RENEWABLES ENERGY MARKET

MODULE 3

INTELLECTUAL OUTPUT 1
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Intro

The third chapter of this manual deals with Renewables Energy Market. The renewable energy market is booming all over the world. From an environmental point of view, the use of renewable energy makes it possible to decrease (and in the future to abolish) the use of fossil and polluting sources of energy. Over the last decade, however, this sector has also opened up incredible economic opportunities. Green jobs have been on the rise for years, supported by European and global policies. In addition to the Green New Deal, the increased use of renewable energy is also one of the pillars of the Next Generation EU.

Objectives

a. Have a clear idea of the European renewable energy context
b. Have a good knowledge of the market that regulates renewable energy sector
c. Have a good knowledge the different sources of renewable energy
d. Know the funding opportunities and policies
e. Be aware of the European best practices and success stories of this sector

3.1 The EU Context

3.1.1 Geographical and economic context

Renewable energy is the joint name for power generated using renewable resources, like wind, water resources, sun, heat from the planet surface. These renewable resources are converted into energy, the process does not produce greenhouse gases (except for biomass-derived energy, which is considered a renewable energy source because its inherent energy comes from the sun and because it can regrow in a relatively short time), which is why renewable energy is also mentioned as 'clean energy'. It can be utilised to generate electricity or heat for our homes and enterprises directly. Moreover, it can also be used for biogases in electricity production, in addition to biofuels in the transport sector.

Renewable energy will play a fundamental role in achieving the EU's energy and climate objectives. Not only is it generously available within the EU, but it is also cost-competitive with fossil fuels. It can make our energy systems more affordable and reduce the EU's dependency on imported fossil fuels. It also can create new jobs, new industrial opportunities and support economic growth.

Renewable energy technology is not something new, and it has a long tradition in Europe. In 1991, Denmark introduced the world's first offshore wind farm "Vindeby" which included 11 wind turbines. In the same year, Germany introduced Europe's first 'feed-in tariff' for renewables. This policy has been designed to increase investments in renewable energy innovative technologies.

By 2000, Europe accounted for more than 70% of all wind power installed globally and 20% of global solar photovoltaic installations. In 2000 the world's first large-scale wind farm 'Horns Rev' saw the light – also this time in Denmark. It used many technologies that later became industry standards for offshore wind.

The share of renewable power in energy consumption has increased from 9.6% in 2004 to 18.9% in 2018. The five EU countries with the largest percentage of their power generated from renewable energy sources (based on 2018 data from Eurostat) are Austria, Latvia, Finland, Sweden and Denmark. Moreover, according to the EU's latest energy statistical datasheets, renewables are currently the leading electricity generation source in the EU.

3.1.2 The EU legislation

In December 2018, the recast Renewable Energy Directive 2018/2001/EU entered into force, (it was part of the Clean energy for all Europeans package), aimed at keeping the EU a global leader in renewables, setting a new binding renewable energy target for the EU for 2030 of at least 32%, and comprises measures for the different. This involves updated provisions for allowing self-consumption of renewable energy, a risen 14 % target for the share of renewable fuels in the transportation sector by 2030 and extended criteria for assuring bioenergy sustainability. According to the Regulation on the Governance of the Energy Union and Climate Action (EU) 2018/1999, EU member states must write a draft of national energy and climate plans (NECPs) for 2021-2030, outlining how they think to meet the new 2030 goals for renewable energy and energy efficiency.

The energy sector is accountable for more than 75% of the EU's greenhouse gas emissions. Expanding the share of renewable energy over the various sectors of the economy is, therefore, a primary building block to reaching a mixed energy system connected with Europe's ambition of climate neutrality.

Solar panels and wind turbines are today common across the EU. In large part, this is due to the expanded market activity. For example, the cost of solar power production has decreased by 75% between 2009 and 2018. In 2014, the onshore wind has finally become cheaper than gas, nuclear and even coal. In 2019, for the first time in EU history, energy production derived from wind and solar power overtook coal, becoming as competitive, or even cheaper, than fossil fuels in most places.

The Clean energy for all Europeans package and the Renewable Energy Directive allows citizens to create energy communities and produce, store, and sell their renewable power.

3.1.3 The future development

The coming decade is supposed to see increased growth in renewables. The rise in solar power, for instance, will principally be encouraged by grown self-consumption and more rooftop panel installation. This puts the EU at a competitive position, encouraging economic growth and creating new jobs: in 2016, the solar PV industry accounted for 81,000 full-time jobs. It is assumed to sustain approximately 175,000 full-time jobs in 2021, and 200,000-300,000 jobs in 2030.

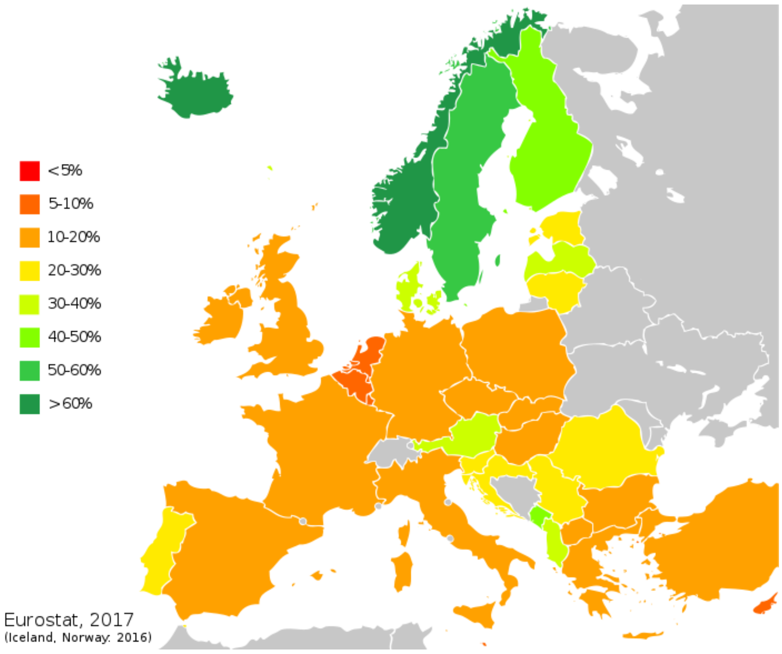


Figure 1 - Share of renewable energies in gross final energy consumption in selected European countries (2017) - Free Image

The share of renewable sources in the final consumption of energy has increased in all EU countries since 2004. The first country was Sweden with over half (54.6%) of its electricity provided by renewable sources in 2018 in terms of gross energy consumption, followed by Finland (41.2%), Latvia (40.3%), Denmark (36.1%) and Austria (33.4%). The lowest percentage of renewables in 2018 was registered in the Netherlands (7.4%), Malta (8.0%), Luxembourg (9.1%) and Belgium (9.4%).

The renewable energy directive established in 2009 lays out a framework for single EU countries to share the overall EU-wide 20% renewable energy target for 2020. Encouraging the usage of renewable energy sources is essential to reduce the EU's energy dependence and meet targets to combat global warming. The directive establishes objectives for each member state taking into account the different starting points and potentials. Goals for renewable energy use by 2020 among other member states vary from 10% to 49%. As of year-end 2018, 12 EU member states had already met their national 2020 targets, two years ahead of schedule.

Moreover, the European Green Deal establishes the EU's road to climate neutrality by 2050, throughout the total decarbonisation of all sectors of the economy, and higher greenhouse gas emission reductions for 2030. As Europe needed to increase energy from renewable sources, the original Renewable Energy Directive (2009/28/EC) established an overall policy for producing and promoting power from renewable sources in the EU.

This revision aims to ensure that renewable energy fully contributes to achieving the EU climate goals for 2030, (in line with the 2030 Climate Target Plan), and to implement the vision described in the energy system integration and hydrogen plans, adopted on 8 July 2020. This process will help build an integrated energy system fit for climate neutrality and turn hydrogen into a viable solution to contribute to this vision.

3.1.4 Renewables for Agriculture: the European Context

The European Green Deal proposes ambitious measures to tackle climate challenges in Europe. Renewable energy has an essential role in the EU Green Deal and could be one tool to reach the EU's energy and climate objectives in agriculture.

Agricultural sector would have notable benefits from the use of renewable energy sources (RES). This sector has high energy needs caused by, e.g. technology and machinery used in production and extensive facilities that require electricity, heating and cooling. Many renewable energy technologies could support farms to meet these energy needs more sustainably. Moreover, environmental advantages, such as the use of renewable energy can:

- Reduce working costs and dependency on imported power
- Improve energy security
- Create extra income through sales of surplus

The preconditions for the making of on-farm renewables are also favourable. Agricultural areas have natural resources, and the size allows larger-scale investments than in urban areas. Even organic manure from animals can be transformed into energy, developing a circular economy and reducing methane emissions.

Despite the benefits and open resources, several barriers exist that impede the use and production of RES in agriculture in Europe. According to the final report (2019) of the EIP-AGRI Focus Group "Renewable energy on the farm", there are financial, technical, regulatory, natural resource and other factors that hinder farms from moving to the low emission pathway. For example, RE technologies are still moderately expensive; new technologies require new skills and expertise, regulations do not support surplus current sale, authorisation procedures are complicated and so on.

To see the growth of renewable power use on farms, we would need to carry them more effectively in their transition to clean energy. In addition to monetary support, such as grants, subsidies and feed-in tariffs, capacity building efforts are crucial enabling factors. Also, information about RE use and production's successful practices should be shared to show farmers the concrete benefits of renewable energy.

In AgroRES project, for example, the partner regions are now exploring the best solutions and innovative strategies for renewable energy use in agriculture and rural sectors. This process intends to improve policymakers', and farmers' know-how on the chances of RES. This will lead to more effective policies and operation models in the partner regions, serving both the Green Deal's objectives and other climate targets at national and European levels.

3.2 Different types of Renewable Energy from the market point of view

3.2.1 Wind Power

Among the most widespread renewable energies in Europe, wind energy has been around for decades. And indeed, research from various sources in various European nations shows that support for wind power is consistently about 80% among the population.

A 2009 European Environment Agency report, "Europe's onshore and offshore wind energy potential", proves that wind energy could power Europe many times. The report highlighted wind power's potential in 2030 as seven times higher than Europe's expected power need. Wind power capacity in the European Union totalled 93,957 megawatts (MW) in 2011, sufficient to satisfy

6.3% of the EU's power. 9,616 MW of wind power has been placed only in 2011, representing 21.4% of new power capacity.

In 2018 wind energy generated enough power to reach 14% of the EU's electricity demand. Denmark had the highest share of wind (41%) in Europe, followed by Ireland (28%) and Portugal (24%). Germany, Spain and the UK follow with 21%, 19% and 18% respectively.

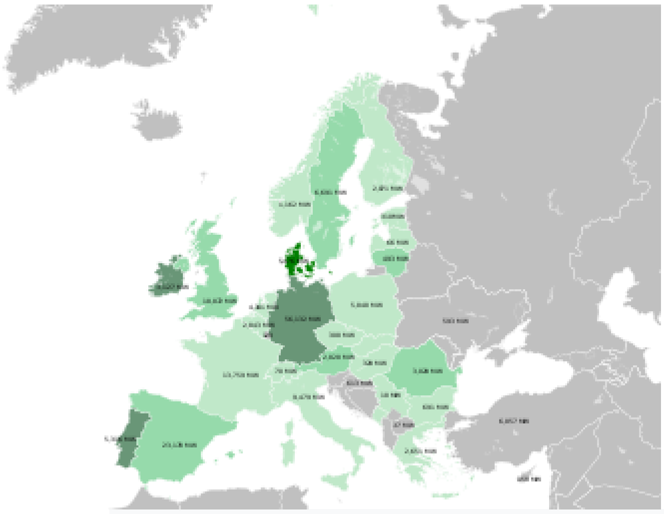


Figure 2- Share of wind power in total electricity demand in Europe in 2017 - Source: Own work, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

> 40%
20-30%
10-20%
< 10%

Onshore wind energy in Europe

Onshore wind continues to be the primary technology and still makes up 89% of all capacity. Europe now has 205 GW of wind energy capacity and wind energy amounts today w to the 15% of the EU's power demand (up from 14% in 2018).

Europe installed 15.4 GW of new wind power capacity in 2019, 27% higher than in 2018 but 10% less than the record of 2017. Wind accounted for 15% of the electricity the EU-28 consumed in 2019. Three-quarters of the new wind installations in 2019 have been onshore.

Spain established the most with 2.2 GW of new onshore wind farms. Wind power capacity grew by 15.2 GW in 2019: 11.6 GW onshore and 3.6 GW offshore, 31% higher than in the previous year.

Denmark had the highest share of wind in its electricity demand last year (48%), followed by Ireland (33%) and Portugal (27%) The UK installed the most wind in 2019 (2.4 GW), followed by Spain, Sweden, France and Germany.

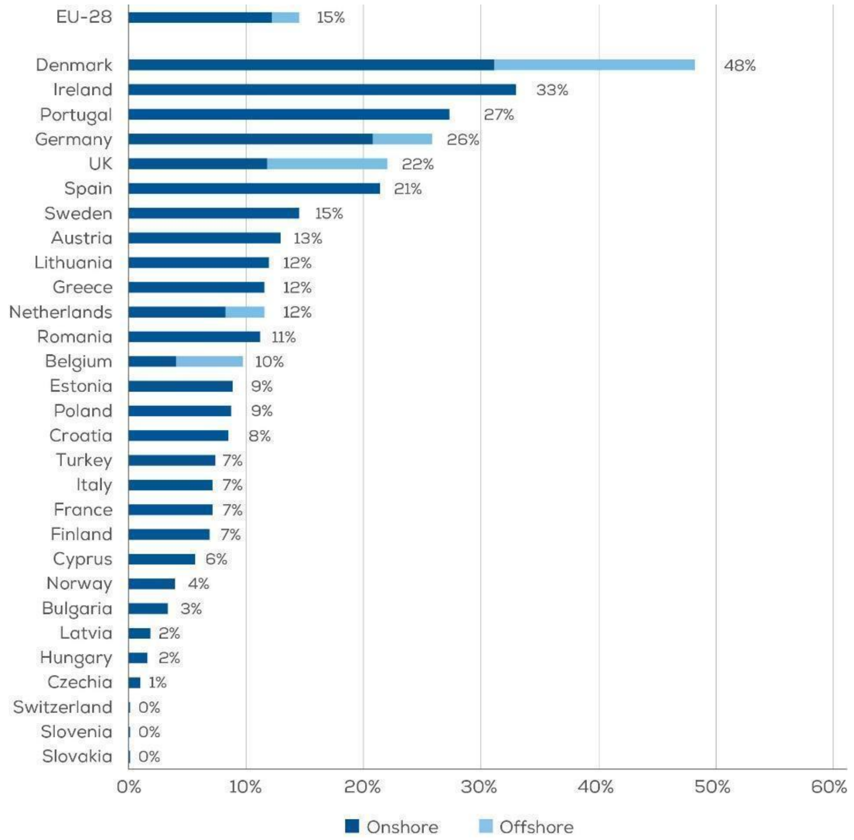
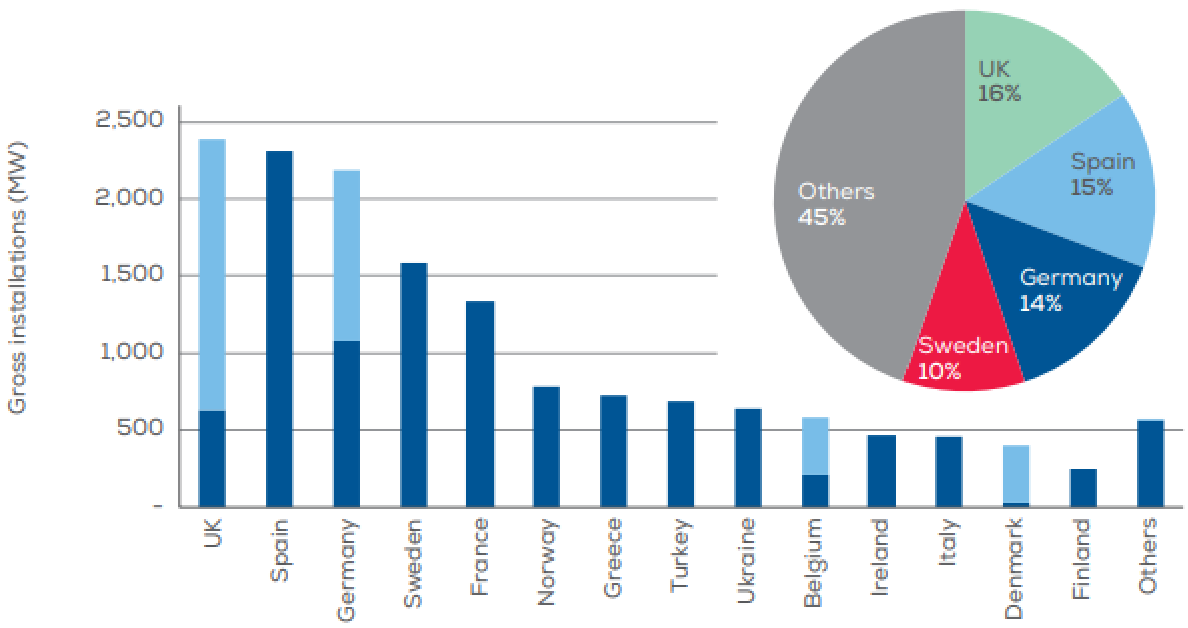


Figure 3 - Percentage of the electricity demand covered by wind in 2019 - Source: fig.8 - WindEurope-Annual-Statistics-2019



MW	UK	Spain	Germany	Sweden	France	Norway	Greece	Turkey	Ukraine	Belgium	Ireland	Italy	Denmark	Finland	Others
Offshore	1,764	-	1,111	-	-	-	-	-	-	370	-	-	374	-	8
Onshore	629	2,319	1,078	1,588	1,336	780	727	686	637	207	463	456	28	243	563
Total	**2,393**	**2,319**	**2,189**	**1,588**	**1,336**	**780**	**727**	**686**	**637**	**577**	**463**	**456**	**402**	**243**	**571**

Source: WindEurope

Figure 4 - 2019 new onshore and offshore wind installations in Europe - Source: fig.3 - WindEurope-Annual-Statistics-2019

Offshore wind in Europe

Europe installed a record 3.6 GW of new offshore wind energy capacity in 2019, connecting 502 new offshore wind turbines to the grid through 10 projects, which brought 3,627 MW of new (gross) additional capacity. At this moment, Europe has a total offshore wind capacity of 22,072 MW from 5,047 grid-connected wind turbines across 12 countries and it has now 22.1 GW of offshore wind capacity.

Four new offshore wind projects reached Final Decision Investment (FID) in four different countries in 2019. €6.0bn was invested to finance 1.4 GW of additional capacity. The UK, Denmark and Belgium set new national installation records. €6.0bn of investments financed 1.4 GW of extra capacity in offshore wind in France, the Netherlands, Norway and the UK 10 offshore wind farms were joined to the grid, and another 5 offshore wind farms began furnishings in 2019.

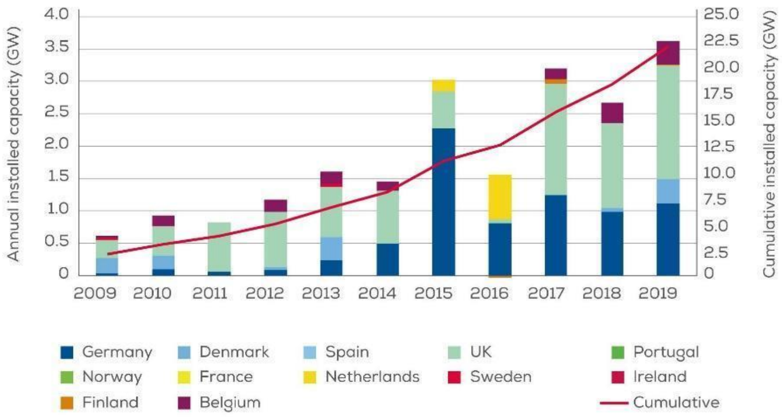
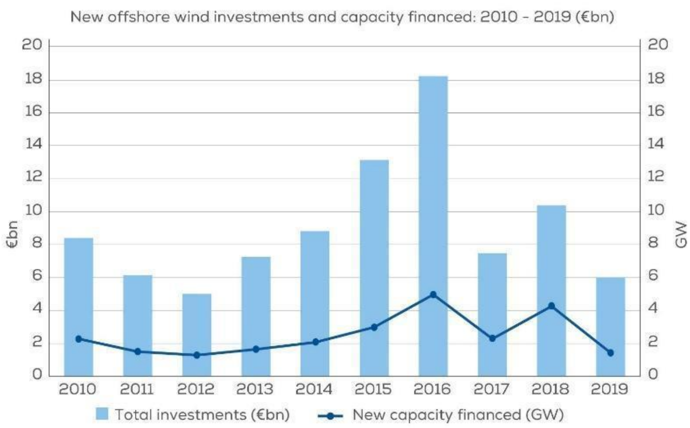


Figure 5 - Offshore wind capacity - Source: fig.4 - WindEurope-Annual-Offshore-Statistics-2019



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total invest-ments (€bn)	8.4	6.1	5.0	7.2	8.8	13.1	18.2	7.5	10.3	6.0
New capacity financed (GW)	2.2	1.5	1.3	1.6	2.1	3.0	5.0	2.3	4.2	1.4

Figure 6 - New Offshore and Investment Capacity 2010-2019 (€bn) - Source: https://windeurope.org/data-and-analysis/product/offshore-wind-in-europe-key-trends-and-statistics-2019/

Figure 7 - Wind Farm - Free picture

3.2.2 Hydropower

For a long time hydropower has been the main source of electricity production in Europe which has been fundamental for economic growth and wealth. Even though other electricity generation technologies such as nuclear, gas and coal were developed later, hydropower has remained for decades, the most cost-effective – supplying and sustainable energy for Europeans.

At the end of the 20th Century, climate change strategies triggered the development of a renewable energy generation base, principally wind and solar PV: Europe's governments (EU-28, Norway, Switzerland, Iceland and Turkey) have all established binding targets to decrease greenhouse gas emissions by at least 40% by 2030 and to significantly expand the share of renewable energy use. As energy demand is continuously growing, renewable and sustainable energy sources are becoming regularly more and more important.

Notwithstanding unfavorable weather conditions with dryness and low rainfall, hydropower produced more than 770 TWh (incl. Georgia, Kazakhstan, Russia, and Turkey) of clean electricity in 2017. While solar, wind, and other renewable energy sources are growing across Europe, these alternate energy systems continue to benefit from and rely upon the balancing capacities, storage potential and other grid settings of hydropower. Thus, hydropower will persist as the backbone of renewables development in the European power grid.

Almost 60% of Europe's whole installed hydropower capability is more than 40 years old and now needs to adapt to evolving grid and environmental laws, as well as new operational requirements. Modernization and uprating are necessary for existing hydropower plants to improve their efficiency and safety, hold their lifetime and provide the necessary grid services. Reduced investment because of very tough environmental stipulations, low electricity prices, and doubtful and inconsistent climate and energy policies, has been countered in European territories where there is a strong interest in boosting the economy and securing better water and electricity supplies.

Together with natural and artificial water basins, another vast renewable energy resource in Europe is the ocean. Ocean energy can play an essential role in the next few years, contributing to the improvement of trendsetting theories. This is exceptionally true in Europe, where in various places geological and topographical conditions are excellent. Nevertheless, today, the commercial aspects of harnessing the oceans' power are not satisfactorily advanced and thus require more political support.

Through the Strategic Energy Technology (SET) Plan, the EU has set cost-reduction targets on ocean technologies for the next decade. For tidal stream technologies, the costs should come down to €0.15 per kWh by 2025 and €0.10 per kWh by 2030, and for wave energy to €0.20 per kWh by 2025 and €0.15 per kWh by 2030. The first areas that could benefit from ocean technologies are offshore installations and islands that today have high electricity costs. All these information will be included in the ocean energy barometer 2019 and in the CORDIS results pack that describes 10 EU-funded ocean energy technology projects.

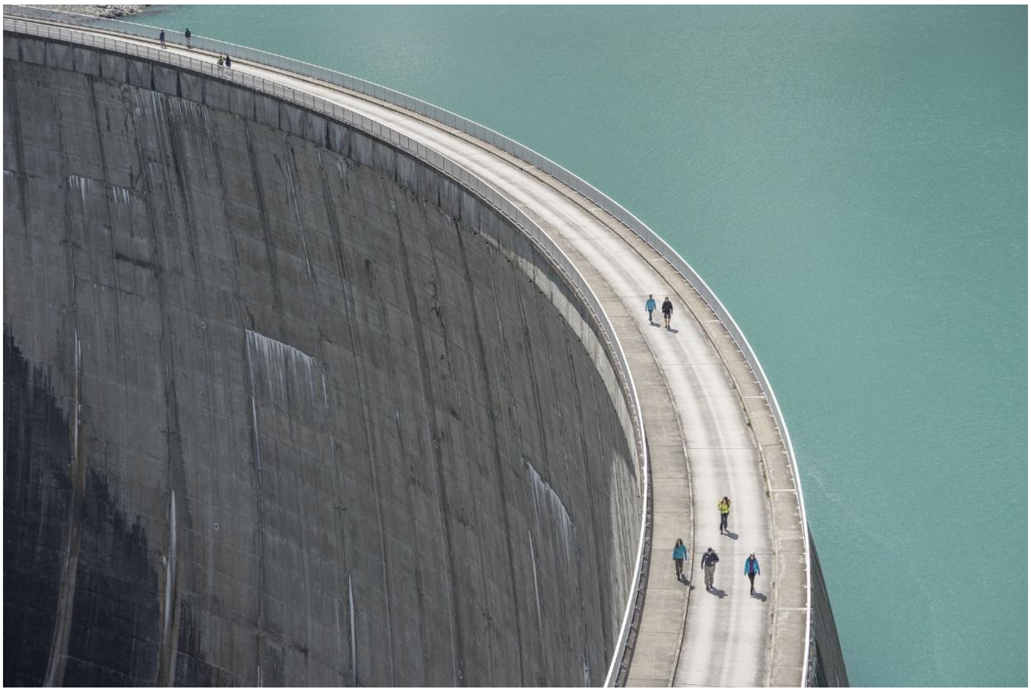


Figure 8 - Dam - Free picture

Hydropower for Agriculture

Hydropower is one of the most constant energy sources among renewables. In various sizes, hydropower plants can be low cost and still produce enough energy for farming purposes. Power is produced from water streams or rivers that run through a turbine which rotates and turns tools or a generator for electricity production. The opportunity of using a "zero-head" or "in-stream" turbine allows applying kinetic and not potential energy, providing a maximum amount of electrical power without building dams or height differences, reducing investment costs for infrastructure and making it a low-cost, convenient solution for powering agriculture.

- Water-powered Water Pumps

In some areas, the application of solar pumps is not proper due to the geographical situation, which may prevent a skilled person's access to maintain the technology, or where there is not enough radiation that reaches the site. This is usually the case in mountain areas, where water is sufficiently available though. In this context, hydropower, or so-called water-powered water pumps can be utilised.

3.2.3 Solar power

Solar energy technologies transform energy from sunlight to electricity This process can be accomplished directly through photovoltaics or indirectly through concentrated solar power or also through a combination of both. The EU is to be considered a frontrunner in the spread of solar power. Due to a solid industrial base, solar power has quickly become one of the most affordable technologies for electricity generation worldwide. Between 2009 and 2018, the generation costs decreased by 75% while the market continued to grow. The solar market is expected to keep growing, making solar capacity a cornerstone of the clean energy transition.

Photovoltaics

Photovoltaics is a way to produce electric power by using solar cells to convert energy from the sun by the photovoltaic effect. The solar cells are then assembled into solar panels; after that, they are installed on the ground, rooftops or even floating on lakes. The technique is becoming more used globally and year on year photovoltaics make up a more significant part of the EU's energy mix. In 2018, the EU output of photovoltaic electricity reached 127 TWh, amounting to 3.9% of the EU's gross electricity output. Recent 100% renewable electricity scenarios have highlighted the importance of solar photovoltaics to achieve this goal and decarbonise the power sector in a cost effective manner. To realise a carbon free power supply by 2050, the installed PV generation capacity of about 650 GW at the end of 2019 has to increase to more than 4 TW by 2025 and 21.9 TW by 2050.

Concentrated solar power

Concentrating Solar Power (CSP) plants use mirrors to gather sunlight and produce heat and steam to generate electricity. They can be coupled with heat storage technologies to be able to produce electricity both day and night. About 2.3 GW of concentrated solar power has installed in the EU since 2013, but most new projects occur in Africa and the Middle East. Solar power in the European Union has shown strong resilience in 2020 despite Coronavirus negative impacts. While the solar industry has successfully reduced costs for solar power generation, commercial power plant developers and operators have been dealing with unexpected competition in 2020. Surprisingly, the demand for solar power technology in the European Union did not decrease but instead increased notably in 2020. EU members states installed 18.2 GW in 2020 – that's an 11% improvement over the 16.2 GW deployed in the previous year. This makes 2020 the second-best year ìfor solar in the EU, only surpassed by 2011, when 21.4 GW was installed. The number is about 12% less than what we had forecasted in last year's Medium Scenario of the EU Market Outlook but higher than in our Global Market Outlook published in June when we had strongly revised the number downwards after the first Coronavirus wave.

Germany is the largest solar market in Europe (a position which this country held for most of the last 20 years). It has been interrupted only six times, by Italy, twice by Spain and three times by the UK. After a consolidation phase following the first full feed-in tariff based European solar boom, the Continent's largest economy's solar sector has been experiencing a second boost as of 2018. This is due to a combination of self-consumption with attractive feed-in premiums for medium- to large-size business systems ranging from 40 kW to 750 kW. These developments have enabled Europe's dominant solar market to grow by around 1 GW per year for the last 3 years, reaching 4.8 GW in 2020, 25% more than last year, and 74% higher than the second-largest European market.

Europe's new No. 2 in 2020 is the Netherlands, which moved up one rank, after installing an estimated 2.8 GW, a 23% rise compared to 2.3 GW established in 2019. The most significant market segment in 2020 again was commercial rooftops, which increased their share to nearly 50%.

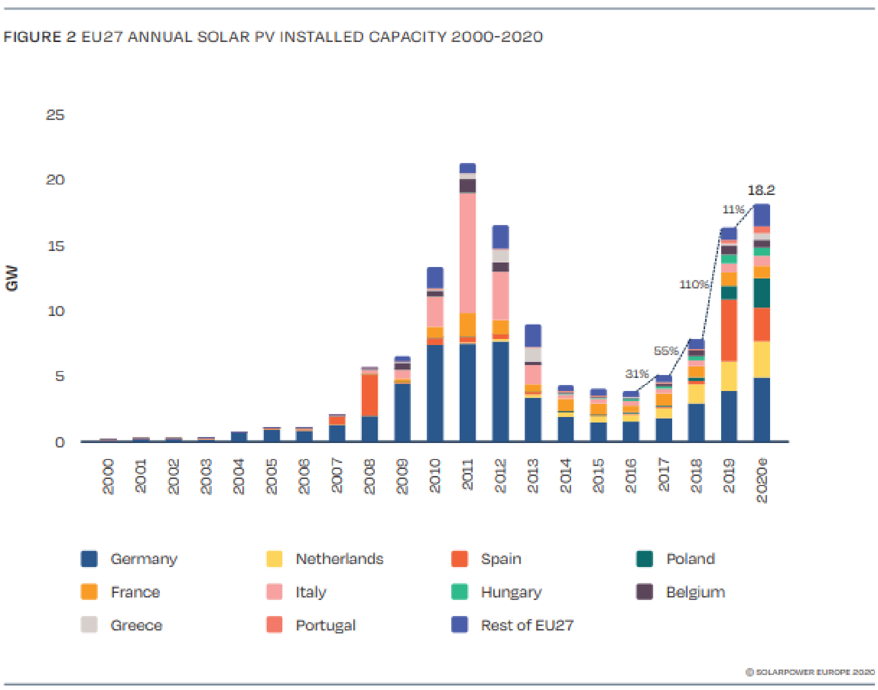


Figure 9 - EU27 Annual Solar PV Installed Capacity 2000-2020 - Source: https://www.solarpowereurope.org/wp-content/uploads/2020/12/3520-SPE-EMO-2020-report-11-mr.pdf?cf_id=26129 fig.2

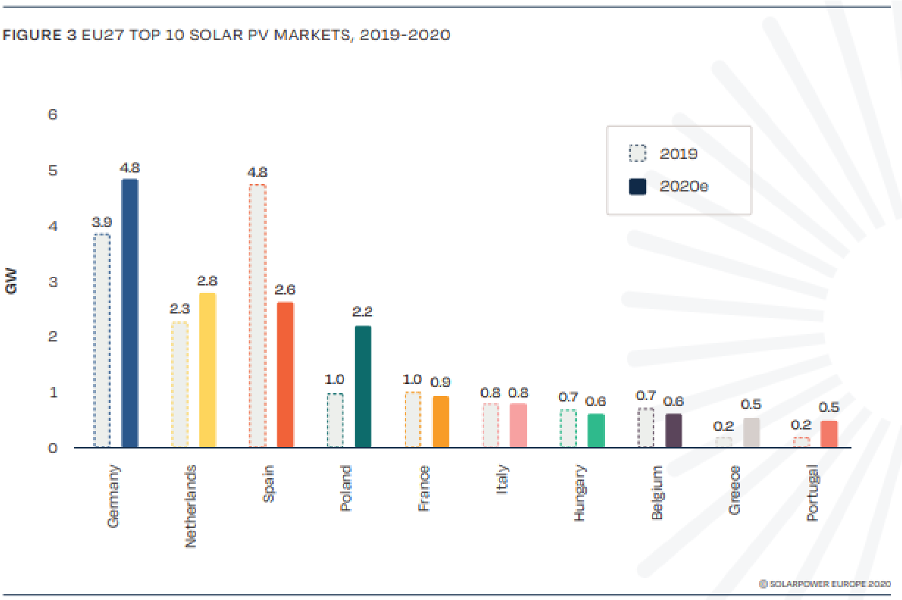


Figure 10 - EU27 Top 10 Solar PV Markets: 2019-2020 - Source: https://www.solarpowereurope.org/wp-content/uploads/2020/12/3520-SPE-EMO-2020-report-11-mr.pdf?cf_id=26129 fig.3

Figure 11 - Photovoltaic Panels - Free picture

Solar Power for Agriculture

Solar energy is the power the Earth receives from the sun, principally as visible light and other electromagnetic radiation forms. Solar energy is among the easily achievable renewable energy sources on the planet, but its availability and features vary enormously from one region to another.

The solar energy potential is higher in regions near the equator, which overlap with many global South countries. Particularly in off-grid areas, solar energy in agriculture can considerably improve livelihoods, enabling access to irrigation, cooling, drying and other agri-food processing methods. Despite the suitability of these regions for solar power and the potential to improve living standards, many obstacles still prevent end-users from adopting this clean energy, including the lack of information and access to finances.

Depending on the solar source potential and its quality, solar energy can serve different purposes, leading to a wide diversity of solar technologies. They can be either passive or active, depending on how daylight is captured, saved and shared. Active solar technologies include solar photovoltaic and solar thermal systems; which turn sunlight into valuable energy. Passive solar techniques involve designing buildings, materials and spaces, allowing the optimization of the use of solar power, such as orienting a building towards the sun or choosing materials with favourable thermal conductivity, or insulation properties.

Solar photovoltaic power can be applied to power pumps in irrigation systems (see next section), increasing agricultural yields and saving costs for other fuels like diesel. It can further power refrigerators, overwhelming the problem of electricity shortages, which interfere with the cold chain, enhancing access to cooling equipment in 'off-grid' regions and reducing post-harvest losses.

Solar thermal energy is used in agri-food methods like drying. As opposed to sun-drying, solar drying avoids contamination of the harvest with contaminants from the ground and enhances energy efficiency. The latter can be improved by using photovoltaic energy to power artificial aeration systems.

- Solar Powered Technologies for Irrigation

Among renewable energy, solar power is the most engaging alternative for irrigation. As costs for solar modules have fallen considerably in recent years, solar-powered irrigation systems (SPIS) have become more attractive from a financial perspective.

- Solar-Powered Water Pump

There are different strategies for integrating renewables in pumping systems. The solar-powered water pump, running on photovoltaic energy, shows excellent results in equatorial regions, where insulation is highest all year long. It uses solar power to pump up water from the origin to an increased storage tank. When water is required for irrigation, it is released gravitationally at a particular pressure, depending on the difference from the tank to the irrigated field, arranged by pipe diameter and length, and the type of emitters employed. As solar panels become more affordable, this technology is increasingly accessible to most smallholder farmers in the Global South, providing agricultural production expansion to initially off-grid areas, and enhancing stepwise agricultural electrification through mini-grid projects.

- Micro-Solar Utilities for Small-Scale Irrigation

However, notwithstanding the plenty of solar sources in the Global South countries, a lack of knowledge and financing options hinders smallholder farmers from choosing solar-powered irrigation systems. In Senegal, farmers currently use the labour-intensive technique of flood irrigation with wells and buckets, or cost- and energy-intensive diesel-powered motor pumps. Nevertheless, the country has enormous solar resources that can be used to produce clean energy for irrigation systems. Earth Institute's solution lets a small group of farmers use a primary solar energy unit to power multiple pumps for irrigation. This procedure takes the power of solar benefits without the high costs associated with powered pumps and battery storage. Being accessed by farmers with prepaid electricity cards, this micro solar utility allows customers to cover their appliance loans in small payments, overcoming the major obstacle that hinders them from adopting the technology, Financial Instruments and Financing for Sustainable Agrifood Systems. The three shared systems implemented until 2016 served 21 farms, which have experienced a 29 per cent average increase in agricultural production, and resulted in 24 tons of CO_2 equivalent.

- Solar Powered Technologies for Cooling
Cooling is a tangible step in agricultural value chains of crops grown in warm climates. These districts often lack the access to a reliable grid supply, necessary for the cold chain, which hinders their outcomes from accessing local and global markets in adequate conditions. Therefore, utilising solar energy to power cooling technologies has a high potential to increase farmers' revenues while reducing post-harvest losses.

- The Solar Icemaker
The solar ice maker uses solar power to maintain a refrigeration system where water can be frozen and used in refrigeration appliances. This technology can find different uses: it can be applied to milk chilling, cooling down vegetables during harvest, and much more.

- The Water Chiller
Another cooling model that involves ice making is the Water Chiller. Adopting a renewable energy source like solar energy can freeze water and generate cold air blown to a storage room for products like vegetables.

Figure 12 - Hydroponics greenhouse- Free picture

Figure 13 - Hydroponics greenhouse- Free picture

- Solar Powered Technologies for Drying

Perishable goods such as fruits, vegetables, tubers, or even meat and fish can be preserved from spoilage by drying, utilising the sun's thermal energy. Particularly in countries where industrial technologies for conservation are not available, such simple solutions like solar drying bare a high potential. Solar drying consists of storing the sun's energy inside a heat collection device, leading the hot airflow within natural or forced convection to the products. When passing the food, the warm, dry air eliminates moisture which is led outside throughout a chimney device at the other end. Depending on the requirements of the end product, solar drying can be more or less complicated. While traditional solar dryers use the natural convection processes of hot air, innovative methods include a fan that runs on photovoltaic energy, moving the air inside the dryer artificially and increasing its efficiency. Unlike conventional sun drying, solar drying usually takes place inside a closed system, protecting the commodities from outside impurities. The complexity of different solar dryers types varies: direct, indirect, mixed or hybrid drying are the principal options for unique needs.

- Agrophotovoltaics: growing under solar panels

Agrophotovoltaics aims to combine electricity production with agricultural activity in the same area. Without certain precautions, it is impossible to cultivate land with photovoltaic panels, which, if placed close to the ground, makes cultivation impossible.
Like the panels, planning aspects must be placed at a height and distance that is adequate for the passage of mechanical means. The climatic conditions of the area concerned must also be taken into account. The panels must be sufficiently stable for safety reasons, as gusts of wind could cause them to fall, which could put farmworkers at risk; crop optimisation. According to the needs of the crops, it is necessary to evaluate the microclimatic conditions created by the panels' presence.

From a construction point of view, two solutions are possible:
- The static configuration, in which the inclination of the panels is predetermined and cannot be changed. This is the simplest, most economical and most reliable type of construction. The critical points are related to the fact that there is no flexibility on the shadow zones created, with possible consequences on the crops;
- The dynamic configuration allows the orientation of the panels to be changed, varying any areas of shade. Therefore, it is possible to place the panels in a vertical position, if you want to avoid or limit damage, or in a horizontal position, for more excellent crop protection in the event of frost and hail.

The solar tracking systems allow increasing the panels' efficiency, since they can tilt according to the sun's position, for more significant light capture and consequent energy production.

A success story, in this case, comes from the Netherlands. The dutch company Kusters Zachtfruit, in fact, has started growing small fruit under solar panels. The solar panel test installation, placed in 2020 above the crops in collaboration will now be extended to full coverage. The installation will generate green energy, but will also act as protection against extreme weather events, enabling crops to have a more favourable climate and better protection. The company believes that the quality of the fruit has improved thanks to the solar panels.

3.2.4 Wave Power

Even though, at the moment, wave energy cannot compete economically against mature technologies, the European wave energy resource has a significant potential contribution to the electricity market. Moving towards an electrified, carbon-neutral system means significantly increasing the uptake of renewable energy, with 80-100% of the future electricity supply set from clean energy sources.

It is estimated that 100GW of wave and tidal energy capacity can be deployed in Europe by 2050, which would meet around 10% of the region's current electricity consumption. While wind and solar power are considered the backbone of the future energy market, ocean energy will be required when the wind drops, or the sun doesn't shine. Each ocean energy technology brings its benefit to the system, but wave energy can also be the largest source of clean energy globally.

Waves are actually a concentrated form of wind energy, capable of travelling considerable distances with minimal losses. Estimates of potential production from wave energy vary from 4000TWh/yr up to 29500TWh/yr. Europe's electricity consumption stands at around 3,300TWh/year. Europe's Atlantic coast offers some of the world's best wave energy sites, with giant swells travelling across the ocean and landing on the UK, Ireland, France, Portugal and Spain.

Wave energy technology was born in Europe, and the first wave energy device has been created in France in 1799. Research into wave energy technologies started in the 1980s but they recently expanded as demand for renewable energies increased. Nowadays, approximately half of the world's wave energy patents are owned by European companies. Waves combine to create deeper, high-energy swells, which can cover long distances without losing power. Wave Energy Converters (WECs) use these swells' energy to generate electricity, even long after the wind has disappeared. There are currently eight types of WEC that capture the wave's energy in different ways. Most are 'point-absorbers', which convert the up-and-down motion of a wave into electricity.

11.3MW of wave energy has been installed in Europe since 2010. Nordic developers have been very active in the wave sector recently. In the high-energy waters off Orkney (Scotland) Finnish developer Wello's 1MW 'Penguin' wave device survived two years and weathered 18-metre waves. At the same place, Swedish CorPower's half-scale machine also proved its reliability, exceeding expectations regarding power production. Another Finnish firm, AW-Energy, is gearing up to export its Waveroller device worldwide after a successful testing in Portugal.

Italy has also emerged as an important European player in wave energy in the past few years. Enel Green Power, in fact, is working with home-grown developer 40South Energy on its device's updated version in the Marina di Pisa. ENI is active in the sector too, with a project in the Adriatic Sea (with the US-based OPT) and another one based in Ravenna. The latter is a pilot plant integrated into a hybrid smart grid system, developed with Italian developer Wave for Energy and the Politecnico di Torino. New wave projects are also underway from developers across Europe, including Marine Power Systems (UK), SINN Power & Nemos (Germany), Laminaria (Belgium), Wavepiston (Denmark), GEPS Techno (France).

Figure 14 - Waves - Free picture

3.3 Some tips for creating a startup in the Green Labour Market

3.3.1 The creation of a new startup in the EU context

Startups are more and more involved in new green technologies, innovation processes, and new eco-products creation. The market for green jobs is certainly on the rise, and will be even more so as a result of the Green New Deal and NextGenerationEU funding. Employment in this sector has grown by 20 % since 2000 and now provides 4.2 million jobs.

In the NextGenerationEU, the first pillar is based on the idea that the Commission's reform action must guarantee effective carbon pricing throughout the economy. The EU aims to increase the European Emission Trading System (ETS) to new areas and assure that taxation is regulated according to climate goals. The Commission plans to propose a carbon border tax (or adjust mechanism) for specific sectors, to minimize the risk of *carbon leakage*. It would be useful because all products consumed in the EU, regardless of their production, would be needed to comply with carbon reduction targets. Carbon-intensive imported products will probably be subject to a tax in order to enter the European market. Moreover, a carbon tax will also push other countries to decarbonize. In this sense, an eco-startup based on renewables or no-carbon production can be more aligned with the NextGenerationEU and be more likely financed.

Sustainable investments are considered the second pillar. According to a recent European Commission report, the European Union is encountering a green investment gap of €260 billion per year, nearly half produced in the housing sector. Moreover, the transport sector contributes €21 billion to the gap and the energy sector €34 billion. To match these targets, the full mobilization of European manufacturing is needed. The Commission has approved an EU industrial strategy to encourage sustainable and digital transformations. Heavy industries, such as chemicals, steel, and cement, can be at the vanguard of the transformation, acknowledging their vital role in Europe's economy and the supply of industrial value chains. All economic sectors will become circular, guaranteeing sustainable processes of production and consumption, and also a substantial reduction of waste. The energy sector (which accounts for 25% of EU GHG), will play a crucial role for the transformation: renewable energy is established to reach a share of between 30.4% and 31.9% in 2030.

3.3.2 Success stories from startups

Following EU-STARTUPS.COM, these are the 10 best cleantech startups in 2019:

Solar Foods is producing a new kind of nutrient-rich protein using air, water, and electricity. Solar Foods is changing food production, as its product is not conditioned by agriculture, weather, or climate, and the technology has huge potential in terms of protecting land and water resources. The company plans to start industrial production of its protein by 2020, which it presumes will be cheaper than other sources such as soy protein. Founded in 2017, Solar Foods has already raised €2 million.

DEPsys is paving the way towards a future of smart grids and microgrids. Its versatile control platform lets power grid operators manage distribution grids safely, reliably and optimally – making it possible to feed huge quantities of renewable energies into their grids from decentralised sources.

Otovo has created a platform that sells solar panels, comparing the costs of dozens of local installers in a very short time. Otovo's solar panels generate clean energy for 25 years, and the startup will buy back any extra energy generated by people. Otovo won the Oslo Innovation Award 2018, raised €10.5 million and acquired the French solar panel startup In Sun We Trust.

The Ocean Cleanup has taken on the massive goal of cleansing the oceans of 90% of their plastic waste by 2040. In September 2018, the startup presented its solution: tube barriers that act as an artificial coastline, collecting ocean debris in the Great Pacific

Garbage Patch discovered between California and Hawaii. The startup is now working to fix the device. The Ocean Cleanup has raised $35.4 million to date, and Time Magazine placed it on its 25 Best Inventions of 2015 list.

Orbital Systems collaborated initially with NASA to develop the technology for their shower system, called OAS, which the company claims decreases water waste from showers by 90%. OAS reuses the same batch of water with a built-in purification system, utilising two gallons per shower – versus 20 gallons of a typical shower. This company intends to take this technology developed for space and put it in people's homes, which would save water and save families a lot of money.

Phytoponics has developed a business-scale hydroponic growing system called Hydrosac, cheaper than traditional hydroponic systems. Hydroponics implements an innovative solution that can address world hunger and sustainability. According to the startup's CEO, Adam Dixon, using hydroponic solutions like Hydrosac, we will only have to utilize 10% of land for agriculture by 2050.

Ducky is tackling climate change with innovative devices to measure, teach, and mobilise citizens to take action on carbon sustainability. Ducky's platform suggests a range of products based on climate and environmental research data. You can monitor your footprint in their climate calculator and reduce your carbon emissions through team games. The startup produces tools for businesses, associations, and schools to mitigate their impact on the climate.

Lilium Aviation is developing a VTOL (Vertical Take Off and Landing) electric jet, which it intends to expand commercially as an air taxi that can be scheduled easily within an app by 2025. The plane will be emission-free, with energy performance comparable to an electric car. Moreover, it has an expected range of 300 km and estimated top speed of up to 300km/hr. Avoiding road congestion, customers will be able to travel from Munich to Frankfurt in over an hour.

Tibber has designed an app that works as an energy business and advisor for homeowners. The app operates as a smart assistant that can buy, control, and conserve energy. You can buy electricity directly through the app, which also monitors your home, using smart analyses to find ways to save you energy.

Wind Mobility is one of the more innovative startups to join the crowd. Like other e-scooter startups, wind's scooters are electric and emissions-free, and clients can open, park, and pay for its dockless scooters through an app, with prices starting from €1 per user.

Other interesting business models regarding this field are:
Farm Renewables
Farm Renewables is a British company specialized on renewable-based systems for agriculture.
Two projects deal with Anaerobic digestion projects, Wind Power and Solar Power for Agriculture among the United Kingdom.
AD is a natural process where plant and animal materials are broken down by microorganisms in an air-tight tank, or digester. This releases a biogas that can be used to

generate renewable heat, power or transport fuel

REM TEC Agrivoltaic

For the development of renewables, is it possible to find common ground between photovoltaics and agriculture and a virtuous combination of both of them. This system is called agrivoltaics. It is made by photovoltaic technologies that allow agricultural activities to be carried out on the same land.

According to Fraunhofer ISE, agrivoltaic technology has grown significantly in recent years and installed agrivoltaic capacity worldwide will increase to approximately 2.9 GW in the following years, with China having the largest share with 1.9 GW of installed systems. In Italy, the agrivoltaic systems developed by the REM Tec company, which holds the patent for the product based on tensile structures, have already been operating for some years in the Po Valley.

Moreover, some studies have shown that the shading caused by the modules reduces evapotranspiration and is beneficial, especially in the summer season, when rainfall is lower and in cases of water stress or lack of irrigation. The world's largest agri-voltaic plant is located near the Gobi Desert in China: berries are grown under solar panels with a capacity of 700 MW. The presence of photovoltaic panels, as with trees, protects crops from overheating and provides soil temperature mitigation.

However, there is still much to be done in Italy on the use of ground-mounted photovoltaic modules in agricultural areas. Technology comes to the rescue. The company REM Tec, has developed the patented AGROVOLTAICO® module. In Italy, it is the only commercial system designed and built on a large scale to combine the cultivation of crops in the field with electricity from photovoltaic panels.

It is made up of panels made from silicon photovoltaic cells, with variable inclination depending on the sun's movement and weather conditions to maximise electricity production and increase safety during extreme weather events. Everything is designed to minimise the impact on the ground, starting with the mounting structures, which are designed to minimise shading of the crops and allow the use of conventional agricultural machinery underneath them, all while minimising the use of highly impactful materials such as steel through the adoption of tensile structures. So far, three plants with a total capacity of 6.7 MW have been built on an area of about 35 hectares.

Photovoltaics, agricultural production and targets for the energy transition

The issue of energy production and land use is particularly relevant in Italy, where there is a need to reach the National Integrated Energy and Climate Plan (PNIEC) targets by 2030, which includes the deployment of large-scale ground-mounted photovoltaic systems. The land where PV system ties are installed is not necessarily unproductive, as it can host horticultural crops, livestock or any other agricultural activity that does not require large machinery. It should also be noted that compared to a biogas plant fed with maize grown in the same area, photovoltaic systems produce 20 to 70 times more energy per square metre with fewer harmful emissions to air, soil and water.

Photovoltaics and agriculture: the results

A specific study focused on the three REM Tec examples located in Lombardy and Emilia Romagna. The life cycle assessment carried out showed that agri-voltaic systems based on tensile structures have a similar environmental performance to other photovoltaic systems in all areas of ecological interest investigated, taking into account parameters such as climate change eutrophication, air quality and resource consumption. But also in terms of economic costs, such infrastructures are comparable to those of other photovoltaic systems (ground- or roof-mounted). Even if they are slightly higher, the reduced land consumption and stabilisation of agricultural production "are relevant added values that should be adequately exploited in a future energy system dominated by increasing human land consumption and climate change", the study authors pointed out. A guide published by Fraunhofer ISE points out that the energy production costs (LCOE) of agro-photovoltaics, between 7 and 12 cents per kWh, are already competitive with other renewable energy sources. Agro PV systems built on tensile structures reduce greenhouse gas emissions, improve air quality, reduce impacts on ecosystems, and deplete fossil energy resources, all compared to the Italian electricity mix and fossil fuels. Considering other renewable energy sources, wind power has the best environmental performance, but this is not a viable option in areas such as the Po Valley, where there is insufficient wind input.

The economic performance of agri-voltaic systems is similar to that of ground-mounted photovoltaic systems due to the higher productivity achieved by solar tracking systems and the material saved by adopting the tensile structure. Above all, they do not affect land consumption, a vital aspect of a future energy system dominated by renewable energies. Furthermore, they have the potential to increase and stabilise the yield of non-irrigated crops in dry conditions by reducing evapotranspiration and soil temperature, especially if the crops and farming practices are developed and optimised to the specific requirements of the agrivoltaic system. Agro-photovoltaic systems can also help combat climate change by reducing greenhouse gas emissions and increasing resilience to climate change in the agri-food sector.

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Summary

Self-checking open questions

1. What are the main features of the EU geographical and economic context about renewable Energy?
2. Which EU legislation rules this sector?
3. What are the main factors of the future development of the renewable energy sector?
4. Which are the main features of Wind Power?
5. Which are the main features of Solar Power?
6. Which are the main features of Hydropower?
7. Which are the main features of Wave Power?
8. What do you need to remember before creating a new European startup?

Test questions

1. What is the connection between renewables and agriculture in the EU?
2. Is Renewable Energy a growing sector? How?
3. How Solar Power can be applied to agriculture?
4. What is the main environmental problem of Hydropower?
5. Can you mention some of the successful cases included in the manual?