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NER300 annual report 2022

Administrative Arrangement

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Abstract

NER 300 is an EU funding programme for the demonstration of innovative renewable energy technologies at the pre-commercial stage. Projects have to submit annually to the European Commission relevant knowledge gained, which is assessed with a view to establishing whether the project has adequately complied with its obligations In 2022, nine projects submitted relevant Knowledge Sharing Reports for the operating year 2021. Five of these projects are Wind Energy projects, two projects submitted in Bioenergy and one each in CSP and DRM domains. The assessment of the submissions was performed by the JRC from February 2022 to May 2022. This report summarises the key lessons learnt so far and the recommendations of the JRC on the knowledge gained and the lessons learnt. The NER 300 projects assessed this year provide valuable information for their continuation and the application of this information to future innovative projects entering the energy market.

1 Introduction

NER 300 is an EU funding programme for the demonstration of carbon capture and storage (CCS) and innovative renewable energy (RES) technologies at the pre-commercial stage. The programme aims to support a wide range of CCS and RES technologies. NER 300 also seeks to leverage a considerable amount of private investment and/or national co-funding across the EU, boost the deployment of innovative low-carbon technologies and stimulate the creation of jobs in those technologies within the EU.

NER 300 is funded from the sale of emission allowances from the new entrants' reserve (NER) set up for the third phase of the EU emissions trading system (EU ETS). 300 million allowances are reserved for the financing of commercial-scale CCS and innovative RES demonstration projects according to Art. 10a(8) of the EU ETS Directive [DIR 2009/29/EC].

Knowledge sharing requirements are built into the legal basis of the programme as a critical tool to lower risks in bridging the transition to large-scale production of innovative renewable energy and CCS deployment. The legal basis obliges project sponsors to submit annually to the European Commission relevant knowledge (RK) gained during that year in the implementation of their project (see Annex 2 and 3 of the Award Decision [C(2012) 9432 final]).

The knowledge sharing element of NER 300 requires the European Commission to collect and assess the relevant knowledge with a view to establishing whether the project has adequately complied with its knowledge sharing obligations. The disbursement of annual payments is conditional to the positive assessment of the Commission on the fulfilment of the KS obligation.

The NER 300 programme differentiates two types of relevant knowledge to be collected and shared. These are defined by the level of data sensitivity. Level 1 (L1) knowledge is only to be shared with other projects in a particular technology category (wind energy projects, bioenergy projects etc.). One L1 community will be set up for each technology category. Level 2 (L2) knowledge is of general interest and includes aggregated and anonymised L1 knowledge and includes knowledge that has to do with the operation of the projects The knowledge is aggregated by technology category to produce comparable results. The target audience for L2 is the general public, industry, research, government, NGOs and other interest groups and associations.

DG CLIMA is in charge of managing the NER 300 programme for the European Commission. The Institute for Energy, Transport and Climate of the Joint Research Centre (JRC) supports DG CLIMA in the implementation of the knowledge sharing from under two Administrative Arrangements (N° 071201/2013/666129/CLIMA.C.1 and №340202/2016/737812/SER/CLIMA.C.3) between DG CLIMA and DG JRC for the project entitled "NER 300 Knowledge Sharing: Assessment and Dissemination" that were successfully executed respectively from 1 December 2013 to 31 December 2016 and 1 January 2017 to 31 December 2019. With the administrative arrangement, DG CLIMA continues to enlist the support of DG JRC for the implementation of NER 300 knowledge sharing from 1 January 2020 to 31 December 2022.

This report provides an overview over the state-of-play of the knowledge sharing of the NER 300 programme so far, in particular the Knowledge Sharing process (Section 2), the aggregation method performed (Section 3) and, most importantly, the results obtained (Section 4).

We summarise the process of the Knowledge Sharing reports from NER 300 projects in 2021. On top of that, we describe the technical assessments and outline the outcomes of them both for L1 and L2 levels. Five indicator categories were used: the technical set-up and performance, the costs, project management, environmental impact and health and safety. We then describe the key aspects of the method used and the communication process with the projects and the national contact points. Moreover, we highlight the needs discovered for a possible update of the knowledge sharing templates that may be applied for the next knowledge sharing cycle.

2 Knowledge Sharing process

In 2022, nine projects submitted relevant knowledge for the reporting year 2021: five wind energy projects, two bioenergy projects, a smart grid project and a concentrated solar power project. Compared to 2021, there is one more bioenergy project. **Table 1** depicts the nine projects assessed for the relevant knowledge shared this year.

TORR and Verbiostraw are bioenergy project, MINOS is a concentrated solar power (CSP) project, PAN is a smart gird project and the latter five are wind energy projects. The TORR project refers to the category BIOb (lignocellulose to intermediate solid, liquid or slurry bioenergy carriers via torrefaction with capacity 40 kt/y of the final product) and entered into operation in November 2021. The Verbiostraw project is affiliated to the category BIOh - lignocellulose and/or household waste to biogas, biofuels or bioliquids via chemical and biological processes with capacity 6 MNm 3 /y (million normal cubic metres per year) of Methane or 10 Ml/y (million litres per year) of the final product and, after a postponement, entered into operation in January 2017. The MINOS project refers to the category CSPc (tower system using superheated steam cycle, either multi-tower or combination linear collectors – tower with nominal capacity 50MWe) and entered into operation in December 2019. The PAN (Puglia Active Network) project refers to the category DRMa (renewable energy management and optimisation for small and medium scale Distributed Generators in rural environment with predominant solar generation: [20MWe] on Low Voltage (LV) network + 50 MW on Medium Voltage (MV) network) and entered into operation in January 2020. The Handalm project belongs to the category WINe (on-shore wind turbines optimised for complex terrains - e.g. forested terrains, mountainous areas - with nominal capacity 25 MWe) and entered into operation in January 2018. The Veja Mate and Nordsee One projects are affiliated to the category WINa (off-shore wind - minimum turbines size 6 MWe - with nominal capacity 40 MWe) and entered into operation, respectively, in July and December 2017. The VERTIMED project and the WindFloat Atlantic project are within the category WINd (floating off-shore wind systems with nominal capacity 25 MWe) and both entered into operation in December 2019. **Table 1** summarizes the projects and relevant details.

Table 1 Overview of NER 300 projects that have submitted relevant knowledge in 2022

Project	Country	Technology category	Date of entry into operation	RK Template
TORR	Estonia	BIOb	29/11/2021	RK/RES/BIO
Verbiostraw	Germany	BIOh	01/01/2017	RK/RES/BIO
MINOS	Greece	CSPc	31/12/2019	RK/RES/CSP
PAN	Italy	DRMa	01/01/2020	RK/RES/DRM
Windpark Handalm	Austria	WINe	01/01/2018	RK/RES/WIN
Nordsee One	Germany	WINa	31/12/2017	RK/RES/WIN
Veja Mate Offshore	Germany	WINa	01/07/2017	RK/RES/WIN
VERTIMED	France	WINd	31/12/2019	RK/RES/WIN
WindFloat Atlantic	Portugal	WINd	31/12/2019	RK/RES/WIN

This report summarises relevant knowledge for the following years:

- for TORR during 2021
- for Verbiostraw during 2017, 2018, 2019, 2020 and 2021;
- for MINOS during 2020 and 2021[1];
- for PAN during 2020 and 2021;
- for Windpark Handalm during 2018, 2019, 2020 and 2021;
- for Nordsee One during 2018, 2019, 2020 and 2021;
- for Veja Mate Offshore during 2017, 2018, 2019, 2020 and 2021;
- for VERTIMED for 2019, 2020 and 2021;

[1] The pilot plant was not operated in 2020 and 2021 due to COVID restrictions

— for WindFloat Atlantic for 2020 and 2021.

The assessment of the RK submissions was performed by the JRC from February to July 2022. Like in previous years, the developed methodology worked well and no significant problems or concerns stemming from the application of the methodology arise. The methodology followed was divided in x steps. First the projects submitted their RK reports. The submissions were evaluated in terms of completeness and the results were communicated to the projects. Then, the submissions were assessed in terms of their content and, if necessary, the projects were asked for clarifications. taking into account the RK submissions and possible comments, corrections or additions the projects were evaluated.

In general, the RK assessment process has tight deadlines. Consequently, it shall always be ensured that RK submissions from projects shall be submitted by the project sponsor on time, otherwise there could be a delay in the RK assessment process and the JRC might not be able to conclude the annual cycle by 15th of May each year. Since only nine submissions had to be assessed in 2022, this did not pose a problem.

As a result, in this annual report we analyse the aggregated knowledge shared for the operating year 2021 with information on two bioenergy projects, one CSP project, one DRM project and five wind energy projects. In the following section, we discuss the aggregation method used.

3 Aggregation method

This report discusses the relevant knowledge of general interest as well as, potentially, some specific relevant knowledge from projects, provided the latter is collated and/or duly anonymised. The target community of this report is the general public, industry, research, government and non-government organisations and any other interest groups and associations.

In addition to providing a picture of 2021, this annual report on aggregation of shared knowledge and lessons learned also traces over time key tendencies and the evolution of projects and relevant knowledge gained. As a result, this report especially focuses on the lessons learnt in the four technology areas covered by NER 300 projects: bioenergy, concentrated solar power, DRM and wind energy.

The bioenergy section refers to two projects, while the CSP and the DRM section each refer to one project. The wind energy section is richer, with five projects.

- Each project category is evaluated by means of the following 5 indicators:Technical set-up and performance
- Costs
- Project Management
- Environmental impact and
- Health and safety.

These subject areas are chosen based on the Knowledge Sharing template that the projects have to fill in. In each of these sections relevant information, evolution of activities or problems faced and solved are shared with the European Commission.

The CSP and DRM sections have only one project reported each in 2022 for the year prior. These projects are analysed but the aggregation method cannot be followed and, thus, the knowledge that can be shared is limited. As for these projects, we are providing information on lessons learnt without photographing the specific technology or project. Therefore, the aggregation method applies especially to the wind energy projects. In the Wind Energy section, we have five projects that reported on time. Here, we apply the aggregation method and report the results in **section 4**.

4 Aggregated Shared Knowledge

MINOS CSP project

The Minos CSP project is a 50-MWe concentrated solar thermal electricity generation plant to be located in Crete, Greece.. In early 2019 the CGGC & SUPCON SOLAR consortium (China) and Nur-MOH Heliothermal S.A. signed an EPC framework contract for the plant design and construction.

The project's first knowledge sharing report describes the construction and commissioning tests on a 50 kW pilot plant (as a precursor to the main plant). It uses a steam/water cycle, tower receiver and a solar field comprising 60 heliostats (the actual plant will have up to 18,000 heliostats). In 2019 the tower was constructed with a receiver, drum, deaerator, steam turbine, generator and auxiliary equipment. The project team noted the challenges of the high wind loads and uneven terrain specific to the project location. The first power generation tests were carried out successfully on 27 December 2019. However, the pilot plant was not operated in 2020 and 2021 due to COVID restrictions.

PAN project

The Puglia Active Network Project (PAN) concerns the whole Apulia Region (IT) and entered into operation on the 1st of January 2020. The main goal of the PAN project is to define and implement an integrated protection, automation and control system based on:

- limited number of devices, with high integration level;
- adequate redundancy;
- high level of distributed intelligence;
- modern communication network;
- very high compatibility with standard market devices (not customized).

- Technical set-up and performance

The Project represents a concrete example of the implementation of a smart grid. Started in 2014 and co-funded by the European Commission in the frame of NER 300 Call, the PAN (Puglia Active Network) Project is an evolution and a large-scale demonstration of innovative solutions developed by E-Distribuzione. After the implementation phase of the Project, from January 2020, a period of five years of observability started. During this period, the electrical network must be able to accept about 19.3 TWh of energy production from renewable sources. Apulia (Puglia) is the first region, in Italy, in terms of installed photovoltaic power plants (2 826 MW in 2019) and it has the highest production level from these sources (3621 GWh in 2019, 15.3% of total national production from photovoltaic plants). The increased amount of energy produced by Distributed Generation requires a novel active management of the network and new design approaches for the entire Remote Control, Automation, Protection and Regulation infrastructure.

In other words, Smart Grid concepts have to be extended to large areas. In particular, in Apulia territory, Smart Grid has been extended to almost all of the entire region. For this reason, the PAN Project transformed Apulia into a Smart Region, thanks to E-Distribuzione Smart Grid technologies.

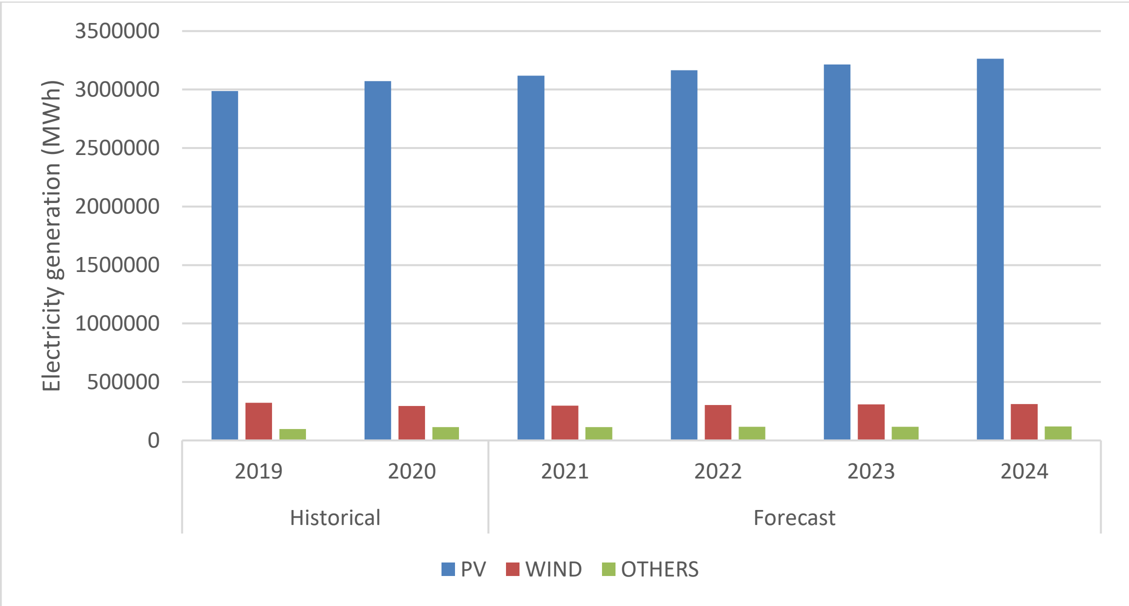
E-Distribuzione developed unified Smart Grid technologies with a “scalable by design” concept and a distributed intelligent architecture, involving Remote Control, System Automation and Protection as well as Advanced Regulation Functionalities. With these technologies, it is possible to maximize the renewable energy hosting capacity, acting on voltage regulation, to clear each kind of faults by the interventions of circuit breakers installed on MV/LV stations, to observe the grid behaviour and then to enable flexibility services. Smart Grid devices work by creating a “device community”, enabling the possibility to communicate with each-others, “horizontally”, or “vertically” with the SCADA/DMS.

The Monitoring is ensured with real measurements coming from RGDM on the field. The Advanced automation is provided by the new solution for automatic fault detection and isolation, Logical Selectivity Function, which aims to reduce the number and cumulative duration of long and short interruptions, with the reduction of the DG production losses. The solution is based on IEC 61850 protocol.

The innovative voltage control improves the network's capability to accommodate DG, the voltage quality and the energy efficiency of the distribution network. The innovative voltage control is realized by DMS (control centre), using advanced network calculations and the measurement (V, I) coming from the RGDM installed on the network. In this way the DMS can estimate the optimal set point of each MV busbar of primary substations. The new HV/MV transformer protection implements the set-point value previously calculated, by operating the On Load Tap Changer (OLTC).

The total anticipated electricity generated in the Project has been calculated assuming a linear growth rate for the next years. In 2020 the electricity generated is about to 3 480 GWh, while that related to the 2021 will be available after 31st of March (**Figure 1**).

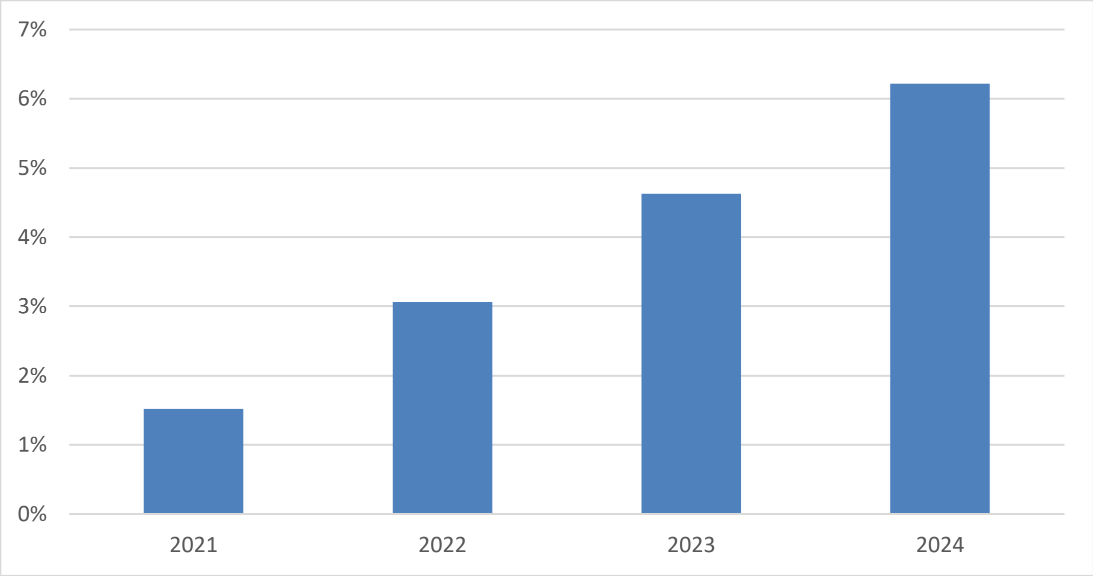
Figure 1 Total historical and anticipated electricity generated in the operation years (MWh) by RES type



Source: JRC, 2022.

It is possible to estimate a growth rate for each type of renewable energy technology as described in the previous point. Taking into account the energy production in 2020, the annual growth rate for all sources has been estimated at 1.52% (**Figure 2**).

Figure 2 Anticipated electricity generation increase compared to the actual electricity generated in 2021

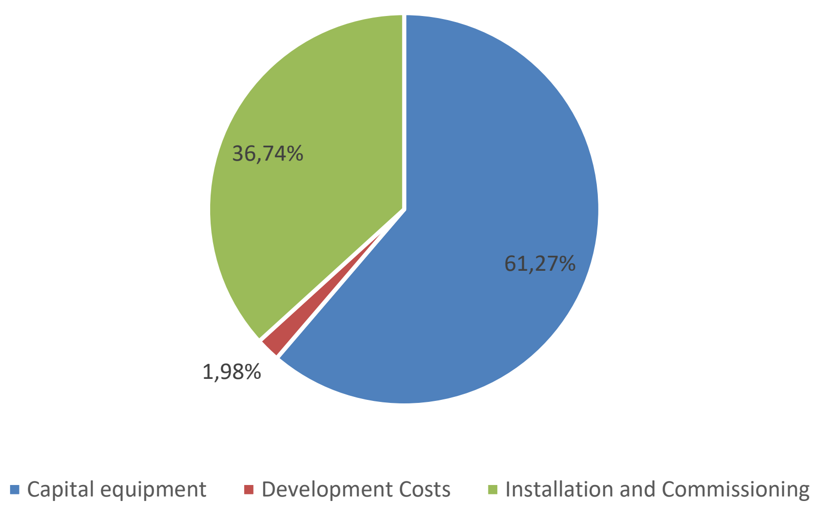


Source: JRC, 2022.

- Project Costs

The investment costs have been incurred for the development of the Project since the date of Project commencement (2014) are presented in **Figure 3**.

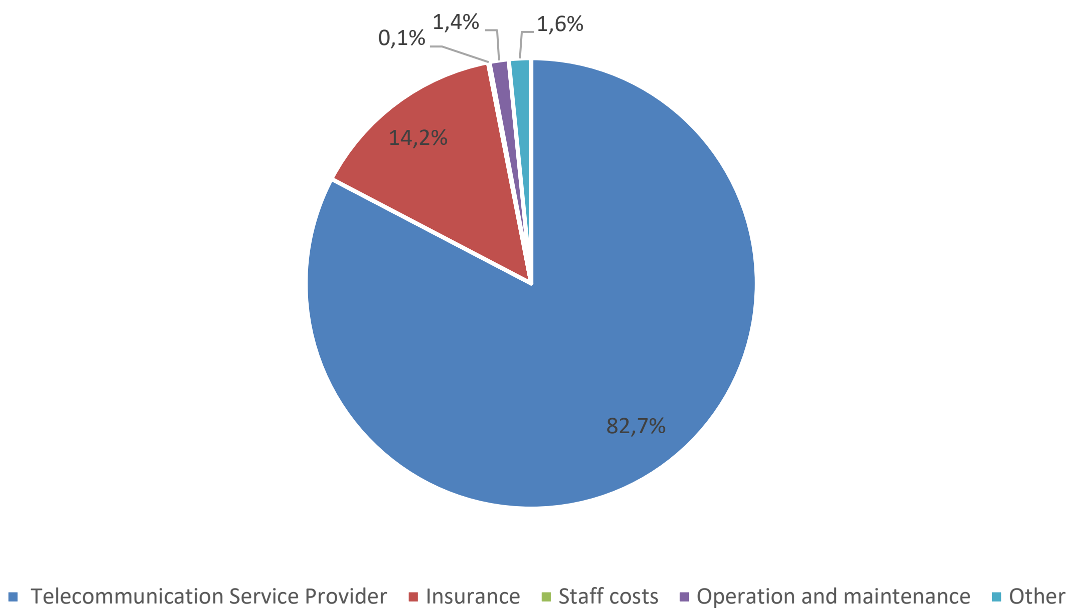
Figure 3 Investment cost shares



Source: JRC, 2021.

The operating costs incurred during the second operative year (2021) are presented in **Figure 4.**

Figure 4 Operating costs shares in 2021



Source: JRC, 2022.

- Project Management

The Project didn't foresee a consortium because it was carried out only by E-Distribuzione.

During all the lifecycle of the Project, a governance model has been put in place characterized by:

- the presence of key staff with experience on technical, management and administrative matters (Project manager, technical Project manager, procurement manager, operational manager, financial reporting manager and deputy manager) and for which role and responsibilities have been set out under the Project;
- the processes put in place in terms of management, cost controls and progress controls, that help to monitor the activities, face risks, identify solutions and actions for mitigation; in this regard, the use of information systems for Asset Management, Financial Management, Accounting, Reporting and Document Management is useful;
- the quality management process, aimed to monitor and control the adherence of the Project to the quality management procedures, thanks also to the internal procedures SGI (quality, security and environment Integrated Management System) certified according UNI EN ISO 9001, 14001 and OHSAS 18001 standards and an Energy Management System certified according to the UNI CEI EN 50001 (Quality Management System Certificate ISO 900, Safety Management System Certificate OHSAS 18001, Environment Management System Certificate ISO 14001 and Energy Management System Certificate UNI CEI EN 50001);
- the continuous flows of communications among the different staff members involved in the realization of meeting and checkpoint moments, aimed to give an overview of the progress of the Project and discuss about the issues related to the activities carried out;
- the internal policies and procedures put in place during the Project, also considering the successfully experiences gained during the implementation of other European Projects such as ADDRESS, a large-scale Integrated Project co-founded by the European Commission under the 7th Framework Programme in the Energy area for the "Development of Interactive Distribution Energy Networks", with EDistribuzione as coordinator;
- the involvements of the stakeholders at an early stage, in particular producers and customers, in order to bring an added value to the Project and to the achievements foreseen;

- the effective supply chain management from the design to procurement, installation and operation phases, thanks also to the experience gained through other Projects such as Telegestore, with the roll-out of 32 million smart meters.

The experience done through the realization of the Project has led the following good practices:

- Strong time and Project management during the planning and the implementation phases of the Project is key to monitor the progress activities and put in place actions to face any occurrences. The PMO carried out an "adaptive" approach, that means not entrusting the Project only to the start-up phase, but adapting it during the execution phase: thanks to the approach used, specific actions have been put in place to prevent unexpected risks (e.g. new regulatory provisions, variations due to the requests unforeseen), reviewing the planning in a cyclic way, adopting heterogeneous approaches in the Project management (agile, incremental, iterative, etc.) and, more generally, adapting the Project to the changing conditions occurred.
- Business model definition, considering possible deviations in the plan, can help to put in place quick response to changes. The changes in Project context required also some changes in the Project that brought E-Distribuzione to put in place some actions to maintain and improve the benefits of the Project in the new market and technology context.
- Manage suppliers to deliver as fast and as much as possible, defining clear contractual responsibilities, defining penalties in contracts to stay within schedule. The respect of procurement procedures (i.e. "Regolamento degli Appalti di Lavoro,Forniture e Servizi") in line with the Italian legislation (i.e. Decreto Legislativo158/95) and EU Directive 2004/17/CE, ensured the choice of suppliers involved in the Project responding to specific requirements. The presence of suppliers of equipment and control and automation systems in the Project ensured the supply and installation in the shortest possible time of all components necessary for the proper functioning of the system. In addition, the provision in the contract of specific conditions allows the compliance with deadlines.
- Close monitoring of regulatory developments could help in identifying fast responses to changes. As for the new emerging regulations relevant to the Project, main evolutions were forecasted in the following sectors: incentive schemes for RES production, technical and procedural conditions for connections (Distribution grid code), new obligations for DG in case of transmission network emergency, incentive schemes for forecasting/flexibilisation of DG injections, possible local dispatching by the DSO and future regulation regarding electric vehicles and charging facilities.
- Early involvement of and continuing communication with key stakeholders will help to increase the commitment in the Project. A communication plan was elaborated in which different actions were foreseen and after carried on in order to involve all stakeholders, in particular producers and customers at early stage of the Project. Thanks to the different methods used to promote the Project and its benefits, a great involvement and commitment was ensured through the participation of Institutions (e.g. European Commission, International Organizations, MATTM, Apulia Region, Local Administrations), operators and/or local development promoters, trade association, citizens, etc.

- Environmental Impact

The production of energy from distributed renewable sources allows a reduction of CO2eq emissions compared to conventional energy production method (i.e. fossil fuels). Moreover, CO2eq savings due to the energy supplied to EV by the energy provided from charging stations of the Project and CO2eq savings due to the improvement of customers' awareness about energy consumption using the Smart Info kit are accounted. Therefore it is possible to evaluate the CO2eq emission avoided in 2019 using the total energy produced through DG applying a conversion factor of 0,150 ton CO2eq/MWh. The total saved CO2eq in 2020 is close to 522.000 ton, a 2% increase compared to 2019.

- Health and safety

Only a single accident occurred in July 2016. A worker cut the back of his left hand while stripping cables into a local electrical panel. The wound was treated with three stitches. This caused two weeks of absence.

A dedicated HSE department is responsible for all the safety, security and environment risks. The monitoring and resolution system of all these aspects is briefly described below.

1. Working methods for all the activities that have to be carried out by the Organization and subcontractors, which describe in detail both the way of working and using equipment, and all the safety protection devices (personal or group) to be used.

2. Pre-job check to evaluate all the possible risks in site, operational safety plan and working plan must be drafted and available for consultation on site. 'Five golden rules' to avoid all the electrical risks have to be respected.

3. Inspection checks are executed, both within the same Organization and the subcontractors (the so called in line and off line checks). All the non-compliances are recorded (number, type, items) and a procedure for workers suspensions and further readmission after dedicated training is in place. Possible penalties.

4. Assessment meeting for all the subcontractors to check safety aspects progress and way of working.

5. Safety and environmental accidents (also for subcontractors) are recorded within an integrated management system. Weekly/monthly monitoring is in place. A detailed procedure for recording near misses is present and used to avoid future possible dangerous situations.

6. Monthly safety updates (occurred events and lessons learned) are shared with all the staff and subcontractors workers.

7. Continuous and substantial training is provided for all the personnel.

Bioenergy projects

Verbiostraw

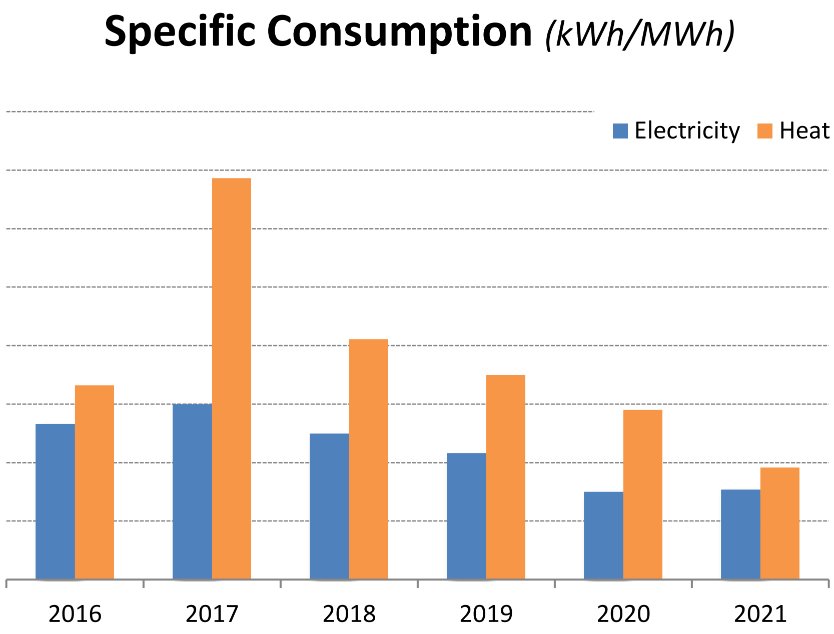
The Verbiostraw project is affiliated to category BIOh (lignocellulose and/or household waste to biogas, biofuels or bioliquids via chemical and biological processes with capacity 6 MNm^3/y of Methane or 10 Ml/y of the final product) and has been submitting Knowledge Sharing reports since 2018. In this section we, qualitatively, describe the progress made and the areas of attention through the five categories, as described in section 3.

The plant is located on the PCK refinery site in Schwedt/Oder in Brandenburg, and it is designed to produce biofuels from lignocellulosic feedstock (e.g. straw). The unit is integrated in an existing bioethanol/biomethane biorefinery on the site. The first biogas, still not upgraded to biomethane, was delivered on 09.10.2014.

— Technical set-up and performance

During 2021, several improvements were made in the modules comprising the technical set up of the project. Like for the previous years, these were aiming at the optimisation of the different processes and the overall procedure with the goal of an increased efficiency, reduced downtime and overall stability of operation. The project increased specific energy input in certain years, which resulted in higher yields (**Figure 5**) but lower environmental performances. Further optimisation made it possible to reduce the specific energy inputs, which however have been always lower than planned during the application for grant in 2011.

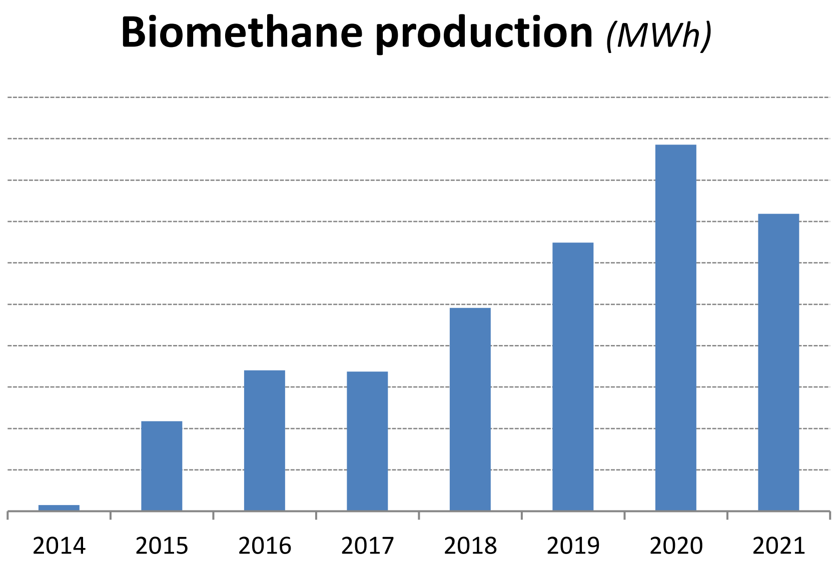
Figure 5 Trends in specific energy consumptions, reporting until 2021



Source: JRC, 2022.

According to the project and our technical analysis, the raw biogas produced showed a rising trend – compared to 2018 and 2019, and the resulting biomethane accordingly (**Figure 6**). The high productions rates of 2020 were not repeated due to the poor quality of the straw, which led to longer processing times and execution of test runs in order to utilize the production in the future. Moreover, negative impacts in the production were apparently due to a cyber-attack that forced the plant to function at a basic mode. Finally, due to the COVID19 pandemic, less staff was available, which caused a reduction of the throughput.

Figure 6 Trend in biomethane output, reporting until 2021



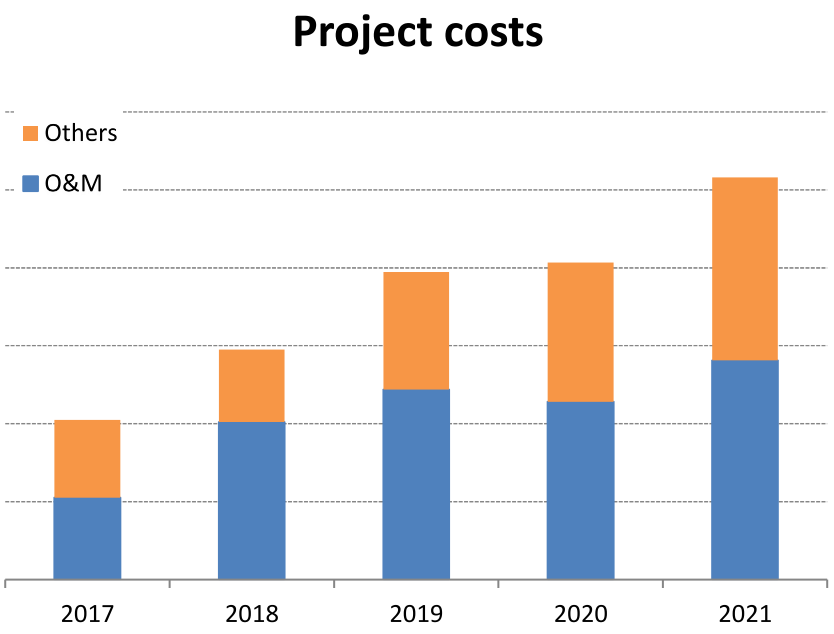
Source: JRC, 2022.

Downtime was marginally increased compared to 2020, with the largest fraction of the corrective maintenance being attributed to blockages in the straw processing due to bad straw quality.

— Costs

The annual project costs increased along the project lifetime (**Figure 7**). Among the various cost items (CAPEX and OPEX), O&M represented the major share: services, staff costs, overheads, waste disposal, local rates and taxes, insurance, knowledge sharing, and others). The percentage of O&M over the total changed along the reported years but was always above 50-60% of the total project costs.

Figure 7 Trend in annual project costs, reporting until 2021



Source: JRC, 2022.

— Project Management

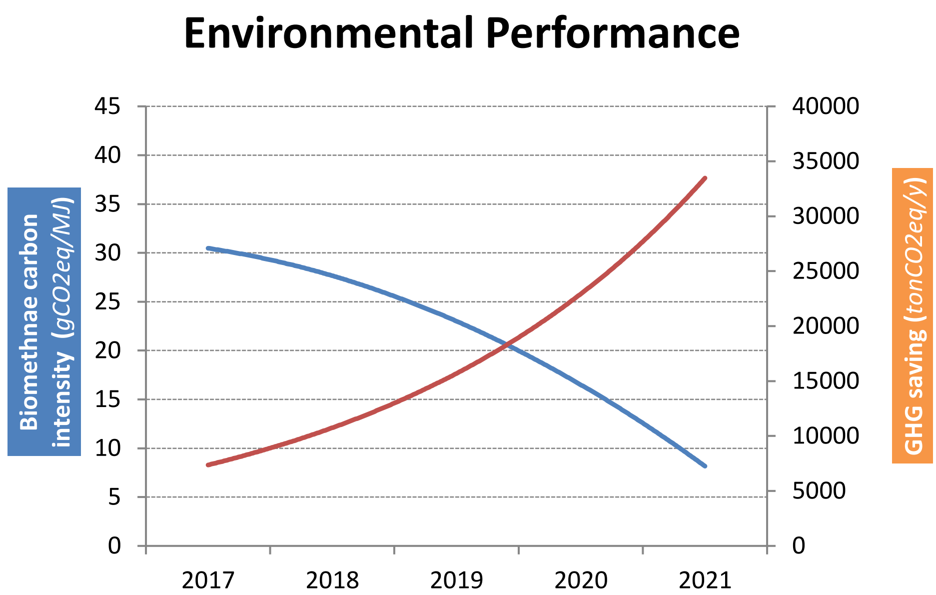
During 2021, and since the beginning of the project, the management plan has been unchanged. The main lessons learnt are summed up in the following points.

The priority is strong time and quality management, especially during planning and construction. Second, the business model should be robust against deviations in the plan. This means quick responses to significant changes in the plan, consideration of changes before they occur and definition of realistic solutions. Third, it is important to minimize investment costs at the beginning (extension of existing plants). Last, the need of close observation of regulatory developments and fast response on changes is highlighted.

— Environmental Impact

The CO_2eq emissions of the project remain at the same levels of the previous years of operation. Based on the data of the energy balance in 2021 the straw bio-methane has a value of 11.14 gr CO2 eq /MJ.. To put this in perspective, in comparison with a fossil fuelled production the CO_2eq emissions are reduced by 25,744 tonnes in 2020. As seen in **Figure 8** the emission intensity of biomethane is decreasing with the increase of its production volumes. According to the REDII requirements, it meets the sustainability threshold to be eligible as sustainable gaseous biofuels

Figure 8 Trend in the environmental performance of the project.



Source: JRC, 2022.

— Health and Safety

In 2021 the project kept focusing on the awareness of employees, focusing on safety. In spite of some improvement, mostly based in new information panels, there were two accidents. Based on the accidents, the project has identified the following key lessons learned relating to safety:

- Improve cleanliness of working areas
- Keep employees aware of risks by walking or cycling on site

In 2021 there were also some fire incidents due to impurities in the straw in the bale grinder. The installed automatic watering systems extinguished these fires and there was no significant impact on the process. The key lesson learnt was not to use flammable materials in the grinding area.

TORR

The TORR project is affiliated to the category BIOb (Lignocellulose to intermediate solid, liquid or slurry bioenergy carriers via torrefaction with capacity 40 kt/y of the final product) and entered into operation in November 2021. The Knowledge Sharing report in 2021 was the first submitted by the project. In this section we, qualitatively, describe the progress made and areas of attention through the five categories, as described in section 3.

The project aims to demonstrate of an innovative torrefaction process for the Baltania OÜ plant in Vägari, Estonia. The scope of the project is to transform low quality biomass into a high calorific, high-density solid biofuel by means of the torrefaction technology. In 2021 grey and black alder was used as biomass, but in the future the feedstock will diversify furtherly.

— Technical set-up and performance

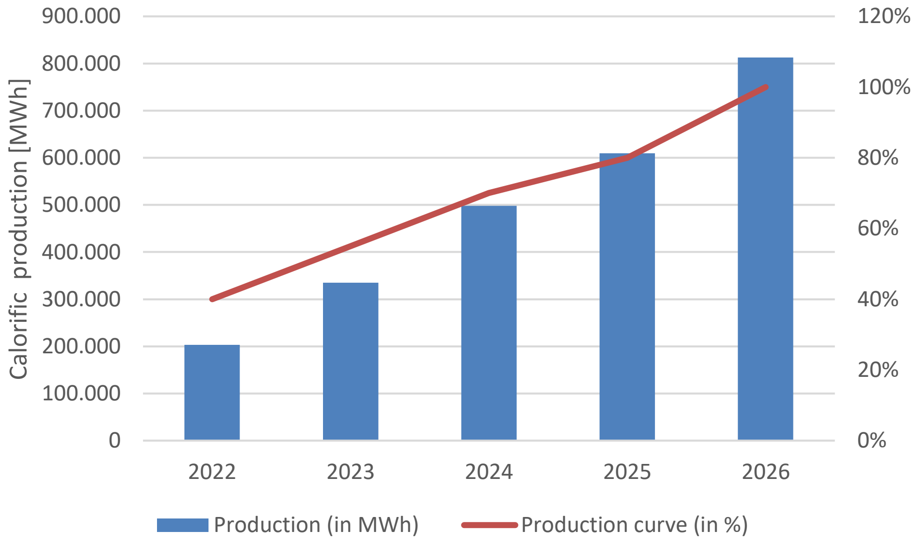
The plant consists of 8 modular torrefaction units and will produce 140 000 tons of pelletized biocoal per year. The plant operation is designed for 7884 full load hours per year, with an average net calorific value of pellets being 21 GJ/ton. Once at full capacity, the torrefaction plant will produce on average 817.000 MWh/year of renewable energy.

Each torrefaction line consists of one reactor (rated at an output of 2,27 t/h of biocoal) and one thermal oxidizer (rated at 4,5 MWth).

The first two torrefaction production lines started their operation in 29.11.21 and were in operation during the reporting period of 2021, but total production volumes resulted lower than what estimated in the project proposal (325171 MWh).

This is partly due to the reporting period falling rather late into the year, but mostly due to the ongoing fine-tuning and ramp up period of the plant operation and construction. The additional five production lines will enter into operation in 2022, and the final production line by 2023. The anticipated calorific production capacity and the biocoal pellet production curve for the following years for 80% plant capacity is presented in **Figure 9**.

Figure 9: Anticipated production in the following operation years



Source: JRC, 2022.

Costs

Since this is the first operation year of the project and furthermore, since the operation started late in the year, the operating costs are not yet representative. Additional investments are expected in the years 2022 and 2023 to make all 8 torrefaction lines operational. Among the various cost items (CAPEX and OPEX), major expenses included preliminary engineering, permitting and operating costs. OPEX was significantly smaller than the CAPEX partially attributed to the start of the project late in the reporting year.

Project Management

As the project was in the commissioning and early operating phase in 2021, stakeholder management was mostly internal. In 2022, a wider community of stakeholders will be approached.

To minimize the technical risks of the project, the developer employed the following technical risk management strategy. The whole project was broken down in 7 scopes, each one of which having a dedicated manager. Each scope was procured from an applicable industry leader and as close to a turn-key island as possible, minimizing the risk for the whole facility. Attention was paid in the communication between the scopes in handover points.

— Environmental Impact

The Project original application estimated that torrefied pellets deliver 94% CO2 emissions avoidance over energy generated from fossil-derived coal. Two scenarios were developed: A – 100% coal and B – 100% torrefied pellets. In terms of CO2eq emissions for every kWh of energy produced the study concluded that torrefied pellets produce 49 gr CO2eq/kWh, compared to 756 CO2eq/kWh when using coal, mainly due to the fact that burning torrefied pellets is carbon neutral.

In 2021, the project developer performed an updated calculation on the Carbon footprint of the facility and related production. Calculations showcased an emission factor of 57.3 gr CO_2/kWh during full production capacity of the project. The slight increase of emissions of 8.3 gr CO_2/kWh is considered within the normal variation in estimations and reality, thus the actual CO_2 savings is almost aligned with expectation.

— Health and Safety

No safety incidents or near misses occurred in the small operation time in 2021.

A monitoring and resolution systems is in place to prevent accidents and cases of work-related ill health and provide adequate control of health and safety risks arising from work activities.

The Baltania safety monitoring, tracking and resolution system consists of e.g.:

- Risk assessments covering all tasks to be undertaken.
- Health and safety procedures to guide and direct all employees to work safely.
- An incident reporting and investigation system, leading to the identification of adequate remedial actions and escalation of incidents.
- Regular safety tours to support health, safety and wellbeing and discuss, observe and review safety matters/items with staff located at the workplace.
- Weekly safety meetings where incidents and the results of safety tours are discussed.

Wind energy projects

In the Wind energy category, we received five full knowledge sharing reports from the projects running. One of the projects is onshore and four are offshore.

Following the structure of the Knowledge Sharing templates, we continue in this section with an overview of the progress of the projects in the five main areas.

However, before the results are presented, we need to stress that responses to reporting templates happened at different time scales and level of detail. The original data was screened and aggregated to a level that does not to disclose detailed project specific information. Thus the aggregated quantitative results presented in this section are limited to dedicated aspects of the reporting that can be either compared to some extent among projects or to an international reference.

As innovations of the NER 300 wind projects include targeting the operation and maintenance (O&M) stage, we decided to compare O&M categories and aggregated this information into two main O&M categories. This allows to identify a broad average relation between planned and unplanned maintenance which could be used in the following years (and at a later stage) to potentially identify a learning effect with respect to maintenance throughout the projects lifetime. Currently, this development over time does not yet lead to meaningful results as we could obtain a complete picture only for three consecutive years of O&M data at best.

A second set of quantitative data presented in this section concerns costs. Similarly as the aforementioned O&M categories, we screened O&M costs during the projects' lifetime. In order to prevent the disclosure of sensitive costs data among NER 300 projects we decided to present NER 300 O&M data in an aggregated form and in comparison to international references (e.g. IEA Wind Technology Cooperation Programme – Task26 'Cost of Wind Energy'). Similarly CAPEX data is aggregated and compared in order to classify them into the international context.

— Technical set-up and performance

The technical set up and performance of all five projects has not deviated or changed significantly from the previous reporting years. In all projects, activities for preventive maintenance have taken place. Still, different innovation aspects regarding the technical set up are unique to each of the projects.

Innovation aspects of the onshore project (Windpark Handalm) include technologies that allow operation at high altitudes or harsh and cold climates. In order to allow operation in these climates the project utilise different de-icing systems and sensors against icing. Innovations in the offshore wind projects (Nordsee One and Veja Mate Offshore) include several technical innovations with respect to components (e.g. XL monopile foundations, bolted flange transition pieces, among others) and installation methods (eg. bubble curtain) which to a large extent became the norm in the fast evolving offshore wind market. Moreover, with Vertimed and Windfloat Atlantic two floating offshore wind projects present innovative solutions in the area of substructure design (tension-leg platforms and semi-submersible floating platforms) providing solutions for countries lacking shallow sea shores. With respect to the Vertimed project, no power was produced on site to date as full scale deployment is planned for 2023.

Table 2 presents the technical details — technology category, wind turbine model and capacity — of the wind energy projects assessed. The five projects are anonymised into five different case studies (in the following Case studies A –D).

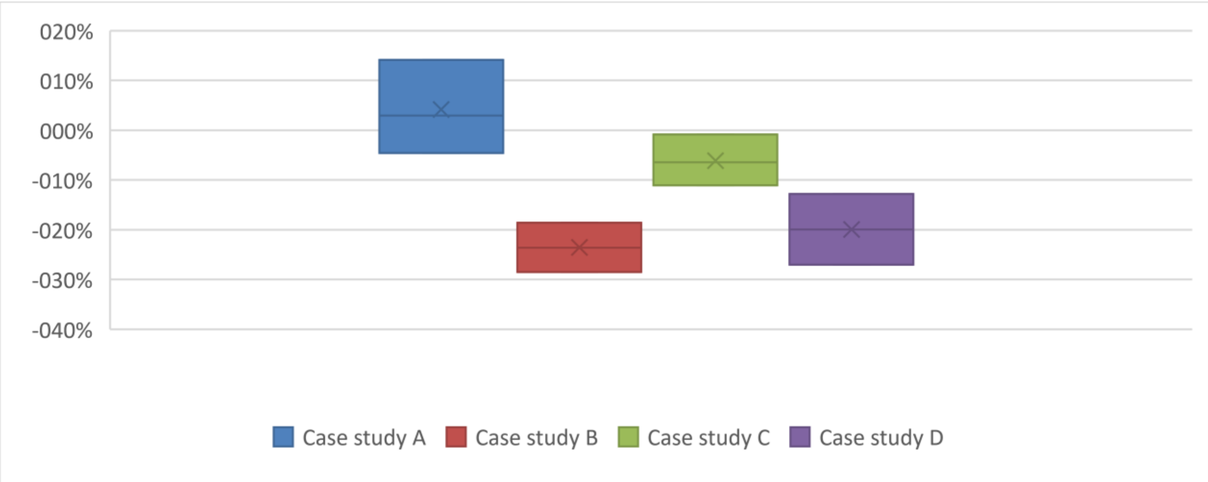
Table 2 Technology characteristics of NER 300 wind energy projects that have submitted relevant knowledge until 2021

Project	Country	Technology category	Wind turbine model	Capacity (MW)
Windpark Handalm	Austria	Onshore Wind	3MW Enercon E-82 E4	39
Nordsee One	Germany	Offshore Wind	6.2MW126 Senvion	334.8
Veja Mate Offshore	Germany	Offshore Wind	6MW Siemens SWT-6.0-154	402
Vertimed	France	Offshore Wind (Floating)	8.4MW SGRE 8MW-154	25.2
WindFloat Atlantic	Portugal	Offshore Wind (Floating)	8.4MW MHI Vestas V164	25.2

Continuing, we are presenting information, through indicators concerning the electricity generation and the maintenance of projects. **Figure 10** shows the electricity deviation levels of the case studies compared to the expected results.

In the first years of reporting, projects showed sometimes a strong deviation from the expected electricity generation for the respective years. A common reason seems to be low wind speeds in these years, particularly in the summer months. Moreover unplanned outages (e.g. by electricity transmission system operator (TSO)) due to component failure or curtailment issues were reported. The levels of deviation from expected electricity generation are ranging from +2.1% to -30% in the cases assessed.

Figure 10 Deviation from expected electricity generation in NER300 projects, reporting until 2021



Source: JRC, 2022.

Maintenance is a crucial activity in the wind energy projects. Each project has a different method and level of detail in reporting maintenance, depending on the monitoring system used and the turbine model. In specific cases all information comes in much aggregated form, from the turbine manufacturer performing the service, and in other cases there is a better level of detail.

Figure 11shows the reported maintenance categories and the aggregated/clustered categories to allow a simplified comparison. We clustered the reported maintenance categories in two main categories

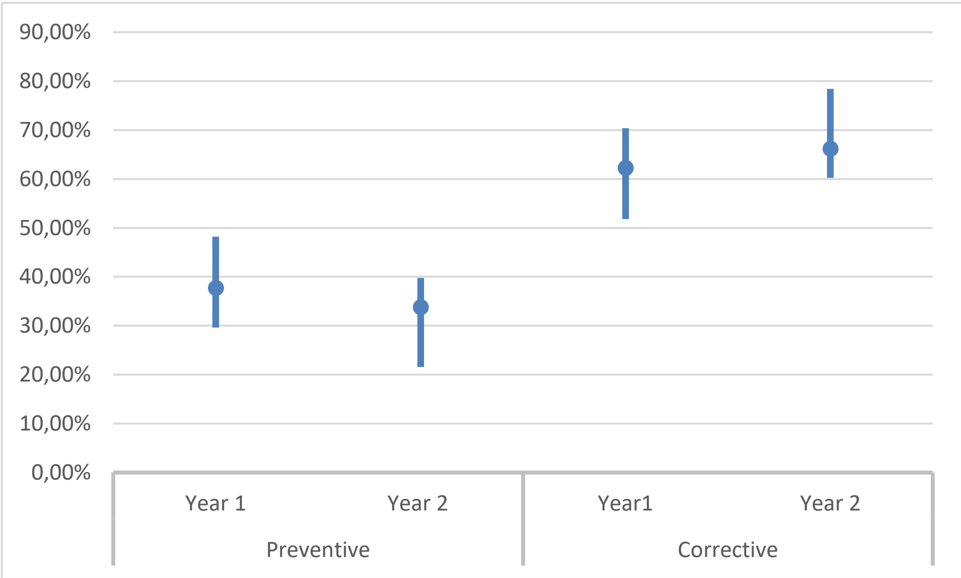
- Corrective and
- Preventive Maintenance.

In corrective maintenance, we find planned and unplanned actions. These focus mostly on repairs, faults and replacements. Inspections take place in the planned corrective maintenance actions.

The work performed in preventive maintenance mostly focuses on improving the maintenance, operating work and services.

The different case studies allow to compare the development of preventive and corrective onshore and offshore O&M. The distribution of maintenance between preventive and corrective maintenancein the last two consecutive years is presented in (**Figure 11**). Due to the different start dates and maturity levels of the projects, the share of preventive and corrective maintenance fluctuates.

Figure 11 Development of O&M shares in two consecutive years of reporting.



Source: JRC, 2022.

Preventive and corrective O&M shares show a wide distribution across all turbines. In 2020 the Handalm project was the only onshore project in the reporting period, and provided estimates from their turbine suppliers that remained unchanged to previous years. Thus no update of the data is provided.

Preventive and corrective O&M shares for offshore wind turbines in the previous two years of reporting averaged between 37-33% and 66-63%, respectively.

Whereas onshore project show minimal decrease (increase) in corrective (preventive) O&M shares, offshore corrective (preventive) O&M shares increased (decreased) noticeable.

Given the limited availability of reported years at this stage, no trend or learning effect in the development can be observed. However, as this year's more consolidated and aligned reporting of data provided a more granular dataset it can be expected that future submissions might show a consolidation of value in this indicator.

— Costs

In general, cost structure and absolute values of project costs are not comparable between onshore and offshore projects. Thus, given the small number of projects, a comparison between each of the two onshore and offshore projects would give limited insight in the overall development of OPEX and CAPEX costs. We, therefore, decided to present NER 300 cost data in an aggregated form and in comparison to international references.

In this section, we, first present data comparisons on onshore wind OPEX and CAPEX, followed by the corresponding offshore cost figures. This is followed by results on the observed ranges of O&M cost shares during the entire reporting period and the relative change between the first and last year in the reported O&M costs across all case studies, which might be a first indication for the relative performance, gained experience and technology learning in the period of reporting.

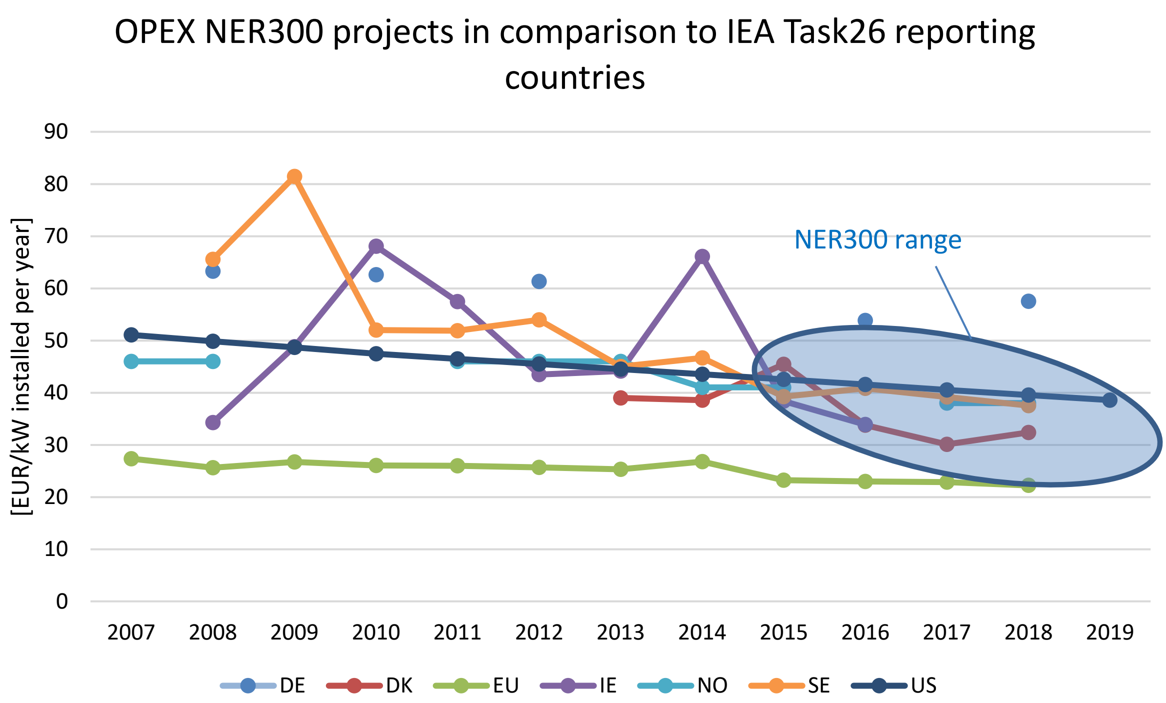
Onshore OPEX and CAPEX are compared against the cost range for onshore wind as reported by the IEA Wind Technology Cooperation Programme – Task26 'Cost of Wind Energy'[2]. **Figure 12** gives the range OPEX costs of NER 300 confirming

a) a decrease in O&M costs since the commissioning of the first project and

b) a general consensus with international data with values ranging between 30 to 50 EUR/kW installedper year since 2015.

The latter might indicate that innovations affecting the operational life cycle stage of projects in NER 300 projects contributed positively to the decrease of O&M costs over time. In 2020 no significant change in the projects' onshore OPEX reporting was observed.

Figure 12 NER 300 onshore O&M cost (OPEX) range in comparison to historic development of onshore wind OPEX (based on IEATask26)
Note: OPEX of NER 300 within the indicated range

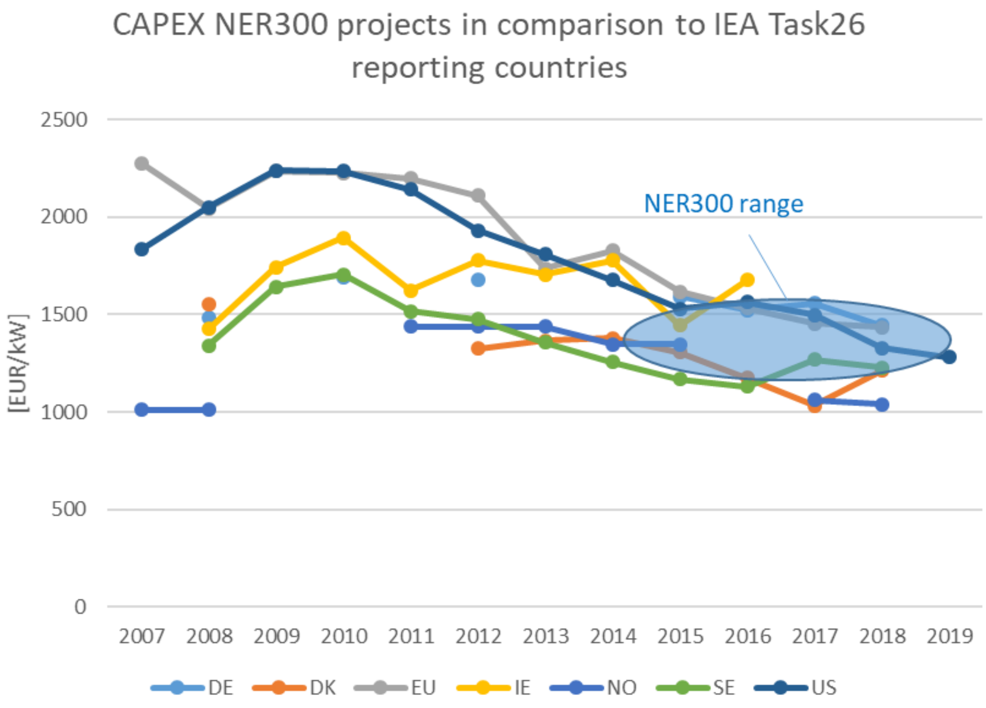


Source: JRC, 2021.

Similarly, the broadly indicated CAPEX range of the onshore NER 300 project is in line with current international estimates (see **Figure 13**).

[2] For IEATASk26 cost data please see IEA DataViewer at https://community.ieawind.org/task26/dataviewer

Figure 13 NER 300 onshore CAPEX range in comparison to historic development of onshore wind CAPEX (based on IEATask26)
Note: CAPEX of NER 300 within the indicated range



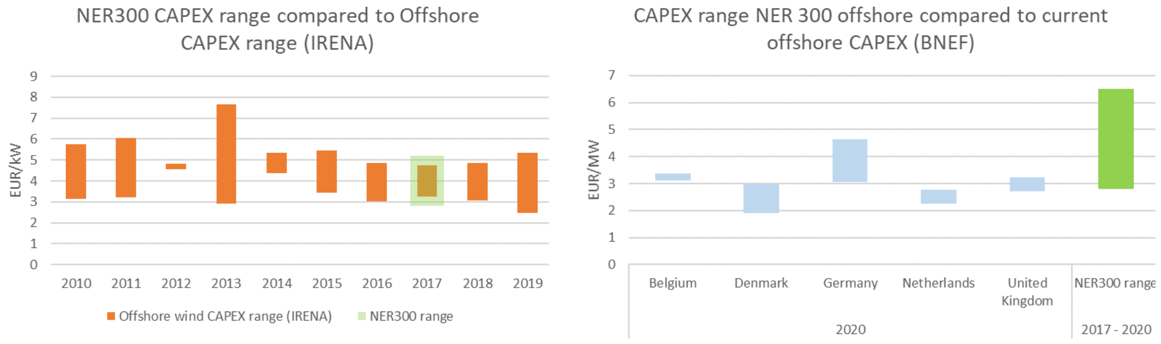
Source: JRC, 2021.

The data reported in NER 300 offshore wind projects did not allow investigating the temporal development of O&M costs (similar to **Figure 12**), given that only two years of reporting preformed at this stage. Moreover, there is some uncertainty on the system boundaries in the OPEX data provided. Current NER 300 reporting does not confirm it, yet, typical offshore O&M costs (e.g. IRENA (2020) reporting a range between 0.017 to 0.025 EUR/kW).

A comparison with sources providing the international development of offshore CAPEX confirms that the projects' innovative character can be seen as fairly representative compared to the EU or global average as the NER 300 CAPEX range of bottom-fixed projects is matching the international figures[3] [4] (see **Figure 14**, left). When adding CAPEX estimates of the NER 300 floating offshore wind projects to this range a significant rise in CAPEX can be observed given the technology's earlier stage of development (see **Figure 14**, right). In total floating offshore CAPEX of the reported projects are on average 50% higher than their bottom-fixed counterparts.

[3] IRENA (2020), Renewable Power Generation Costs in 2019, International Renewable Energy Agency, Abu Dhabi.
[4] BNEF (2020) offshore wind cost data

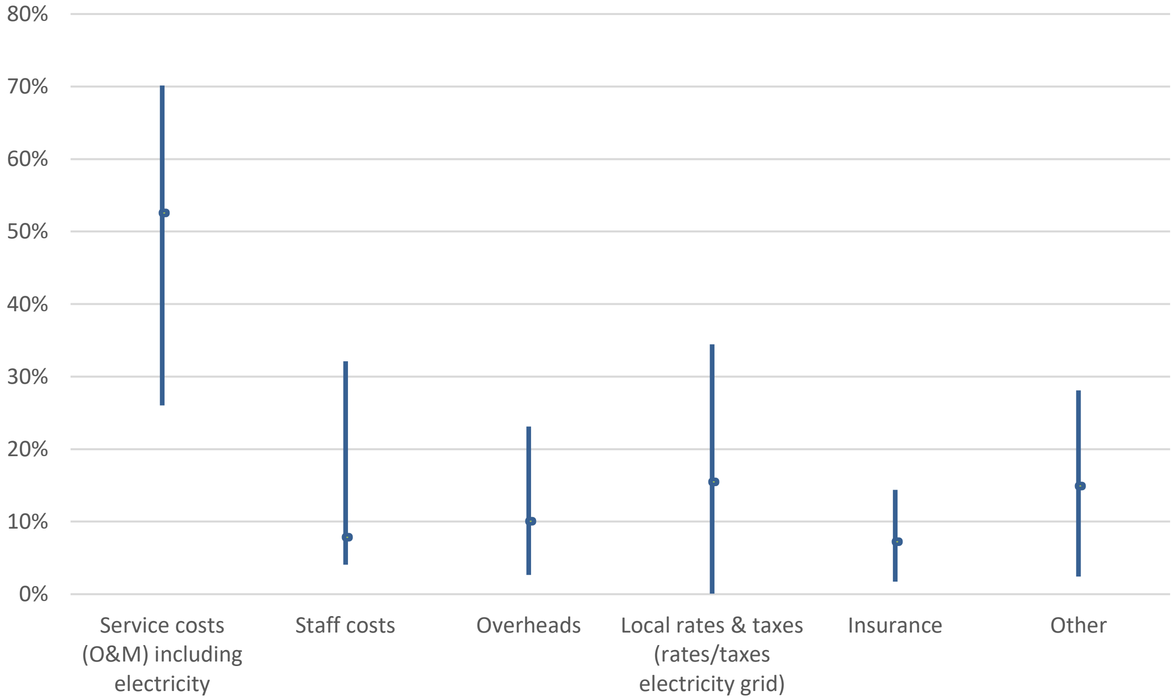
Figure 14 NER 300 bottom-fixed offshore CAPEX range in comparison to historic development (left) and current status and NER300 reporting (right, includes capex estimates of floating offshore) of offshore wind CAPEX
Note: CAPEX of NER 300 within the indicated range (but are not MIN and MAX)



Source: JRC, 2021.

In addition to the overall O&M costs, the different cost shares of O&M costs are investigated. The reported NER 300 onshore data (two projects/eight project years and updated with data from 2020) shows a rather low variation and unveils that most of the O&M onshore costs are declared as 'Service cost' ranging from 55% to 73% of the total (see **Figure 15**), a slight decrease as compared to previous years reporting.

Figure 15 Range of O&M cost shares for all case studies and reported years

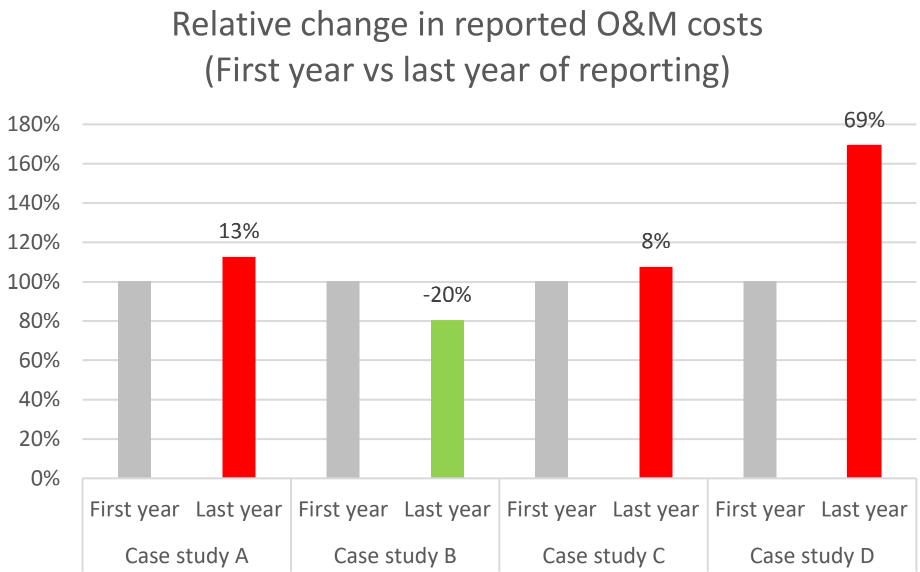


Source: JRC, 2022.

A high variation can be observed in the different reported O&M shares for the wind projects. This is particularly the case for the reported Service Costs (see **Figure 15**) ranging from 26% to 70%. In these cases it seems that the RK template is understood and filled in by the projects in very different manner.

Last, a comparison of O&M costs across all case studies with more than one year of reporting (both onshore and offshore wind) at the beginning and the end of the reporting period identifies no clear trend in O&M cost reduction (see **Figure 16**).

Figure 16 Relative change in reported O&M costs comparing first and last year of reporting



Source: JRC, 2022.

— Project management

The most common element in the aggregated shared knowledge analysis that we performed is early engagement of projects in almost all areas concerning project management.

One of the highlights is the continuous communication and early involvement dialogue with the authorities and stakeholders involved. These include financing institutions and advisers, insurance advisers & brokers, direct marketing companies and grid providers/TSOs.

In more detail, the continuous communication with stakeholders and key lessons learnt include the following aggregated elements:

- Good planning at an early stage in the investigation of several alternative designs of the project is one of the key factors for a successful project.
- Oversight of technical and contractual interfaces.
- Ensuring that resources are available during the project and that technical specialists are available during the first years of operation.
- Engagement and employment of experienced personnel for drafting contractual scope and for operation.
- Limitation of the number of contractors as much as possible and clear definition of contractual responsibilities.
- Continuous attention and readiness to adopt to innovative/new-to-market technologies.
- Use of risk management tools.
- Digitalisation of processes.
- Communication with wind turbine manufacturers as this will be crucial for the wind park operation and fulfilment of requirements to the grid provider.
- Preparation for curtailment recording and compensation calculation; special attention should be paid to the communication with the grid provider.
- Provision of information to all parties involved in the project and operation on the measures promised in the environmental permit.
- Ensure a proper understanding of the project within the local population at an early stage (e.g. project launch in 2010).

- Identify the public opinion leaders and establish the needed level of cooperation and confidence with these local representatives (e.g. for the offshore case: the key local political leaders, the local environmental players, the fishermen, the neighbouring communities, the local councils as well as representatives of the local industries and unions).
- Constant project coordination meetings maintaining everyone up to date (especially when many team members are assigned in the premises of the suppliers).
- The physical presence of the project team members in fabrication yards, installation harbours, on board of the installation vessels also brought the advantages of the owner's presence and not only a "client representative".
- Having had a multi-contract approach again brought much more learning points than awarding supplies under big turnkey contracts.

Overall, there is extensive knowledge and experience gathered on a project management level by the projects. The above lessons learnt and knowledge gathered provide a useful guidance to future innovative wind energy and other renewable energy projects.

Moreover project management was confronted in 2020 with restrictions originating from the COVID-19 pandemic. The projects implemented different mitigation measures and activities in this respect targeting different elements of their operations. Among others these aggregated elements and measures were reported:

- Ensuring distance rules, a disinfection concept and regulations which and how many employees are on duty at which time and location in order to reduce the infection risk for employees, contractors and related third parties.
- Donation campaigns in relation to COVID-19 targeting social and environmental dimensions.
- Creation of hygiene guidelines and in coordination with the local Health authorities.
- Set up of a COVID-19 Management Response Team.
- Single accommodation was provided to technicians. Employees have been asked to work from home if possible (e.g. office staff did most of their work from home in the second half of 2020).
- A health declaration must be submitted at the earliest 4 days, but at the latest 48 hours before arrival at offshore sites.
- Several contacts are in place to take PCR or Quick Tests if required.
- Additional Crew Transfer Vessel has been chartered to avoid that people are sitting to close to each other. Implemented the use of FFP2 Masks on the vessels.
- A contract with a cleaning company was concluded to disinfect the offices, sanitary rooms, vessels, or materials if required.
- The corona pandemic in particular has shown how important digital strategies are in order to develop and expand future-oriented and agile communication and business processes, so that the position of a "digital transformation lead" was established.

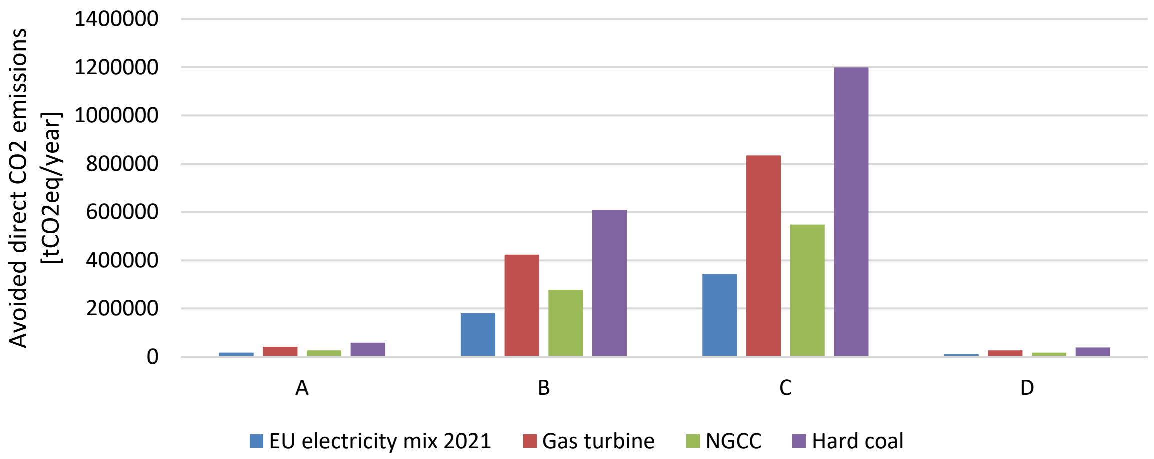
Projects in construction or coming online since 2020 faced some difficulties as a consequence of COVID-19, leading to delays in planning and maintenance activities.

- Environmental Impact

All wind energy projects are reducing the amount of CO_2 eq. emissions when compared to the mean production by the energy system today. **Figure 17** compares the avoided CO2eq. emissions against different direct CO2 emission factors (EU27 electricity mix, gas turbine, natural gas combined cycle and hard coal). Depending on the project size of the NER300 project a CO2eq emission avoidance between 12 Mtons CO_2 eq. /year and 341 Mtons CO_2 eq. /year is achieved when assuming the emission factor of the EU27 electricity mix in 2021 (EEA, 2022)[5] as a reference and the respective NER300 project's electricity generation.

[5] (EEA,2022) https://www.eea.europa.eu/ims/greenhouse-gas-emission-intensity-of-1

Figure 17 Yearly direct CO2eq emission avoidance of NER 300 projects as compared to the emission intensity of the EU27 electricity mix, a gas turbine, a natural gas combined cycle plant and a hard coal power plant
Note: This assumes the last year of electricity generation of the NER300 projects



Source: JRC, 2022.

Regarding the rest of environmental issues — visual impact on the landscape, noise, impact on cultural heritage, impact on designated ecological and environmental receptors and especially birdlife — all projects perform environmental assessments and have advanced awareness that develops through their years into operation.

The measures to reduce environmental impacts include the minimisation of transport to the project areas – especially because they are in the operation phase - technical equipment for bird protection (bird radars) and environmental investigations (offshore maritime flora and fauna), turbine shut down measures, meetings with local authorities for impacts on cultural heritage and underwater noise monitoring. On top of that, projects are using Life Cycle Assessment tools and investigations to forecast the lifecycle environmental impacts of the respective ecosystems where the projects are located.

There are no incidents where the environmental impact of these projects has been a serious cause for concern. It is highlighted, however, that the environmental assessments are a useful tool together with the continuous monitoring by Member States.

— Health and safety

Projects provided an update of all health and safety incidents. Aside from minor incidents no major health and safety incidents or near misses are being reported by the projects. Due to the degree of innovation and the numerous preventive and corrective maintenance events, there is a close observation of health and safety issues of the personnel. It is also generally agreed that the employees of such projects should be highly skilled.

5 Conclusions

Overall, the Knowledge Sharing communication, submission process and technical assessment developed on time and effectively. This is true for the majority of the projects that have prior experience with this exercise.

In 2022, nine projects submitted relevant knowledge for the operating year 2021. Five of these projects are Wind Energy projects, two projects submitted in Bioenergy and one each in CSP and DRM domains.

The assessment of the Knowledge Sharing Reports submissions was performed by the JRC from February 2022 to May 2022.

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In all projects assessed, the technical set up and performance does not deviate significantly from the initial proposals. Here, we studied and showed mostly the energy production of these innovative projects and possible deviation from initial plans. This information helps to understand issues on maintenance — preventive and corrective —, weather conditions and their effects on renewable energy production and possible measures to tackle them.

When it comes to costs, in the wind energy group of projects we were able to understand the main composition and shares of preventive and corrective maintenance as well as the temporal development of O&M costs (OPEX) over the first years of operation of the NER 300 wind projects. Moreover, we were able to benchmark the projects OPEX and CAPEX as compared to the international development of onshore and offshore wind costs. Given the small subset of data, no final conclusion can be made on the potential downward trend of OPEX costs over project lifetime or the development of maintenance categories over time.

According to the reports received, project management plays a vital role for the construction, commissioning and operation of the projects. The information received and assessed highlighted two main lessons learnt. The first one refers to the continuous communication and early involvement dialogue with the authorities and stakeholders involved. Among the key points, a strong time and quality management, especially during planning and construction, is referred to. The second key lesson is communication and proper arrangement early on with all key players, including experienced employees, contractors and project and technical experts. Overall, there is extensive knowledge and experience gathered on a project management level by the projects.

Another aspect covered by this year's project management section refers to the measures implemented in response to the COVID-19 pandemic. The projects implemented different mitigation measures and activities in this respect, targeting different elements of their operations. Projects in the wind energy domain implemented guidelines to address hygienic standards (ensuring distance rules, disinfection concepts, supply of PCR or Quick Tests, and additional Crew Transfer Vessels (offshore)) and set up COVID-19 response teams ensuring an uninterrupted operation of the projects. Projects in construction or coming online in 2020 and 2021 faced some difficulties as a consequence of COVID-19.

On the environmental impact assessment, we found that all projects are reducing the amount of CO_2 eq. emissions when compared to the mean production by the energy system today. Moreover, all projects perform environmental assessments and have advanced awareness on the topic.

Last, when it comes to health and safety, no major accidents or near misses were reported. For those that occurred, proper measures were taken. These include reassessments of the project setup and training of employees.

The NER 300 projects assessed this year provide valuable information for their continuation and the application of this information to future innovative projects entering the energy market. Here, we demonstrate that even with a small number of projects and scarcity of statistically significant information, when these are assessed over time and the Knowledge Sharing process is functional, results can be aggregated and the knowledge can be shared with the wider community.

List of figures

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List of acronyms

CAPEX: Capital Expenditure

CCS: Carbon Capture and Storage

CSP: Concentrated Solar Power

CSPc: tower system using superheated steam cycle, either multi-tower or combination linear collectors – tower with nominal capacity 50MWe

DRMa: renewable energy management and optimisation for small and medium scale Distributed Generators in rural environment with predominant solar generation: [20MWe] on Low Voltage (LV) network + 50 MW on Medium Voltage (MV) network

DG CLIMA: Directorate-General for Climate Action

EU ETS: European Union Emissions trading system

JRC: Joint Research Centre

KS: Knowledge Sharing

OLTC: On Load Tap Charger

OPEX: Operating Expenditure

O&M: Operation and Maintenance

PAN: Puglia Active Network

RES: Renewable Energy Sources

RK: Relevant Knowledge

WINa: off-shore wind - minimum turbines size 6 MWe - with nominal capacity 40 MWe

WINd: floating off-shore wind systems with nominal capacity 25 MWe

WINe: on-shore wind turbines optimised for complex terrains - e.g. forested terrains, mountainous areas - with nominal capacity 25 MWe

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