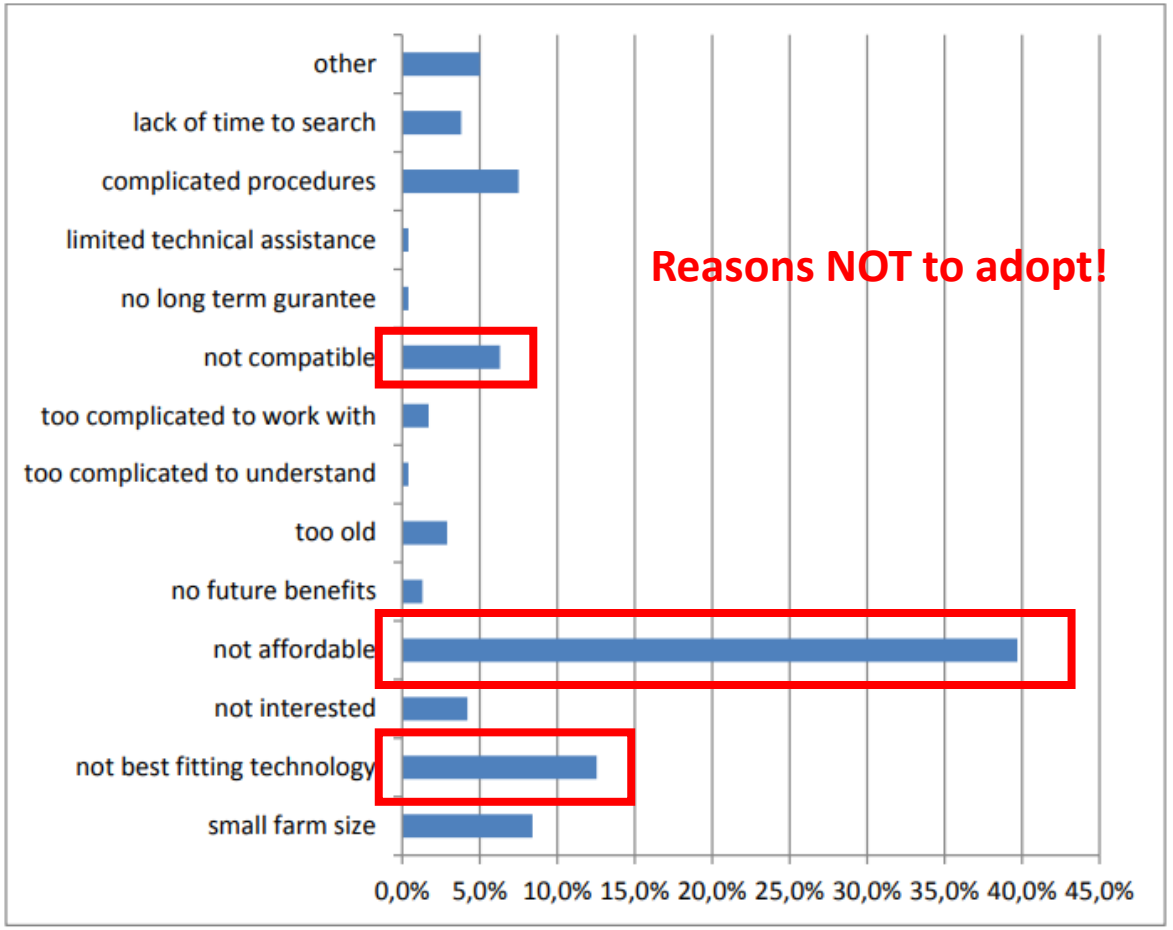
Adopters

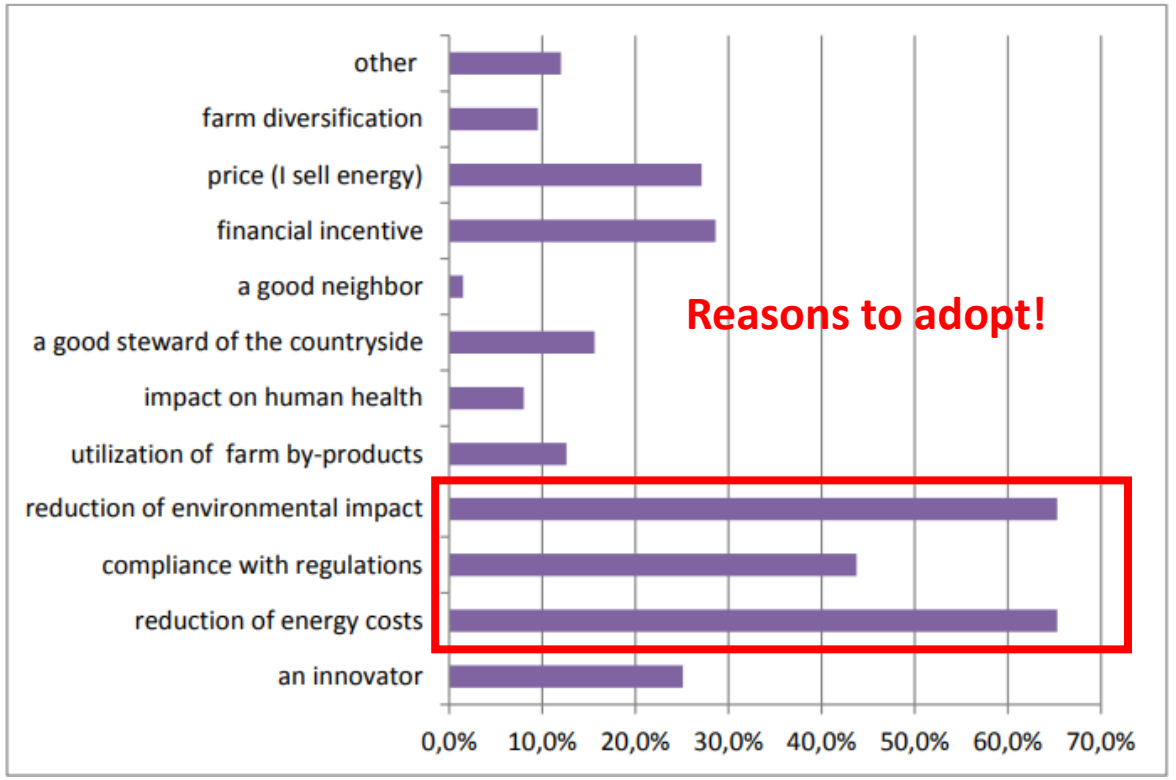
- More likely to be **full-time farmers**
- Have **chosen** agriculture as their profession (vs. family tradition)
- **Most family income** coming from agriculture
- **More satisfied** from farming
- Engaged in **diversified** on-farm activities
- Participation in **Certification schemes** and **CAP Pillar II** projects
- Visit agricultural **fairs**, field days/demonstrations

Koutsouris, A. et al. Report on farmers' needs, innovative ideas and interests; AgroFossilFree H2020 Deliverable 1.3, 2021

Adoption of renewable energy sources (RES)

Non-adopters will use RES if they get a **subsidy** (90%) and **training** (66%)





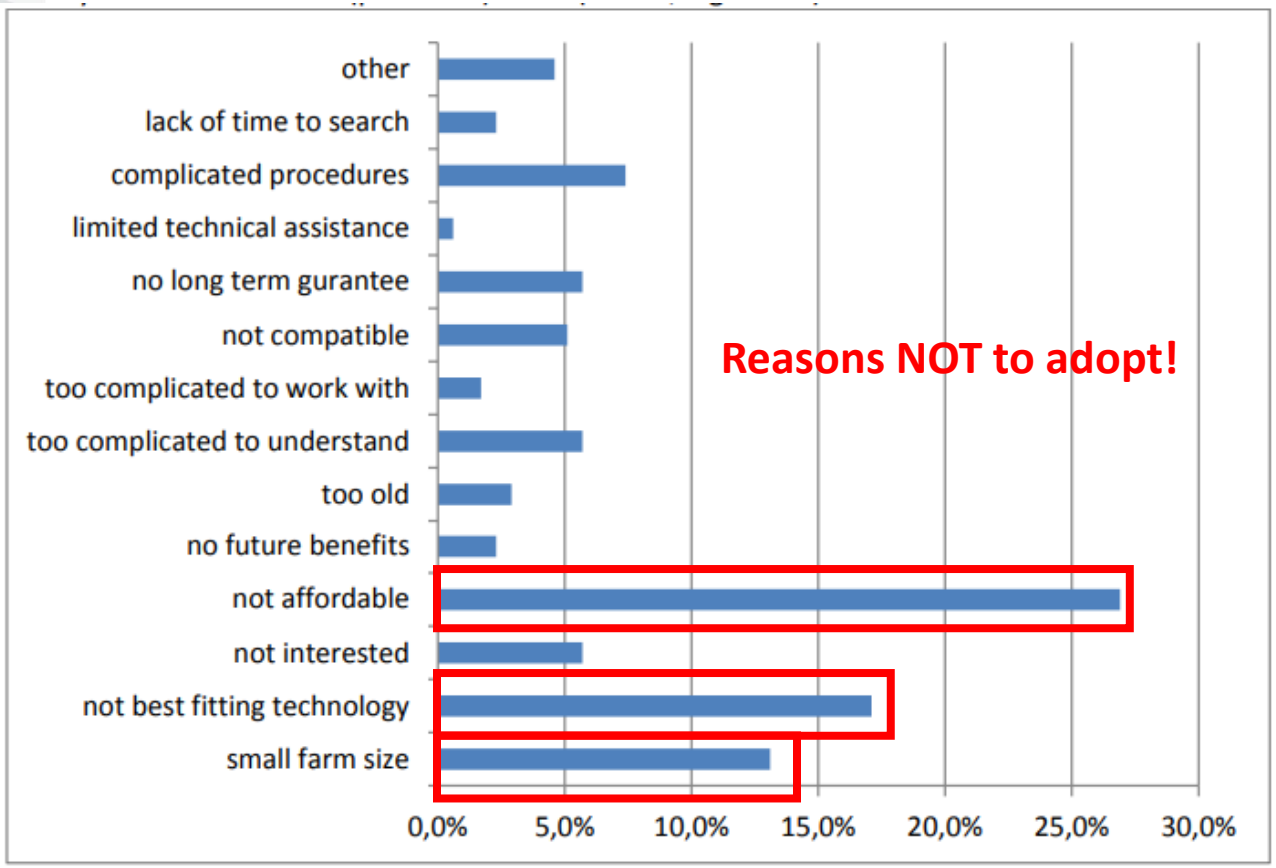
Less than 7% of those surveyed **not having heard** about RES

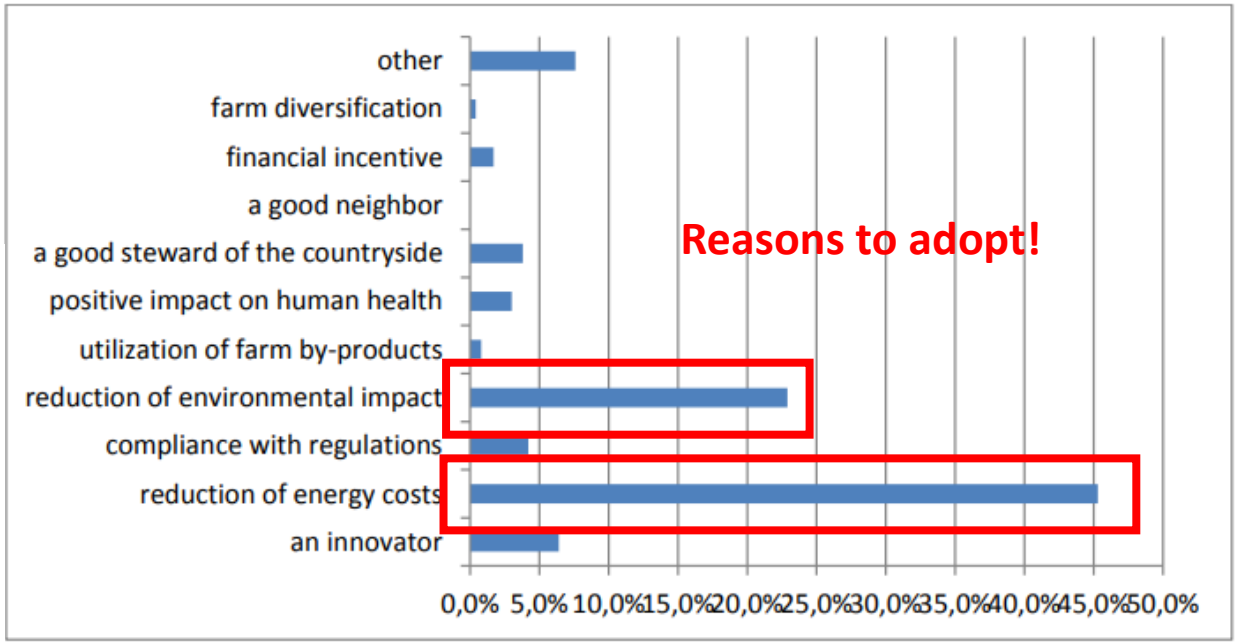
Solar - 76% of RES adopters, **Biomass/biofuels/biogas** - 36%

Around 65% saw in use or tested the technology before purchase

Adoption of energy efficiency solutions (EES)

Non-adopters will use RES if they get a **subsidy** (96%) and **training** (71%)





84% of sample farmers indicated that they are aware of a range of EES

59% saw in use or tested the technology before purchase

33% of EES adopters received a specific subsidy to invest

FEFTS for open-field agriculture systems

Direct Energy

Self-propelled machinery

- Efficient tractor/implement combinations
- E-tractors or Bio-tractors powered by on-farm **agrivoltaics** and **biomethane** from manure and waste residues
- Adopting agricultural practices that minimize tillage

Electricity for irrigation, storage and drying

- Become a **prosumer**, covering primarily farm needs and then sell to the grid
- **Optimise electricity loads** efficiency to reduce consumption
- Switch most (or all) on-farm operations to **electricity powered systems**

Indirect Energy

Fertilisers

- Increasing the use of **organic** fertilizers
- Minimising fertiliser spreading using **precision** techniques
- Transitioning to lower input and more sustainable systems (e.g. **agroforestry**, **conservation agriculture**)
- Renewable hydrogen as feedstocks and using RES to power the **Haber-Bosch process** for nitrogen fertilizers' production

Pesticides

- minimizing the consumption of pesticides using smart technologies (**Prediction, Detection, Selection, Application**)
- transitioning to more sustainable production systems (e.g. **organic farming**)
- increasing the share of **locally produced organic** pesticides

FEFTS for greenhouse production systems

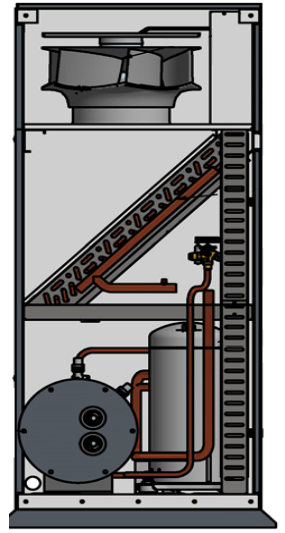
integrating solar technologies within greenhouse production

heat pumps

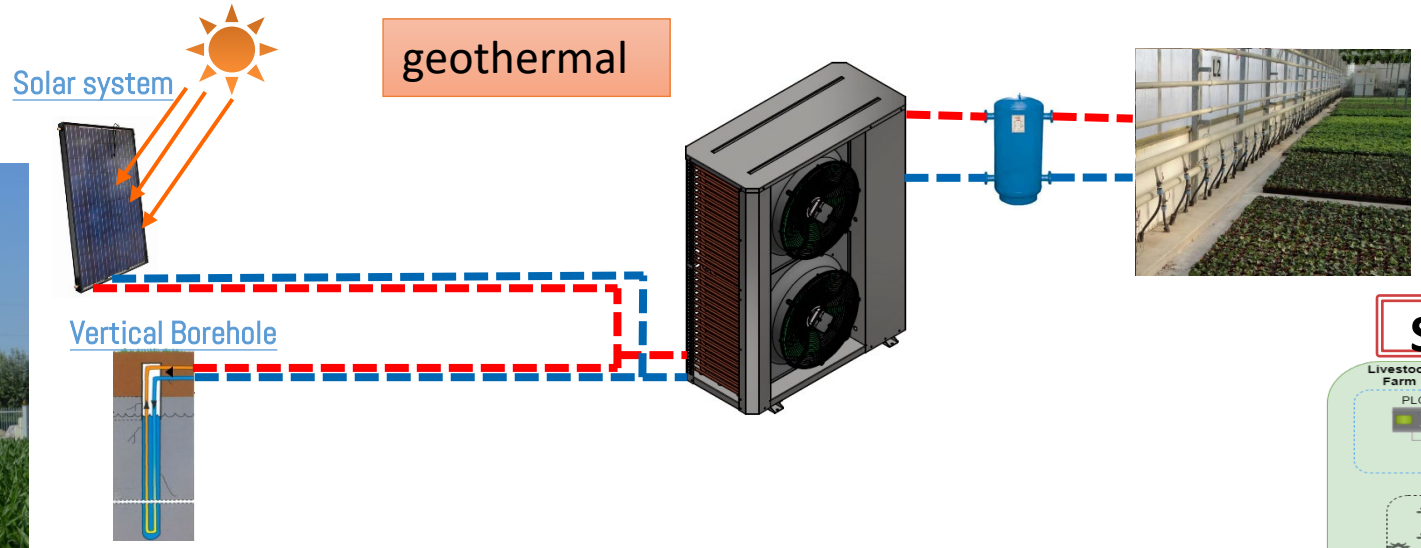
Heating / Cooling

Thermal PV

Modular Heat Pump

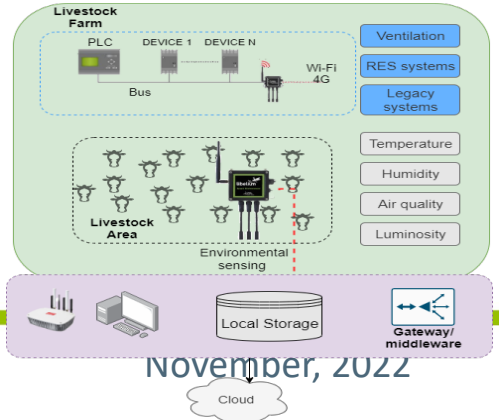


biogas and bioenergy



geothermal

Smart Control



Conclusions

- **Limited and fragmented information about agricultural energy profile**
  Need for common statistical methodology
- **FEFTS in different combinations based on each farm needs could be a partial or even a complete fossil substitute**

- High adoption through better **Agricultural Knowledge Information System (AKIS)**
- **Research:** **Adaptation** of existing industrial or residential FEFTS solutions to farming
- **Extension services:** Multiplier of FEFTS by **showcasing** and **training** farmers
- **Technology providers:** Offer FEFTS, always after **solid feasibility studies** to avoid failures that hinder adoption
- **Farmer: Identification of today's challenges and activation to return to the basis of agriculture –**
  circularity, self-dependency, locality!

Thank you for your attention!

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