Capacity Building Material

HarvRESt
Greener Farming with RES

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Pourpuse of the training

HarvRESt project proposes a modular training framework grounded in partners high expertise, desk research, and regional stakeholder engagement divided in 5 modules.

These modules reflect HarvRESt's systemic understanding of RES uptake as not only a technological transition but a social and organisational one. By embedding training within broader knowledge exchange networks - linking farmers, cooperatives, research institutions, and advisors - **the project aims to create conditions for inclusive, scalable, and context-sensitive innovation** in the agricultural energy transition

Modules Index

1. Technical module
2. Environmental & Sustainability module
3. Policy Module
4. Business Module
5. Stakeholder Engagement & Market Research for RES Integration Module

Capacity Building Material

Technical Module

CIRCE – Suite5

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Index

- Context
- Renewable Energies
- Hybridization & AVPP
- DSS & MCDA

Context

Objective of HarvRest:

- Develop innovative solutions to decarbonize the agricultural sector through the use of renewable energies, electrification, and advanced digital tools.

Current Challenges in the Agricultural Sector:

- High energy costs.
- Dependence on fossil fuels.
- Need for sustainability and emission reduction.
- Limited water resources.

Renewable Energies

-What are renewable energies?

-Application of RES (Renewable Energy Sources) in the agricultural sector

-Wind, hydraulic, green hydrogen, solar photovoltaic, biomass, and biogas energy

-Energy self-consumptionEuropean policies

Renewable Energies

What Are Renewable Energies?

- Renewable energies are those obtained from inexhaustible natural sources such as the sun, wind, water, or organic matter.
- Unlike fossil fuels, their use does not generate net greenhouse gas emissions or deplete planetary resources.
- They are adaptable to various scales, from domestic self-consumption to large plants.
- Renewable energies can be applied in a wide range of contexts and activities, from decentralized generation to intensive use in industrial or agricultural processes.

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Renewable Energies

What Are Renewable Energies?

General Uses in Different Sectors:

Residential

- Heating, domestic hot water, household electricity.

Industrial

- Thermal processes, electricity generation, energy self-consumption.

Transport

- Biofuels, green hydrogen, electric vehicle charging.

Agricultural

- Irrigation, pumping, drying, heat or electricity generation on farms.

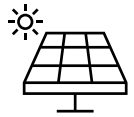
Electric Grid

- Energy injection into the grid and support for the electrical system.

Renewable Energies

What Are Renewable Energies?

Main Renewable Energy Sources Applicable in the Agricultural Sector:

- **Solar** (photovoltaic and thermal) 
- **Wind** (small-scale and medium-scale wind turbines)
- **Biogas** (from livestock and vegetable waste)
- **Biomass** (firewood, forest residues, or energy crops)
- **Hydraulic** (micro-hydropower in rural areas)
- **Green Hydrogen** (produced via electrolysis using renewable energy).

Renewable Energies

Application of Renewable Energies in the Agricultural Sector

The **agricultural sector** requires electricity and fuels for irrigation, machinery, greenhouse climate control, and product preservation.

Renewable energies offer solutions to:

- Reduce dependence on fossil fuels.
- Cut CO_2 emissions.
- Lower medium-term operational costs and energy expenses.
- Support rural electrification and access to energy in isolated areas.
- Provide autonomy against price volatility.
- Improve public image, facilitate access to funding, and meet climate and regulatory targets.

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Renewable Energies

Application of Renewable Energies in the Agricultural Sector

Detailed uses in agriculture:

- **Irrigation and water pumping:** solar or wind systems enable efficient irrigation.
- **Heating and cooling:** biomass used to heat livestock or agricultural facilities.
- **Agro-industrial processing:** biogas to fuel boilers or thermal engines.
- **Lighting and general electricity:** pv systems or micro-hydroturbines for farms, greenhouses, and collection centers.
- **Energy storage:** batteries or green hydrogen to ensure continuous availability.

Strategic benefits:

- Improves competitiveness by lowering structural costs.
- Facilitates compliance with environmental regulations and sustainability criteria.
- Contributes to income diversification (selling energy surplus or joining energy communities).

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Renewable Energies

Application of Renewable Energies in the Agricultural Sector

Specific challenges of the sector:

- Need to adapt technological solutions to local characteristics: solar availability, water resources, type of crops or livestock.
- Administrative and technical barriers for grid connection or implementation of installations.
- Training and awareness-raising of agricultural personnel in the efficient use and maintenance of technologies.

Emerging opportunities:

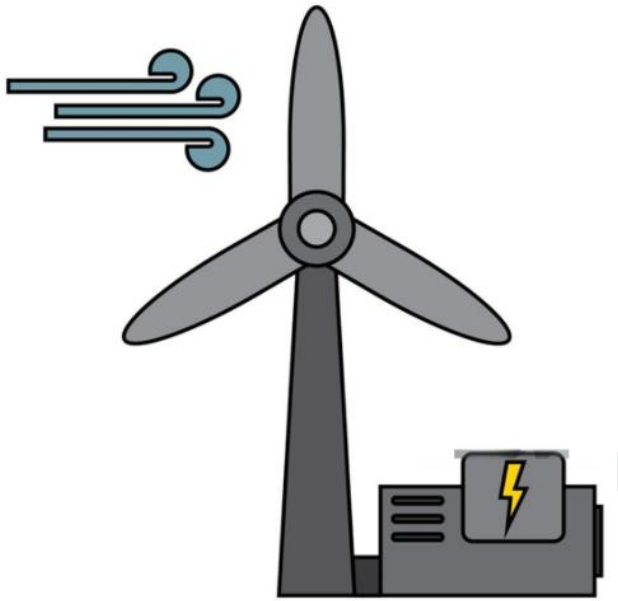
- Digitalization linked to energy generation (monitoring, remote control).
- Green job creation in rural areas.
- Collective self-consumption models or integration with agri-food cooperatives.

Renewable Energies

Wind Energy

Wind energy is a power generation technology that converts the kinetic energy of the wind into electricity through the use of wind turbines, which transform the rotational movement of their blades into electricity by applying principles of aerodynamics and electromechanical conversion.

- The aerodynamic effect causes the rotor to spin when the wind strikes the blades, generating rotational motion.
- This motion drives an electric generator, which converts the mechanical energy into alternating current (AC) electricity.

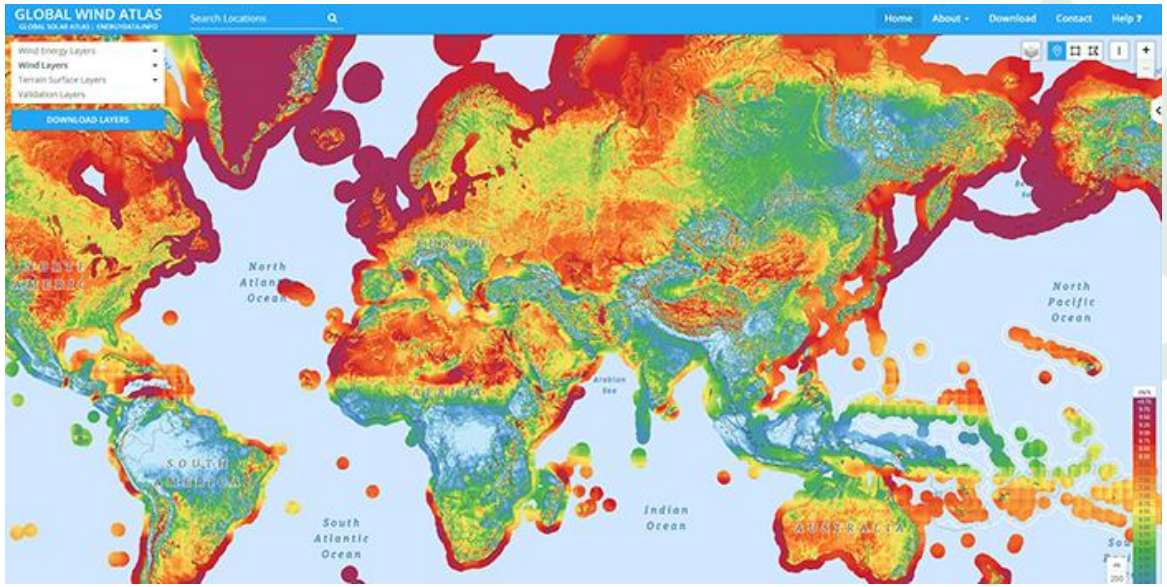


Renewable Energies

Wind Energy

Power generation depends on the **height** of the wind turbine, the **roughness of the terrain**, the availability of the resource (**wind hours**), and the **performance** of the turbines.

The speed and quality of the wind will depend on factors such as **terrain relief**, **season** of the year, **time of day, atmospheric pressure**, and the presence of **obstacles** (buildings, vegetation).



Mean wind speed. Credit: Global Wind Atlas.

Renewable Energies

Wind Energy in Agriculture

Wind turbines can be installed on agricultural land, providing a clean source of energy.

Applications:

- Wind turbines can generate electricity to power various agricultural operations, from lighting and heating to the operation of machinery and equipment.
- Similar to solar-powered irrigation systems, wind-powered water pumps are a viable option for crop irrigation, especially in areas with good wind resources and ideal for locations with limited access to the electricity grid.
- Electricity supply for agricultural facilities such as farms, storage buildings, or greenhouses, significantly reducing operational costs and increasing energy independence.
- Support for hybrid systems (solar + wind) to ensure a constant electricity supply.

Renewable Energies

Wind Energy in Agriculture

Key considerations:

- Requires constant wind speeds >4–5 m/s on average.
- Better in elevated, open plains or wind corridors.
- Prior wind resource assessment is crucial.

Operation & Maintenance:

- Inspections every 6–12 months (blades, nacelle, anchoring, brakes).
- Regular lubrication and replacement of bearings, gears, and moving parts.
- SCADA or IoT systems for remote monitoring.
- Cleaning in dusty, salty, or insect-prone areas.
- Estimated lifespan: 20–25 years, with possible repowering or modernization.

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Renewable Energies

Wind Energy in Agriculture

Challenges and barriers:

- High initial investment for small farms if there is no access to financing or subsidies.
- Wind variability and the natural intermittency of the resource (although predictable in many environments).Visual and noise impact of the turbines.
- Location must have sufficient wind resources.
- Possible administrative or social barriers if the turbine is considered an intrusive element.

Renewable Energies

Wind Energy in Agriculture

Case study: Gorona del Viento – El Hierro, Islas Canarias (Spain)

- **Hybrid project**: combines 5 wind turbines (11.5 MW) with a pumped hydro storage system, using water in a former volcanic crater.
- **Agricultural use**: electricity supply for water desalination for irrigation and consumption on the island.
- **Impact:** near-total energy autonomy for the island system (around 11,000 inhabitants); direct use in three desalination plants.

Credit: viva-espana.at

Renewable Energies

Hydropower

Hydropower harnesses the potential energy of water stored at height or in motion to produce electricity through **hydraulic turbines** connected to generators.

- Falling or flowing water pushes the turbine blades, generating rotational movement.
- This movement is converted into alternating current (AC) electricity by a generator coupled to the turbine.

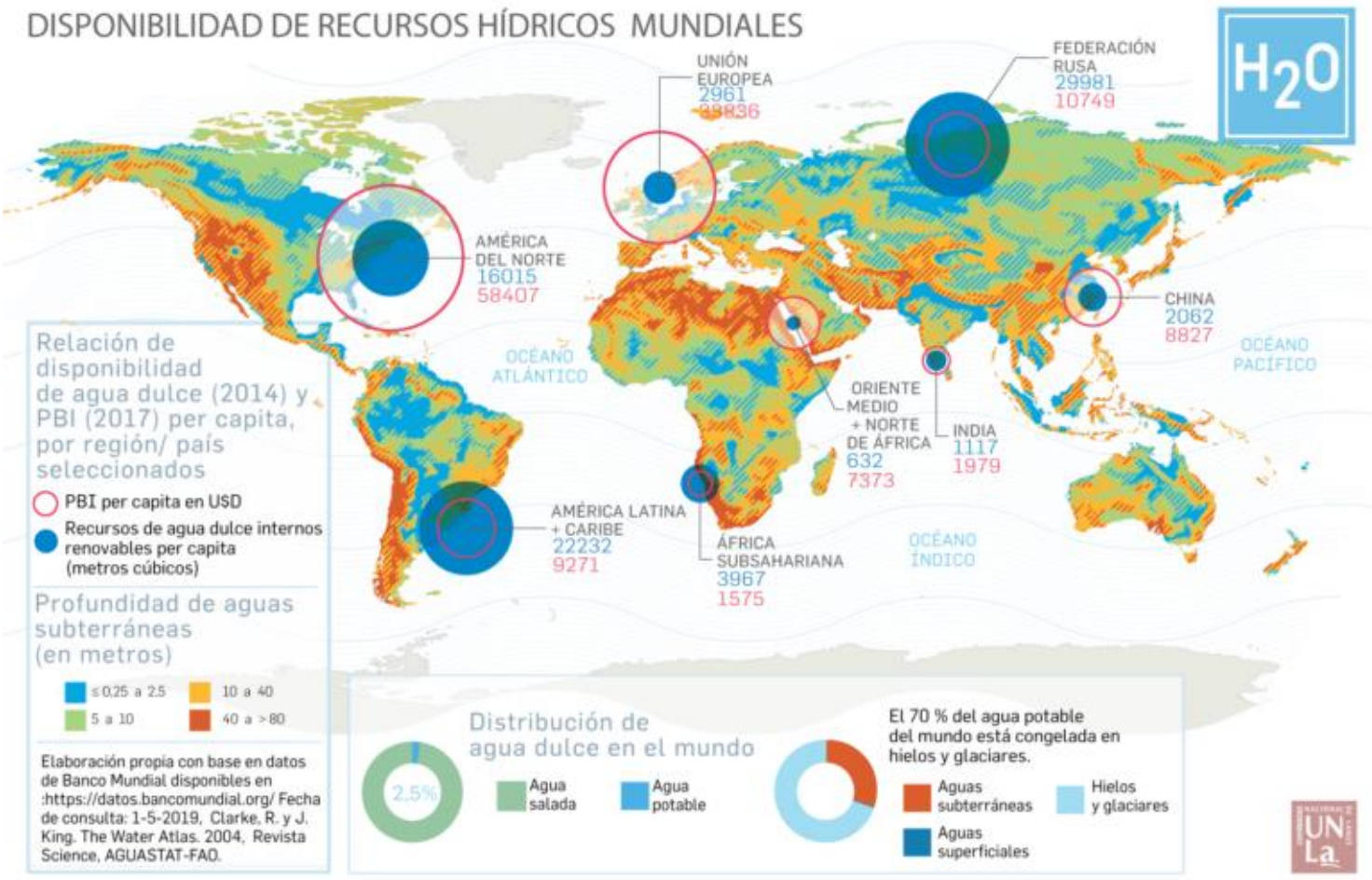
Credit: lifeder.com

Renewable Energies

Hydropower

Power generation will also depend on the performance of the hydraulic and electrical system, including turbines, generators, and transformers, as well as friction losses in pipelines and conduits.

The flow rate and hydraulic head will depend on the hydrological regime, climate, terrain topography, seasonality, and the management of the water resource (reservoirs, water transfers, agricultural uses).



Credit: institutodelagua.es

Renewable Energies

Hydropower in Agriculture

It is one of the oldest forms of energy use and can play a very significant role in the self-sufficiency of agricultural operations with water resources available either continuously or seasonally.

Applications:

- Installation of microturbines in irrigation canals, and natural or artificial waterfalls.
- Electricity generation for farms, storage centers, or rural lighting systems.
- Hybrid hydro-solar systems on farms with access to watercourses.

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Renewable Energies

Hydropower in Agriculture

Advantages:

- Continuous generation (24/7) when a constant flow is available (uninterrupted energy production).
- High efficiency (up to 90%) under suitable hydraulic conditions.
- Discreet integration into the agricultural landscape.
- Storage capacity through elevated tanks or batteries.

Considerations:

- Requires a sufficient and stable flow throughout most of the year.
- A prior hydrological study is essential to determine the energy potential.
- Coordination with other water users is necessary to avoid conflicts during periods of scarcity.

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Renewable Energies

Hydropower in Agriculture

Operation & Maintenance:

- Requires a hydraulic design adapted to the available flow.
- Routine maintenance of turbines, gates, filters, and pipelines.
- Structural inspections to prevent blockages or leaks.
- Monitoring of water levels and cleaning of solid debris.
- Can operate autonomously with remote controls such as level and flow sensors.
- Average lifespan of 30–50 years with proper maintenance.

Challenges and barriers:

- High initial costs for civil works and infrastructure.
- Seasonal limitations in areas with variable water flow.
- Administrative procedures related to water use.

Renewable Energies

Hydropower in Agriculture

Case study: Microturbine irrigation system in Binéfar (Spain, 2021)

Water enters the turbine station through the suction manifold (5), from where it is directed to each of the two turbines (1), causing them to rotate. The water then exits through the turbine discharge manifolds (2) and flows through the chamber into reservoir 3, which is the lower reservoir used to irrigate the area with excess pressure.

The rotation generated by the turbines mechanically drives the pumping equipment (3), which draws water from the suction manifold and pushes it through the discharge manifold (6) into reservoir 1, the elevated reservoir supplying the area with pressure deficit.

The hydraulic units (4) adjust the turbine distributor to place it at the point of maximum efficiency.

The by-pass (7) allows the Irrigation Community to channel water directly into reservoir 3 without passing through the turbines.

Credit: cingral.com

Renewable Energies

Hydrogen

Hydrogen is not a primary energy source, but rather an energy carrier that allows energy generated from other sources (renewable or fossil) to be stored, transported, and used. Its energy use is based on its high energy density per unit of mass (≈120 MJ/kg, about three times that of gasoline).

Hydrogen can be obtained through various methods, the most relevant being:

- **Water electrolysis**: separation of H_2 and O_2 using electricity. If the electricity comes from renewable sources, it is called green hydrogen.
- **Natural gas reforming**: the most common method, but it emits CO_2 (grey hydrogen, or blue hydrogen if carbon capture is applied).
- **Biomass gasification**: an alternative with potential in rural environments.

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Renewable Energies

Hydrogen

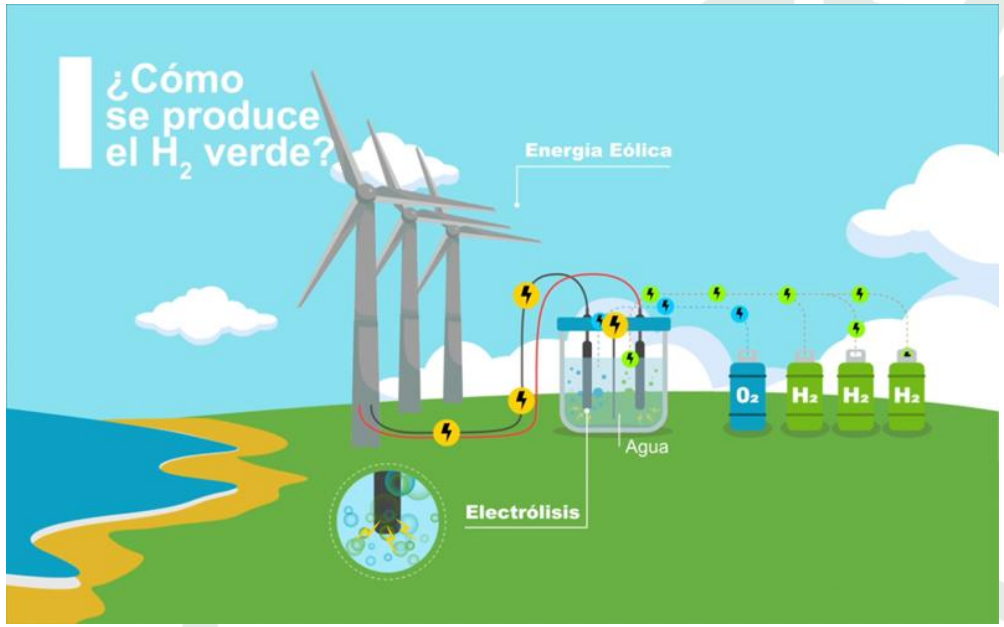
Electrolysis separates **water** (H_2O) into **hydrogen** (H_2) and **oxygen** (O_2) by applying electricity.

If this electricity comes from renewable sources, green hydrogen is obtained: clean and emission-free.

Reaction: $2H_2O$ + electricity $\longrightarrow$ $2H_2$+O_2

System components:

- **Renewable source:** solar, wind, or hydropower.
- **Electrolyzer:** converts electricity into H_2.
- **Storage:** hydrogen is compressed or liquefied for later use.



Credit: OvejeroNoticias.cl

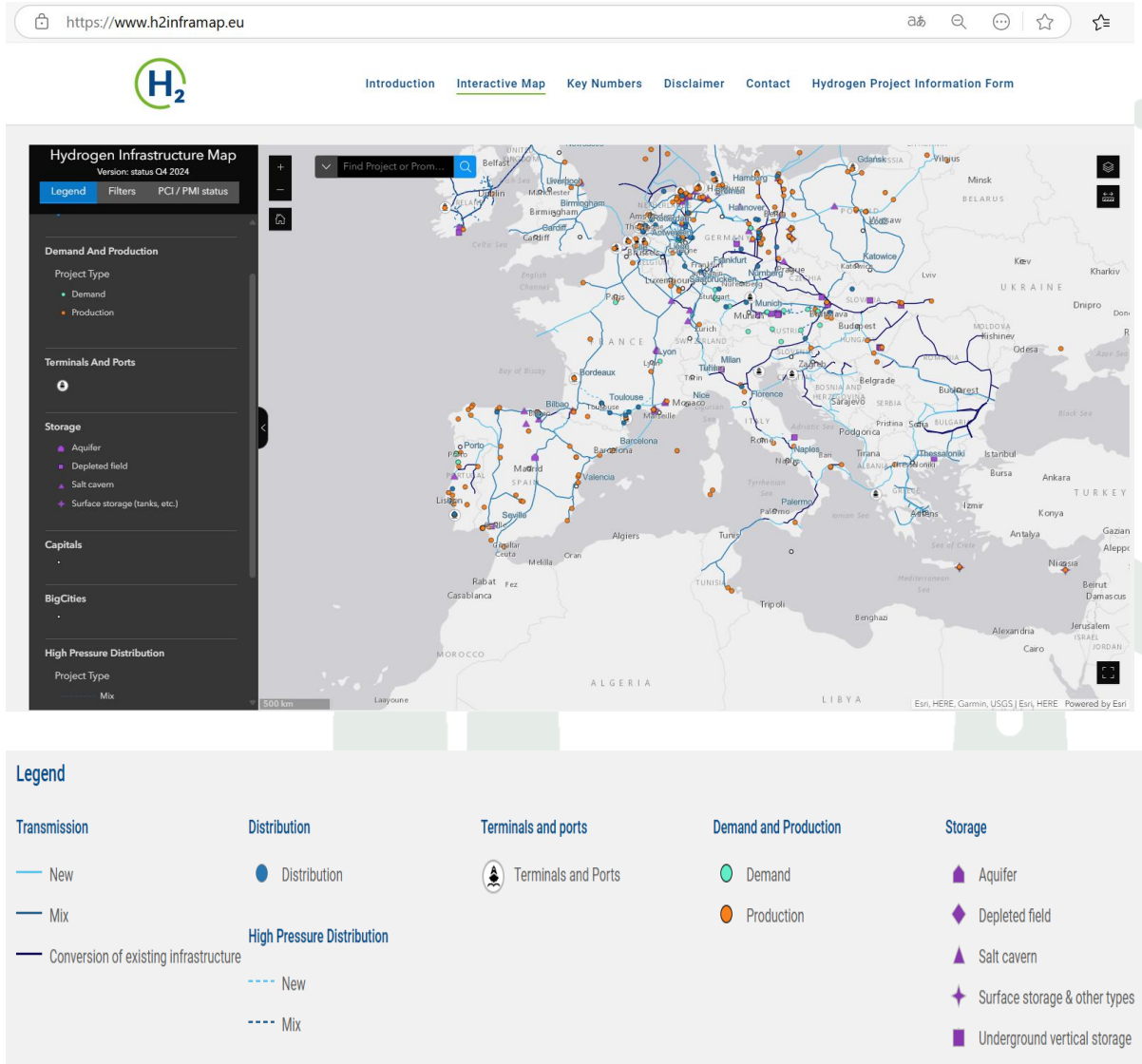
Renewable Energies

Hydrogen

There are interactive maps that display hydrogen infrastructure projects, as well as their development through to 2050.

On the website shown, the projects are divided into six categories, including transmission pipelines, distribution pipelines, terminals and ports, storage facilities, as well as demand and production projects.

These types of web applications allow users to visualize the impact of H_2 projects.



Credit: h2inframap.eu

Renewable Energies

Green Hydrogen in Agriculture

Energy vector produced through water electrolysis using electricity from renewable sources.

Agricultural applications:

- Tractors and machinery powered by fuel cells.
- Production of green fertilizers (ammonia from H_2).
- Seasonal storage of renewable energy in isolated areas.
- Integration into rural energy communities.

Outlook:

- A long-term solution to decarbonize uses that are difficult to electrify.
- Its development depends on cost reduction and infrastructure expansion.

Renewable Energies

Green Hydrogen in Agriculture

Operation & Maintenance:

- Requires deionized water and precise control of temperature and pressure in electrolyzers.
- Continuous monitoring by sensors for pressure, leaks, and temperature.
- Monthly inspection cycles and preventive maintenance of membranes, valves, and electronic components.
- Storage tanks require fire protection and safe ventilation.
- Infrastructure is still costly but evolving rapidly in terms of technology.

Challenges and barriers:

- High production cost compared to conventional alternatives.
- Requires access to cheap and abundant renewable energy.
- Distribution and storage infrastructure is still under development.
- Need for clear regulations and institutional support.

Renewable Energies

Green Hydrogen in Agriculture

Case study: H2Agrar Pilot Project – Hydrogen-Powered Tractors

- Development of hydrogen-powered tractor prototypes using fuel cells.
- The DLG (German Agricultural Society) has recognized this pioneering project as the best in the DLG Agrifuture Concept Award 2022.
- Green hydrogen is produced with the help of renewable energy from a local wind farm.
- Several prototypes are being used on farms to establish a hydrogen infrastructure for agriculture in the Emsland region, Germany.
- As part of the project, the hydrogen consumption of the tractors and the technical requirements for a suitable hydrogen infrastructure in agriculture will be determined.

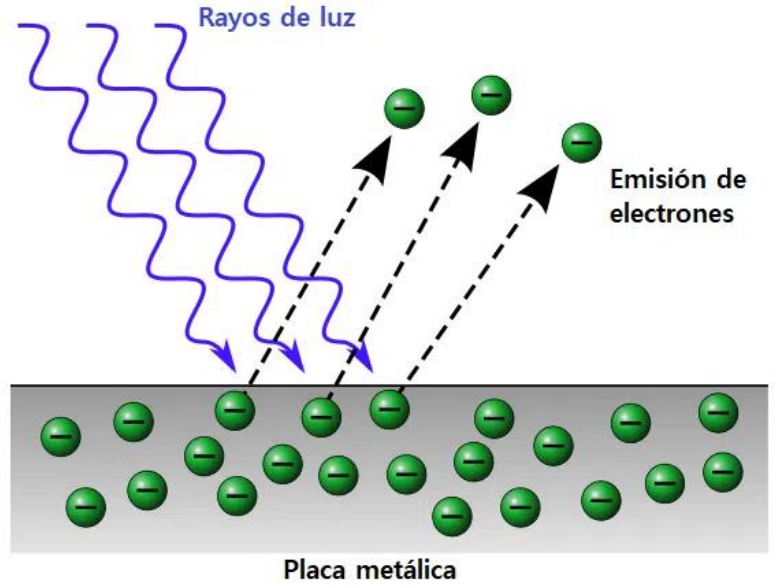
Credit: fendt.com

Renewable Energies

Photovoltaic Solar Energy

Photovoltaic solar energy is a power generation technology that converts **solar radiation** directly into **direct current (DC) electricity** using **semiconductor devices** that harness the **photovoltaic effect**.

- The **photoelectric effect** occurs when a photon (a light particle) strikes a photovoltaic cell made of silicon (or another semiconductor material), releasing **electrons** from the material.
- This generates an electric potential difference, producing a **direct current (DC).**



Photoelectric effect Credit: StudySmarter

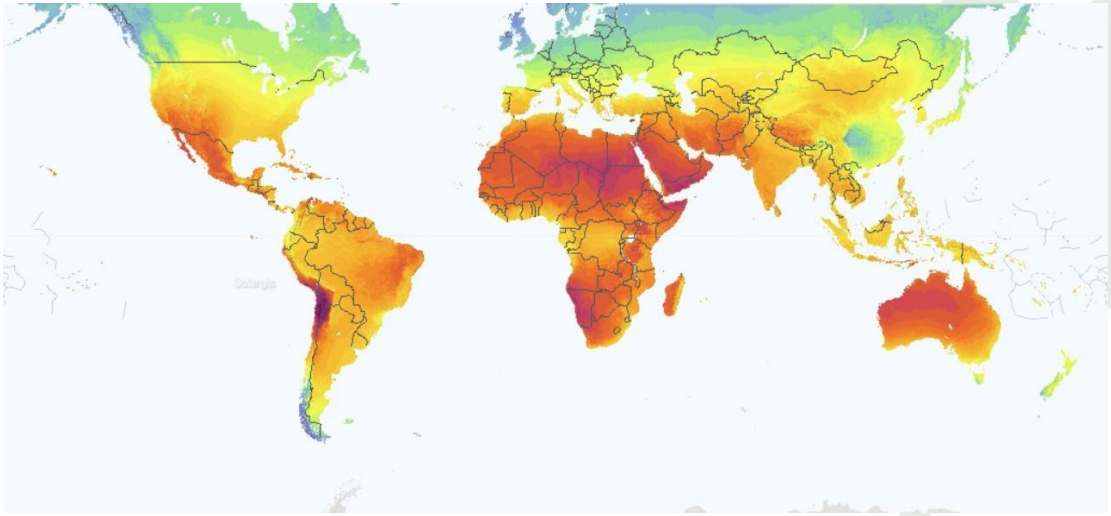
Renewable Energies

Photovoltaic Solar Energy

The most important resource for generating this energy is **solar irradiance** (W/m^2): the amount of available radiation.

Generation also depends on the **tilt angle** of the modules, **shading**, **temperature**, and the **system performance**.

Solar irradiance depends on **weather**, **air pollution**, **latitude**, **season of the year**, and **time of day**.



Global Horizontal Irradiance. Credit: https://globalsolaratlas.info

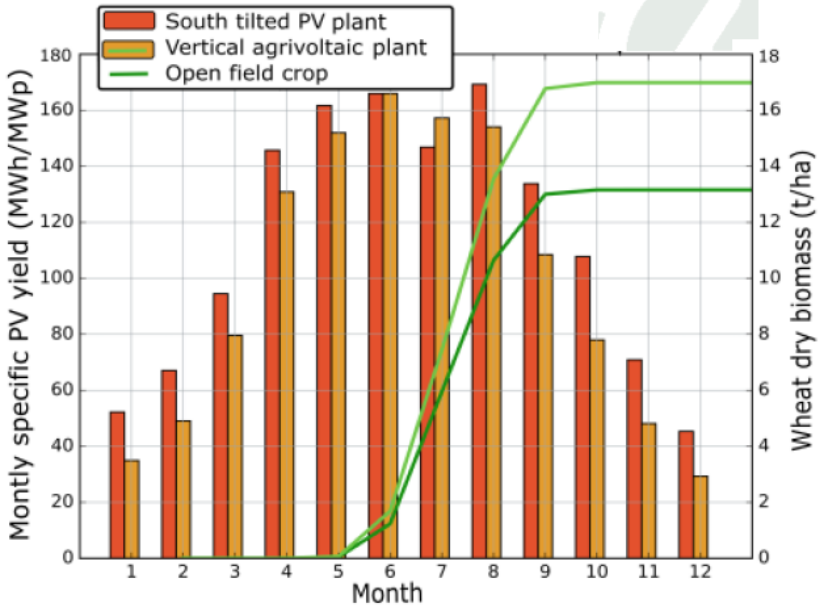
Renewable Energies

Photovoltaic Solar Energy in Agriculture

Photovoltaic modules can be installed on agricultural land, both on the ground and on rooftops.

Applications:

- **Solar pumping for irrigation** uses photovoltaic energy to extract and transport water, allowing crops to be irrigated sustainably and efficiently without depending on the electrical grid or fossil fuels.
- **Self-consumption** for **climate control, lighting, machinery**, and **refrigeration**.
- **Agrivoltaics** is a technique that combines energy generation through photovoltaic modules with agricultural production on the same land, optimizing land use and improving both energy and agricultural efficiency.



Credit: Roxane Bruhwyler – Liège université

Renewable Energies

Photovoltaic Solar Energy in Agriculture

Considerations:

- Requires good direct and diffuse radiation.
- Best utilized in areas with high solar radiation and low cloudiness.
- Prior evaluation of the solar resource using historical data or meteorological stations is key to system sizing.
- Compatible with fixed and mobile installations.
- The orientation and tilt of the modules matter, as well as shading from trees, buildings, or terrain.

Operation & Maintenance:

- Regular cleaning of panels (every 1–3 months) to maintain efficiency.
- Inspection of electrical connections, support structures, and grounding systems.
- Inverter and battery checks (if applicable) every 6–12 months.
- Estimated lifespan: 25 to 30 years for modules; 10 to 15 years for inverters, with replacement possible.

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Renewable Energies

Photovoltaic Solar Energy in Agriculture

Challenges and barriers:

- High initial investment, especially for systems with storage (batteries) or elevated agrivoltaic structures.
- Variability of solar radiation depending on the time of year, cloudiness, and local weather (though predictable).
- Need for shadow-free space to maximize production, which may limit site selection.
- Accumulation of dust, dirt, or animal waste in agricultural areas may reduce performance if frequent cleaning is not done.
- Dependence on specialized technical support for design, installation, and maintenance.
- Possible administrative barriers or permit requirements, especially in protected agricultural soils or restricted rural areas.

Renewable Energies

Photovoltaic Solar Energy in Agriculture

Case study: Photovoltaic Project “Sun’Agri” – France

- **Agrivoltaic Project**: Structures with mobile solar panels installed over crops (vineyards, vegetables), which automatically adjust their tilt to simultaneously optimize electricity production and agronomic conditions (partial shading, thermal control).
- **Agricultural Use:** Improves water-use efficiency in areas with thermal stress and seasonal drought; crops benefit from reduced evaporation and better microclimate conditions.
- **Impact:** Reduces water consumption by up to 30% in some crops, while maintaining or improving agricultural yield under extreme climatic conditions. Additionally, it allows for renewable energy generation without net loss of cultivable surface.

Agrivoltaic facility. Credit: sunagri.fr

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Renewable Energies

Biomass and Biogas Energy

Biomass energy is obtained from the **combustion of organic matter** (agricultural and forestry waste, manure, pruning waste, etc.).

Biogas energy is produced by introducing organic waste (manure, slurry, vegetable waste) into a **hermetic digester** that allows microorganisms to decompose the matter in the absence of oxygen and produce biogas, which is then burned in an internal combustion engine.

Biogas plant. Credit: host-bioenergy

Renewable Energies

Biomass and Biogas Energy

- The most important **resource** for generating this energy is the available biomass: agricultural waste, manure, harvest residues, prunings, energy crops, or agro-industrial byproducts.
- Energy **generation** also depends on the type of biomass, its energy content (calorific value), moisture content, conversion method (combustion, anaerobic digestion, gasification), and system efficiency.
- The availability of the **resource** depends on the **seasonality of crops,** the type of agricultural exploitation, waste management, collection and storage logistics, and climatic conditions that affect plant or animal production.

Renewable Energies

Biomass and Biogas Energy

Biomass and biogas energy facilities can be integrated into agricultural and livestock farms, using their own waste to generate thermal and/or electrical energy.

Main Applications:

- **Biogas generation via anaerobic digestion**: Use of manure, slurry, crop residues, and agro-industrial byproducts to produce biogas, which can be used in boilers, engines, or microturbines for energy self-consumption or grid injection.

- **Thermal and electrical self-consumption**: Use of biogas or solid biomass (pellets, chips, straw) for greenhouse heating, crop drying, hot water production, electricity generation for machinery, lighting, or refrigeration.

- **Circular economy in farming**: Reduction of organic waste, production of organic fertilizers (**digestate**), and reduced energy costs through the energy recovery of agricultural and livestock byproducts.

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Renewable Energies

Biomass and Biogas Energy in Agriculture

Considerations:

- Requires availability of biomass (manure, harvest residues, prunings, etc.) either consistently or seasonally.
- More efficient on farms with high production of organic waste.
- It is essential to evaluate the quantity, type, and moisture content of the biomass before installation.
- Modular installations, adaptable to different farm sizes.
- The location should facilitate the supply of raw materials and proximity for energy use.

Operation & Maintenance:

- Regular cleaning and monitoring of the digester or boiler.
- Inspection of engines, valves, burners, and safety systems.
- Monitoring of parameters such as pressure, temperature, and mixing.
- Proper management of **digestate** or ashes as agricultural byproducts.
- Estimated useful life: 15–20 years with regular maintenance.

Renewable Energies

Biomass and Biogas Energy in Agriculture

Challenges and barriers:

- High initial investment, especially for biogas systems with electricity generation and automated control.
- Requires a constant and sufficient biomass supply, which may limit feasibility on small farms.
- Complex logistics: storage, transportation, and handling of organic waste.
- Need for qualified technical staff for safe and efficient operation.
- Odors, emissions, or **digestate** management may cause social rejection or require mitigation measures.
- Possible administrative obstacles (environmental, health, or land-use permits), especially in protected areas or near urban centers.

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Renewable Energies

Biomass and Biogas Energy in Agriculture

Case study: Biogas Plant “Métha-Ferchaud ” – France

- **Agro-Livestock Project**: a collective biogas plant located in Martigné-Ferchaud, in the Brittany region of France. It is owned by three livestock farms: two dairy and one pig farm.
- **Agricultural use**: The plant processes slurry and manure generated by the associated farms to produce electricity and heat. The electricity generated is injected into the grid, while the heat is used to dry alfalfa grown on the same farms.
- **Impact:** Electricity supply for approximately 1,000 households, reduction of greenhouse gas emissions by treating organic waste on-site, production of organic fertilizers from digestate, and promotion of collaboration among farmers.

Biogas Plant. Credit: campogalego.es

Renewable Energies

Self-Consumption Energy

Self-Consumption Energy is the use of renewable sources to generate and consume energy in the same place where it is needed.

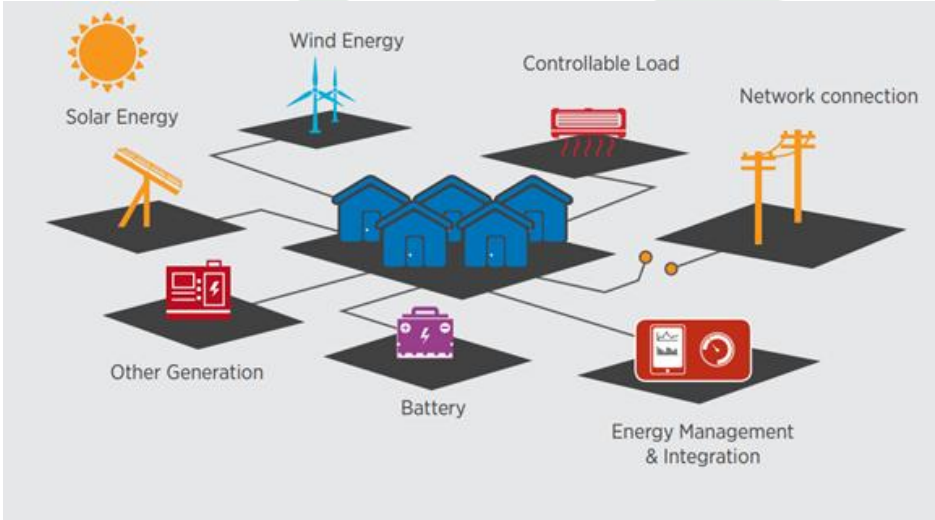
In this way, **dependence on the electricity or gas grid** is avoided or reduced.

Energy can be consumed immediately or **stored** (using batteries, hot water…).

Emissions and environmental footprint are **reduced**.

There are two types:

- **Self-consumption without surplus:** all the energy generated is consumed.
- **Self-consumption with surplus:** unused energy is injected into the grid.

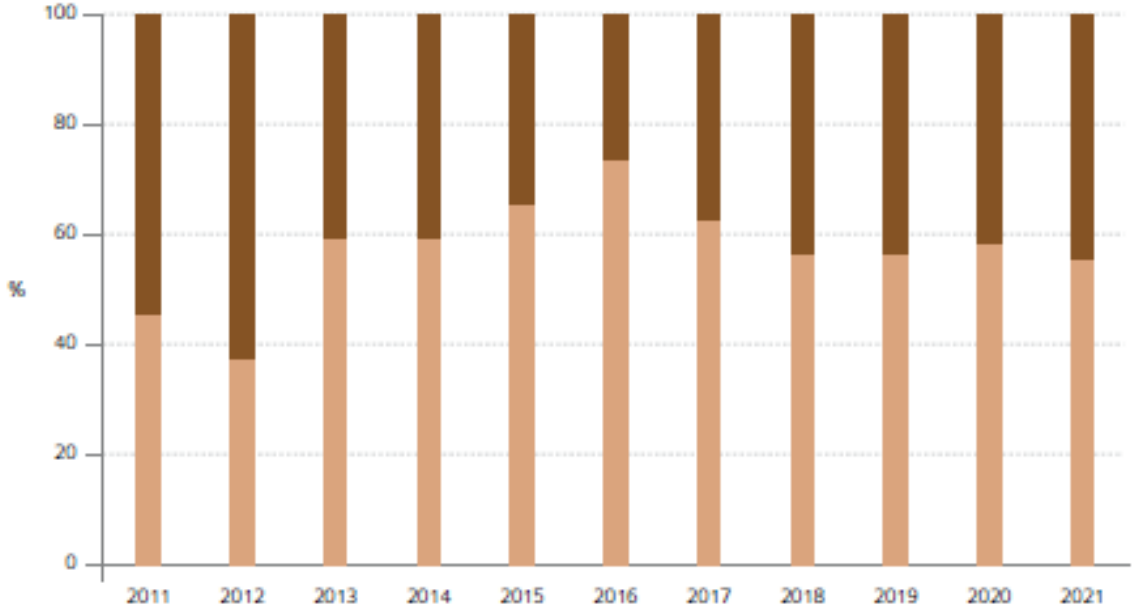


Credit: energynetworks.com.au

Renewable Energies

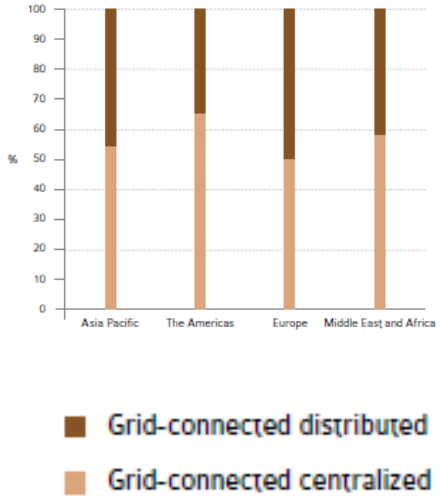
Self-Consumption Energy in Figures

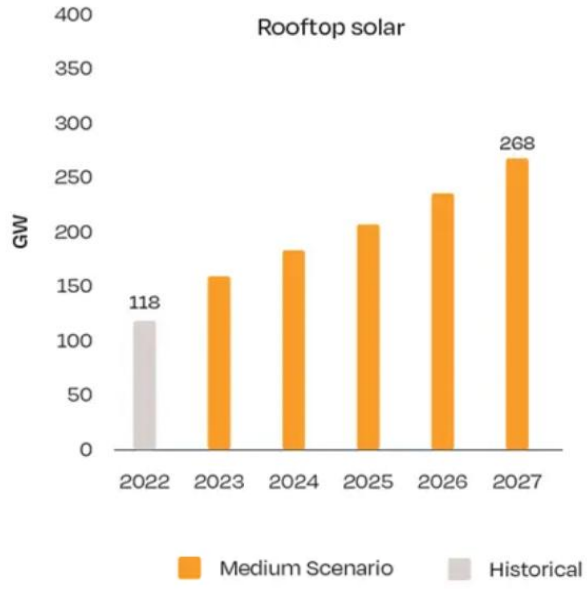
FIGURE 2.13: ANNUAL SHARE OF CENTRALIZED AND DISTRIBUTED GRID-CONNECTED INSTALLATIONS 2011 – 2021



Credit: Irena

FIGURE 2.15: ANNUAL GRID-CONNECTED CENTRALIZED AND DISTRIBUTED PV INSTALLATIONS BY REGION IN 2021





Expected growth of rooftop photovoltaic. Credit: Solar Power Europe

Renewable Energies

European Policy 2030

- Promotes universal access to **clean energy**.
- Encourages the use of **solar, wind, biogas, and biomass** sources in rural areas.
- Facilitates technologies for **irrigation, storage, and food processing.**
- FEADER and FEAGA support for **financing renewable energy infrastructure, energy efficiency projects** in agricultural facilities, or the implementation of **sustainable practices.**

- Calls for the **urgent reduction of CO_2 emissions.**
- Promotes **low-carbon agricultural practices**.
- Supports **climate resilience in agriculture.**

Hybridization and Agro Virtual Power Plant (AVPP)

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Energy hybridization in agricultural environments

What is energy hybridization?

It is the combination of multiple energy generation and/or storage technologies (e.g., solar, wind, batteries, hydrogen, etc.) to optimize energy supply in a reliable, cost-effective, and sustainable way.

Application in agriculture:

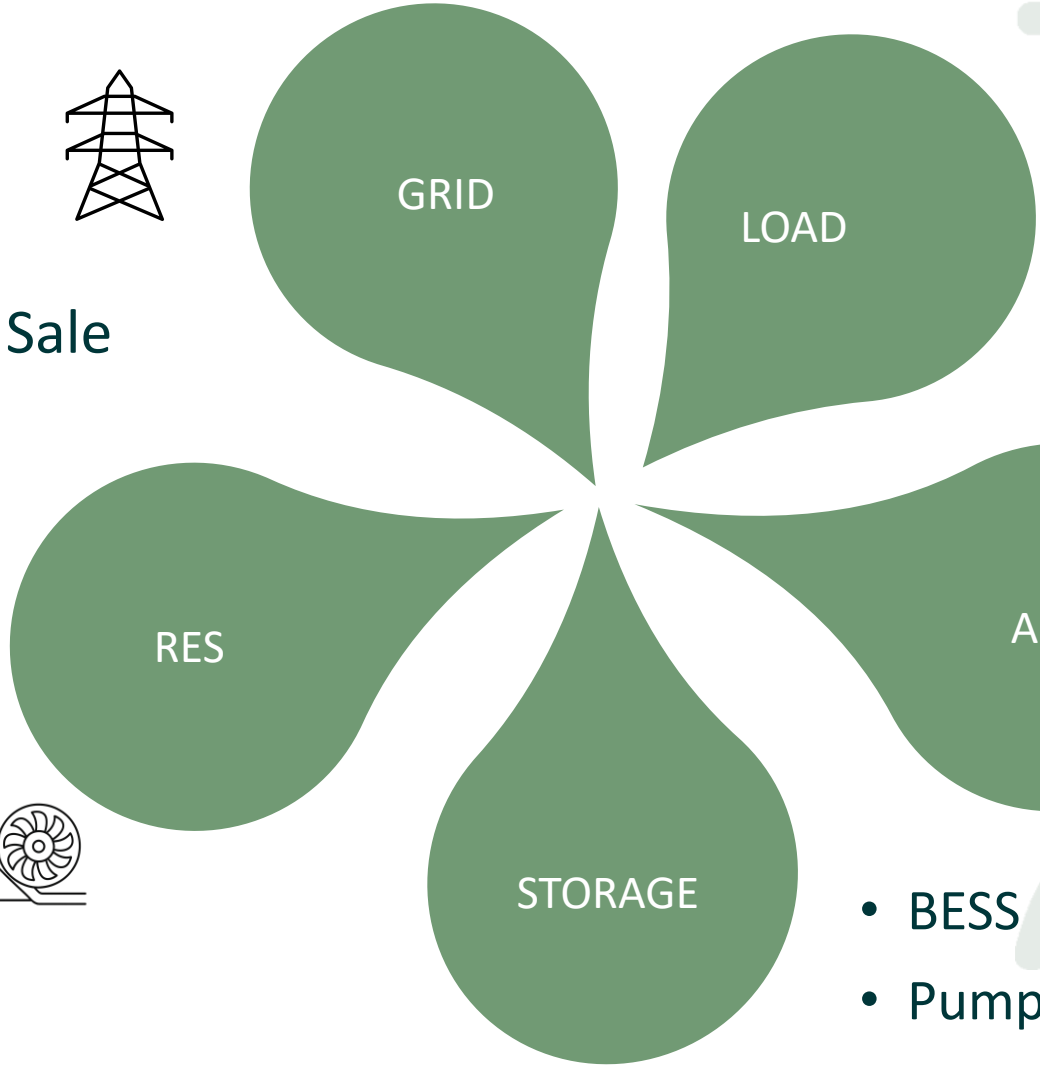
- **Agrivoltaics**: Solar panels installed above crops to produce energy without losing productive land.
- **Hybrid solar pumping**: Combination of solar power with batteries or grid connection to ensure water availability.
- **Energy storage:** To meet demand during periods without sun or wind.
- **Electrification of consumption:** Replacement of fossil-fuel machinery with electric alternatives (tractors, irrigation systems, etc.).

Key advantages:

- Reduction of carbon footprint
- Greater energy independence
- Improved profitability and resilience of the sector

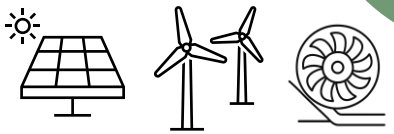
Energy hybridization + Agrivoltaics: typologies

- Standalone
- Purchase
- Purchase + Sale



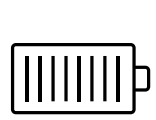
- Consumption
- Flexible Loads

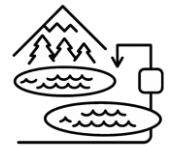
- Solar
- Wind
- Hydro



- Agrivoltaics
- Agriculture
- Livestock farming

- BESS
- Pumped Hydro





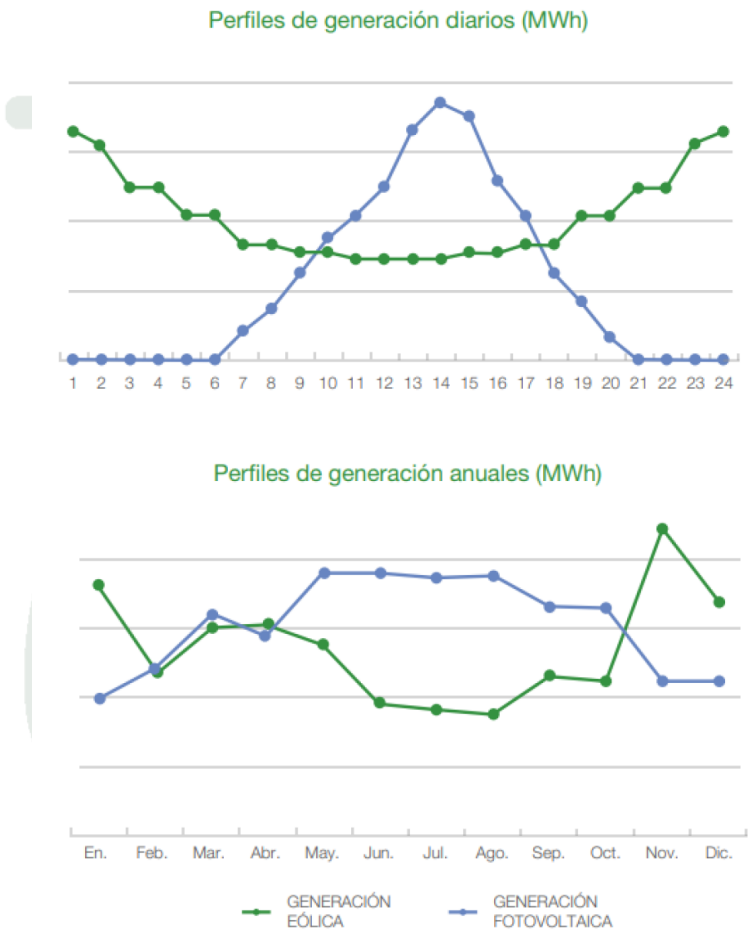
Hybridization – Wind and PV

Wind and photovoltaic energy complement each other effectively in hybridization schemes.

On a daily basis, photovoltaic generation is concentrated during the central hours of the day, while wind energy has a more consistent presence during the night and early morning.

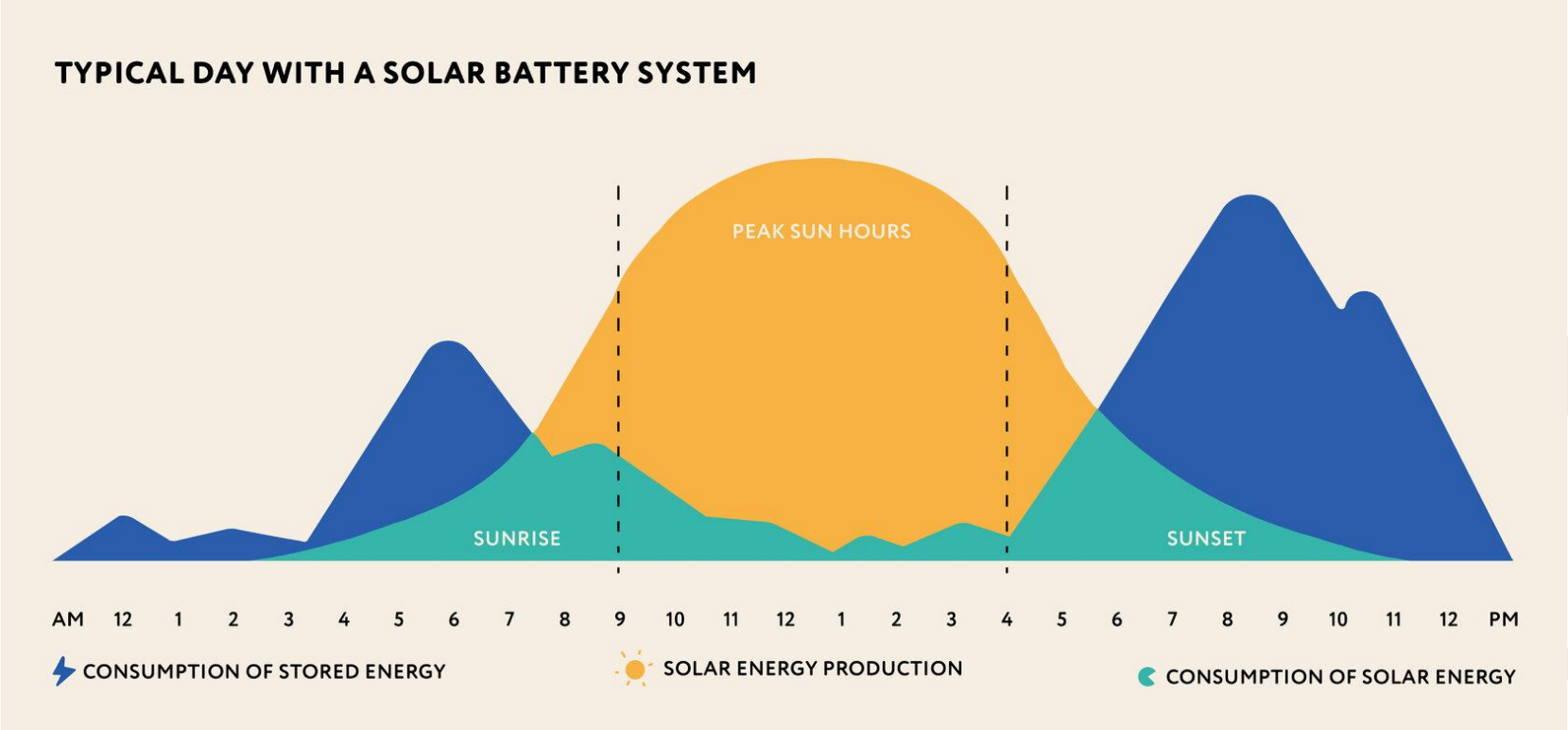
On an annual basis, solar energy reaches its peak during the spring and summer months, when wind energy typically decreases, while wind energy increases its production in autumn and winter, when solar radiation is lower.

This temporal complementarity allows for a more balanced and continuous production of renewable energy throughout the day and the year.



Credit: APPA Renovables

Hybridization – Solar + BESS



Credit: Maxim Kulik A1SOLARSTORE

Hybridization – Case study

- Cas de Pedro Farm (Lugo) has an off-grid hybrid self-consumption installation combining photovoltaic and wind energy, with an installed photovoltaic capacity of 35.28 kWp, consisting of a total of 98 solar modules and 2 Bornay wind turbines of 5 kW each.
- The system is complemented by a battery storage capacity of 52,320 kWh.
- Thanks to this off-grid self-consumption installation, the owner achieves an annual energy production of 64,131 kWh from 100% renewable sources, which is equivalent to a reduction of nearly 26 tons of CO_2 emissions per year.

Credit: Instalación autoconsumo híbrida aislada Granja Cas de Pedro - EiDF Solar

Agro Virtual Power Plant – AVPP

Definition:

The AVPP is a digital platform for energy simulation and management in agricultural operations that integrates different sources of generation, storage, and demand, simulating their combined behavior as if they were a single virtual power plant.

Objectives:

- Evaluate the technical and economic viability of hybrid projects.
- Identify optimal configurations for each operation.
- Maximize flexibility and energy efficiency.
- Support informed investment decisions.

Key components of the AVPP:

- **Energy modeling**: Consumption, generation, storage, prices, etc.
- **Hourly simulation:** Calculation of energy flows based on real or simulated data.
- **Optimization**: Algorithms to find the best configuration
- **Economic analysis**: Return on investment, LCOE, energy savings.

Technological integrations included in the AVPP

Generation sources:

- Conventional and agrivoltaic solar PV
- Small-scale wind
- Biogas
- Hydropower

Storage:

- Battery Energy Storage Systems

Flexibility:

- Controllable loads (irrigation, ventilation, climate control, electric vehicles)

Strategic advantages of the AVPP:

Advantage	Descripction
Scalability	It can be applied from small farms to agricultural cooperatives.
Diigitalization	It promotes the use of smart tools in rural areas.
Energy efficiency	Reduction of losses and better utilization of resources.
Sustainability	It contributes to the European climate goals.
Costs optimization	It helps reduce energy costs with customized solutions.

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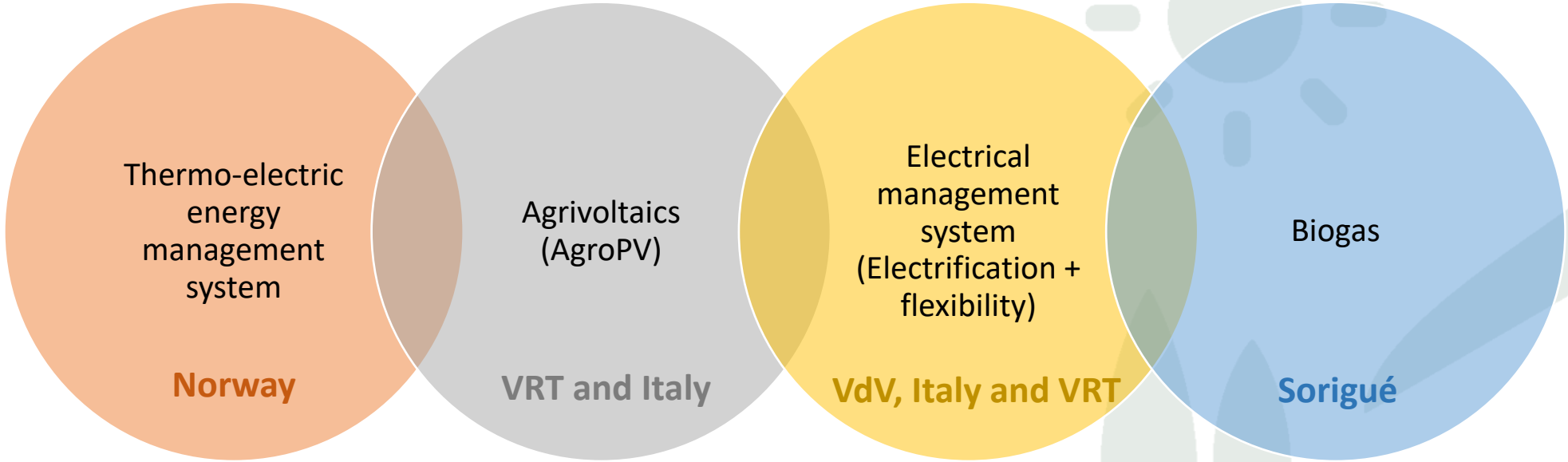
AVPP – Use Cases



Performance optimization of the generation/transmission system with thermal and electrical loads.

Integration of photovoltaic modules in agriculture to combine agricultural production and clean energy generation on the same land.

Investment in replacing fossil fuel equipment with electric equipment and optimization of the electrical system's performance.

Study and potential of biogas.

Decision Support System (DSS) and Multi-Criteria Decision Analysis (MCDA)

A Strategic Approach to Renewable Energy Investments in Agriculture

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Greener Farming with RES

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Navigating Renewable Energy Investments

Agro-community stakeholders face complex decisions when considering investments in RES

Evaluating various generation, storage, and demand options, along with economic and technical viability, can be daunting

There's a need to identify optimal configurations and maximise energy efficiency for specific agricultural operations

HarvRESt addresses this by developing tools that support informed, data-driven investment decisions for agro-community members

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HarvRESt's Decision Support System (DSS)

The HarvRESt project shall develop a specialised Decision Support System (DSS) to aid in strategic planning for RES integration

This DSS blends renewable energy generation forecasts and optimisation tools from earlier project work with farm-specific constraints

Its core purpose is to guide optimal RES choices and system sizing on farms

The aim is to reduce the uncertainty and complexity farmers face in long-term energy investment decisions, providing a transparent tool that aligns with EU climate goals

How it Works: Multi-Criteria Decision Analysis (MCDA)

Core Methodology: The HarvRESt DSS shall utilisee Multi-Criteria Decision Analysis (MCDA) to evaluate various scenarios for RES adoption

Holistic Evaluation: MCDA allows the DSS to consider and balance trade-offs across environmental, economic, and technical dimensions, within a unified decision tool

Hybrid Modelling: The system shall combine energy forecasting results, local farm constraints (like size, energy needs, regulatory limits), and optimisation strategies to generate tailored recommendations

User-Centered Design: The tool is being developed with practical application in mind, enabling agro-community members to input relevant parameters and receive clear, actionable insights for optimal sizing and deployment of RES

Key Benefits & Strategic Advantages

Data-Informed Investment: Helps agro-communities make data-informed investment decisions in RES

Unified Criteria: Incorporates sustainability, technical, and economic dimensions into one unified decision tool

Optimised Infrastructure: Supports optimised sizing and deployment of RES infrastructure in agricultural systems

Scalability: Applicable from small farms to large agricultural cooperatives

Digitalisation: Promotes the use of smart tools in rural areas

Sustainability: Directly contributes to EU climate goals

Cost Optimisation: Helps reduce energy costs through customised solutions

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Capacity Building Material

Environmental & Sustainability module

BETA

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Index

1.Introduction

2. Sustainability of Renewable Energy Systems

3.Positive Environmental Impacts

4.Potential Negative Environmental Impacts

5.Case Study

6.Path to Environmental Sustainability

7.Conclusion

8.Discussion & Q&A

1. Introduction

1.1 Objectives of the Module

1.2 Global Environmental Challenges

1.3 Why do we study Environmental Impacts of RES?

1.1 Objectives of the Module

Objective of HarvRest:

Develop innovative solutions to decarbonize the agricultural sector through the use of renewable energies, electrification, and advanced digital tools.

Objective of this training module:

- Understand the environmental benefits of using RES in agriculture
- Recognize the potential negative impacts and trade-offs
- Identify opportunities for sustainable deployment of RES

1.2 Global Environmental Challenges

- **Climate Change**: Agriculture both contributes to and is affected by GHG emissions
- **Resource Depletion**: Fossil fuel dependence strains ecosystems
- **Pollution**: Air, water, and soil degradation linked to traditional energy sources
- **Biodiversity Loss**: Deforestation and habitat destruction from unsustainable energy use

➞ Renewable energy in agriculture = **part of the solution** to these global challenges.

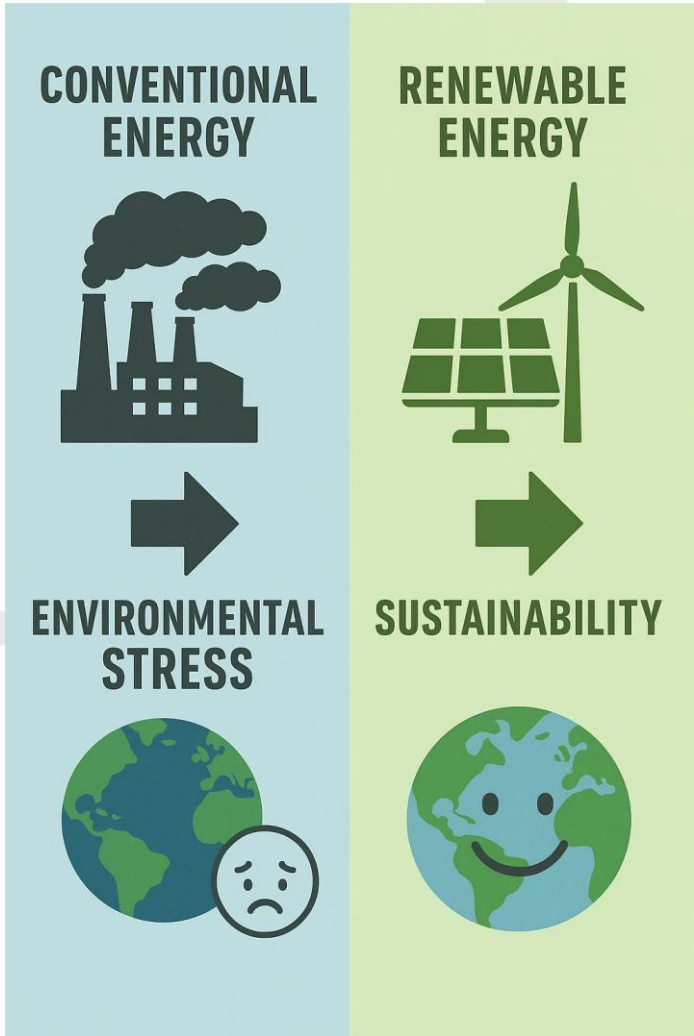
1.3 Why do we study environmental impacts of RES?

- Agriculture is highly dependent on natural resources (soil, water, biodiversity)
- Energy use in farming has major **environmental consequences**
- Transitioning to RES can:

✓ Reduce greenhouse gas emissions

✓ Protect ecosystems and biodiversity

✓ Improve long-term sustainability of farming systems



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2. Sustainability of Renewable Energy Systems

2.1 Environmental rationale for RES

2.2 RES and Agriculture

2.3 RES as a Driver of Sustainability

2.1 Environmental rationale for RES

- RES: energy systems that rely on **naturally replenished sources**
  - Solar, wind, hydropower, biomass
- Provide **clean alternatives** to fossil fuels
- Play a central role in addressing **climate, energy, and sustainability challenges**
- Reduce greenhouse gas (GHG) emissions
- Minimize air, water, and soil pollution
- Enable a **transition to a circular economy**

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2.2 RES and Agriculture

- Agriculture is both a contributor to environmental problems (emissions, deforestation, waste) and a sector highly impacted by them
- RES provide opportunities for:
  - Cleaner irrigation, transport and processing
  - Waste reduction
  - Reduced land degradation
- Agriculture becomes a test case for demonstrating RES's environmental value

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2.3 RES as a Driver of Sustainability

- Integrates **energy, environment, and socio-economic systems**
- Contributes to:
  - **Climate change mitigation**
  - **Resource efficiency** (energy, water, biomass)
  - **Ecosystem protection** (air, soil, biodiversity)
- Foundation for a **sustainable energy transition** in rural and urban context

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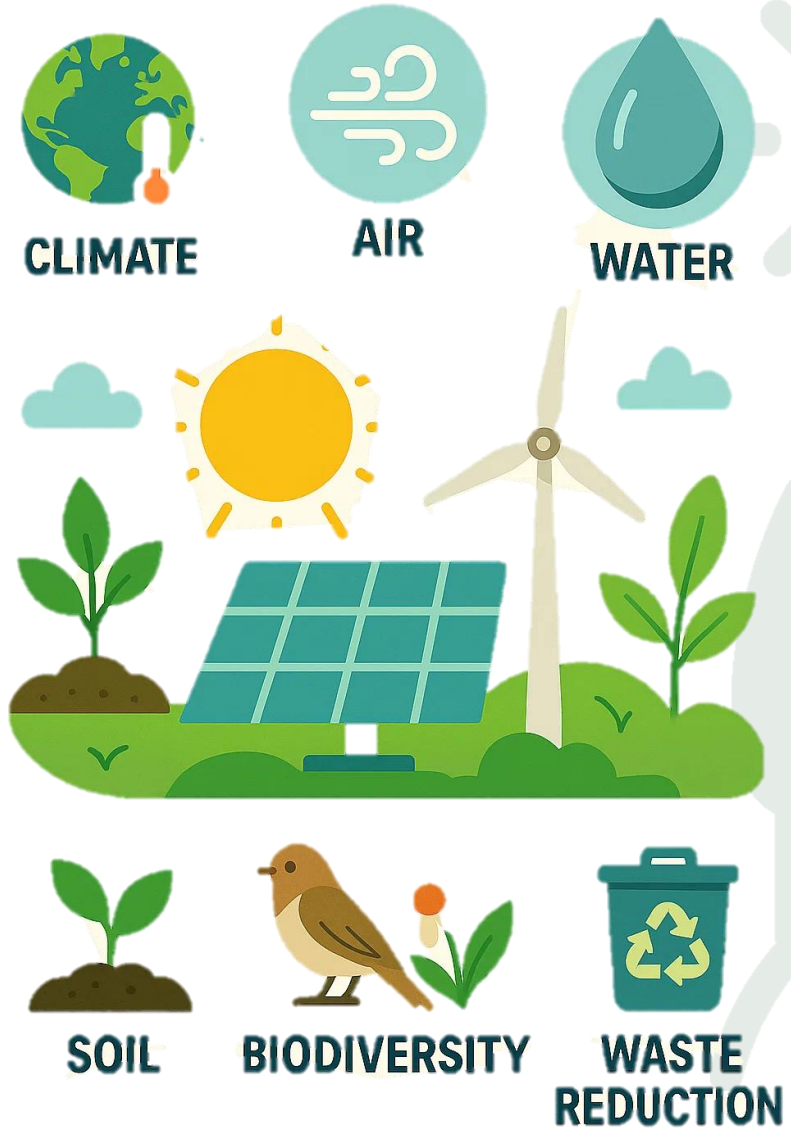
3. Positive environmental impacts

- 3.1 Climate Change Mitigation
- 3.2 Biodiversity protection
- 3.3 Soil health and fertility
- 3.4 Waste Management & Circular Economy
- 3.5 Improved air quality
- 3.6 Water resource management

Clean energy as a driver of environmental sustainability



3.1- Climate Change Mitigation (GHG Reductions)

- RES replace fossil fuels → **lower CO_2 emissions**
- Decentralized energy reduces transmission losses
- Supports **climate-smart agriculture and sustainable food systems**

The air movement from turbines down to the soil **enhances carbon dioxide availability** for photosynthesis and increases sunlight penetration in dense crop canopies. Large wind turbines can modify local wind patterns, impacting **microclimates.**

3.2 Biodiversity Protection

- Less deforestation → habitat preservation
- Reduced fossil fuel extraction → lower ecosystem disruption
- Renewable landscapes can coexist with agriculture and nature

E.g.: The land beneath and around solar panels can be managed to foster **biodiversity**. For example, creating **pollinator habitats** under solar arrays

3.3 Soil and plant Health

- Biogas turns organic waste into energy + biobased fertilizer (digestate)
- Reduced deforestation = less land degradation

Fruit and specialty crops that are being increasingly damaged by hail, wind erosion, frost and drought can also benefit from the **protection** offered by the PV modules, which **partially cover the crops**. Also, using solar tracking PV systems help to optimize the **available light** for crops.

Turbines create **intermittent shade** on crops that can be benefitial. Wind turbines help **reduce dew on crops**, lowering the risk of diseases.

3.4 Waste Management & Circular Economy

- Agricultural residues → bioenergy instead of burning
- Manure digestion → provides energy and fertilizers

Circular economy in farming: Reduction of organic waste, production of organic fertilizers (**digestate**), and reduced energy costs through the energy recovery of agricultural and livestock byproducts.

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3.5 Improved air quality

- No particulate emissions from solar, wind, hydro
- Replacing diesel generators reduces**, NOx, SO_2**
- Manure anaerobic digestion to produce biogas **reduces methane emissions**

The airflow from the blades can enhance **ventilation**, benefiting certain crops and reducing humidity-related diseases

3.6 water resource management

- **Solar irrigation** reduces risk of diesel contamination in water bodies
- Biogas digesters minimize slurry discharge into rivers
- The liquid fraction of digestate can be use as fertirrigation

Agri-PVs can help create an improved microclimate by **offering shade and reducing evaporation**, which helps to **preserve soil moisture** and can end reducing irrigation demand by up to 20 percent.

4. Potential Negative Environmental Impacts

- 4.1 Land Use Conflicts
- 4.2 Resource-Intensive Manufacturing
- 4.3 Waste and Disposal Challenges
- 4.4 Impacts on Wildlife and Ecosystems
- 4.5 Managing Trade-offs

4.1- Land use conflicts and effect on soil

- Large solar farms may compete with agricultural land
- Wind farms require significant land footprints
- Potential habitat fragmentation
- Biogas production can require large amounts of feedstock → land & water demand and competition with food production
- The presence of heavy infrastructure and heavy construction machinery can cause soil compaction, which may negatively affect soil health

4.2 Resource-Intensive Manufacturing

- Solar panels, wind turbines, and batteries require rare earth metals and intensive mining
- Risk of shifting environmental burden somewhere else
- High energy input during production

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4.3 Waste and Disposal Challenges

- End-of-life solar panels, batteries, and turbine blades
- Recycling technologies not yet widely available
- Risk of soil and water contamination from improper disposal
- High amounts of digestates to be disposed

4.4 Impacts on Wildlife and Ecosystems

- Wind turbines → bird & bat mortality
- Hydropower dams → disrupt fish migration and aquatic ecosystems
- Sediment trapping from hydropower dams → reduces soil fertility downstream
- Solar farms → habitat loss for native species
- Turbines, transformers, and transmission lines generate **Electromagnetic fields** that may affect soil life, microbes, fungi, earthworms, and grazing animals.
- Changes in airflow and humidity from wind turbines could disrupt cloud formation and precipitation patterns

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4.5 Managing Trade-offs

- Need for environmental impact assessments (EIA) before projects
- The real footprint of wind installations should include access roads and infrastructure.
- Focus on sustainable siting and life-cycle management
- Circular economy: recycling and reuse of components
- Policy regulation of digestate application
- Integrated planning to balance energy, food, and ecosystem needs

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	Environmetal impact		Agricultural impact	
RES Technology	Positive	Negative	Positive	Negative
Hydropower	Low GHG emissions; water storage for multiple uses; supports off-grid	Alters river flow and aquatic ecosystems; sediment trapping; habitat	Reliable irrigation; multipurpose reservoirs; supports water and energy	Downstream water reduction; waterlogging or flood risk; possible land
Solar PV	Reduces GHG emissions; land under panels can retain moisture and biodiversity	Land occupation; habitat fragmentation; heat island effects in dry	Dual land use (agriPV); improved microclimate and soil moisture	Shading may reduce yield (depending on crop); compaction from panel
Wind Energy	Clean electricity; low water use; minimal emissions during operation	Bird and bat collisions; noise pollution; landscape alteration	Powers farm equipment; minimal land footprint if placed on margins	Noise may affect livestock; access restrictions during installation
Biogas	GHG mitigation from methane capture; promotes waste circularity; reduces odours	Risk of nutrient runoff; odours if mismanaged; localised air and water quality reduction	Fertiliser substitution (digestate); on-site energy for heat/electricity	Digestate overapplication risks soil and water pollution; requires

5. Biogas and digestate: Case study and evidences

- 5.1 Biomas and Biogas energy
- 5.2 Diferences between organic, synthetic and biobased fertilizers
- 5.3 The Catalan Use Case
- 5.4 How to analyze the impact of biobased fertilizers

5.1 Biomass and Biogas Energy

Biomass energy is obtained from the **combustion of organic matter** (agricultural and forestry waste, manure, pruning waste, etc.). **Biogas energy** is produced by introducing organic waste (manure, slurry, vegetable waste) into a **hermetic digester** that allows microorganisms to decompose the matter in the absence of oxygen and produce biogas, which is then burned in an internal combustion engine.

5.2 Organic – Synthetic - Biobased fertilizers

Organic Fertilizers: Organic fertilizers are derived from natural sources such as manure, plant residues, and bio-based materials. They also contribute to soil organic matter and improve soil structure, enhancing overall soil health and fertility.

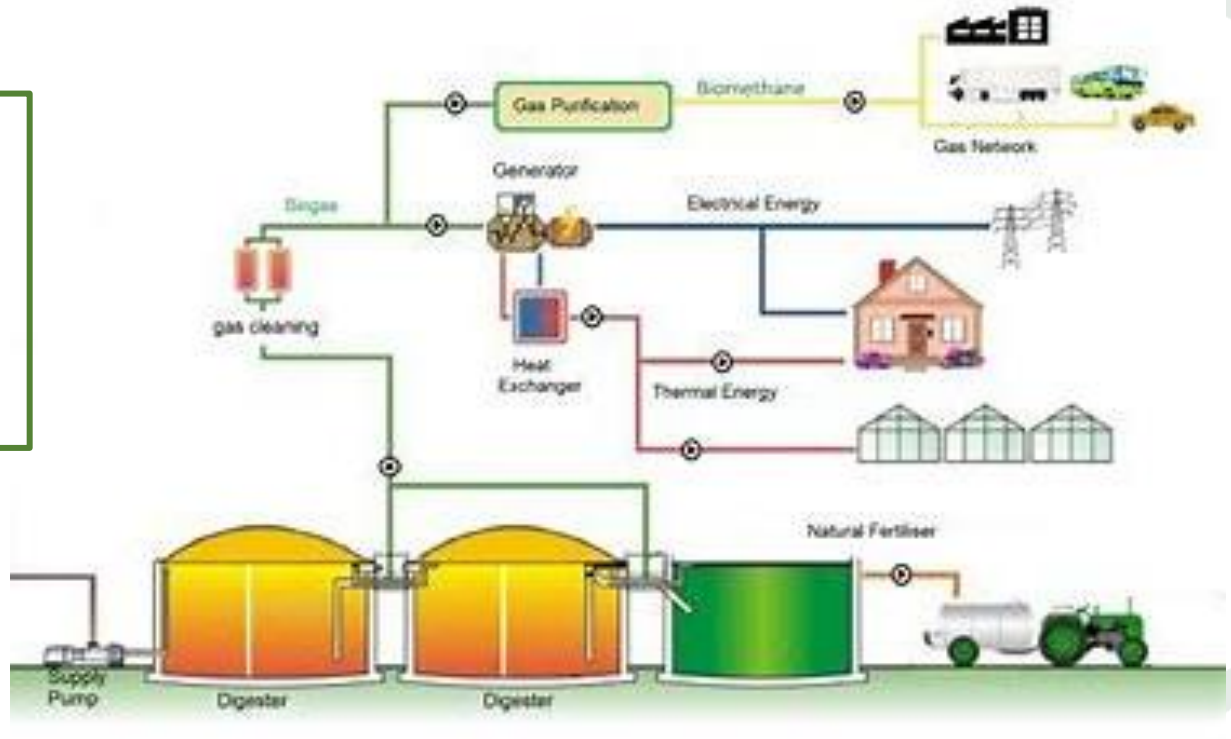
Synthetic fertilizers are designed to provide crops with the nutrients that they need. They offer readily available nutrients that plants can quickly absorb through their roots, making them more efficient and requiring smaller volumes compared to organic alternatives

Biobased fertilizers are obtained through a physical, thermal/thermo-chemical, chemical, and/or biological processes for the treatment of an organic waste stream that result into a change in composition due to a change in concentration of nutrients

Biobased fertilizers (mineral or organic)

- Treated manure
- Digestate
- Sewage sludge
- Wastewater
- Bio waste
- Biological byproduct

Biogas Plant Overview



End-Products

- Struvite
- Vivianite
- K-struvite
- Phosphates
- Stabilised sludge
- Compost
- Digestate
- P-rich ashes
- Ammonium sulphate
- Ammonium nitrate
- N&K concentrate

→ **Biobased fertilisers**

5.3 The Catalan use case: Noguera-Sorigué

Biogas production unit consisting of 4 digesters that valorise agro-residues and produce digestates in the process

To collect data from the biorefinery to model and optimise biogas production from agro-residues

The fertiliser potential of the nutrients recovered from the the digestate will be assessed

Crude digestate

Solid fraction

Liquid fraction

Solid fraction

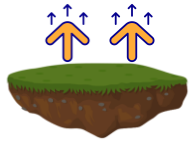
Experimental campaigns

Different experimental activities will be carried out on an experimental campaign to achieve the objectives of the Catalan UC:

1. **Agronomic assays** will be performed under natural conditions in the **field** and controlled conditions in the **laboratory** through **pot-tests** using representative soil to analyse the capacity of the digestate for improving nutrient management, soil quality and **crop yield** and replace current mineral fertilizers in crops.

2. **N release dynamics** of the digestate will be assessed and compared with other similar fertilizers by **soil incubation assays** to determinate whether the product can be deemed as worthy substitute of current products in the market.

3. **Nutrient losses** will be evaluated through two approaches:
   - Nitrate residues & leaching risk will be assessed by the determination of NO3-N residue in the simulated soil profile (0 – 90 cm) in the post-harvest period.
   - Gaseous emissions from digestate will be evaluated by calculating the emission of ammonia (NH3) and greenhouse gases (N2O, NO, and CO2).

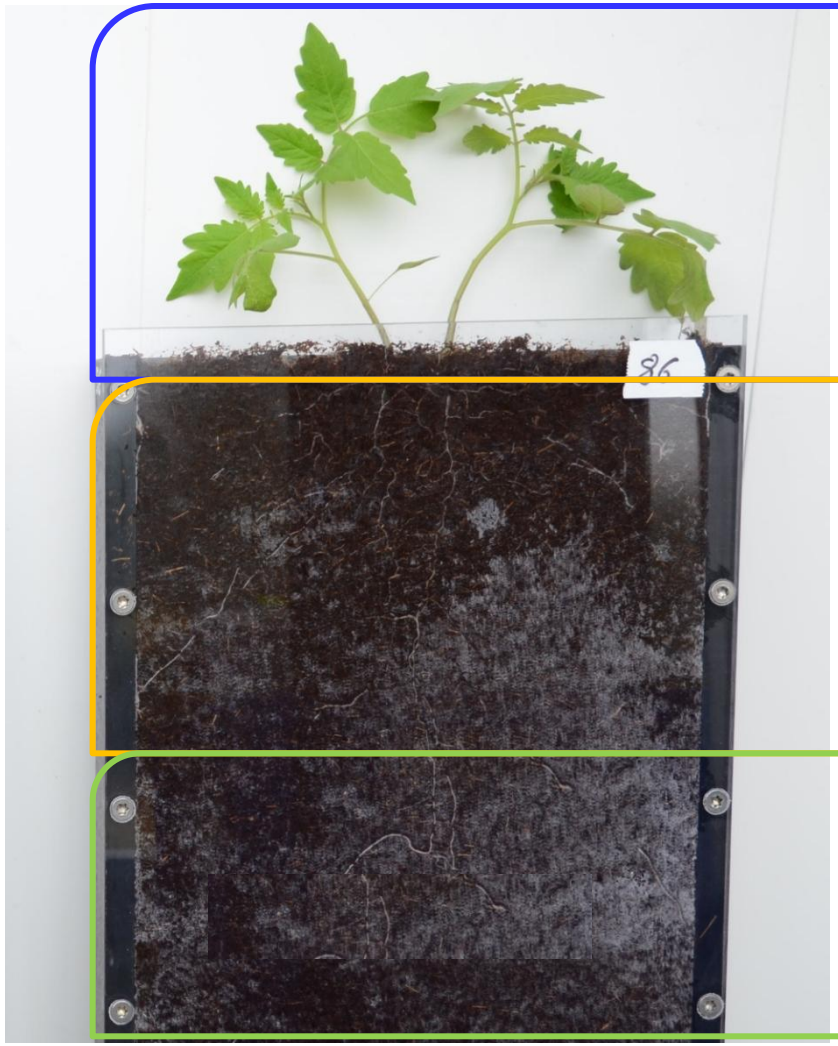


Experimental campaigns

Campo de regadío de doble cultivo

- Cebada: Nov-May
- Maíz: May- Nov

5.4 How to analyze the impact of biobased fertilizers



Plant growth

Nutritional status

Root and soil analyses

Microbial analyses

Soil incubations

Pot tests

Field trials

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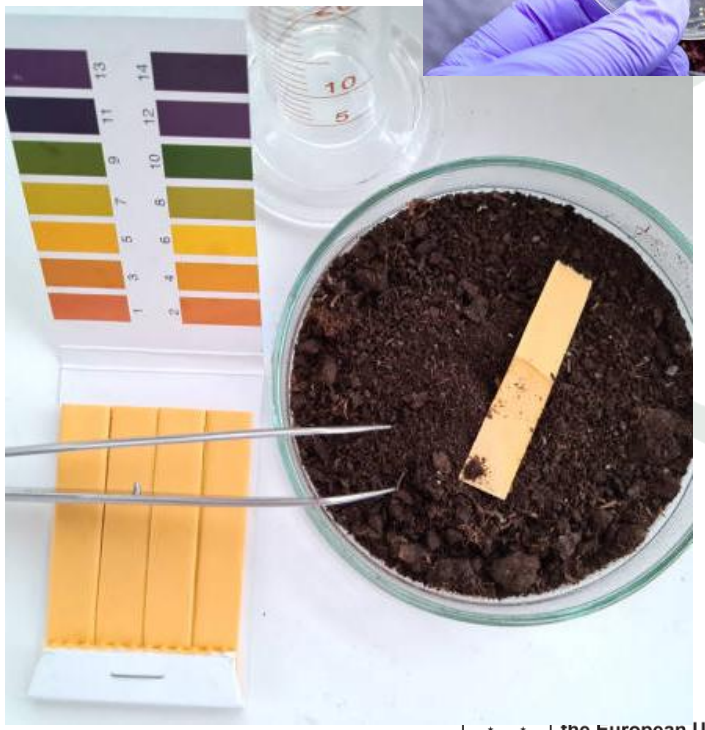
Example of soil health analyses after digestate application

- KPIs:
- Soil organic carbon
- Soil pH
- Soil N&P content and leaching
- Water holding capacity
- Microbial community structure



KPIs to monitor sustainability

Environmental Parameter	Example Indicators	Relevant EU Tools / Frameworks
GHG Emissions	CO2e per ha; CH4 and N2O emissions (kg/ha/year)	Life Cycle Assessment (LCA), GHG Protocol, IPCC Guidelines
Air Quality	NOx, PM2.5 levels; VOC emissions	EMEP/EEA Air Pollutant Inventory Guidebook
Soil Health	Soil organic carbon (%); bulk density; pH; microbial biomass	CWA 17898:2022, Soil Health Indicator Set (EU Mission Soil)
Water Resources	Water use (m3/ha); N and P leaching (mg/L)	Water Framework Directive, LCA, CAP agri-environment indicators
Land Use	Land occupation (m2 per functional unit); land use change rate	Corine Land Cover, Land Use Change Mapping, SDG 15
Biodiversity	Species richness; pollinator abundance; habitat connectivity index	EU Biodiversity Strategy Indicators, IPBES Framework
Energy & Resource Efficiency	Energy return on investment (EROI); energy consumption per ha	Energy Efficiency Directive, RES Directive, LCA
Climate Regulation	Microclimate variation (temperature, humidity); shading index	Agroclimatic models, IPCC Tier 1 indicators
Waste & Circularity	Recycled nutrients (%); digestate use (kg/ha); reduction in synthetic inputs	Circular Economy Action Plan, LCA, EMAS, SDG 12

6. Path to Environmental Sustainability

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Pathways to Sustainability

- Promote environmentally sound siting of RES (avoid fragile habitats)
- Support circular economy approaches
- Integrate RES into climate-smart agriculture & ecosystem protection
- Strengthen partnerships (farmers, NGOs, government, private sector) for knowledge-sharing

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Capacity building

- Ensuring RES adoption leads to **long-term environmental benefits**
- Building the skills, systems, and policies to manage trade-offs

What is needed?

- Technical training: sustainable operation & maintenance of RES
- Environmental monitoring: tracking soil, water, biodiversity impacts

What is needed?

- Awareness raising: educating farmers, communities, and decision-makers
- Policy & institutional support: guidelines, standards,
- incentives for green practices

7. Conclusions

Key Takeaways

❖**Renewable Energy Systems (RES) offer significant environmental benefits**:

- Lower GHG emissions → climate change mitigation
- Cleaner air and water
- Improved soil health and biodiversity protection
- Waste-to-energy and circular economy opportunities

❖**But RES also bring trade-offs**:

- Land use conflicts
- Resource-intensive manufacturing
- Waste management challenges
- Ecosystem impacts (biogas, hydropower, wind)

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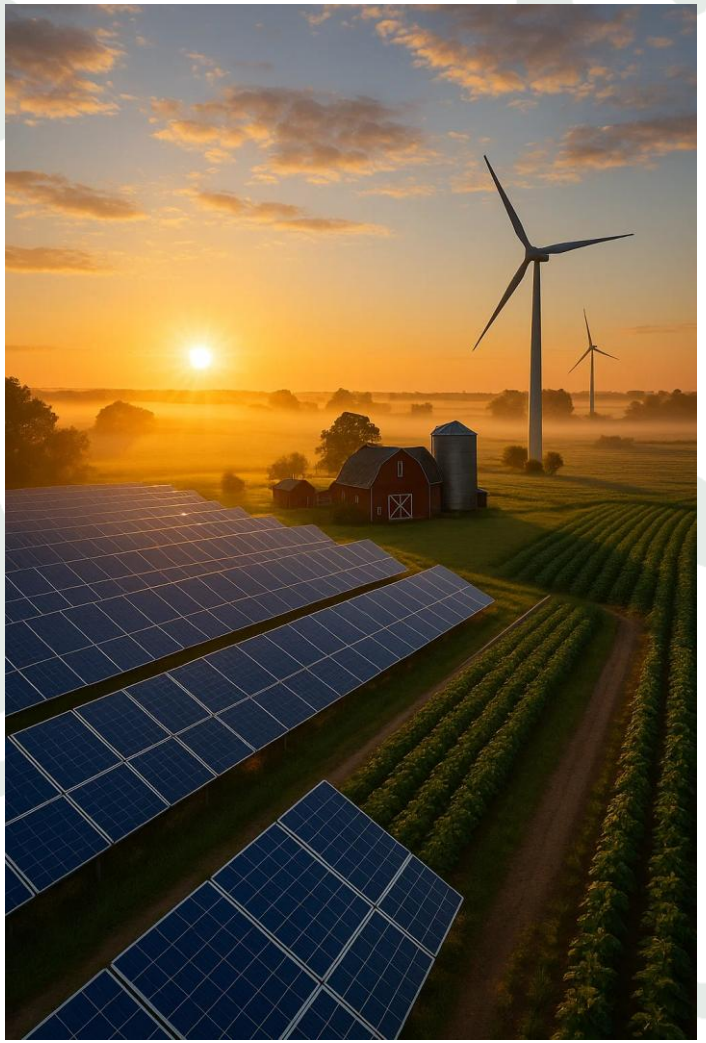
Key Takeaways

- RES are **not automatically sustainable** → they require responsible planning, management, and monitoring
- Environmental sustainability depends on:
  - Informed communities
  - Supportive institutions
  - Integrated policies
- RES are a **pathway to greener, climate-resilient futures**



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Q&A session

- Which environmental impact of RES do you see as most important in your context (climate, water, soil, biodiversity, waste)?
- Can you think of an example where RES had unintended negative effects on the environment?
- What types of capacity building are most needed in your sector to maximize environmental benefits of RES?
- How can we ensure RES adoption contributes to long-term sustainability?

Capacity Building Material

Policy Module

HEC Paris - CKIC

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Content

- Context
- Learning objectives & definitions
- Role of policy in RES technology uptake
- Exercise: Group discussion
- EU Policies for RES
- Examples
- Exercise: Policy roadmap
- Conclusions

•**Aligning with Climate Commitments:** Agricultural decarbonization supports national and international climate goals (e
•**Creating Incentives and Removing Barriers:** Policies can provide financial incentives, regulatory clarity, and infrastru

Context of the HARVREST project

Objective of HarvRESt:

- Develop innovative solutions to decarbonize the agricultural sector through the use of renewable energies, electrification, and advanced digital tools.

Why does HARVREST include a policy focus?

Public policies are critical for:

- ***Creating incentives and removing barriers***
- ***Promoting RES implementation aligned with climate commitments***
- ***Enabling systemic change***

Learning objectives

Learning Objectives

- Learn about the role of public policies as a mechanism to support **sustainability, growth and competitiveness** at the farm level.
- Understand the role of EU policies in RES development and adoption.
- Familiarise with **EU and national policies** supporting RES on farms.
- Learn about RES adoption policy uptake **barriers** and **success cases.**
- Explore examples of **policy instruments**: subsidies, carbon pricing, taxation, other financial incentives.
- Develop ideas for a **farm-level policy roadmap**.

Key definitions

Key definitions, topics, and acronyms

- Renewable energy
- Types of renewable energy technologies.
- Public policy
- Policy instrument
- Innovation
- Sustainability
- Circular economy
- Greenhouse gas emissions
- Climate mitigation
- Climate adaptation
- Climate resilience

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Role of policies in technology uptake: creating a business case for RES adoption.

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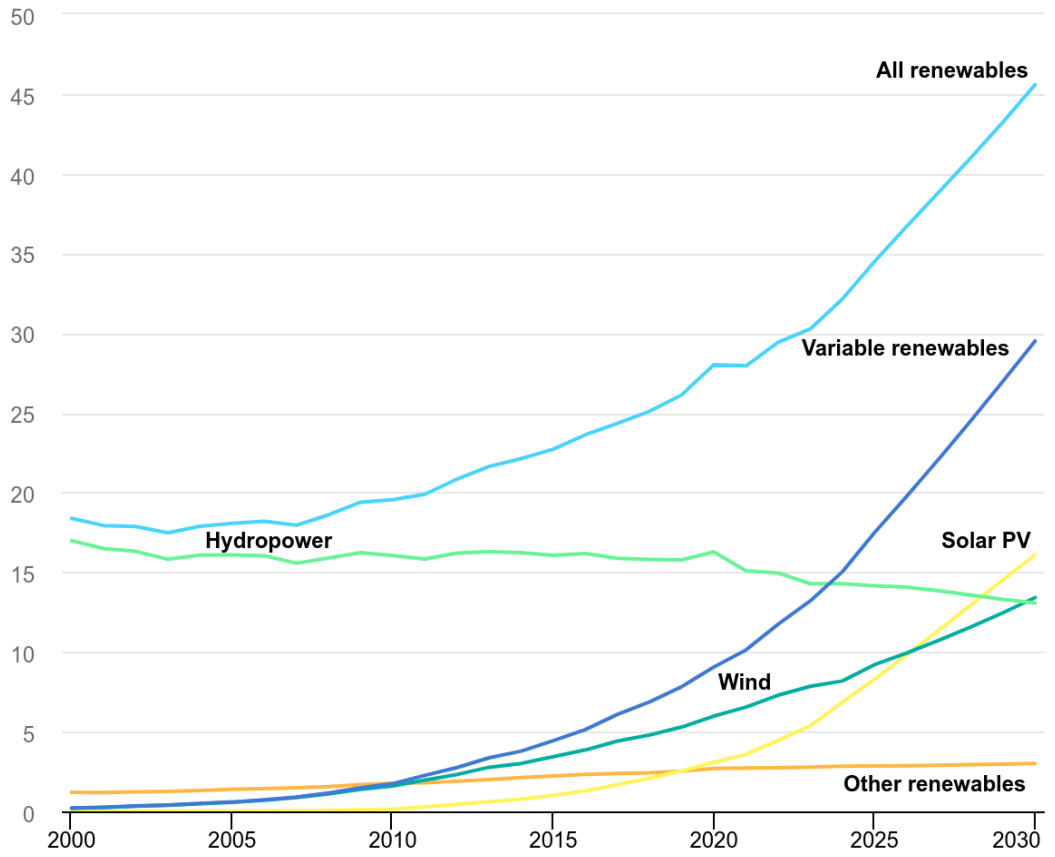
The main role of public policy: why is it used to support technology adoption?

- In principle, governments (or designated bodies) have the mandate and ability to act on behalf of their citizens.
- The basic rationale for government intervention is based on the identification of a wicked or persistent problem, and the capacity of the government to solve it (or to reduce its significance) (Edquist, 2011).
- Very often, policy instruments are used to correct failures in the market – especially when technology is initially too expensive, too risky, or it faces major barriers for its adoption.

Why relying on public policies for RES technology uptake?

- Greenhouse gas emissions (and other pollutants) are a major externality of our economy.
- RES have the potential to mitigate GHG emissions, and to help decarbonising economic activities.
- For RES uptake, there has been a stronger need for regulation, because until recently markets were not ready, investment was reticent, and business models highly unproven (goods, services, technologies
- Public policies have made RES attractive, affordable and reliable.



IEA, 2024

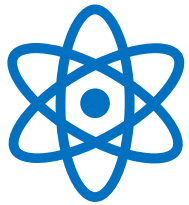
Source: IEA (2024)

Key drivers of change: why adopting RES at the farm level?

- Farmers can **consume and produce** renewable energy, **reduce** costs, and **sell** surplus to the grid.
- **Agriculture** is both a **climate challenge** (10% of EU GHG emissions) and an **opportunity for RES**.
- **Circular Economy**: Turning waste into resources (e.g., manure → biogas, crop residues → bioenergy).
- **Climate policy drivers**: EU Green Deal & Fit for 55 (net-zero by 2050). CAP eco-schemes promoting sustainable practices, National Energy and Climate Plans (key national framework)

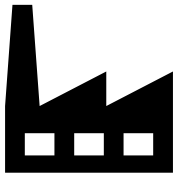
Source: EuroNews

What policy areas can influence RES adoption?

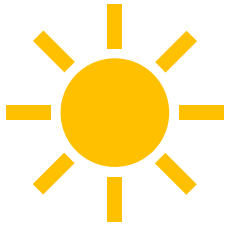


Research and innovation (R&I)

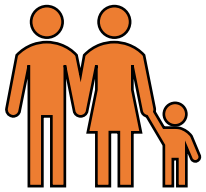
Climate and environment



Economy, industry and competitive ness



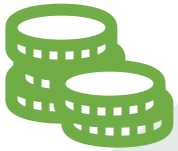
Energy



Social development and cohesion

Consumer

Education



Fiscal

Agriculture

Such diversity in terms of policy areas is directly translated to the number of actors (public bodies) that interact with the implementation of programmes, funds and other policy instruments.

Source: Diaz Lopez et al (2023)

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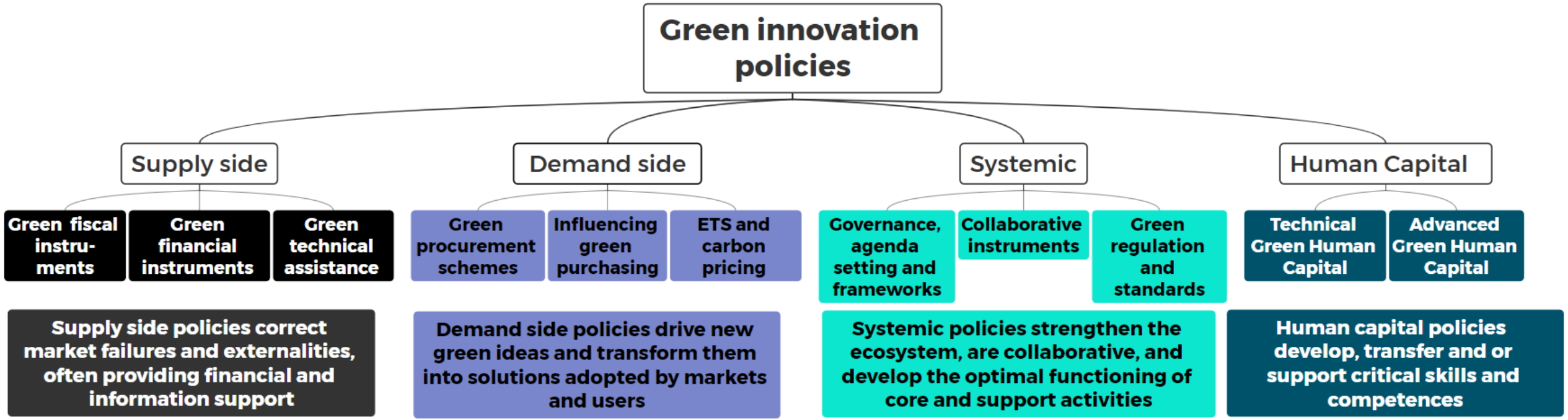
RES uptake policy taxonomy: four types of instruments supporting eco-innovation and green technologies (RES).



Source: Diaz Lopez, Grazzi, et al (2025)

RES uptake policy instruments: specific examples.

Green procurement

R&D support

Carbon taxes

Subsidies and financial support

Vouchers

Information services

Technical support

Labelling

ETV schemes

Certifications

Regulations and standards

Capacity building

Feed in tariffs

Faster permitting

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Source: Diaz Lopez, Grazzi, et al (2025)

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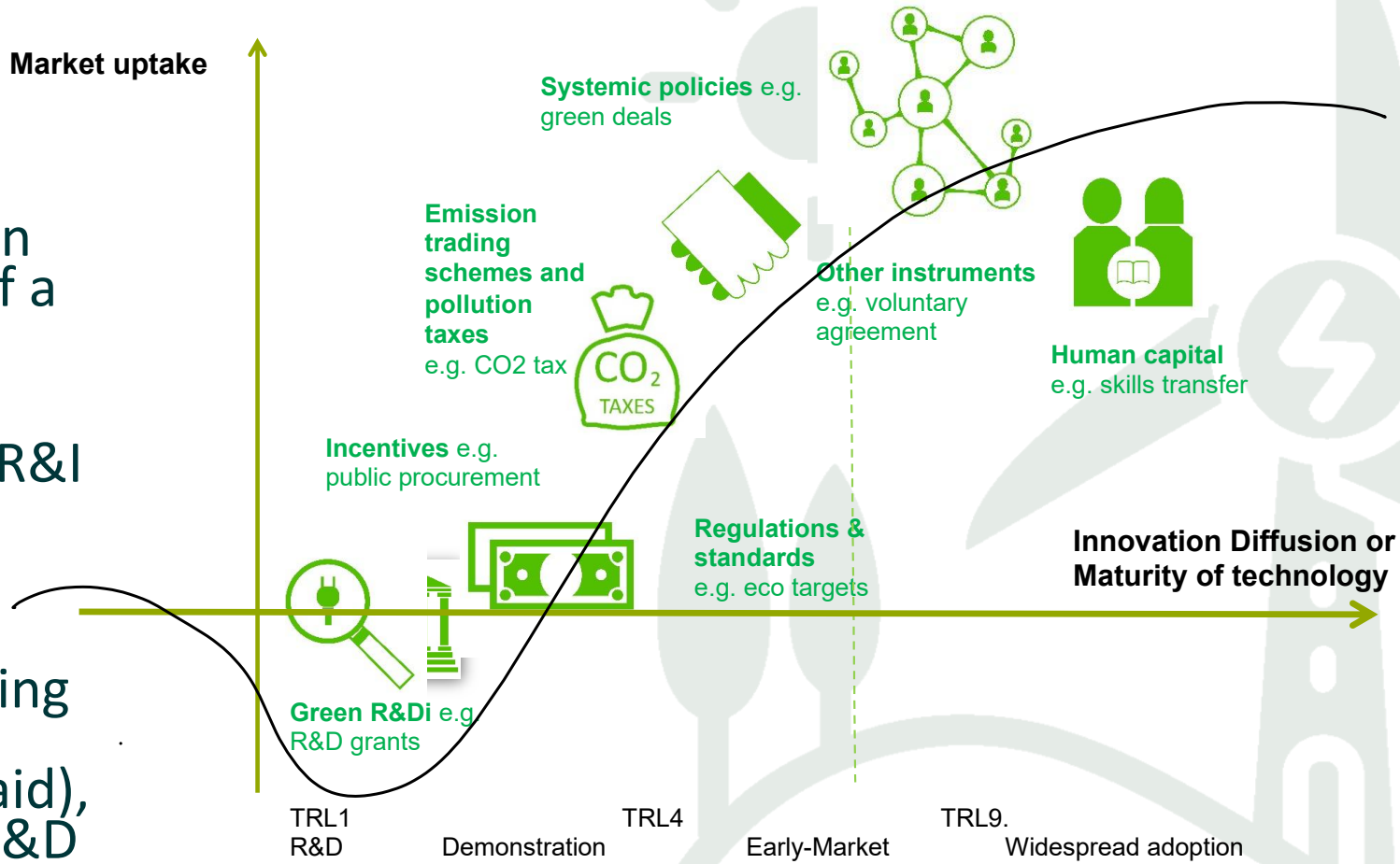
Do all policies are used for the same purpose or at the same time?

- In short, no.
- Their (coordinated) use can vary across the life cycle of a technology, project or investment.
- Here an example from an R&I perspective.
- Farmers can benefit from different policy support mechanisms, e.g. for training (e.g. capacity building), purchase (e.g. a financial aid), testing (e.g. a twining or R&D project).



Source: Diaz Lopez, Grazzi, et al (2025)

EU Policies for RES Adoption

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Contributing to the Sustainable Development Goals

EU Policy to support renewable enery

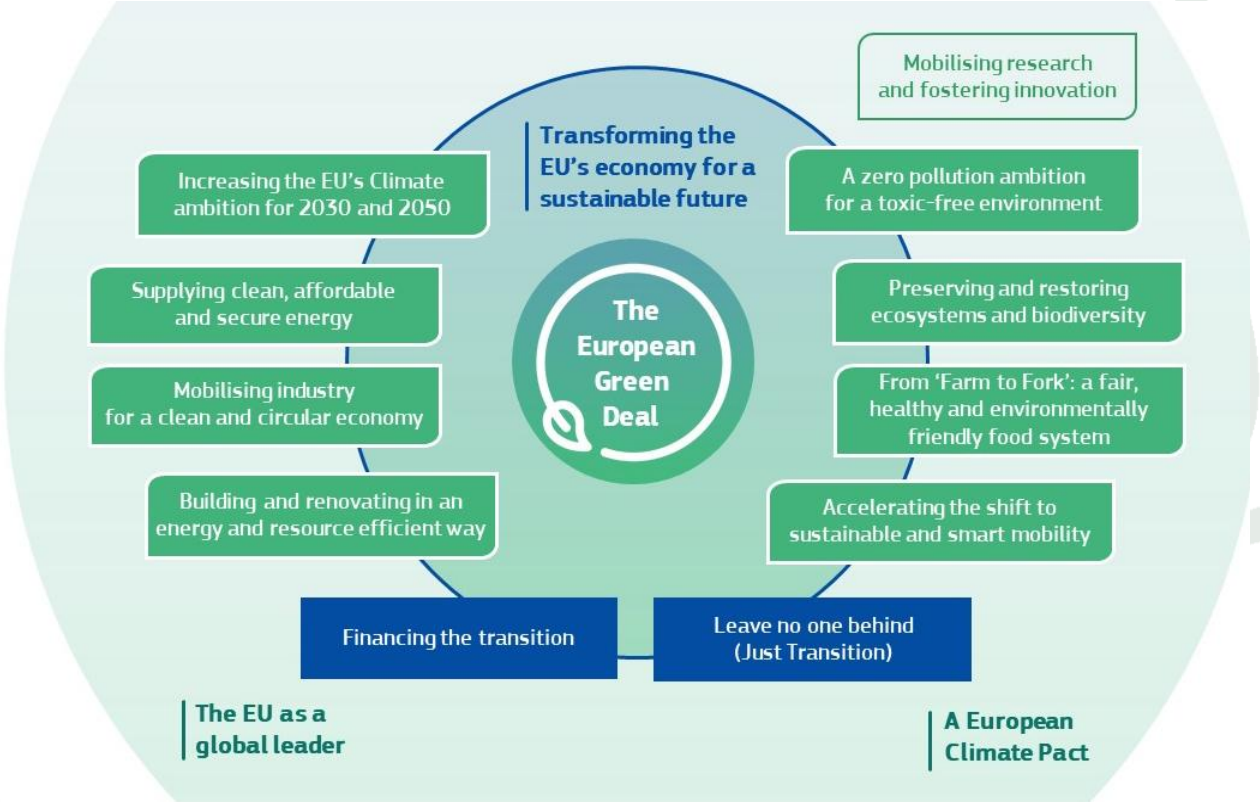
Agriculture, energy, climate, R&I

- Promotes universal access to **clean energy**.
- Encourages the use of **solar, wind, biogas, and biomass** sources in rural areas.
- Facilitates technologies for **irrigation, storage, and food processing.**
- FEADER and FEAGA support for **financing renewable energy infrastructure, energy efficiency projects** in agricultural facilities, or the implementation of **sustainable practices.**

- Calls for the **urgent reduction of CO_2 emissions.**
- Promotes **low-carbon agricultural practices**.
- Supports **climate resilience in agriculture.**

EU Green Deal

- **EU Green Deal:** net zero by 2050, binding 2030 targets (55% reduction in GHG emissions); Climate neutrality, circular economy, and sustainable agriculture alignment.



Key EU Policies: Agriculture

- **Common Agricultural Policy (CAP) Strategic Plans (2023-2027):** €8.1 billior allocated to Climate & Environmental objectives; has been supporting nearly 180,000 farms to engage in renewables especially with eco-schemes funding on-farm RES, rural development programs.
- **European Agricultural Fund for Rural Development:** Finances Rural Development Programmes (RDPs), €95.5 billion 2021–2027, supports agri-environment, innovation & RES on farms.

Key EU Policies: Energy, Climate, Innovation

- **Renewable Energy Directive (RED III, 2023):** 42.5% RES target by 2030; incentives for bioenergy, solar, wind.
- **Recovery & Resilience Facility (RRF / PRTR):** Funding for farm-level solar, biogas, and energy efficiency; at least 37% of the RRF budget allocated to green measures.
- **Climate Law & Climate Pact: Law -** Legally binding ~55% GHG cuts by 2030, climate neutrality by 2050, proposed in a better way; **Pact:** Citizen platform mobilising local climate action, tools, and ambassadors.
- **National Energy & Climate Plans (2021-2 (030):** Sets binding renewable energy and emission reduction targets for Member States, guiding national support schemes establishing precise actions and policies to achieve the 2030 climate and energy targets.
- **Horizon Europe (2021–2027):**
  €93.5 billion funding programme for R&I, supporting farm-level renewable energy projects, circular bioeconomy innovations, and climate-smart agriculture

Key EU Policies: Circularity, Bioeconomy

- **Circular Economy Action Plan (2020):** Encourages waste valorisation, nutrient loops, and resource efficiency.
- **Industrial Emissions Directive (IED, 2023 revision):** includes large livestock farms, encourages emission reduction tech.
- **EU Bioeconomy Strategy:** promotes biogas, nutrient recycling, and sustainable bio-based production
- **FEAGA:** Finances income support for farmers and market measures; funded with approx. €40.95 billion in 2021.

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Barriers to RES Adoption

- **Technological:** High upfront costs, limited grid capacity, intermittency of solar/wind.
- **Organisational:** Small farm size, lack of cooperatives for shared RES.
- **Institutional:** Complex permitting, fragmented support schemes.
- **Behavioural:** Low awareness & lack of advisory/training services, “food vs energy” debates, risk aversion & doubt on profitability of technologies,
- **Financial:** Access to credit, subsidy application complexity.

Group discussion

Group Discussion: RES Policy Support Around You

Objective: Identify a wide set of RES adoption policies or instruments in your country, region and city/town

- **Instructions:**
  - **Form groups of 5 people**
  - **Select the level of supportive policies:** EU, national, or regional frameworks (CAP, RED III, NECPs, RRF, Horizon Europe, bioeconomy/circular economy measures).
- **Identify at least five policy instruments:**
  - Which RES technology are covered (solar, wind, biomass, biogas, energy storage)?
  - What is the type of support or benefit that could be obtained?
  - What are the key requirements to become a beneficiary?
- **Select one specific policy, e.g. a public subsidy for RES purchase. Discuss:**
  - Key barriers to access it.
  - What additional skills or competences would you need to use said policy scheme? If unavailable, how would you acquire them?
  - What would be the ideal outcome as a beneficiary?

Making policies work for RES Adoption at the Farm level

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Opportunities of RES Adoption

- **Technological:** Energy cost savings, energy storage & smart grids, diversified solar/wind/biomass, on-farm innovation
- **Organisational:** Cooperatives & shared RES, knowledge-sharing networks, scale efficiencies
- **Institutional:** CAP & national subsidies, streamlined permitting, alignment with climate targets
- **Behavioural:** Advisory/training support, proven profitability, “green” marketing opportunities
- **Financial:** Revenue from excess energy, grants & subsidies, risk reduction via stable tariffs
- **Broader:** Circular bioeconomy (nutrient recycling, digestate), energy independence, enhanced competitiveness, income diversification and risk mititgation

Instruments Supporting RES adoption in Farms

- **Subsidies & Grants:** CAP eco-schemes, rural development funds.
- **Feed-in tariffs / premiums** for selling surplus energy.
- **Carbon pricing:** incentivising emission reduction.
- **Tax incentives:** VAT reduction for RES equipment.
- **Advisory services and training:** EIP-AGRI networks, training for farmers.
- **Cooperatives & energy communities:** sharing costs & benefits.

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Policy Uptake Examples

Cooperative Biogas Plants - Denmark

- **Type of adoption:** Farmers collaborate in **biogas cooperatives (main 50 large plants)** supported by national feed-in tariffs and subsidies.
- **RE Source:** Manure and crop residues supplied to centralised digesters, injected into the gas grid.
- **Energy use:** Generate 11**% of Denmark's gas demand** as biomethane in 2023, contributing to displacing fossil natural gas.
- **Impact:** Farmers gain stable income, reduced manure management costs, and access to digestate fertilizer.
- **Sustainability:** Large-scale GHG reduction, nutrient recycling, and community energy autonomy.
- **Policy:** Agriculture & forestry to cut GHG 55–65% by 2030 (vs. 1990) with €500M incentives for farm modernisation under the climate agreement; encouraged by carbon tax reductions

Farmer takeaway: Stable **policy support, cooperation** makes biogas highly viable at farm level, easier manure management while lowering costs.

Policy Uptake Examples

Energy Storage on Arable Farms - Netherlands

- **Project:** De Jong Odoorn - Energy Storage on the Farm (2016) tested **battery storage for solar energy**.
- **Source:** 4 Dutch arable farmers invested in a **300-kWh battery** to store PV electricity.
- **Energy use:** Solar power stored in batteries and sold to the grid during high-price peaks.
- **Impact:**
  - Expected to improve farm revenues by **playing electricity market peaks**.
  - After 2 years, **returns too low** due to **low electricity prices** and **high battery costs**.
  - **Short technical lifetime** of batteries reduced profitability.
- **Sustainability:** Demonstrated technical feasibility of on-farm storage but highlighted **economic and technological barriers** to adoption.
- **Policy:**
  - **Supported** by Dutch Climate Agreement, NECPs, RVO frameworks (SDE+, DEI+)
  - Poor profitability due to **lack** of targeted incentives and market support for battery storage, short-term subsidies, and limited advisory guidance

Farmer takeaway: Storage can help farmers capture more value from solar energy, but **current costs and market conditions limit profitability**.

Policy Uptake Examples

Solar-Powered Irrigation - Montesusín, Spain

- **Project**: “Innovation in Photovoltaic Pumping in Irrigation Communities” led by ACCIONA; 1.58 MW solar PV plant in Montesusín (Huesca), among other Ebro Basin communities, providing irrigation energy to 150 farmers over 3,400 hectares.
- **Technology**: 2,400 PV modules with solar trackers; grid-connected system without batteries.
- **Energy Use**: Produces around **3,000 MWh/year**, covering **44% of irrigation energy needs**.
- **Impact**: Reduces energy costs for farmers by **30–40%**; cuts CO_2 emissions by about **2,100 tonnes annually**.
- **Innovation**: First collective self-consumption irrigation plant of its scale in Spain, ensuring stable water supply during peak demand.
- **Policy Support**: Funded through the **EU Innovation Fund** and Spain’s **Recovery and Resilience Plan (PRTR), under the** Climate Change and Energy Transition Act; is part of the **Ebro Basin Irrigation Modernisation Strategy**.
- **Farmer Takeaway**: Demonstrates how cooperative solar irrigation can deliver **cost savings**, **climate resilience**, and **scalability** for large farming communities.

Policy Uptake Examples

Farmers' Biomass Cooperative - Flanders, Belgium

- **Project:** EU **Twecom** initiative supported 5 farmers forming a cooperative.
- **Source:** Hedgerows in Bocholt (previously unmanaged, now maintained).
- **Energy use:** Wood chips dried & supplied to a **250-kW biomass boiler** for municipal buildings.
- **Impact:**
  - **~195 tonnes wood chips/year** = replacement of **60,000 L fuel oil**.
  - Current supply from **4 km hedgerows**; municipality has **100 km available** → strong potential for scaling.
- **Sustainability:** Uses only **untreated prunings & wood**; promotes **landscape maintenance + energy self-sufficiency**.
- **Policy:** Supported by **Flemish subsidies + EU LIFE funding** to harvest hedgerows for municipal heat.

Farmer takeaway: Cooperatives can turn unused local biomass into a **stable energy income stream** while reducing fossil fuel use.

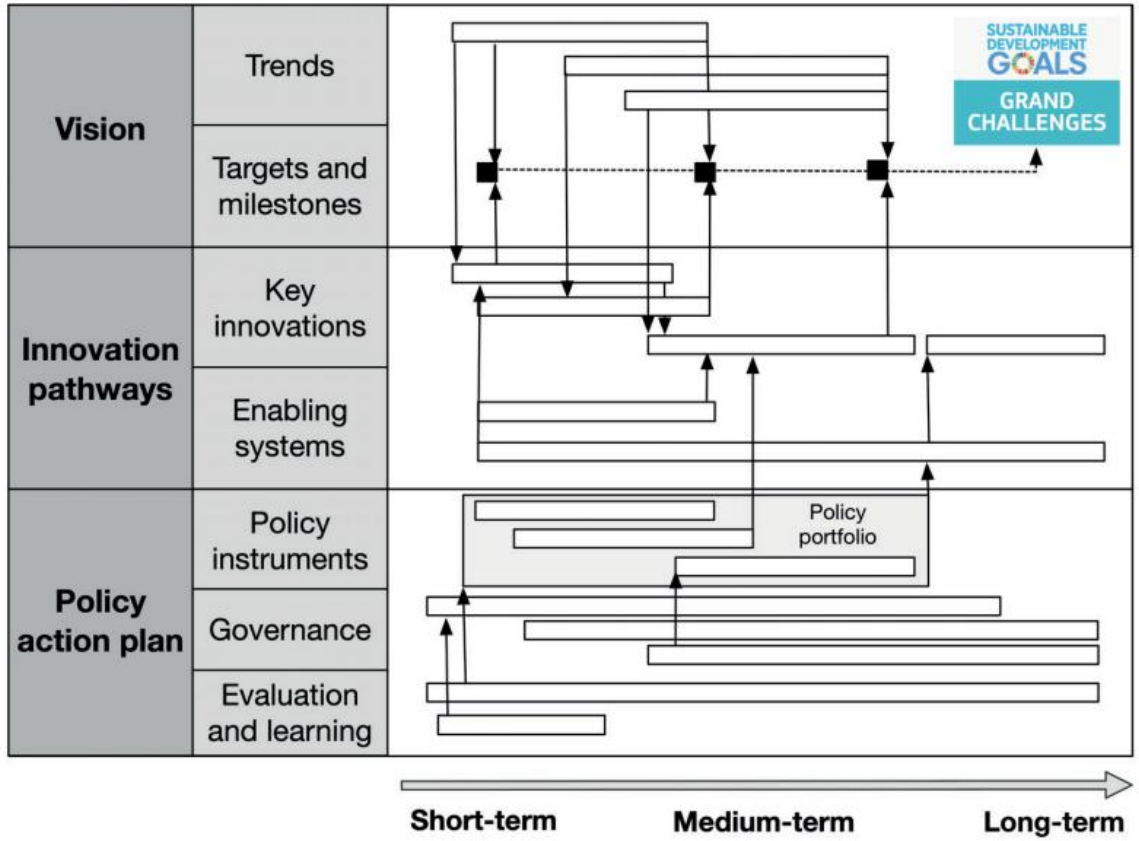
Group Activity

Group Activity: RES Policy Roadmap

Objective: Identify suitable RES adoption policies or instruments to your own farming context.

- **Instructions:**
  - **Work again in the same groups as the previous exercise.**
  - **Think about your farm:** type, size, crops/livestock, energy needs.
  - **Identify barriers** to renewable energy adoption: technological, financial, institutional, or behavioural.
- **Identify policy opportunities:**
  - **Focus: Select TWO policies or schemes:** from those identified in the previous exercise.
  - **Vision:** Which RES technology fits best (solar, wind, biomass, biogas, energy storage) and what capacity would you look at?
  - **Enabling system:** Can you access the programme by yourself? What funding or advisory support can you access? Is there any additional infrastructure development envisioned? (e.g. future battery storage for solar PV)
- **Create a mini roadmap or action plan:**
  - Step 1: Identify the key barrier to overcome and develop and ideal vision (desired outcome)
  - Step 2: Match with a policy instrument or a specific scheme with a particular RES; describe what additional system-level requirements are needed.
  - Step 3: Outline practical action /actions to use the desired policy instrument to adopt a specific RES, and under what timeline.
- **Elaborate a 2 minute pitch for discussion with the rest of the group. Include a visual representation of how your actions/activities would look like over time.**

Example of a policy roadmap template



Source: Miedzinski et al 2018

Conclusions and wrap-up

Group restitution

Each group reports back to the plenary about:

- Selected case (farm)
- Main barriers
- Main opportunities created by policy instruments /a particular policy scheme.
- For what technologies
- Key steps for action

Policy opportunities - Farm-level RES adoption

- **Streamline Funding & Permits:** Simplify CAP, PRTR, national RES subsidies; fast-track on-farm approvals.
- **Support Cooperatives:** Encourage collective RES projects to overcome small farm size barriers.
- **Integrate with Water & Bioeconomy:** Link RES adoption to irrigation modernisation, nutrient recycling, biogas, and circular economy.
- **Advisory & Capacity-Building:** Provide training, ROI tools, and guidance to reduce risk perception.
- **Stable Financial Incentives:** Feed-in tariffs, PPAs, and tax incentives for predictable support.
- **Align with Climate Plans:** Connect farm RES adoption to NECP targets, EU Green Deal, RRF, and R&I initiatives.

Recommended Readings

- ACCIONA Energía. (2021, December 1). *ACCIONA Energía secures European funding for agricultural irrigation with an innovative photovoltaic solution.* https://www.acciona.com/es/actualidad/noticias/acciona-energia-logra-financiacion-europea-riego-agrario-solucion-fotovoltaica-innovadora
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- State of Green. (2021). *Denmark sets binding 2030 climate target for agriculture*. https://stateofgreen.com/en/news/denmark-sets-binding-2030-climate-target-for-agriculture/
- Diaz Lopez, F.J., Grazzi, M. S. Sasso. (forthcoming) Green innovation policies for a Circular Economy. Inter-American Development Bank.

Capacity building – Module: Business models

Provider: EnGreen

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Table of Contents

- Objective of the module
- Business model: what and why
- Tools for business model development
- Examples of business model
- Business plan
- Financial sourcing and mechanisms

The objectives of Business model module

- Understand the scope of Business Modelling
- Learn what is the key tool for Business Modelling (the Business Model Canvas-BMC)
- Understand the main concept about Business Plan and financial plan
- Discuss the main financial instrument for energy and agricutural sector and the HarvRESt contribution to the topic
- Get to grips with the different sections of the Business Model Canvas by means of practical example

Business Model

Why we talk, study, design and develop Business model and what they are

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The overall vision of the business

"A major mistake made by many start-ups around the world is focusing on the technology, the software, the product, and the design, but neglecting to ever figure out the business.

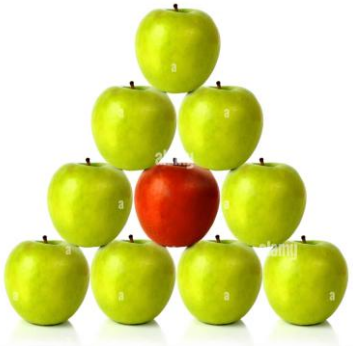
And by "business" we simply mean how the company makes money by acquiring and serving its customers".

Reid Hoffman
Executive Chairman

WHAT ?...the product system

- Products / services

- Distinctive features

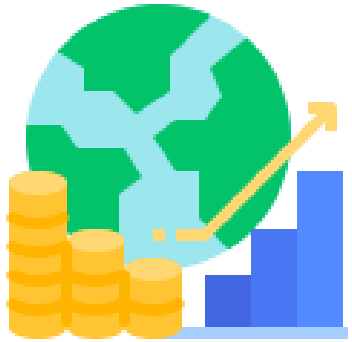


- Complementary services

- Competitive advantages

WHO ?...the market system

- Economic environment



- Competitors

- Market segments

- Channels (supply, marketing, distribution, assistance)

HOW ?...the organizational system

- Human resources

- Financial resources

- Material resources

- Management

- Legal status

- Permit/authorization processes

Behind few words…

To formulate the mission statement's few words…

…you have to work hard on your business model!

The Business Model

"The business model is the logic of the overall business which is applied to its relation with the customer, chain of values, resources, operational management, income or profit generation, and the sustainability of the business entity."

Source: Osterwalder et al., 2005.

Business model tool: BMC

The main tool for developement and desingning of the business model

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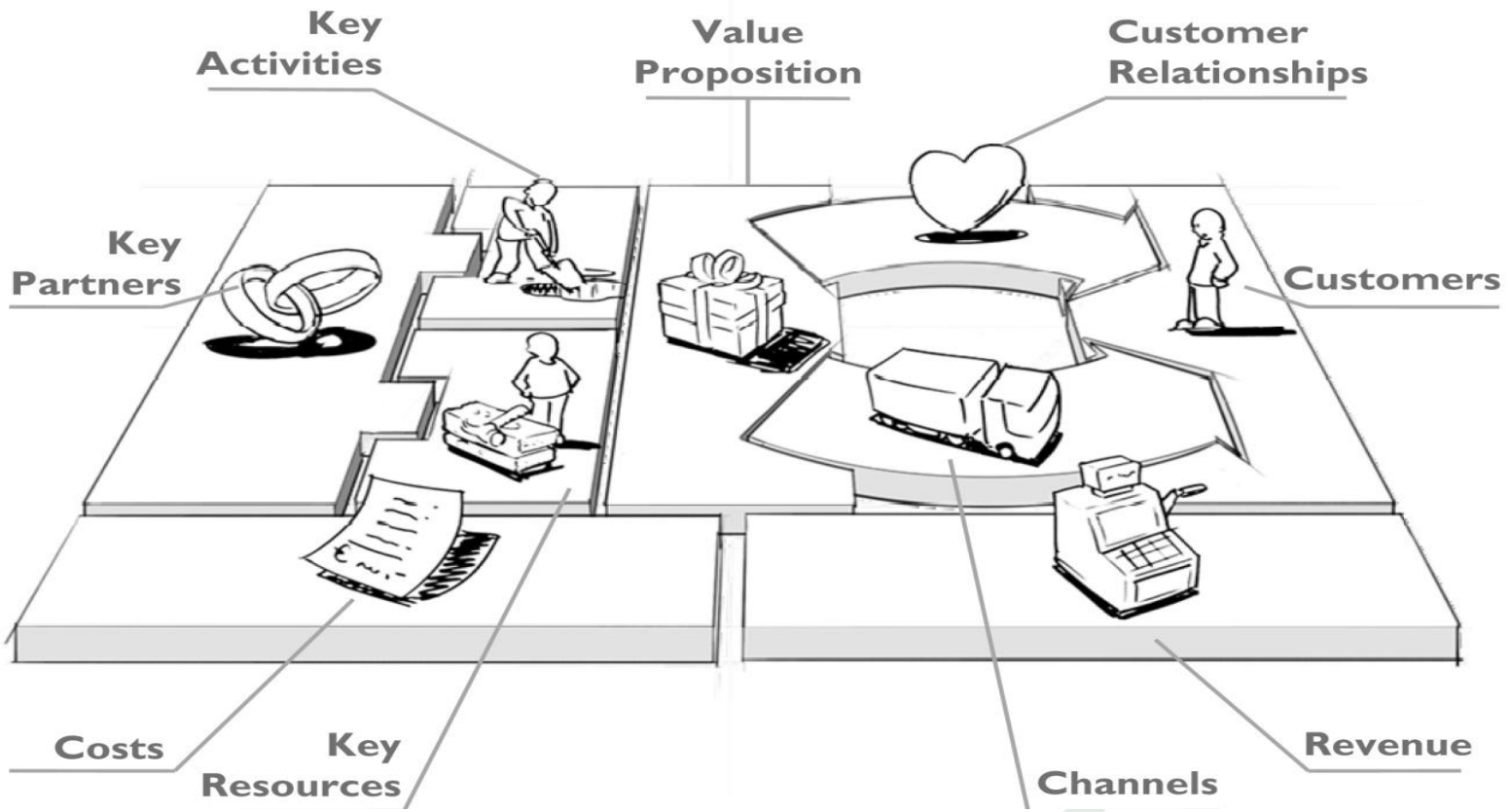
Business Model Canvas (BMC)

A think-tool to build your business



Source: JAM

BMC in a nutshell

- 2005: BMC was initially proposed by Alexander Osterwalder.
- 2010: BMC was validated with the book **"Business Model Generation: A Handbook for visionaries, game changers and challengers"** [1] written by Osterwalder and Pigneur, and also co-created by 470 practitioners from 45 countries.
- *The book is thus a good example of how a global creative collaboration effort can contribute positively to the business and management literature and subsequently to the advancement of society.* [2]
- **The extensive use of the BMC-tool has been disruptive**.

[1]Osterwalder, Alexander; Pigneur, Yves; Clark, Tim (2010). Business Model Generation: A Handbook For Visionaries, Game Changers, and Challengers. Strategyzer series. Hoboken, NJ: John Wiley & Sons. ISBN 9780470876411. .

[2]Alam and Hoque, 2010; Alam et al., 2010a, b

BMC scope

The 9 building blocks show:

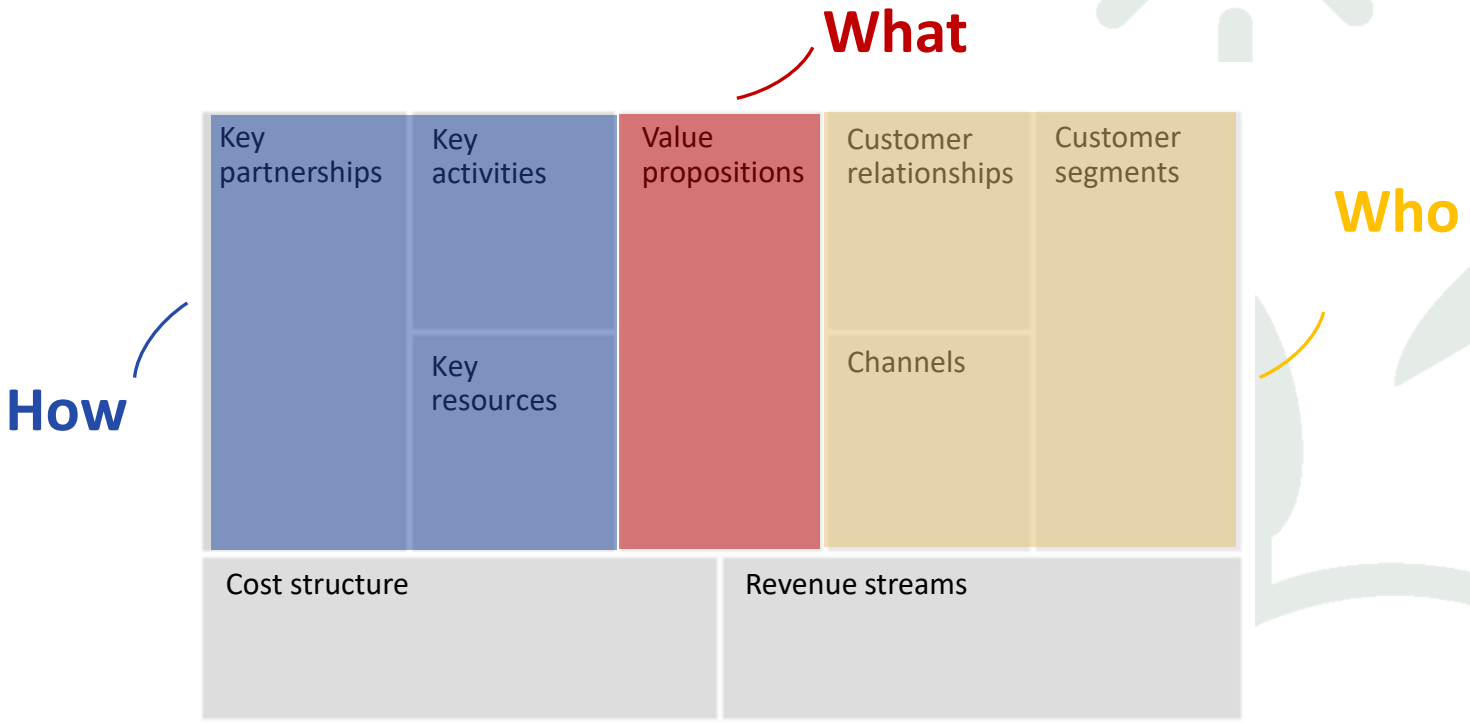
- the **logic of how a company intends to deliver value in a financially sustainable manner**
- the business strategic management
- the constituent elements of the corporate system
- a visual chart with elements describing a firm's or product's value proposition, infrastructure, customers, and finances
- how to align business activities by illustrating potential trade-offs

BMC structure 1/3

There are different ways to explain the BMC structure…

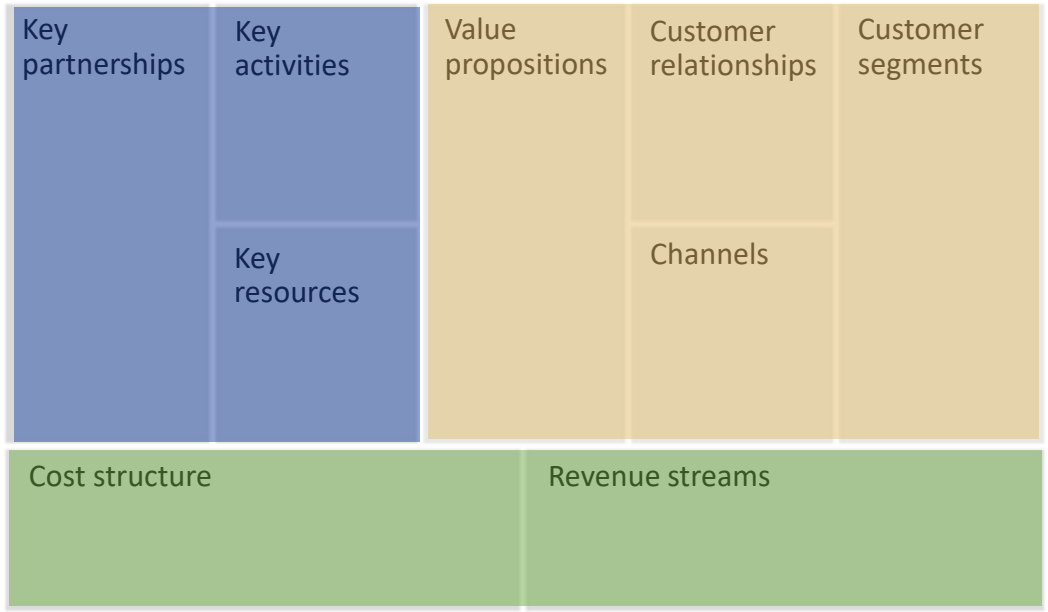
BMC structure 2/3

9 building blocks show the **entrepreneurial formula** at a glance



BMC structure 3/3

9 building blocks cover the three **main areas of a business**



Feasibility

Can we deliver it?

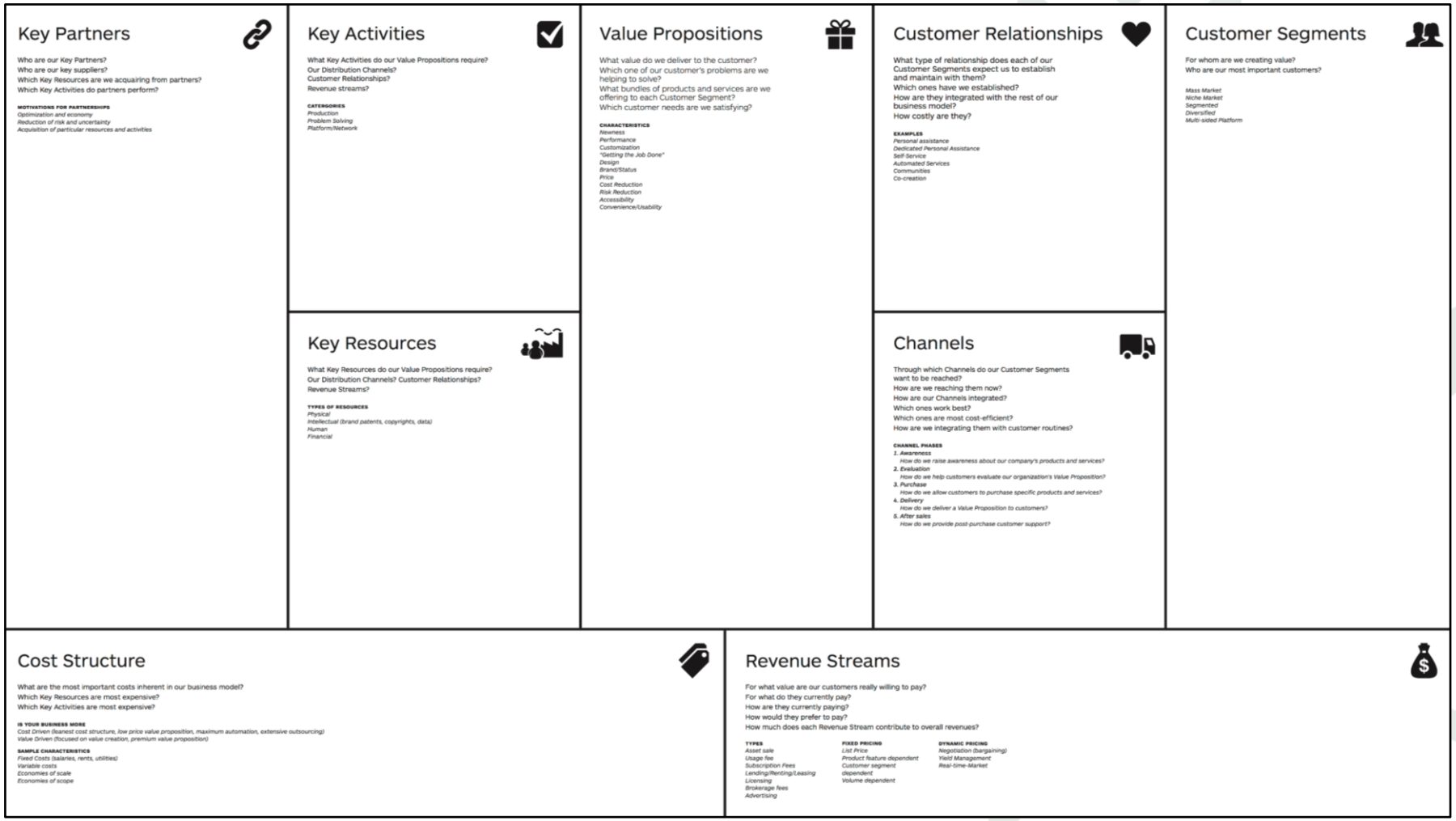
Desirability

Do customers want it?

Viability

What is it worth?

BMC original version



Source: Osterwalder A. et al. , 2010.

Business Plan

What is a business plan and how it is related to the business model

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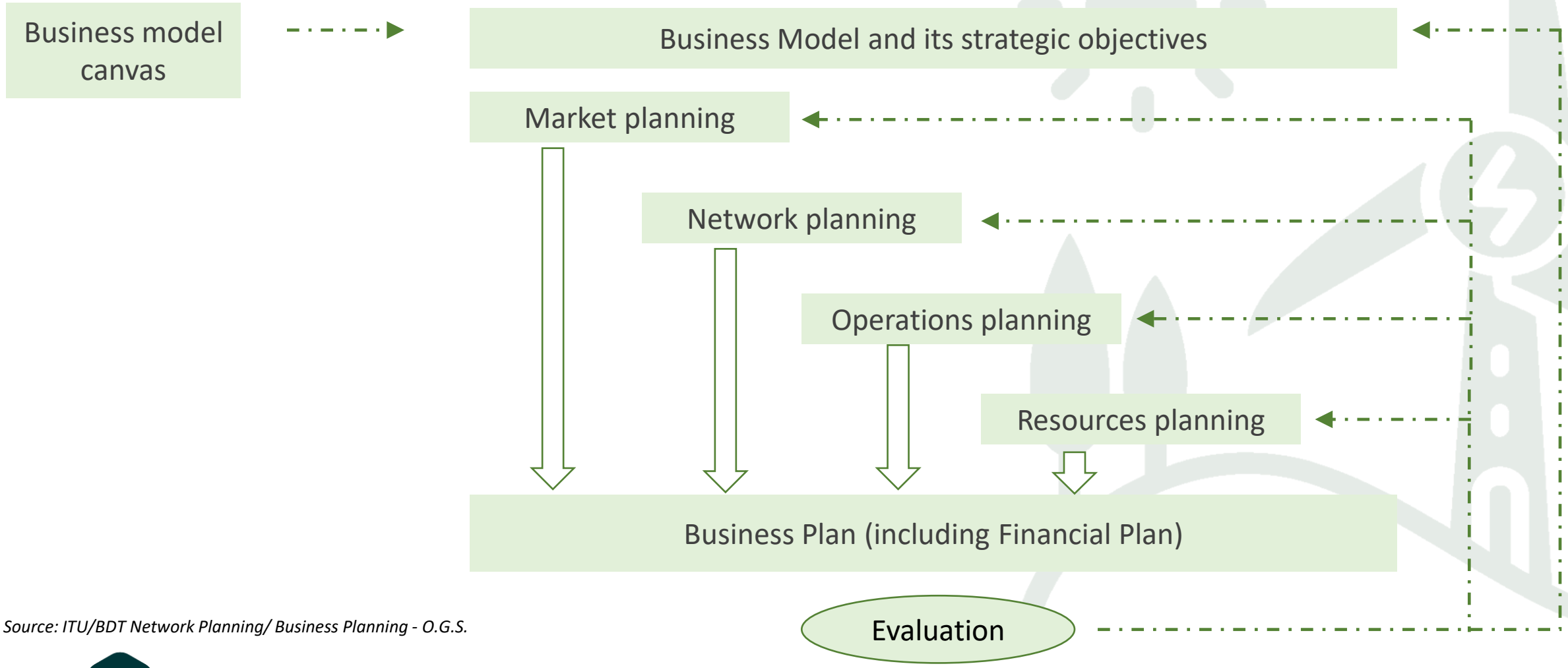
The company’s Business Planning

- A business plan is a document that defines in detail a company's objectives and how it plans to achieve its goals.
- A business plan lays out a written road map for the firm from marketing, financial, and operational standpoints.
- A business plan is an important document aimed at a company's external and internal audiences. For instance, a business plan is used to attract investment before a company has established a proven track record. It can also help to secure lending from financial institutions.
- Business Plan includes the Financial Plan.

Role of Financial Plan

- Forecast solutions, costs and revenues
- Evaluate future cashflows and financial performance (NPV, IRR, ROI, etc.)
- Perform “What-if” analysis for optional alternatives (e.g. on volume of customers, customer mixes and services domains)
- Perform benchmarking with “best in class” operators
- Decision making on strategy and actions in competition based on quantified evaluations
- Recommend alternatives and actions to ensure success

Business Modelling and Planning Process



Source: ITU/BDT Network Planning/ Business Planning - O.G.S.

Comparison between BM and BP 1/2: differences

BUSINESS MODEL	BUSINESS PLAN
the main idea of the business together with the description of how it is working.	the detailed explanation of the business to show how the idea could work.
a gateway to show how an organization is functioning, thus the mechanism to generate profits, **at a glance**	a document to show how an organization is functioning, thus the mechanism to generate profits, **in detail**
it may not include financial planning, thus expected performance details	it always includes financial planning, thus expected performance details
key tool for business model development	key document for access to finance (business proposal for investors)

Comparison between BM and BP 2/2: interconnections

- Bus Plan and Bus Model development are two integrated processes
- Bus Plan synthesizes project marketing, engineering and financials
- Bus Plan is a key tool to verify the Bus Model viability
- Bus Plan is a design tool: it supports the entire business development and is optimized along such process
- Bus Plan is the starting point to set M&E and O&M* tools in operations
- Bus Plan is crucial to establish business partnerships

Overview of a typical Fianancial Plan' structure

CAPEX

REVENUES

OPEX

CASHFLOW

	Inflation rate	2022 0	2023 1	2024 2	2025 3	2026 4	2027 5	2028 6	2029 7	2030 8	2031 9	2032 10	2033 11	2034 12	2035 13	2036 14	2037 15	2038 16	2039 17	2040 18	2041 19	2042 20
Total Direct Costs (excluding Connections)		1.033.120																				
H2: CAPEX distribution - connections		90.574					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total CAPEX		**1.123.694**	**0**	**0**	**0**	**0**	**0**															
Electricity tariff (inflated)	2%	EURO/kWh	0,40	0,41	0,42	0,42	0,43	0,44	0,45	0,46	0,47	0,48	0,49	0,50	0,51	0,52	0,53	0,54	0,55	0,56	0,57	0,58
Connection fee (cost-reflective)		EURO	71.546	7.705	5.735	3.200	2.388	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Revenues 1: electricity sales		EURO	51.849	63.280	75.148	87.466	100.245	104.295	108.509	112.893	117.454	122.199	127.136	132.272	137.616	143.175	148.960	154.977	161.239	167.753	174.530	181.581
Revenues 2: Agri-food (processing / sale of agri/livestock products)		EURO	50.000	51.000	52.020	53.060	54.122	55.204	56.308	57.434	58.583	59.755	60.950	62.169	63.412	64.680	65.974	67.293	68.639	70.012	71.412	72.841
Revenues 3: to be specified		EURO																				
OPEX (inflated)	2%	EURO	29.579	30.171	30.774	31.390	32.017	32.658	33.311	33.977	34.657	35.350	36.057	36.778	37.513	38.264	39.029	39.809	40.606	41.418	42.246	43.091
OPEX - battery replacement													43.365									
OPEX - Mobile money fee	1%		422	542	667	796	931	972	1.014	1.058	1.104	1.152	1.201	1.253	1.307	1.364	1.422	1.483	1.547	1.613	1.682	1.754
OPEX - Community supporting programme in start-up phase			18.728	18.728	18.728																	
OPEX - Agri-food (processing / sale of agri/livestock products)			30.000	30.600	31.212	31.836	32.473	33.122	33.785	34.461	35.150	35.853	36.570	37.301	38.047	38.808	39.584	40.376	41.184	42.007	42.847	43.704
EBITDA			**13.475**	**25.176**	**37.332**	**68.685**	**81.793**	**85.604**	**89.579**	**93.725**	**98.050**	**102.559**	**63.898**	**112.166**	**117.280**	**122.612**	**128.171**	**133.967**	**140.009**	**146.308**	**152.875**	**159.719**
Depreciation	20		18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817	18.817
EBIT			**-5.342**	**6.359**	**18.515**	**49.868**	**62.976**	**66.787**	**70.762**	**74.908**	**79.233**	**83.742**	**45.081**	**93.349**	**98.463**	**103.795**	######	**115.150**	**121.192**	**127.491**	**134.058**	**140.902**
Withholding Taxes	10%		0	-636	-1.852	-4.987	-6.298	-6.679	-7.076	-7.491	-7.923	-8.374	-4.508	-9.335	-9.846	-10.379	-10.935	-11.515	-12.119	-12.749	-13.406	-14.090
VAT	17%		0	-1.081	-3.148	-8.478	-10.706	-11.354	-12.030	-12.734	-13.470	-14.236	-7.664	-15.869	-16.739	-17.645	-18.590	-19.575	-20.603	-21.674	-22.790	-23.953
NET PROFIT			**13.475**	**23.459**	**32.333**	**55.221**	**64.789**	**67.571**	**70.473**	**73.500**	**76.657**	**79.949**	**51.726**	**86.962**	**90.695**	**94.587**	**98.645**	**102.876**	**107.287**	**111.886**	**116.679**	**121.676**

		2022 0	2023 1	2024 2	2025 3	2026 4	2027 5	2028 6	2029 7	2030 8	2031 9	2032 10	2033 11	2034 12	2035 13	2036 14	2037 15	2038 16	2039 17	2040 18	2041 19	2042 20
ENERGY-PLAYER investment		283.531																				
ENERGY-PLAYER net profit	85%		**11.427**	**19.894**	**27.419**	**46.828**	**54.942**	######	######	**62.329**	**65.006**	**67.798**	**43.864**	**73.745**	**76.911**	**80.211**	#####	**87.241**	**90.981**	**94.881**	**98.946**	**103.183**

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Unlevered CASH FLOW	-283.531	11.427	19.894	27.419	46.828	54.942	57.302	59.762	62.329	65.006	67.798	43.864	73.745	76.911	80.211	83.653	87.241	90.981	94.881	98.946	103.183
Cumulated Unlevered CASH FLOW	-283.531	-272.104	-252.210	-224.791	-177.963	-123.021	-65.719	-5.957	56.373	121.379	189.177	233.041	306.786	383.697	463.908	547.561	634.802	725.783	820.663	919.609	1.022.792
Unlevered Discounted CASH FLOW	**- 283.531**	**10.388**	**16.441**	**20.600**	**31.984**	**34.115**	######	######	**29.077**	**27.569**	**26.139**	**15.374**	**23.497**	**22.278**	**21.122**	#####	**18.986**	**18.000**	**17.065**	**16.178**	**15.337**
Cumulated Unlevered Discounted CASH FLOW	-283.531	-273.143	-256.702	-236.101	-204.117	-170.002	-137.657	-106.989	-77.912	-50.343	-24.204	-8.830	14.667	36.946	58.068	78.094	97.080	115.080	132.145	148.323	163.661
Fraction	-	-	-	-	-	-	-	-	-	-	-	-	**0,05**	**0,13**	**0,20**	**0,28**	**0,34**	**0,41**	**0,47**	**0,52**	**0,58**

Unlevered IRR		**15,6%**
Pay Back Period		**8**
NPV	**10%**	**163661**
	Discount rate	

FINANCIAL PERFORMANCE INDICATORS

Problem Setting before Business Modelling 1/5

- The success of an innovative product or service highly depends on its ability to respond to end users' needs and to alleviate their pains.
- An innovative design solution must generate economic value for the company, which allows the creation of loyality links with customers.
- The ease of use of the BMC makes it convenient to be adapted in early design stages. However, a major question at this stage remains to be answered:

is the design solution really able to alleviate important pains or sufferings of end users?

Source: Bekkadi, Alexandre & Yannou, Bernard & Cluzel, François. (2016). IMPORTANCE OF PROBLEM SETTING BEFORE DEVELOPING A BUSINESS MODEL CANVAS

Problem Setting before Business Modelling 2/5

The most important failure reason of innovative businesses is generally due to the lack of useful problem exploration

The importance of useful design problem identification prior to any business model development

Source: Bekkadi, Alexandre & Yannou, Bernard & Cluzel, François. (2016). IMPORTANCE OF PROBLEM SETTING BEFORE DEVELOPING A BUSINESS MODEL CANVAS

Problem Setting before Business Modelling 3/5

BMC provide a simple and intuitive tool that can be developed quickly and applied to iterate and verify the company's business strategy.

At the heart of the BMC, the Value Proposition represents a central pillar around which other blocks evolve.

The Value Proposition determines the core behaviours and activities of a given business.

the relevance of matching between

value proposition and customer segments

Source: Bekhradi, Alexandre & Yannou, Bernard & Cluzel, François. (2016). IMPORTANCE OF PROBLEM SETTING BEFORE DEVELOPING A BUSINESS MODEL CANVAS

Problem Setting before Business Modelling 4/5

Shortcomings of BMC usage in early design stages:

- It is not obvious to set priorities when one wants to design a solution aiming at alleviating users' and customers' pains. Where to start inside the BMC to radically innovate?
- How to verify and validate the legitimacy of value-creating ideas? And how to make sure that the problem is well identified and evaluated?
- A given value proposition cannot be assessed in terms of its value creation. How to judge whether a value proposition alternative is better than another? How to nourish the perception of value offer and customer segmentation?

Problem Setting before Business Modelling 5/5

Three recommendations to advocate a better use of the BMC:

1. Identify and evaluate the design problem, before developing the BMC
2. Use of the BMC in 3 steps (1 in problem setting and 2 in problem solving phases)
3. Advance progressively in a secure way following a problem and solution systematic experimentations

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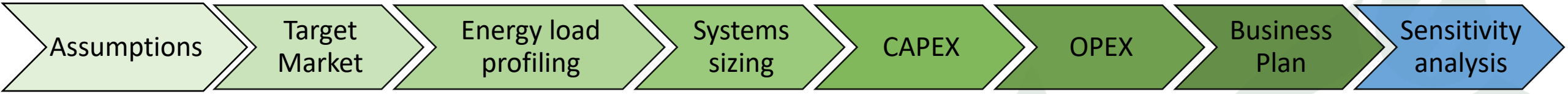
Sensitivity analysis: definition and use

- Sensitivity Analysis is the process of recalculating outcomes under alternative assumptions to determine the impact of a variable[1].

- Sensitivity Analysis is used in financial modeling to analyze how the different values of a set of independent variables affect a specific dependent variable under certain specific conditions[2].

[1] Saltelli, A. (2002). "Sensitivity Analysis for Importance Assessment". Risk Analysis. 22 (3): 1–12.
[2] corporatefinanceinstitute.com

Sensitivity analysis: the process



Sensitivity analysis: potential variables

Exemples of variables used in sensitivity analysis:

1. Business Model
2. Market size
3. Energy mix (e.g. share of energy from the diesel component)
4. Electricity tariff
5. Financing sources

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Financial sourcing and mechanisms

Why financial sourcing is important, which are the main istruments and what HarvRESt project put in play to help the energy and agri-food sector to meet

HarvRESt
Greener Farming with RES

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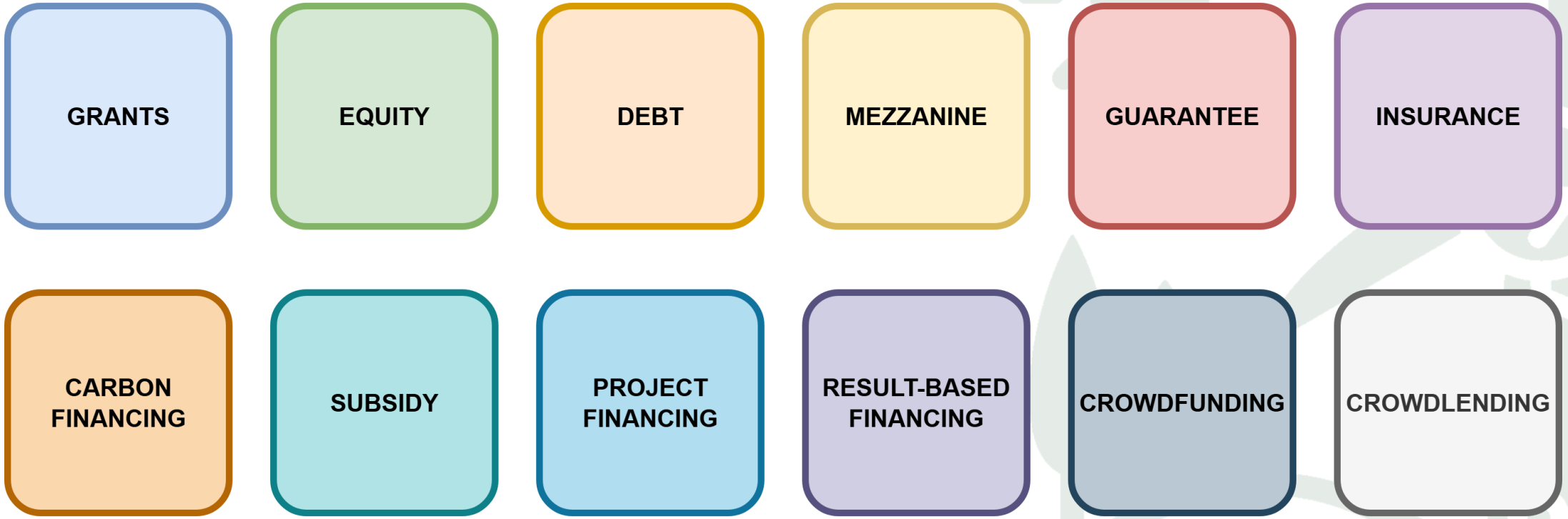
Categories of financial instruments

A lot of financial instruments …



Let’s see the main one…

Macro-categories of financial instruments

Grants
Financing secure from grants is not repayable.
Grants usually target social impact , environmental protection and other development goals.
Sources of grant funding include, governments, international development organizations, development finance institutions, foundations and not-for-profit organizations.
As reference, grant component is <50% of CAPEX

Macro-categories of financial instruments

Equity
Equity funds invest in a company by purchasing shares of that company.
Equity financing sources include, angel investors, venture capitalists, impact investors, clean energy fund, pension funds and other private capital sources.

Macro-categories of financial instruments

Debt
Debt refers to cash borrowed by a developer that is repaid within a specified period of time with interest.
Common sources of debt financing include commercial banks, international finance institutions, foundations, international development organization use clean energy funds to refinance banks (i.e. with lines of credit that can be used by project developers)

D3.2: HarvRESt financial context

What HarvRESt is doing:

1. Financial context analysis
2. Financial mechanism catalogue
3. Financial gap and risk analysis

D3.2: financial mechanism catalogue 1/4

Name of the financial mechanism	Main Sector	Financial Instrument	Validity period	TFA/SA	Description	Reference

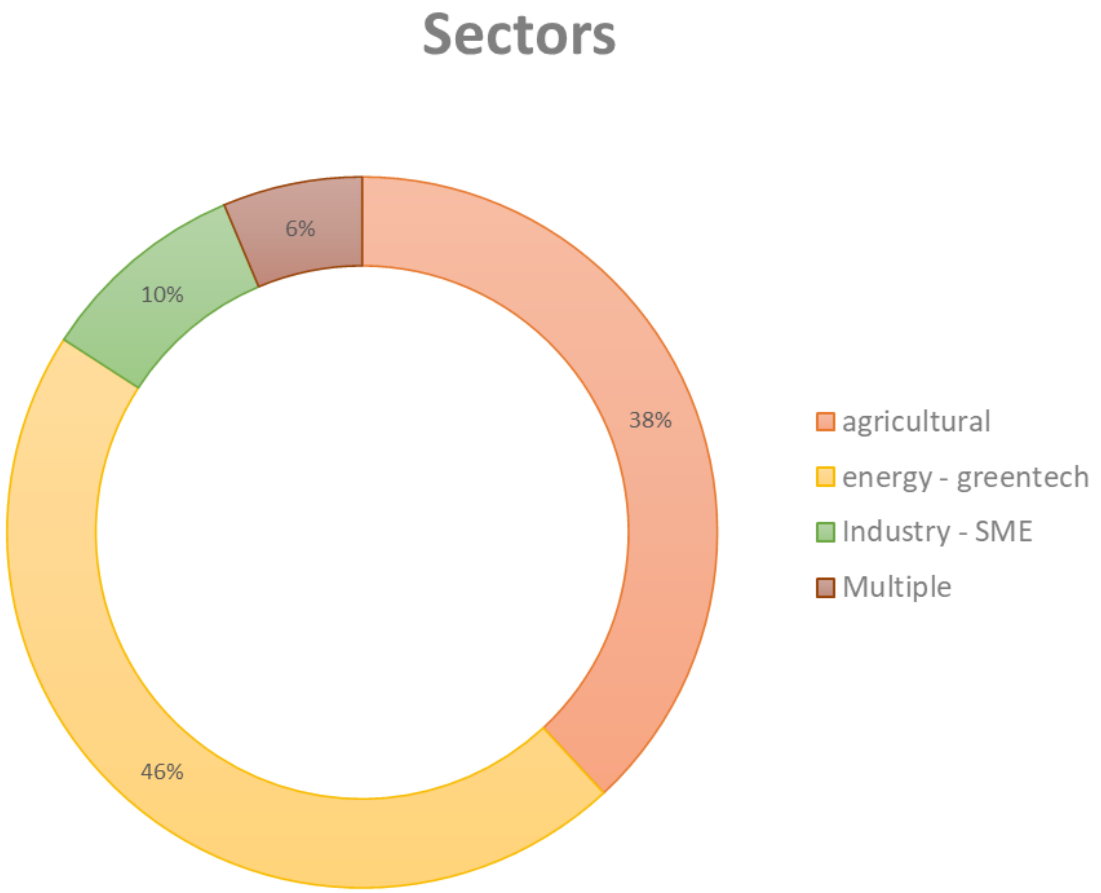
Funding programs are summarized in tables with the following structure:

- **Name of the project/program**: the official title of the funding mechanism.
- **Main sector**: the organization or authority responsible for managing and emitting the fund.
- **Financial instrument**: the financial instrument used in the mechanism, such as grants, loans, or co-financing rates.
- **Validity period**: the timeline during which the funding mechanism is available. Value as *Ongoing* means that there is no validity period indicated for those financial mechanisms.
- **Total Funding Amount (TFA) / Subsidize Amount and Other info (SA)**: the total allocated budget or the financial aid provided to beneficiaries and information about it if available. Value as *N/A* means that the value is not provided, whereas values as *Variable* means that the amount depends on the request or the project.
- **Description**: a brief explanation of the funding's organizations and objectives.
- **Link**: a reference link for further information.

D3.2: financial mechanism catalogue 2/4

Financial mechanism catalogue dedicated to specific sector

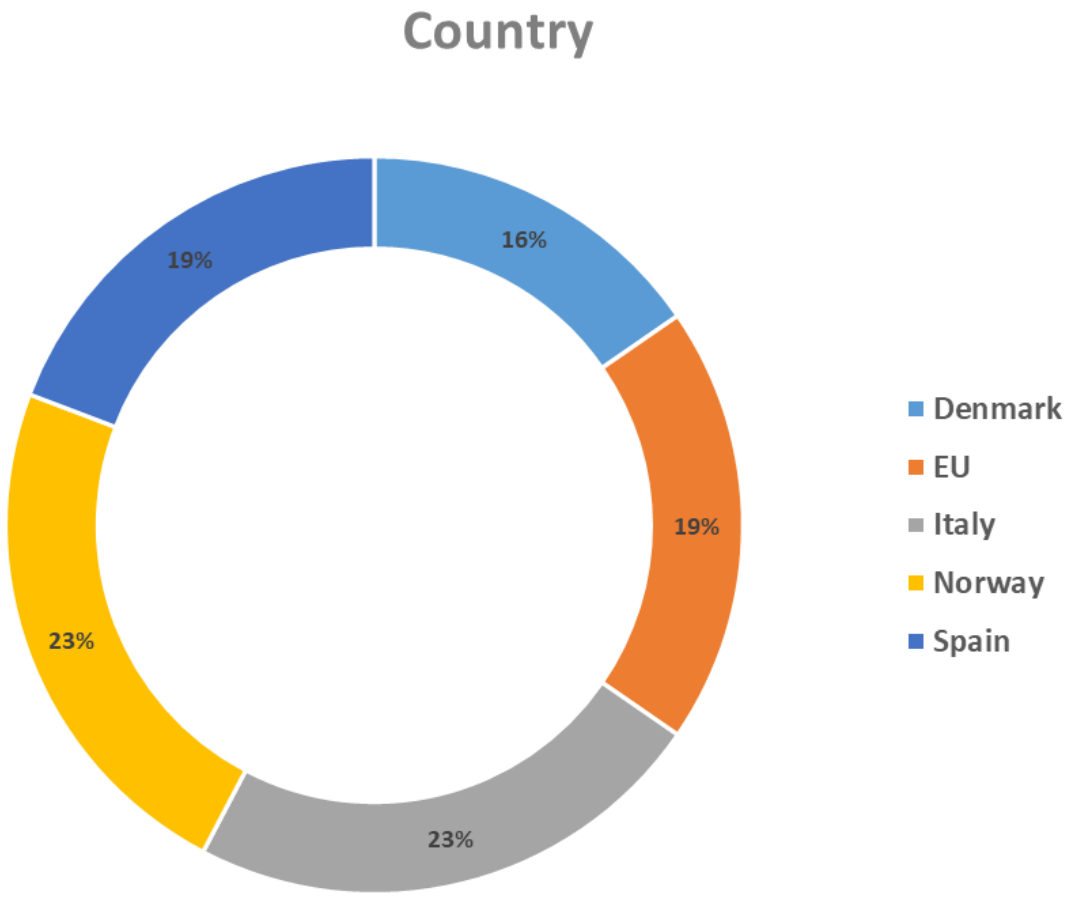
- Total of 78 financial instruments
- Divided by UC country and an additional 5th category for multi country FM
- A separete section of the catalogue has been dedicated to Crowdfunding, crowdlending and other non-conventional financial mechanism.



D3.2: financial mechanism catalogue 3/4

Financial mechanism catalogue per country

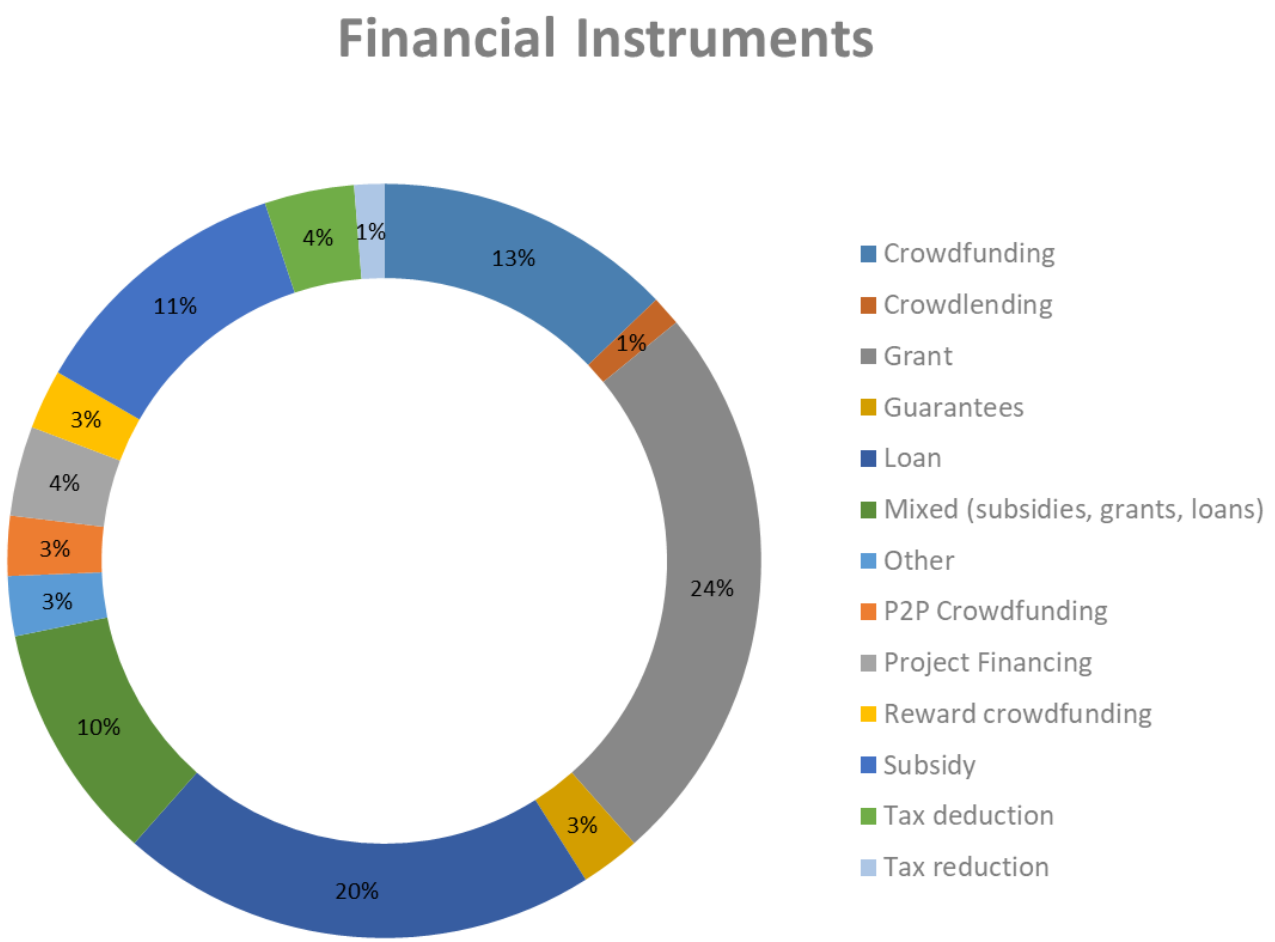
- Total of 78 financial instruments
- Divided by UC country and an additional 5th category for multi country FM
- A separete section of the catalogue has been dedicated to Crowdfunding, crowdlending and other non-conventional financial mechanism.



D3.2: financial mechanism catalogue 4/4

Financial mechanism catalogue per different type of financial instrument

- Total of 78 financial instruments
- Divided by UC country and an additional 5th category for multi country FM
- A separete section of the catalogue has been dedicated to Crowdfunding, crowdlending and other non-conventional financial mechanism.



D3.2: Risk analysis 1/2

Risks are assessed across 4 domains i.e., financial, operational, market, and regulatory,

Each risk is scored according to the likelihood of materialisation: low, medium, or high.

Table 5. Summary of the risks assessment

Mechanism	Supply (S) & Demand (D)		Financial	Operation	Market	Regulatory
Corporate premiums	From private to farmers	S	Low	Medium	High	-
		D	Low	Medium	High	-
Feed-in tariffs	From public to SMEs	S	Medium	Medium	Low	High
		D	High	Medium	Low	High
Tax credits	From public to SMEs	S	Medium	Low	Medium	High
		D	Medium	Low	Medium	High
R&D grants	From public to SMEs	S	Medium	Medium	Medium	-
		D	-	Medium	Medium	-
Co-financing grants	From public to farmers & private to farmers	S	Low	-	-	Medium
		D	Low	Medium	High	Medium
Co-financing loans	From public to start-ups	S	High	Medium	Low	Medium
		D	High	-	Low	Medium
Concessional loans	From private to SMEs	S	Low	High	Medium	
		D	Low	-	-	-

D3.2: Risk analysis 2/2

For each type of financing mechanism, risks are characterised and assessed in a structured risk matrix built around four dimensions: i) risk domain, ii) risk category, iii) risk score and iv) risk description.

Table 5. Summary of the risks assessment

Mechanism	Supply (S) & Demand (D)		Financial	Operation	Market	Regulatory
Sustainable-linked loans	From private to SMEs	S	Medium	High	High	Low
		D	Medium	High	-	Low
Green loans	From private to SMEs	S	Medium	High	High	Medium
		D	Medium	High	-	Medium
Commercial loans	From private to farmers	S	Medium	High	High	-
		D	Medium	-	High	-
Loan guarantees	From public to financial institutions to farmers	S	Medium	Low	-	Low
		D	-	Low	-	Low
Equity	From public to start-ups	S	Medium	High	High	Medium
		D	Medium	-	High	Medium

D3.2: gap analysis

Gap analysis focuses on gap market per RES technologies

RES Segment	Tech Readiness	Investment Flow	Business Models	Regulatory Alignment
Solar	High	Strong	Established	Supportive
Biomass	High	Emerging	Scaling Needed	Evolving
Wind	Medium	Low	Weak	Fragmented
Geothermal	Low	Minimal	Early-stage	Nascent
Hydropower	Low	Negligible	Absent	Undeveloped

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D3.2: Recommendations

- Funders designing tailored instruments should ensure their mechanisms are interoperable with complementary financing solutions and that recipients are actively connected to other capital providers in the ecosystem.
- The administrative burden risk can be issued through digital tools, as well as technical assistance structures that aggregate beneficiaries and spread operational costs, thereby creating economies of scale. Market distortion is another notable risk, especially associated with concessional instruments.
- To avoid undermining long-term commercial viability, it is essential that these mechanisms are designed to phase out over time and target recipients with clear market traction and credible business models for RES integration.
- Avoiding grant and concessional capital dependency will help ensure that funded interventions remain sustainable beyond the life of the support.
- Financing schemes should be designed with multi-year time horizons. In parallel, risk mitigation tools such as insurance or guarantee mechanisms should be embedded from the outset to protect beneficiaries against abrupt regulatory changes that could affect project viability.

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Business models examples

Practical exemple of two business model in the agri-food sector

HarvRESt
Greener Farming with RES

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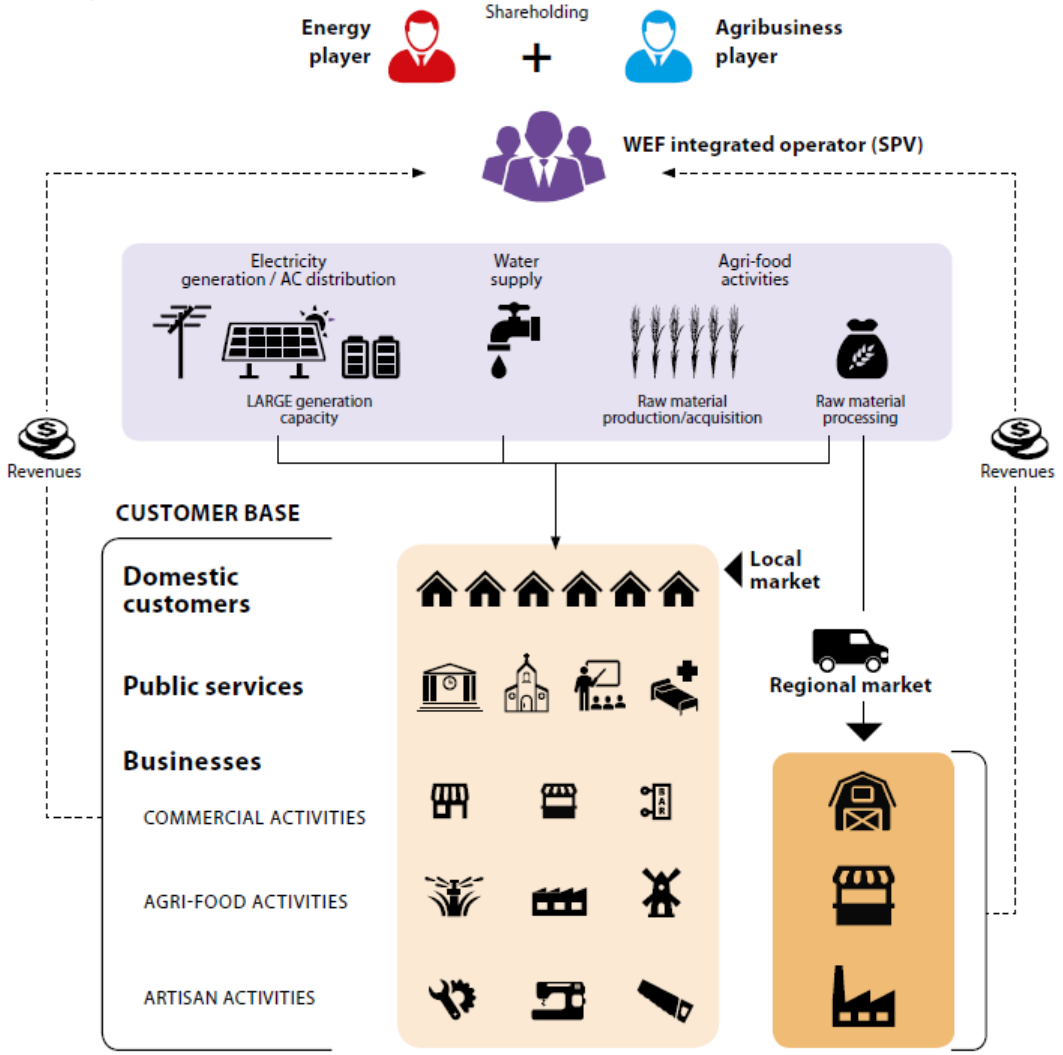
the European Union

www.harvrest.eu

Business Model A:
Energy & agri-food asset jointly owned and operated

A Special Purpose Vehicle (SPV) is created between a private energy player and an agribusiness entity, that could be either a private company or a community-based organization, as shareholding company.



Source: RE-thinking Access to Energy Business Models Ways to Walk the Water-Energy-Food Nexus Talk in Sub-Saharan Africa. RES4Africa publication, EnGreen Overall Editor and co-author.

Business Model A:
Overview

- **The SPV operates with a Water Energy Food nexus integrated business** that relies on a large generation capacity to provide electricity and water to the local customer base of connected users, and to power its own agri-food production and processing facilities.

- In this scenario, **the agribusiness shareholder contributes with the know-how needed to acquire or produce raw materials** as well as process and retail agri-food products.

- The BMA foresees to sell products **not only to the local market but also to the regional and national ones** allows the SPV to enlarge the market segment by sector and geographic scope.

- **Investing through this model expects to gain relevant profit share from the agri-food business**, as well as high development impact at the local level.

Business Model A:
Real example

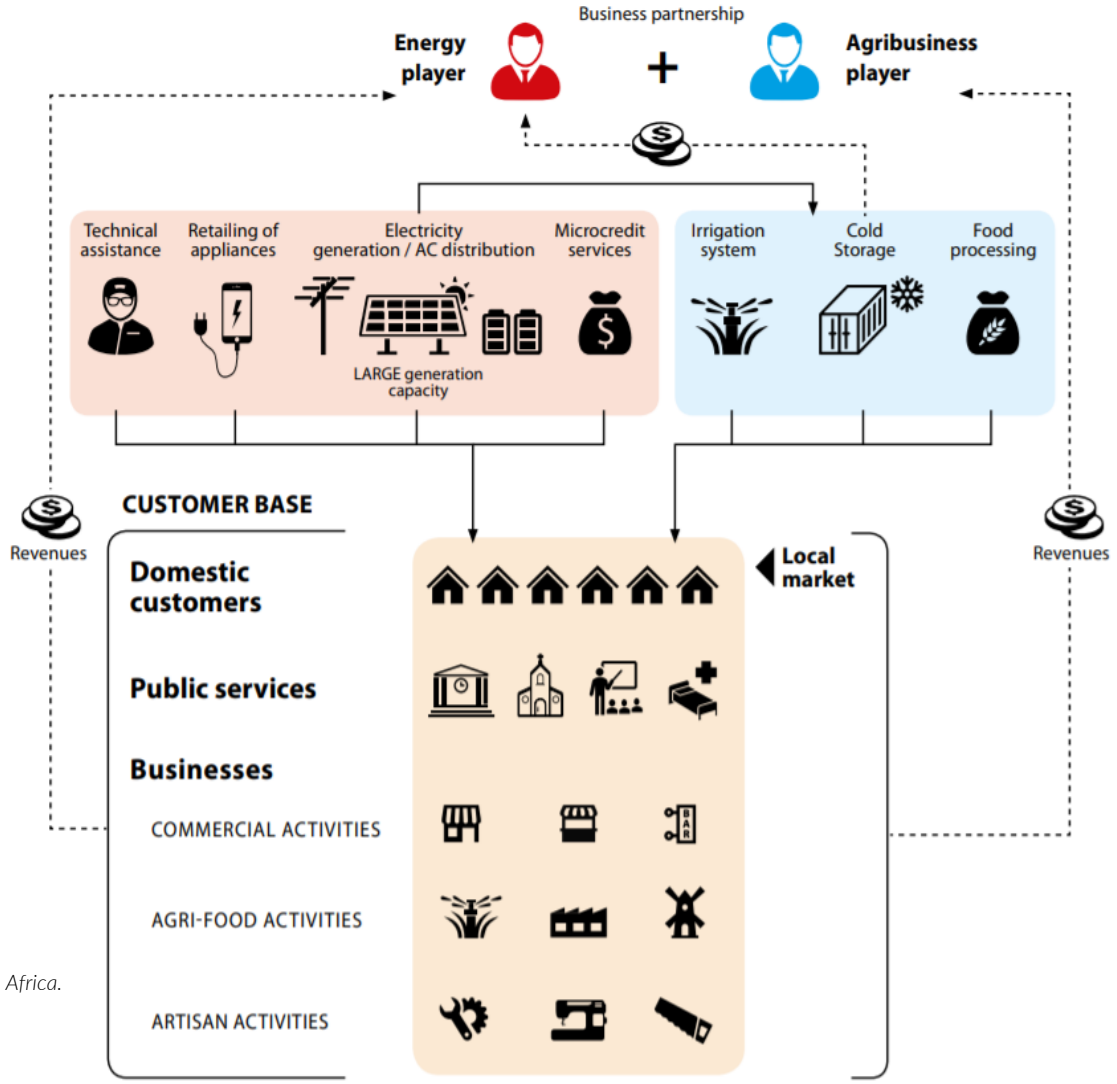
Denmark E.ON & Sønderjysk Biogas

- This SPV is a 50:50 joint venture between E.ON Denmark A/S (private energy major) and Sønderjysk Biogas Invest A/S (SBI), a cooperative of ~70 local farmers.
- The plant (EUR 33M capex) processes ~540,000 tonnes/year of livestock manure, straw and farm residues into biomethane for injection into the gas grid.
- The farmers' association (SBI) supplies feedstock from its members' farms, while E.ON provides financing and technical expertise.
- This structure aligns interests: the cooperative ensures a steady biomass supply (over 75% of the manure comes from nearby farms) and E.ON handles plant construction and operation.
- The SPV's purpose is strictly to develop and operate the biomethane facility; it isolates project risks from the parents, following a classic SPV model.

https://bioenergyinternational.com

Business Model B:
Energy & Agri-food asset owned & operated independently

Two private entities operate an agro-energy business in partnership, without creating a joint Special Purpose Vehicle, and maintaining the energy asset separated from the agri-asset in a hybrid ownership model.



Source: RE-thinking Access to Energy Business Models Ways to Walk the Water-Energy-Food Nexus Talk in Sub-Saharan Africa. RES4Africa publication, EnGreen Overall Editor and co-author.

Business Model B:
Overview

- **The Energy-Player operates the electricity supply**, along with other energy-related services (retailing of small electrical appliances, microcredit services, and clean cooking, technical assistance) thanks to a skilled technical team.
- **The Agri-Player provides powered agricultural facilities to local farmers** which has entered a trade agreement.
- **The two partners operate interlinked businesses** since the mini-grid operator supplies electricity through a private agreement to the agri-assets, which offer services to a common customer base (local farmers). For avoidance of doubt, the mini-grid customer base goes beyond farmers and includes the entire local community.
- **This model allows the sharing of investment risks** between two players as well as mutual benefits of specialized expertise. The strength of this business model is that allows players to operate in their core business only.
- **Suitable financing sources for BMC**: i) Commercial loans ii) Equity (

Business Model B:
Real example

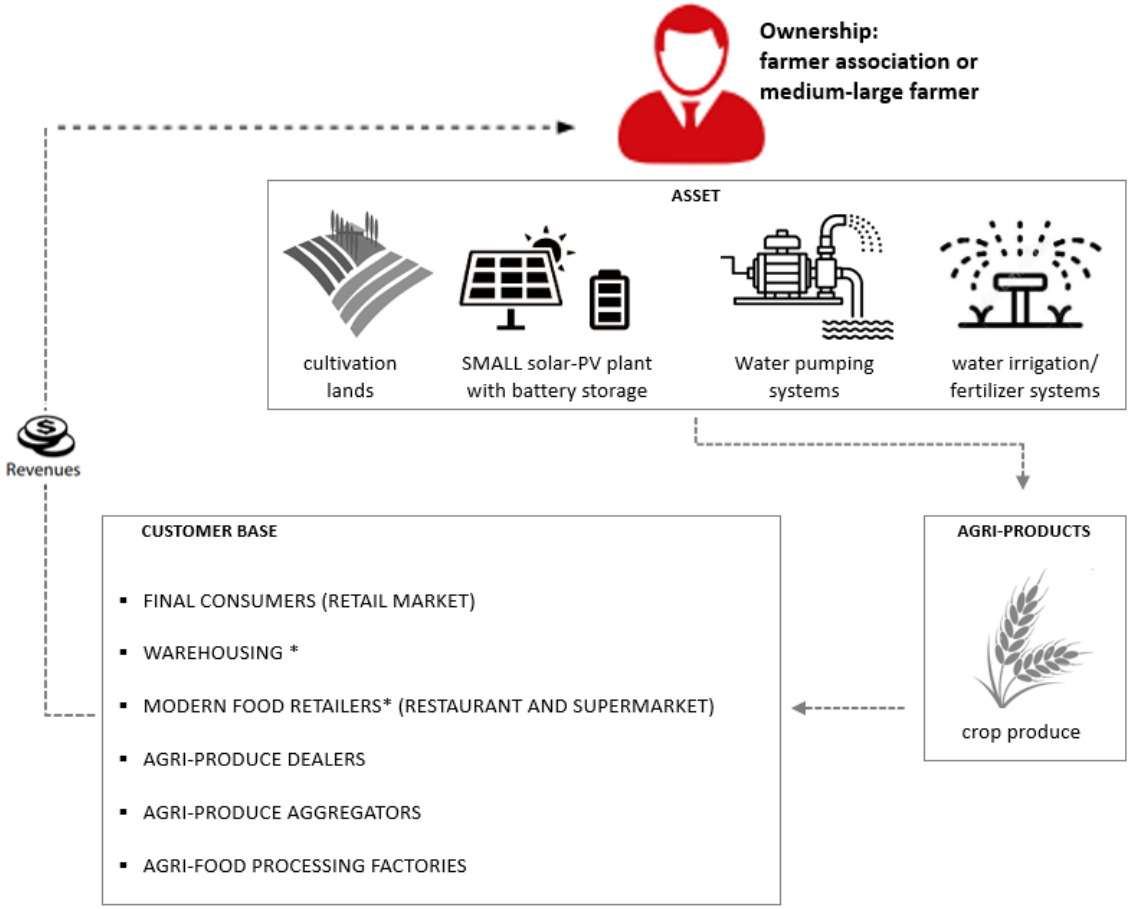
Aggreko Energy Transition Solutions (ETS) partnership with the community initiative called Farmers Powering Communities I

- Located in the United States
- Aggreko ETS provides capital and development expertise, owning and operating the solar community assets.
- The agrarian groups, including farmland preservation organizations, maintain their agricultural operations.
- The partnership enables co-benefits of energy production and farmland stewardship without merging assets into a joint venture or SPV.
- Each party retains distinct ownership but partners strategically.

https://aggreko.com

Business Model C:
Precision irrigation

An Agri-player invests in the PV plant, that is installed in its own cultivate lands to (i) power efficient irrigation systems and (ii) enter into the energy market. It is the sole owner of both land and technical asset (PV and agri-related asset) and it operates and maintains the technological asset thanks to the support of external technical assistance.



* only in case of large farms

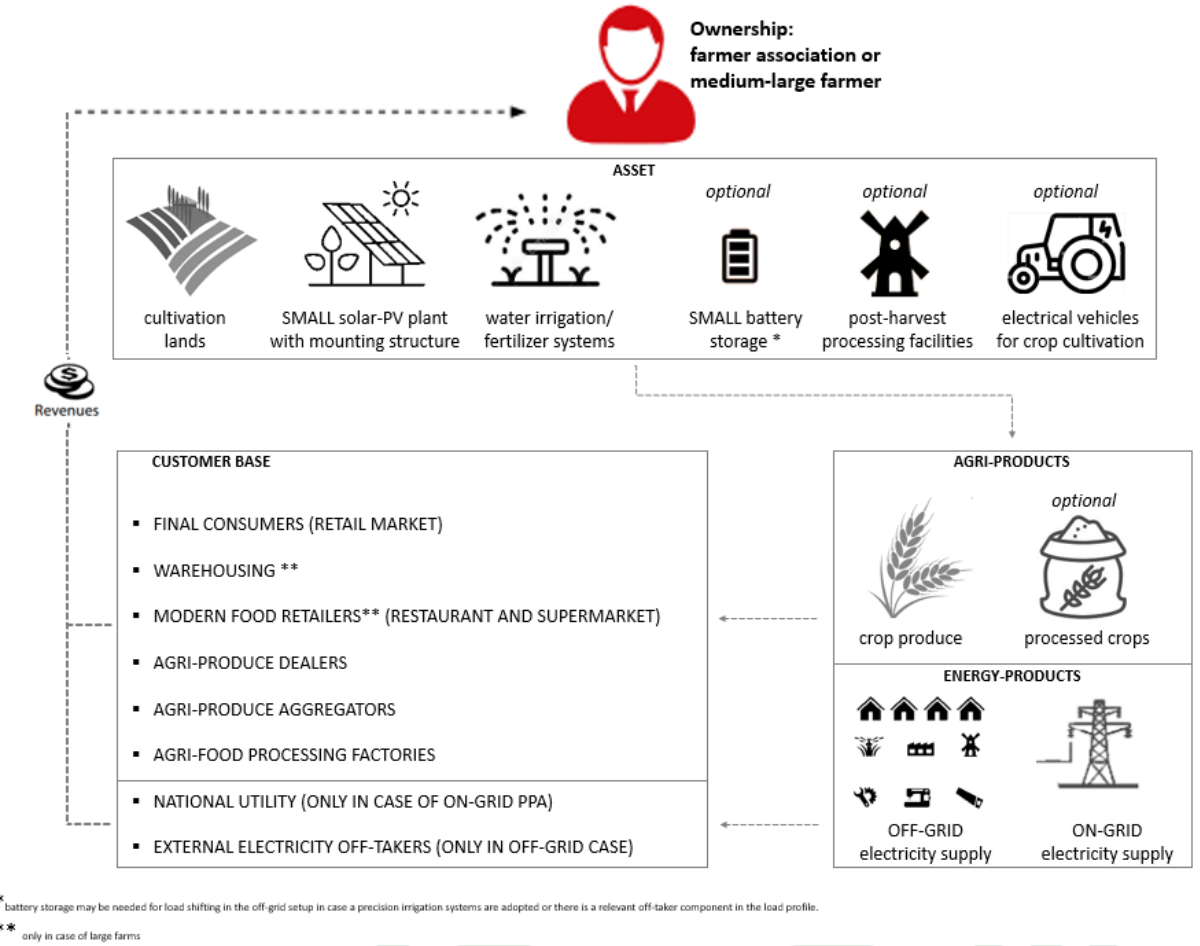
Decoppet, J-B., Guzzo, D., Traini, L., Gambino,V., Roncallo, F., Bagnara, G.L. (2023). Designing innovative solutions for the Water, Energy and Food Nexus. A comprehensive review of business models for the WEF Nexus. *Res4Africa Foundation.*

Business Model C:
Overview

- **BMC promotes a highly efficient PV-powered irrigation technology**, that allows to optimize resources and generate higher economic and production benefits.
- Depending on the nature of BM actors**, it directly and positively impacts on rural farmers**
- A set of services and asset are needed to assure a proper operation of precision irrigation systems. **The BM C' value proposition foresees an all-inclusive management carried out by the owner.**
- Depending on the owner's nature**, O&M could be an outsourced specialized service**. Such choice will be reflected in an appropriate management and governance model and thus will affects the BM sustainability.
- **This model is very replicable and scalable**, being available for different sizes of cultivated lands
- **Suitable financing sources for BMC**: (i) grant financing, (ii) microfinancing in case of farmer association, (iii) commercial loan in case of medium-large farmer and (iv) junior debt

Business Model D:
Farm owned PV plant

An Agri-player invests in the PV plant, that is installed in its own cultivate lands to (i) power efficient irrigation systems and (ii) enter into the energy market (on-grid or off-grid). It is the sole owner of both land and technical asset (PV and agri-related asset) and it operates and maintains the technological asset thanks to the support of external technical assistance.



Decoppet, J-B., Guzzo, D., Traini, L., Gambino,V., Roncallo, F., Bagnara, G.L. (2023). Designing innovative solutions for the Water, Energy and Food Nexus. A comprehensive review of business models for the WEF Nexus. *Res4Africa Foundation.*

Business Model D:
Overview

- BMD aims to: (i) enable farmers to access to the energy market and mitigate seasonality of agriculture activities (ii) to provide shading for horticulture with positive effects on agriculture production and water saving.

- **BMD approach generates higher revenues streams than sole farming** (sales of crop produce and sales of energy)

- This BM is suitable for both on-grid and off-grid contexts

- **This model is very replicable and scalable**, being available for different sizes of cultivated lands

- **Suitable financing sources for BMC**: (i) grant financing, (ii) microfinancing in case of farmer association, (iii) commercial loan in case of medium-large farmer and (iv) junior debt

Business Model C/D:
Real example

Comunidad de Regantes del Valle Inferior del Guadalquivir (Sevilla)

- This irrigation community (~2,300 farmers over ~19,000 ha) invested in a 6 MWp ground-mounted PV plant (17,880 panels with single-axis trackers) on its own lands.
- The PV array powers nine pumping stations for irrigation.
- In 2022 it produced ~10.8 GWh: about 3.5 GWh were used on-site (autoconsumed for pumping) and ~7.3 GWh were fed back to the grid. Thus the community (sole owner of the land and solar equipment) covers roughly 57% of its energy needs from solar and sells the surplus into the market.
- The project was planned and built with professional support (engineering firm, certification by ECOQuality, etc.), and the community operates it with external technical assistance.

https://www.energias-renovables.com

Recommended literature

- *Alexander Osterwalder, Yves Pigneur. Business Model Generation: A handbook for visionaries, game changers and challengers. John Wiley and Sons, Inc., Hoboken, New Jersey (2010)*
- *Manuel Au-Yong Oliveira, João José Pinto Ferreira. Book Review. Business Model Generation: A handbook for visionaries, game changers and challengers. African Journal of Business Management Vol.5 (7), 4 April,*
- *Maria Partalidou & Aikaterini Paltaki & Dimitra Lazaridou & Marco Vieri & Stefania Lombardo & Anastasios Michailidis, 2018. "Business model canvas analysis on Greek farms implementing Precision Agriculture," Agricultural Economics Review, Greek Association of Agricultural Economists, vol. 0(Issue 2), January.*
- *Bekhradi, Alexandre & Yannou, Bernard & Cluzel, François. (2016). Importance Of Problem Setting Before Developing A Business Model Canvas*
- *Osterwalder A. et al. Value Proposition Design: How to Create Products and Services Customers Want. John Wiley and Sons, Inc., Hoboken, New Jersey, 2014.*
- *Wyn Morris and Robert Bowen, "Renewable Energy Diversification: Considerations for Farm Business Resilience," Journal of Rural Studies 80 (December 1, 2020): 380–90, link*
- *Effective Approaches for Facilitating a Transition to Clean Energy in the Agriculture and Forestry Sectors Using the CAP (European Network for rural development, 2021), link*
- *D2.1 Mapping of RES Integration in Farms at EU Level, link*
- *Financing Renewable Energy Options for Developing Financing Instruments Using Public Funds" (CIF, World Bank, 2016), link*
- *Fi-compass, "Financial Needs in the Agriculture and Agri-Food Sectors in the European Union," link*
- *Renewable Energy for Agri-Food Systems (IRENA, 2021), link*

Discussion inputs

Let’s try together to:

Share our business’ characteristic, do anyone of us has ever designed its BMC?

Share our preferred financial sourcing mechanisms, which type of financing source we used or we are currently using?

Share any impression and thoughts about risks encountered in our professional experience related to the financing source of our business?

Identify which aspects of the financial planning may hide pitfalls.

Capacity Building Material

Module: Stakeholder Engagement & Market Research for RES Integration

White Research

HarvRESt
Greener Farming with RES

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www.harvrest.eu

Table of Contents

- Module Objectives & Introduction
- Why multi-actor engagement & market research matter
- Steps to develop a stakeholder engagement strategy
- Stakeholder Matrix: Influence & Impact
- Stakeholder engagement in the HarvRESt pilots
- Strategies to avoid stakeholder fatigue
- Ethical & inclusive engagement principles
- Stakeholder engagement tools
- Market Research: primary & secondary
- Insights from HarvRESt project results
- Conclusions & key takeaways

Main module objectives

This module provides **practical guidance on how to better understand, engage, and collaborate with local stakeholders and markets** in the context of renewable energy adoption in agriculture.

It supports **local stakeholders, farmers, cooperatives, local energy actors, and rural development practitioners**, in designing more inclusive, informed, and effective strategies for stakeholder engagement and market understanding.

Main module objectives

This module aims boosting rural stakeholders':

- Understanding of the importance of stakeholder engagement and market research for accelerating the uptake of RES in their local agricultural contexts
- Learn how to identify key actors, map their roles, and build trust-based relationships that support joint decision making and long-term collaboration
- Discover how these methods are being applied in HarvRESt use cases to develop locally grounded awareness campaigns and business strategies for RES
- Build local capacity ands trengthen their ability to shape energy transitions in ways that reflect the values, needs, and realities of their own communities.

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Why multi-actor engagement & research matter

- Stakeholders shape adoption.
- Market insights guide investments.
- Both enable co-creation.

HarvRESt promotes a multi-actor approach that emphasises trust-building, transparency, iterative engagement, and inclusivity. It encourages adapting language and tools to the local context, using existing networks to amplify reach, and maintaining a continuous feedback loop so that stakeholders feel heard and supported. This co-creative method helps align diverse interests and accelerates adoption of RES solutions.

Stakeholder engagement

Engaging with those who influence or are affected by a project. Key for legitimacy, co-creation, and adoption of RES.

Steps to develop a stakeholder engagement strategy

Step 1: Foundations (objectives, mapping, analysis)

Step 2: Designing & Tailoring (formats, timing, roles)

Step 3:Monitoring & Adaptation (feedback, adjusting strategy)

Steps to develop a stakeholder engagement strategy

Step 1: Foundations - define clear objectives, map & analyse stakeholders

- **Identify** what you want to achieve (e.g., awareness-raising, co-creation of solutions, policy alignment, market readiness)
- **Decide** why stakeholders are being engaged: to inform, consult, involve, or empower
- **Tailor** objectives to each stakeholder group's needs (e.g., technical clarity for farmers vs. policy alignment for authorities)
- **Analyse** stakeholders, **understand** motivations, concerns, knowledge gaps, and potential contributions.

Stakeholder Matrix: Influence & Impact

Step 1: Foundations - define clear objectives, map & analyse stakeholders

Map stakeholders by:

- Influence: Resources & ability to affect RES projects
- Impact: Degree to which stakeholders are affected by RES)

→ Use matrix to prioritise and tailor engagement.

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Steps to develop a stakeholder engagement strategy

Step 2: Designing and tailoring the engagement process

- **Tailor engagement activities:** Match methods to stakeholders (e.g., one-on-one meetings for high influence, open workshops for broader input).
- **Define timeline & roles:** Clarify when stakeholders are involved, at what intensity, and who manages the relationship.
- **Plan feedback & adaptation:** Build in mechanisms for feedback, iteration, and co-evaluation of the engagement process.

Reassess positioning regularly, stakeholders may shift due to project developments or external events.

Stakeholder Engagement Examples -1-

Farmer Field Days:
Organise regular, on-site events at pilot farms demonstrating working agrivoltaic systems, including practical Q&A sessions to address farmer concerns on crop compatibility.

Policy roundtables:
Host targeted dialogues between local policymakers, farmers, and renewable energy investors to collaboratively simplify permitting processes and enhance local incentives.

Technology demo events:
Conduct live demonstrations of solar-powered equipment (e.g., electric tractors, robotic harvesters), allowing vineyard owners to test and discuss usability directly with technology providers.

Local champions & peer testimonials:
Engage influential local vineyard owners or cooperative leaders as visible RES champions, sharing personal success stories through video testimonials and social media campaigns.

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Stakeholder Engagement Examples -2-

Collaborative GIS workshops:
Organise participatory workshops where municipal planners and farmers jointly classify land parcels and identify optimal locations for biogas plants, using interactive GIS mapping tools.

Advisory service sessions:
Set up advisory sessions where farmers receive tailored, farm-specific energy integration advice from dedicated renewable energy consultants.

Storytelling & media engagement:
Publish farmer-led stories and case studies showcasing pilot farms' successful renewable energy integration in local newspapers, social media, and agricultural magazines.

Cross-sector workshops:
Facilitate regular workshops bringing together farmers, energy SMEs, agricultural cooperatives, and local policymakers to collaboratively address technical, financial, and regulatory barriers.

Stakeholder Engagement Tools -1-

Several online tools and resources can support stakeholder mapping, analysis, and engagement planning for RES integration:

- ✓ **Stakeholder Map** (stakeholdermap.com) - Offers free templates and examples for mapping influence and interest.
- ✓ **Net-Map Toolbox -** A participatory interview tool that helps visualize influence networks in decision-making.
- ✓ **Power/Interest Grid Templates** (Lucidchart, Miro, Canva) - Online tools to create custom influence-impact grids.
- ✓ **Engage2020 Action Catalogue -** EU-funded database of public engagement methods (https://actioncatalogue.eu).
- ✓ **Stakeholder Analysis Tools by FAO & GIZ -** Practical guides tailored for agriculture and rural development contexts.
- ✓ **Participedia.net -** Global repository of case studies and tools for participatory governance and stakeholder involvement.

Encourage users to choose tools based on digital literacy, language options, and visual accessibility.

Stakeholder Engagement Tools -2-

Several online tools can support stakeholder mapping, communication, and engagement planning:

- ✓ **Stakeholder Mapping Tool** (MindTools) - A free online tool that allows you to map stakeholders by influence and interest: mindtools.com.
- ✓ **Kumu** - A visualisation tool to create stakeholder maps, network diagrams, and dynamic relationship tracking: kumu.io.
- ✓ **Stakeholder Circle -** Designed to help visualise and prioritise stakeholders based on influence, support, and proximity: stakeholdermap.com.
- ✓ **MURAL/Miro -** Digital whiteboards useful for collaborative mapping, workshop co-creation, and idea sorting.
- ✓ **Slido or Mentimeter -** Useful during engagement events for live polling, Q&A, and feedback gathering.

Use these tools to support transparent, inclusive and data-driven engagement processes tailored to local needs.

Steps to develop a stakeholder engagement strategy

Step 3: Monitoring the engagement process

- **Monitoring** ensures your engagement remains effective and trusted.
- **Track** participation, feedback, and stakeholder satisfaction through attendance records, quick surveys, or informal pulse checks.
- Use this information to **adjust activities, refine messages**, and show stakeholders their input is valued and used.
- **Continuous monitoring** helps build trust, improve relevance, and sustain long-term engagement.

Why monitor and evaluate engagement?

Monitoring and evaluating your engagement strategy is essential to ensure it remains effective, relevant, and trusted by stakeholders.

It helps you understand whether objectives are being met, identify gaps, and demonstrate responsiveness.

Regular evaluation builds credibility, improves relationships, and supports long-term adoption of RES solutions.

How to monitor and evaluate engagement

Track progress through:

- Engagement metrics (e.g., event attendance, survey response rates)
- Stakeholder feedback (short forms, interviews, focus groups)
- Changes in attitudes, knowledge, or behaviour

Adapt and refine:

- Use feedback to adjust formats, timing, or content
- Share findings back with stakeholders to reinforce trust

Adjust strategy based on feedback and results.

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Example of a tracking template

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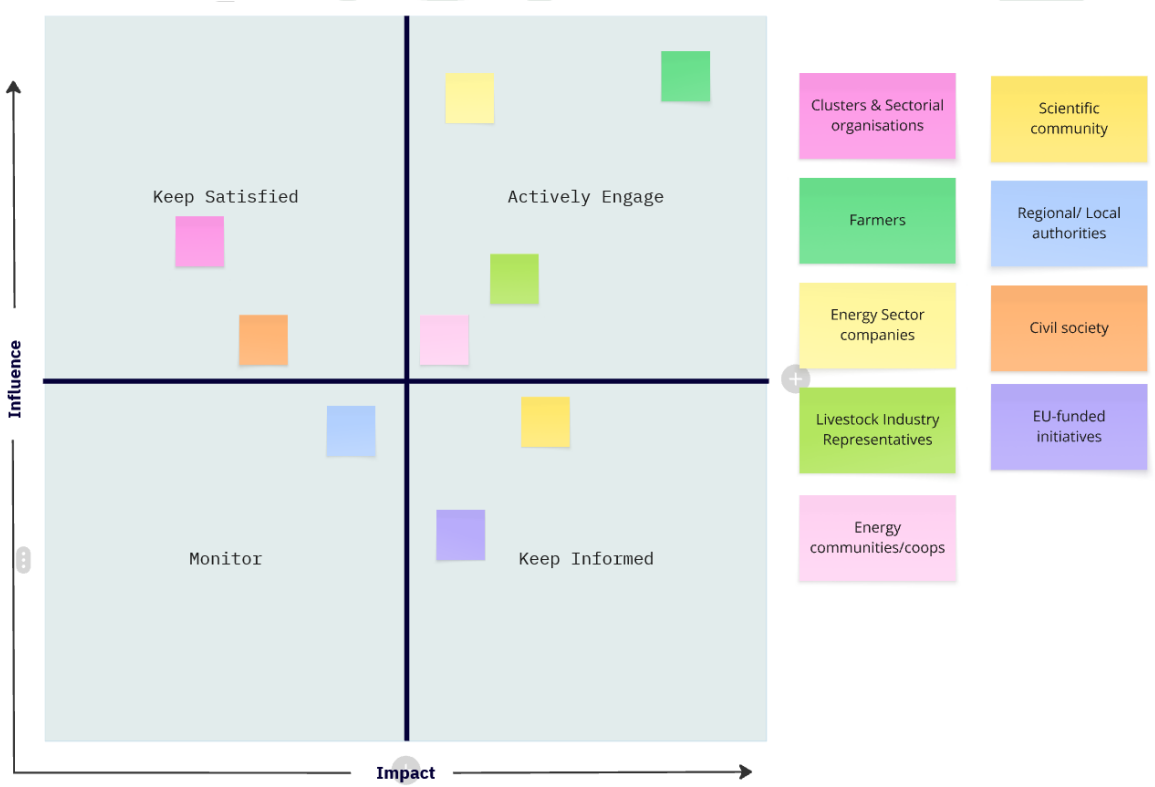
The form below has been designed to help us keep track of any kind of awareness activities of your Use Case (incl. meetings, workshops, interviews, informal discussions, seminars, etc.). The output from each AR activity is of key importance for feeding into D3.5 .

Important: Specify the type of activity as well as the type of the audience(s) addressed using the categories provided in the drop-down menu.

No. of Action	Date of activity	Location (remote/physical)	Type of activity (drop-down menu)	Channels (e.g., Social Media, Traditional Media, On-site Event etc.,)	Type of audience (in case the action reached more than one type of stakeholders please describe this type in the line below. Use as many lines as necessary)	Size of audience per type of stakeholder group (no. of persons per stakeholder group)	Gender of audience			Total number of participants	Role and description of your organisation's involvement (e.g. presenter, facilitator, interviewer, speaker, discussant, author, participant, etc.)	Key messages	Additional resources (links to presentation slides, photographs, links to events recordings etc.,)	Materials required (e.g., visual identity, flyers, posters, social media banners)	Other comments (IF RELEVANT)	Significant contacts made IF RELEVANT (name, position, organisation; if consent to store and share data was given, add also address, tel, fax, e-mail)
							Male	Female	Other							
1	Example 15/01/2023	Brussels, Belgium	Organisation of a conference		Energy Industries	5	3	2		60	Presenter; Powerpoint presentation of the HarvRESt project	e.g., environmental benefits of using RES at farm level			The participation in the event was sussessful since the project was introduced to important stakeholders.	1. Contact No. 1 2. Contact No2
					Farmers	20	8	12								
					Financial institutions & individual investors	30	21	9								
					Civil society	3	3	0								
					Farmer groups and associations, agricultural cooperatives	2	0	2								

HarvRESt Stakeholders

- Industry (RES firms, agro-entrepreneurs)
- Agri-sector (farmers, cooperatives)
- Academia & R&D
- Civil Society (NGOs, RESCoops)
- Policymakers (EU, national, local)



Example: Tailoring Strategy to Farmers vs Policymakers

Farmers:

- Preferred methods: Peer exchanges, demo visits, trusted cooperative intermediaries
- Messages: Practical benefits, simplicity, cost-effectiveness
- Timing: Early (co-design) + ongoing (co-learning)

Policymakers:

- Preferred methods: Roundtables, policy briefs, technical dossiers
- Messages: Alignment with national/EU targets, social/economic co-benefits
- Timing: At planning and regulatory decision points

Warm-up events & early engagement

- Early-stage engagements:
  - Raise awareness and identify concerns
  - Build initial relationships and trust
  - Refine project objectives based on early feedback

HarvRESt UC Example: Italy

In Italy, the FSDC Use Case focuses on **integrating agrivoltaics and exploring carbon credit markets.**

Stakeholders include farmers, renewable investors, agri-businesses, and tech providers.

Engagement strategies include promoting the economic co-benefits of RES (e.g. dual land use), hosting partnerships with universities, and showcasing return-on-investment models to attract interest from policy actors and potential adopters.

HarvRESt UC Example: Spain (VdV-VRT)

The Spanish VdV Use Case works with **vineyard owners to integrate photovoltaic technologies**.

Stakeholders range from cooperatives and RESCoops to regional policymakers. Feedback is collected through co-design sessions and policy dialogues to fine-tune business cases.

Engagement tools include site visits and awareness campaigns on how solar can enhance sustainability and economic resilience.

HarvRESt UC Example: Spain (ACSA-Sorigué)

In the ACSA-Sorigué UC, the project addresses **biogas production using agricultural waste and manure**.

Key stakeholders include livestock farmers, waste management companies, local municipalities, and bioenergy technology providers.

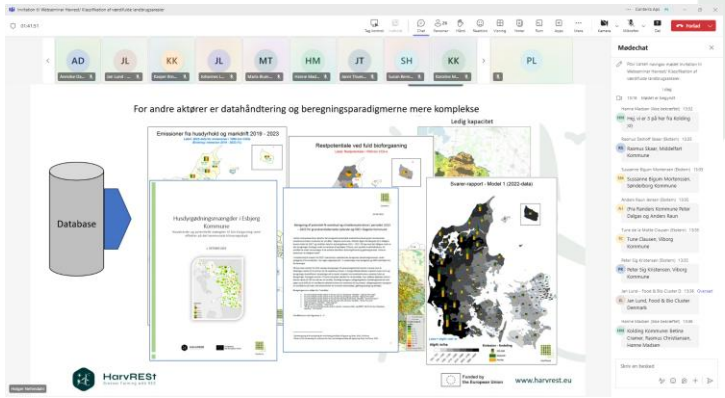
Engagement relies on local champions and pilot site visits to build trust, reinforce circular economy benefits, and highlight how biogas can align with broader EU climate goals.

HarvRESt UC Example: Denmark

Denmark's UC focuses on **biogas integration via energy advisory services and agriculture-energy partnerships**.

Key stakeholders involve farmers, municipal authorities, biogas operators, and land-use planners.

The approach involves recurring engagement rounds, policy and planning workshops, and interactive events that link local concerns with national energy strategies. Farmer participation is encouraged through co-creation of farm-specific RES integration scenarios.



HarvRESt UC Example: Norway

The Norwegian UC in Røysland Gaard focuses on **decentralised renewable energy solutions that strengthen farm-level sustainability and resilience**.

Key stakeholders include local farmers, agricultural cooperatives, energy consultants, SMEs, and regional policymakers.

Engagement relies on practical on-farm demonstrations, storytelling through peer testimonials, and cross-sector workshops to foster collaboration and policy dialogue. Media visibility of pilot successes further enhances public awareness. Early results show increased stakeholder interest and trust, with simplified permitting and tangible examples proving crucial to building engagement momentum.

Challenges in stakeholder engagement

Conflicting Interests: Stakeholders may have divergent economic, environmental, or social priorities

Communication Barriers: Language, technical jargon, or cultural differences can hinder understanding

Low Trust or Resistance: Historical scepticism towards new technologies or external actors

Limited Time & Resources: Farmers and rural actors often have limited availability and capacity to participate

Regulatory Complexity: Overlapping or unclear policies may confuse stakeholders and slow decision-making

Strategies to avoid fatigue of agri-stakeholders

Plan around the farming calendar: schedule engagement activities outside peak periods (e.g., planting, harvesting, pruning seasons) and provide advance notice so stakeholders can prepare.

Be targeted & efficient: only involve those essential to the topic. Use group sessions or representative structures to gather input without overburdening individuals.

Clarify purpose & value up front: before reaching out, explain what decisions are happening, how stakeholder input will be used, and what benefits participants will gain.

Strategies to avoid fatigue of agri-stakeholders

Diverse engagement formats: rotate between short surveys, field visits, advisory meetings, and digital polls. This variety helps reduce repetition and engagement fatigue.

Close the feedback loop: always follow up by reporting on how stakeholder contributions were used and any resulting project changes. This motivates continued participation.

Coordinate across initiatives: align and de-conflict consultation efforts within cooperatives or regional groups. Avoid multiple overlapping calls for input.

Ethical considerations in engagement

- **Inclusiveness & Fairness**: Engage all relevant groups, ideally including minorities, women, and youth, ensuring all voices are heard. Tailor engagement times, venues, and methods for accessibility
- **Transparency**: Clearly communicate project goals, risks, and expected outcomes
- **Informed Consent**: Ensure participants understand what their input will be used for (GDPR compliance if personal data collected)
- **Respect for local context**: Adapt engagement formats and messages to local culture, literacy levels, and traditions
- **Reciprocity**: Share results back with stakeholders and acknowledge their contributions

Addressing ethical challenges

- Design neutral, inclusive invitations and avoid biased framing
- Use trusted local intermediaries (e.g., cooperatives or farmer associations)
- Provide feedback sessions where stakeholders see how their input influenced outcomes
- Maintain clear records of consent and participation

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Market Research

To align RES solutions with real needs. Enables:

- Understanding demand
- Addressing risks
- Designing strategy

Types of Market Research

- **Primary**: surveys, interviews, co-design
- **Secondary**: policy scans, market stats

Primary Research: What it is

Primary research involves collecting new, original data directly from stakeholders.

It includes surveys, interviews, focus groups, observations, and field trials. It helps tailor RES strategies to specific needs, perceptions, and behavioural profiles.

Surveys: Best Practices

- Surveys should be short, clear, and purpose-driven.
- Can be telephone ones (CATI) or web-based ones (CAWI)
- Use a mix of closed and open-ended questions.
- Pre-test with a small group.
- Translate if needed.
- Digital or paper formats depending on access.
- Include a GDPR-compliant consent statement.

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Interviews & focus groups

- Interviews allow deep exploration of motivations, concerns, and trust.
- Focus groups capture collective views and community dynamics.
- Use a topic guide, record with permission, and summarise key takeaways.
- Ideal for validating business models and testing engagement ideas.

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Secondary research: what it is

Secondary research involves analysing existing data and resources created by others. This includes:

- Government reports and statistics
- Academic papers and feasibility studies
- Industry reports and white papers
- Existing market and policy assessments

This helps benchmark RES strategies, understand regional conditions, and identify gaps in knowledge.

Using secondary data for RES planning

Steps to use secondary research effectively:

- Identify credible sources (EU databases, agricultural stats, policy trackers)
- Extract relevant figures (e.g., RES adoption rates, grid capacity)
- Compare across regions or farm types
- Use to complement stakeholder views

Useful sources: Eurostat, FAO, JRC reports, local energy agencies, CAP/RED II guidance

Market research examples -1-

Farmer surveys on agrivoltaic acceptance:
Conduct structured surveys targeting farmers' perceptions and willingness to adopt agrivoltaics, collecting data on perceived economic, environmental, and operational benefits and barriers.

Economic viability studies:
Perform case-specific financial analyses comparing agrivoltaics versus traditional agriculture, clearly presenting return-on-investment (ROI) scenarios to stakeholders.

Consumer preferences & branding:
Run market studies to gauge consumer willingness to pay premiums for wine produced sustainably using renewable energy (solar-powered vineyards), informing marketing strategies for cooperative brands.

Stakeholder interviews:
Conduct qualitative interviews with vineyard managers and cooperative leaders to identify precise incentives and support mechanisms needed for widespread RES adoption.

Market research examples -2-

Municipal land use analysis:
Execute detailed secondary research, including municipal zoning regulations and land-use policies, to identify policy gaps affecting biogas development.

Farmer risk & opportunity assessment:
Conduct farmer-focused research assessing perceived risks and opportunities around biogas integration, using focus groups to validate findings.

Decentralised energy surveys:
Distribute surveys capturing farmer attitudes toward decentralised renewable energy, assessing knowledge gaps, preferred technologies, and desired support mechanisms.

Pilot site evaluations:
Implement structured observational studies and technical evaluations of existing renewable energy installations at demonstration farms to derive best practices for scalability.

Insights from HarvRESt market research studies

Market research across HarvRESt use cases revealed **strong interest in renewable energy solutions but highlighted major barriers** including high initial investment costs, complex regulatory frameworks, and limited technical knowledge among farmers.

Surveys showed that **trust in local cooperatives and peer examples significantly influences willingness to adopt RES**.

Stakeholders prioritise clear financial benefits, **operational simplicity, and visible, successful pilot projects**.

Across regions, there is a **strong preference for hands-on learning opportunities** (e.g., farm visits, demonstrations) and tailored business models that address specific farm needs.

These insights confirm that **combining evidence-based market research with practical,** locally adapted engagement strategies is critical to support widespread RES uptake.

What drives or slows down RES uptake?

Motivators

- Energy independence
- Financial (energy savings, co-investment)
- Social (local employment, education)
- Environmental (ecosystem services, sustainability branding)

Barriers

- High initial costs
- Lack of awareness or technical support
- Bureaucracy and grid issues

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Common Stakeholder Attitudes

- **Farmers**: value simplicity, peer stories
- **Cooperatives**: seek financial clarity
- **Public bodies**: focus on regulation, land use

→ All support visibility & peer learning

Conclusions & key takeaways

- **Stakeholder engagement and market research are complementary tools** essential for successful RES integration at farm level.
- Clearly understanding **stakeholders' motivations, barriers, and needs** helps tailor more effective and sustainable RES solutions.
- **Early, inclusive, and iterative engagement**, combined with practical demonstrations and visible pilot successes, significantly boosts stakeholder trust and adoption rates.
- Effective market research, both primary and secondary, provides **critical insights** for strategic decision-making and targeted stakeholder communication.
- Continuous feedback loops and adaptation of strategies based on stakeholder input are critical to **maintain relevance and build local capacity**.
- HarvRESt promotes ongoing peer learning, co-creation, and accessible resources to facilitate widespread adoption and long-term sustainability of renewable energy solutions.

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