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European Scalable Offshore Renewable Energy Sources

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Executive Summary

This deliverable D7.11 aims to provide a public audience with insight into how design decisions throughout the lifetime of a project may be made, using optimisation to identify the highest performing project combinations and quantifying these with key financial metrics.

This deliverable investigates a wind energy park, Romagna 1, off the coast of Italy and the added value that integrating an offshore solar farm can bring. The high-level project information is publicly available and the farm is currently in planning by the consortium[1] Saipem, Agnes srl., and Qint'x srl. There are further plans[2] to expand the site in phases with more wind turbines (400MW), 100MWp solar farm, and storage (50MW).

This deliverable will build a baseline for the offshore wind farm based on the public information found and backfill gaps with other public sources to calculate a first pass of the financial Key performance Indicators identified in D7.10, Levelised Cost of Electricity, Internal Rate of Return, Net Present Value, and Payback period.

Two scenarios are then investigated to see whether the financial Key Performance Indicators of the baseline case of 200MW can be optimised. Firstly, adding more wind turbines (overplanting) and secondly, by adding a 100MWp offshore solar farm. Both scenarios assume no increase in size of the export cable from the baseline. In other words, can more power be produced without negatively impacting on the financial KPIs.

Some technical project information will also be included to better understand the potential yield output and capacity factor of the energy park, and to provide a high-level breakdown of bill of materials.

Outside of the scope of this deliverable is the optimisation of energy input from solar and wind and park layout(s). However, some high-level yield analysis has been conducted to understand the value add of offshore solar at this particular site as opposed to overplanting of wind turbines.

The key conclusion from the analysis of the Romagna 1 baseline is that there is more value in the addition of offshore solar, due to seasonal complementarity than overplanting with a few extra wind turbines.

[1] https://www.4coffshore.com/windfarms/italy/romagna-1-italy-it42.html

[2] https://www.interregeurope.eu/green-hydra/news-and-events/news/an-important-energy-project-in-ravenna-progressed

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Abbreviations

CAPEX	Capital Expenditure
DECEX	Decommissioning Expenditure
DEVEX	Development Expenditure
IRR	Internal Rate of Return
LCOE	Levelised Cost of Electricity
OPEX	Operational Expenditure
NPV	Net Present Value
ROI	Return on Investment
WACC	Weighted Average Cost of Capital

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Contents

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1. Introduction

The objective of this deliverable D7.11 is to give insight into how optimising a project for the highest performing combinations, can be quantified with financial key performance indicators[3] (KPIs), thus enabling design decisions throughout the project lifetime.

This deliverable will investigate a wind farm project as the baseline, with technical inputs including the wind turbine and wind resource, cost inputs of capital and operational expenditure, and financial inputs of revenue, discount rate, and debt equity. Results will be LCOE, IRR and NPV.

Two different scenarios will be explored to see whether more power can be produced without negatively impacting the financial KPIs. Firstly, overplanting with additional turbines and secondly adding a 100MWp offshore solar farm.

2. Methodology

The methodology used in this report follows a number of steps:

1. **Collect publicly available information on the Baseline**

This deliverable uses a real project in planning for the baseline wind farm project. Only limited information is publicly available regarding this project. Other publicly available sources, information and expert knowledge have been used to collect the relevant information needed to build the baseline.

- Wind resource: the New European Wind Atlas[4] is used
- Turbine power curve: In-house power output calculation tool is used, which can be adjusted for different blade diameters.

2. **Build the Baseline**

To build the baseline, the by Exceedence owned financial digital twin software, Exfin[5] is used. The inputs required to calculate the financial KPIs are:

- Lifetime
- Technical inputs: farm size, number of turbines, wind resource, wind turbine power curve
- Cost inputs: capital, operational, decommissioning expenditures
- Financial inputs: revenue, discount rate, inflation, debt/equity and interest rate
- Results: Levelised Cost of Electricity (LCOE), Internal Rate of Return (IRR), Net Present Value (NPV), Payback period

[3] EU-SCORES, 2025. D7.10 Analysis of financial KPIs for future systems and scenarios_V2_17.04.2025
[4] https://map.neweuropeanwindatlas.eu/
[5] https://exfinsoftware.com/

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3. Optimise for Scenario 1: overplanting

Adjust the baseline inputs accordingly to allow for more wind turbines, however, the export cable size is not adjusted and remains the same as for baseline at 200MW.

4. Optimise for Scenario 2: adding 100MWp offshore solar

Adjust the baseline inputs accordingly to allow for 100MWp offshore solar, however, the export cable size in not adjusted and remains the same as for baseline at 200MW. The relevant technical, cost, and financial information needs to also be collected for offshore solar from publicly available sources.

- Offshore solar resource and calculated yield: Global Solar Atlas[6]
- Combine[7] the wind and offshore solar in Exfin: Since the underlying technical and financial inputs are different, two separate financial models are built. Once the individual cashflows are available, these are combined to generate 'combined KPIs'.

5. Compare the financial KPIs

Compare financial KPIs side by side for the baseline, the overplanting scenario, and the scenario with wind/offshore solar, to determine the best project combination.

3. Baseline wind farm project

3.1 Romagna 1 Project

The Romagna 1 project[8], is a planned 200MW fixed offshore wind farm approximately 22km off the coast of the Emilia Romagna region, Italy. It is currently at permitting stage, and is being developed by the consortium Saipmen, Agnes srl., Qint'x srl., who each own a 33.33% stake.

The wind farm will span an area of 85km^2 and be interconnected with a 66kV inter-array cable. Furthermore, it will consist of 25 x 8MW wind turbines, each with a height of 170 meters, and a rotor diameter of 260 meters.

It is expected to be commercially operational in 2029.

There are further plans[9] to expand the site in phases with more wind turbines (400MW), 100MWp solar farm, and storage (50MW).

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[6] https://globalsolaratlas.info/map?c=11.523088,8.173828,3

[7] EU-SCORES, 2025. D7.8 Report and case studies from use of SCORES Financial Analysis Platform_V2_11.04.2025

[8] https://www.power-technology.com/data-insights/power-plant-profile-romagna-1-offshore-wind-project-italy/

[9] https://www.interregeurope.eu/green-hydra/news-and-events/news/an-important-energy-project-in-ravenna-progressed

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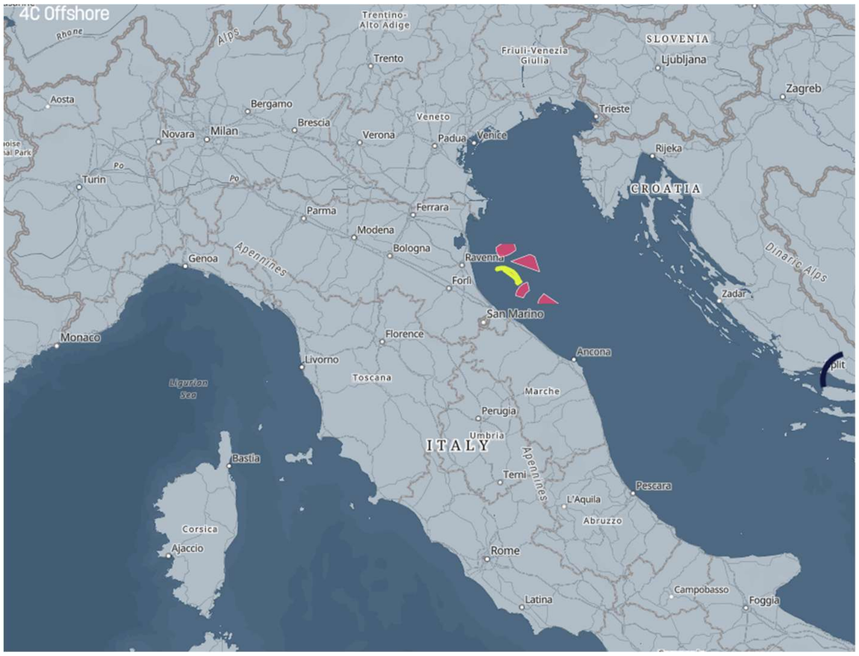

Figure 1: Location[10] of Romagna 1 200MW wind farm off the coast of Italy.

Figure 2: Key information[11] on *Romagna 1*

3.2 Wind Resource & yield calculation

From the New European Wind Atlas[12], 10 years of open-source wind data (2012-2022) was downloaded and aggregated into an average wind histogram, shown in Figure 4. The average windspeed for the location is approximately 6m/s. In Figure 5 the average wind speed is shown per month, to highlight potential seasonality of the wind resource.

[10] https://map.4coffshore.com/offshorewind/default.aspx?lat=44.339&lon=12.784&wfid=IT42
[11] https://www.agnespower.com/en/eolico-offshore-adriatico/
[12] https://map.neweuropeanwindatlas.eu/

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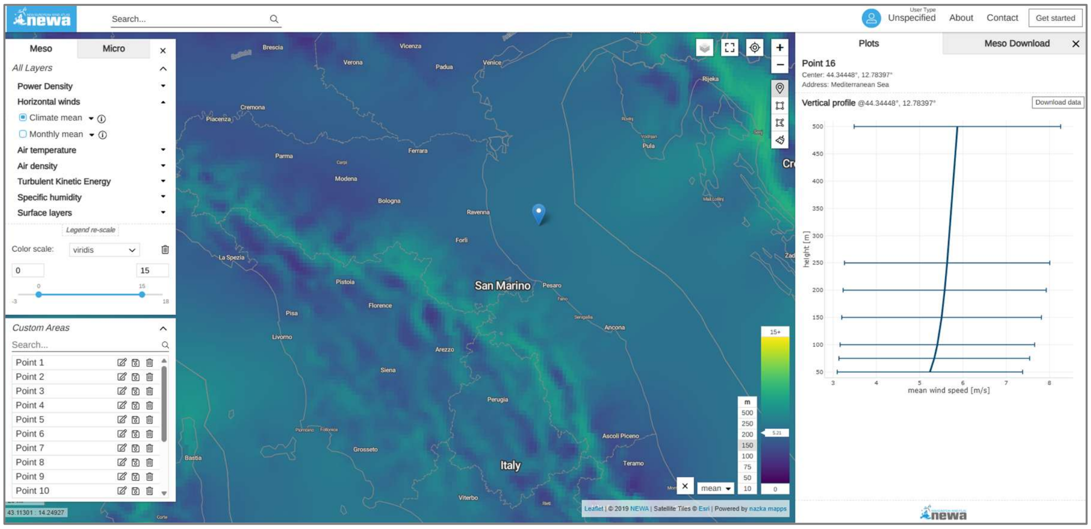

Figure 3: Point location for 10 years of wind data from New European Wind Atlas

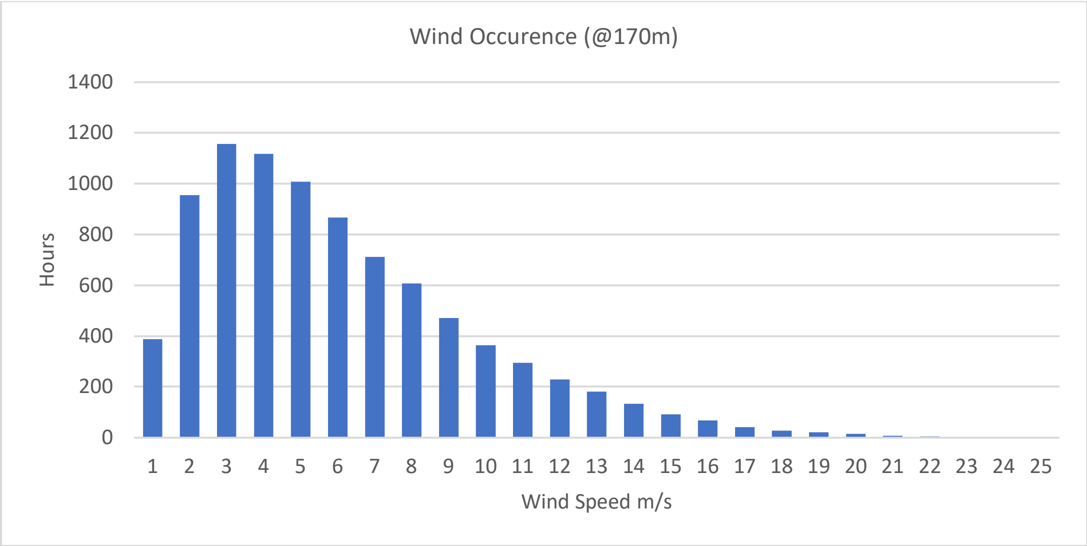

Figure 4: Wind histogram for the 10-year average 2012-2022, at 170m height

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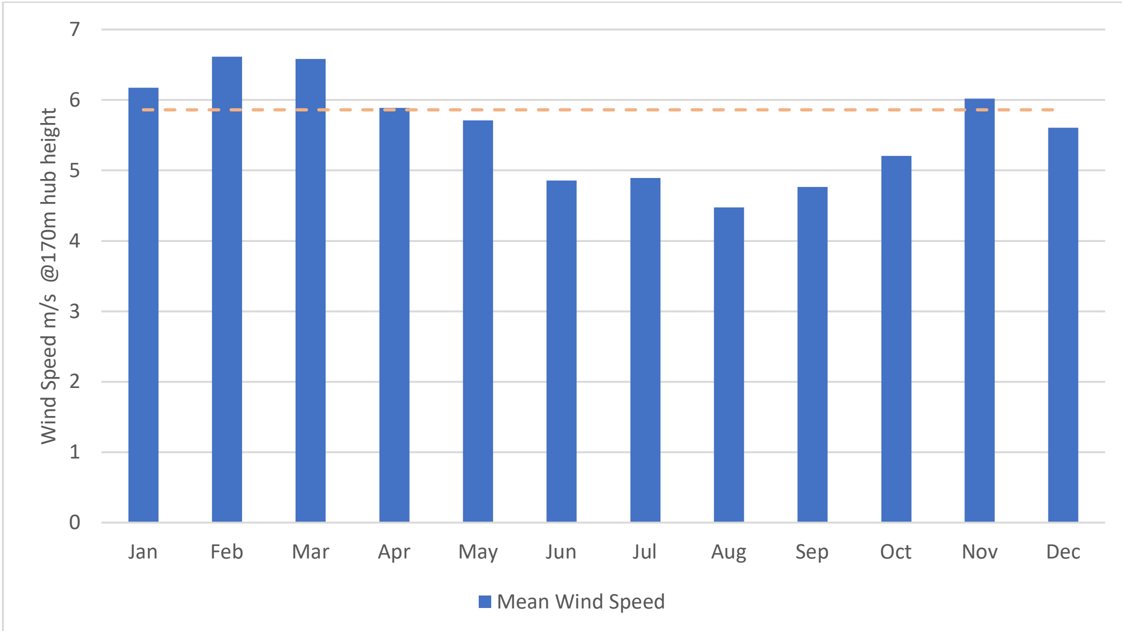

Figure 5: Monthly average wind speed for 10-year average 2012-2022, at *170m* height

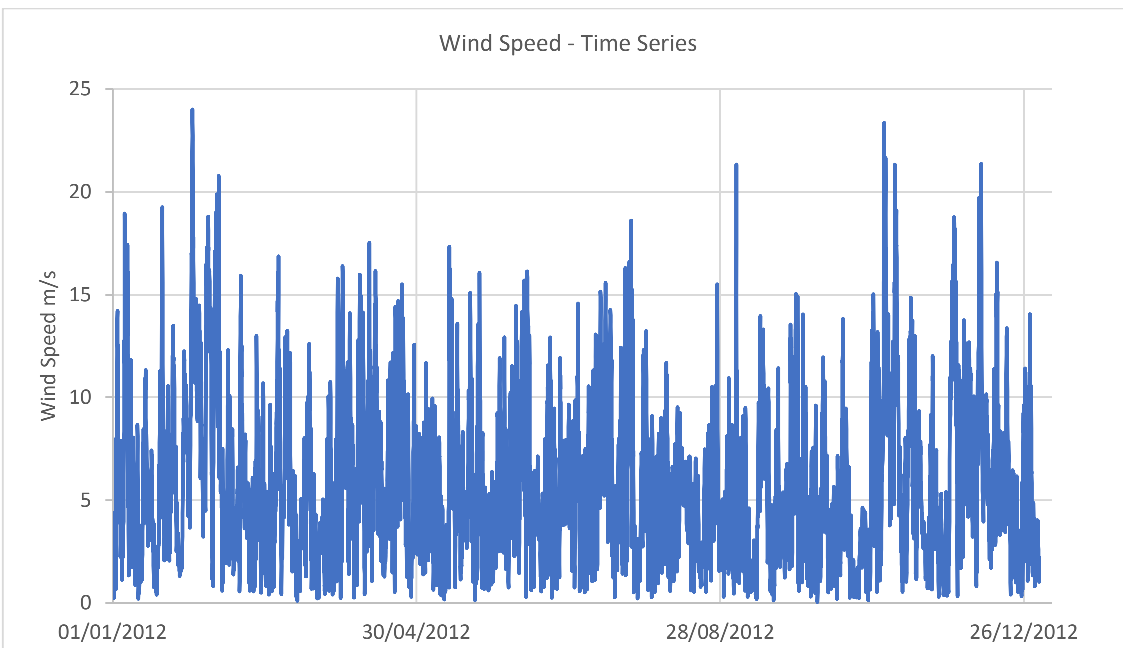

Figure 6: Wind speed for year 2012 in time series

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The wind turbine of 8MW, 170m hub height and a rotor diameter of 260m, does not exist in the public domain. The wind turbine commissioned for Romagna 1 is likely bespoke to maximise the electricity production from the lower wind speed profile in the region. The power curve in Figure 7 has been generated by Exceedence and shows the estimated profile for the 8MW wind turbine with a rotor diameter of 260m.

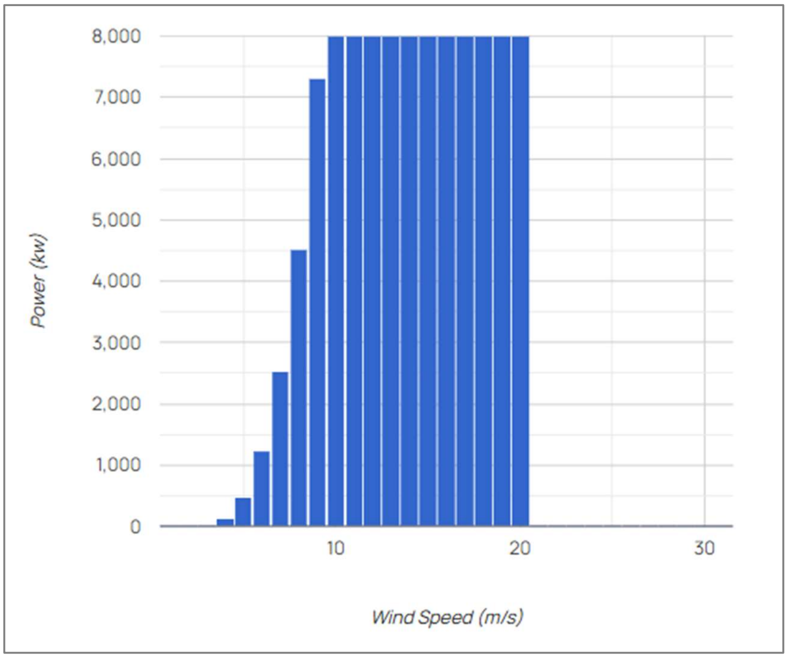

Figure 7: Generated by Exceedence - Estimated power curve for the 8MW and 260m rotor diameter

Yield calculation using Exfin

Importing both power curve and resource to Exfin, the digital twin software can now calculate the Annual Energy Production (AEP), or gross yield, for the 200MW wind farm. The AEP is 580,367MWh annual. Applying a 95% availability calculates the Annual Energy Capture (AEC) to 551,349MWh as well as the Capacity Factor to 33.4%. The Annual Delivered Energy (ADE) is calculated to 534,808MWh as the final step, which also includes a 3% transmission loss. The ADE is the electricity that can be sold to the grid. This calculates to approximately 2,674 MWh/MW/year.

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Table 1: Technical input for the Romagna 1 baseline

Farm size (wind)	200MW
Wind Turbine size	8MW
# of wind turbines	25
Annual Energy Production (AEP)	580,367MWh
Availability	95%
Annual Energy Capture (AEC)	551,349MWh
Capacity Factor	33.4%
Transmission loss	3%
ADE	534,808MWh

3.3 Financial Project Inputs Wind

Now that the yield has been calculated, the lifetime, cost inputs, and expected revenue and discount rate can be added to the financial model to estimate a first pass of levelised cost of electricity (LCOE), internal rate of return (IRR), net present value (NPV) and payback period.

Lifetime of between 25 to 30 years for fixed offshore wind is currently used. For Romagna 1 baseline, 30 years is used.

Total capital expenditure (CAPEX) for a fixed offshore wind turbine in Italy[13] is currently estimated to 3.3M€/MW. However, the ORE Catapult[14] Guide to an offshore wind farm, estimates a total CAPEX of 2.38M£/MW or approximately 2.8M€/MW for a project with Financial Investment Decision in 2027, and First operation date in 2030. Since the real Romagna 1 Project is currently on track for operation in 2029, it aligns well with the dates estimated from the ORE Catapult. Therefore, the Romagna 1 Baseline in this report uses the lower CAPEX estimate of 2.8M€/MW. Whilst the 2.8M€/MW figure is associated with larger turbines, with a lower cost per MW, this CAPEX amount is still deemed appropriate for likely market conditions. The listed sub categories have been rounded to the nearest whole number.

Total annual operational expenditure (OPEX) is estimated by ORE Catapult[14] to 85,000£/MW, for a farm at 50m water depth and 75km to shore/grid/port. Peak Wind[15] estimate 41,000€/MW annual OPEX as the best performers, 61,000€/MW for the norm, and 82,000€/MW for challenging sites. Since Romagna 1 is 12km offshore, it is likely that the OPEX cost will be towards the lower end of the cost range, and therefore the estimate of 41,000€/MW is used.

Decommissioning cost is taken from ORE Catapult[14] estimated at 426,000£/MW, which is approximately 500,000€/MW.

[13] https://ionanalytics.com/insights/infralogic/italy-plots-floating-offshore-wind-boom/
[14] https://guidetoanoffshorewindfarm.com/wind-farm-costs
[15] https://peak-wind.com/update-2022-opex-benchmark-an-insight-into-the-operational-expenditures-of-european-offshore-wind-farms/

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For **revenue**, Italy has set a maximum cap of 185€/MWh[16] on offshore wind generation both fixed and floating for 25 years. However, the actual feed-in tariff will depend on the actual bidding price. Green Giraffe[17] have investigated similar auctions for fixed offshore wind farms in the UK in Allocation Round 6 (AR6) was ~100€/MWh and in France where the strike price was ~86€/MWh in France, with an auction cap of 140€/MWh. **Revenue is linked to IRR,** and according to Wood Mackenzie[18], offshore wind companies are quoting a need to achieve between 8 and 12% IRR. To achieve this target, a revenue of 105€/MWh is used for the first 25 years.

The eventual strike price will depend on the **discount rate** or weighted average cost of capital (WACC). In this deliverable, these terms are used interchangeably. The discount rate reflects industry risk, competition, and the companies' cost of capital, where WACC takes into account both debt and equity financing. One public source was found for WACC across Italy. Aurora ER[19] conduct sensitivity analysis on LCOE with WACC ranging between 7 and 11% for offshore wind farms around the Italian coast, highlighting that a 7% WACC provides significant LCOE reductions over time. To reflect this more optimistic yet still feasible scenario, in this report for the Romagna 1 baseline, a 7% WACC is used.

16 https://www.wfw.com/articles/italys-new-fer-2-decree-focusses-on-the-incentives-for-offshore-wind-projects/
17 https://green-giraffe.com/publication/blog-post/is-fer-2-the-beginning-of-the-offshore-wind-era-in-italy/
18 https://www.woodmac.com/news/opinion/how-big-oil-is-set-to-transform-the-offshore-wind-sector/
19 https://auroraer.com/wp-content/uploads/2023/01/The-Future-of-Offshore-Wind-in-Italy-Will-It-Sink-or-Flo%D0%B0t.pdf

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Table 2: Project inputs to financial model

Lifetime	**30 years**
CAPEX	**2,800,000€/MW**
Dev &PM	140,000€/MW
Wind Turbine Generator	1,085,000€/MW
Export Cable	240,000€/MW
Offshore Substation	215,000€/MW
Onshore Substation	40,000€/MW
Balance of Plant (rest)	490,000€/MW
Export Cable installation onshore	8,000€/MW
Offshore Substation installation	40,000€/MW
Onshore Substation installation	27,000€/MW
Installation and Commissioning (rest)	515,000€/MW
OPEX	**41,000€/MW/year**
Decommissioning	**500,000€/MW**
Revenue / FiT	**105€/MWh**
WACC	**7%**
Escalation on OPEX	**2%**
Debt/Equity	**80/20**
Loan term	**20 years**
Interest Rate	**5%**

3.4 Resulting KPIs for Baseline

LCOE for offshore wind in Italy has the highest average with 92€/MWh as compared to other European markets with 72€/MWh, according to Aegir[20]. This is largely due to the relatively low average wind speeds of 7.4m/s. Romagna 1 was found to have average wind speeds of 6m/s, which likely means that the LCOE will also be slightly higher. With the technical and financial inputs discussed previously, the LCOE is calculated to approximately 94€/MWh for the Romagna 1 Baseline, as shown in

IRR is dependent on the revenue. As discussed in the previous chapter, on the one hand, the Italian government has set a maximum cap of 185€/MWh, but it is a competitive bid. On the other hand, in general, developers are targeting approximately 8-12%.

The resulting KPIs for the Romagna 1 baseline are shown in Table 3.

[20] https://www.rivieramm.com/news-content-hub/news-content-hub/aegir-urges-caution-as-developers-target-italian-offshore-wind-opportunities-68945

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Table 3: Resulting KPIs for the Romagna 1 baseline

LCOE	94.2€/MWh
IRR	10.8%
NPV	49,486,029 €
Payback period (simple)	10 years
Payback period (discounted)	18 years

4. Scenario 1: overplanting with additional wind turbines

This scenario is a high-level analysis of whether there is benefit to overplanting, whilst keeping the export cable limit of 200MW. This scenario will be used to compare against the baseline as well as the second scenario (chapter 5) which investigates a wind/offshore solar combination.

The analysis is conducted by adding 1, 2, 3, 6 and 12 additional 8MW turbines, with both the unconstrained and constrained additional power output shown in Figure 7. As can be seen, by adding 1-2 extra turbines approximately half the additional power is constrained. From 3 turbines onwards the percentage constrained becomes much larger, and in reality, the most probably course of action would be to resize the export cable.

For the purpose of this scenario, the financial inputs from the baseline have been adjusted for the addition of 1, 2, 3 and 6 turbines. All the costs within the baseline have been adjusted linearly on a €/MW and €/MWh basis, expect for the cost of the export cable which has been kept the same as for the baseline. The total top level technical and financial inputs, as well as resulting KPIs are shown in Table 4.

The resulting KPIs show there is diminishing value in overplanting beyond a few additional turbines, without further optimisation to the overall project inputs.

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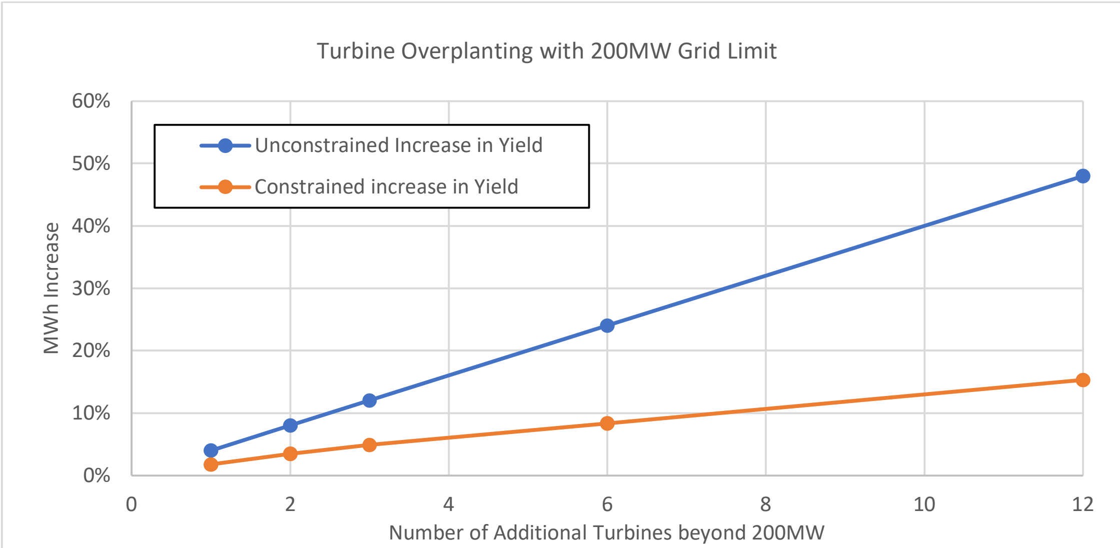

Figure 7: Benefits of additional wind turbines, while maintaining the 200MW export cable (overplanting) diminishes as numbers increase

Table 4: Comparison between the Baseline and three and six additional turbines

	Baseline	+1 turbines	+2 turbines	+3 turbines	+6 turbines
Farm size	200MW	208MW	216MW	224MW	248MW
ADE* MWh	534,808MWh	∩ 2%	∩ 3%	∩ 5%	∩ 8%
Constrained MWh	-	2%	5%	7%	16%
Total CAPEX	560M€	∩ 4%	∩ 7%	∩ 11%	∩ 22%
Annual Total OPEX	8.2M€	∩ 4%	∩ 8%	∩ 12%	∩ 24%
Total Decom	100M€	∩ 4%	∩ 8%	∩ 12%	∩ 24%
Avg Annual Revenue	51.2M€	∩ 2%	∩ 3%	∩ 5%	∩ 8%
LCOE	**94.2€/MWh**	**95.8€/MWh**	**98.3€/MWh**	**99.7€/MWh**	**106.7€/MWh**
IRR	**10.8%**	**9.9%**	**8.7%**	**7.9%**	**4.5%**
NPV	**49.5M€**	**39.7M€**	**23.1M€**	**13.3M€**	**-36.4M€**
Payback (simple)	**10 years**	**11**	**13**	**14**	**21**
Payback (discounted)	**18 years**	**21**	**22**	**23**	**N/A**

*includes availability 95%, and transmission losses 3%

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5. Scenario 2: adding 100MWp offshore solar

5.1 Combining wind and offshore solar yield

This scenario investigates the addition of 100MWp offshore solar to the baseline 200MW wind farm. The resulting KPIs from this scenario will then be compared to the baseline and scenario 1: overplanting.

Using the Global Solar Atlas[21] and the JRC Photovoltaic GIS[22], the user can calculate the power output using the resource and the generic PV panels provided along with any losses. Including 14% losses, **the net annual energy capture (AEC) from the offshore solar panels provides 101,991MWh annually** (before transmission loss).

System losses of 14% are the recommended default value from the JRC system accounting for cable losses, inverter losses and panel contamination. Export cable losses are not included in this figure and are taken account of additionally. In this study the focus is to combine the power from wind and PV at an offshore connection point and transmit the combine power through the export cable. This figure of 14% corresponds the common industry view of 13%-15% for utility scale.[23]

The PV system was set with panel slope of 10 degrees and azimuth of 180 (pointing south to the sun). The slope is reasonable for a floating PV system as is the azimuth. The resulting CF of 11.6% is perhaps considered low for this location. This could be improved by increased slope of the panels but this makes them more susceptible to damage offshore. At this location, an optimised slope with tracking would give a CF of 12.8%. Tracking the azimuth and the slope would improve CF to 15.2% but this would require an offshore tracking system. This study therefore uses the pre-set values in the software and the resulting CF of 11.6%.

The screenshots from the different software tools, and technical inputs are shown in Figure 8, Figure 9, Figure 10, and Table 5. The time series for one year (2012) is shown in Figure 11.

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21 https://globalsolaratlas.info/map?c=44.335636,12.779846,8&s=44.339,12.78&m=site&pv=hydro,180,10,1000

22 https://re.jrc.ec.europa.eu/pvg_tools/en/

23 https://ratedpower.com/blog/utility-scale-pv-losses/

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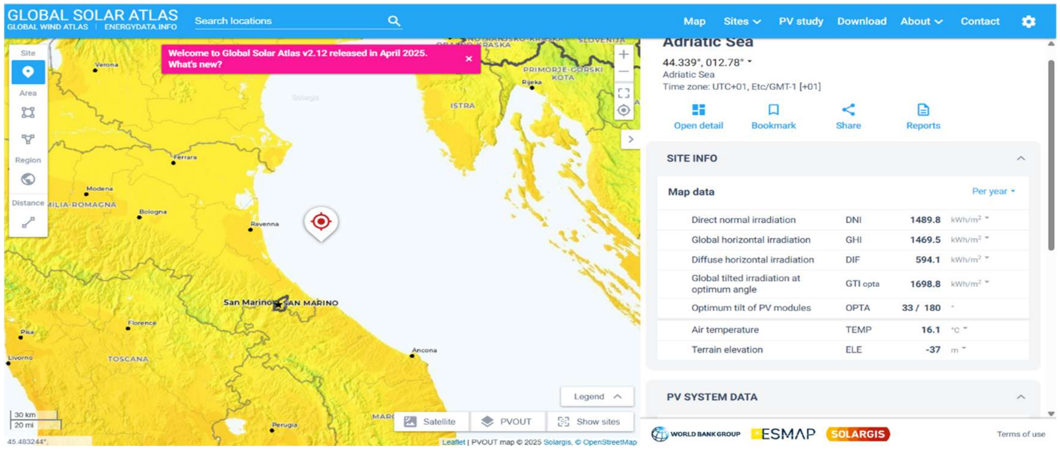

Figure 8: Solar yield as calculated by Global Solar Atlas

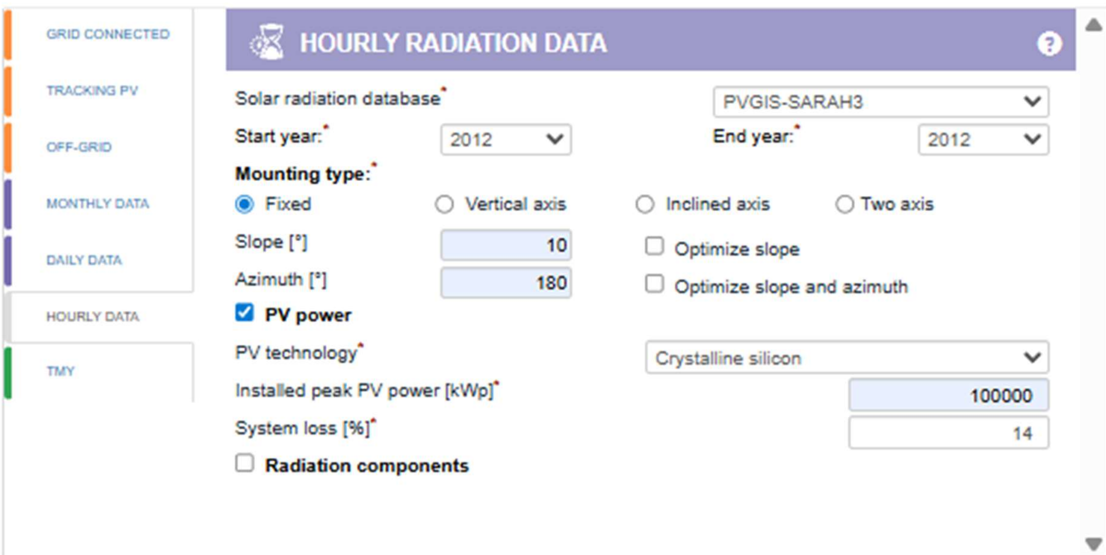

Figure 9: Inputs and pre-set values in the JRC software tool

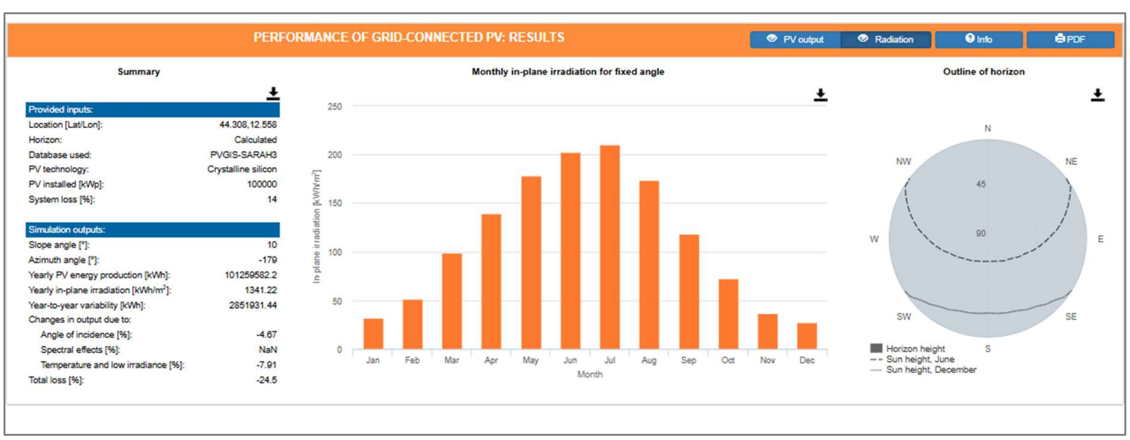

Figure 10: The resulting technical performance of the PV system in the JRC software tool

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Table 5: Technical inputs for the PV system as entered in the JRC software tool

Variable	Parameter
Latitude (decimal degrees):	44.216
Longitude (decimal degrees):	12.636
Elevation (m):	0
Radiation database:	PVGIS-SARAH3
Slope: 10 deg.	10 deg
Azimuth:	180
Nominal power of the PV system (c-Si) (kWp):	100000.0
System losses (%):	14.0
Year	2012

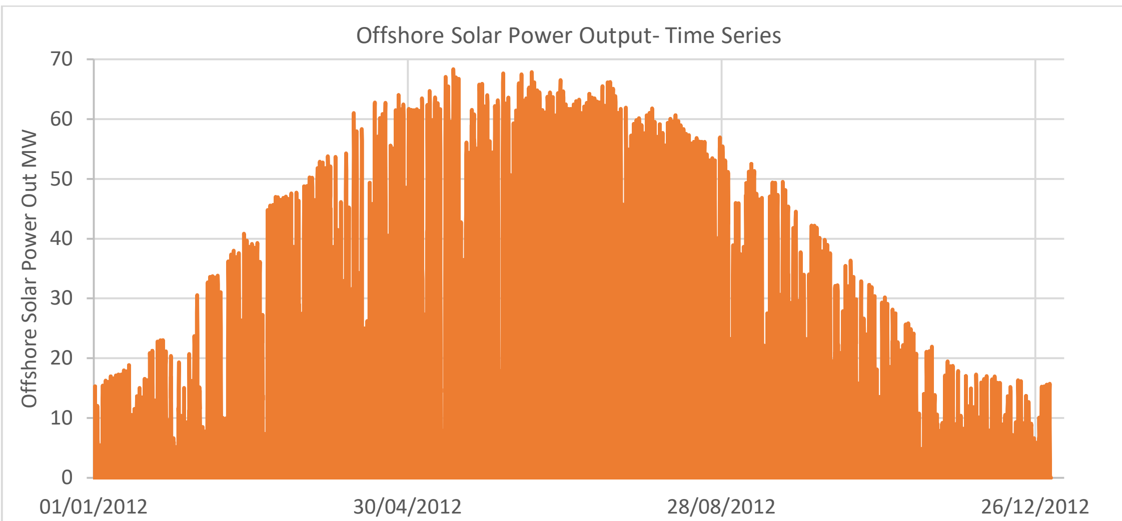

Figure 11: Offshore Solar power output in time series for one year

As discussed in Chapter 3, the AEC for wind was 551,348MWh. Combining this with the AEC for offshore solar gives a total combined AEC of 653,340MWh. However, when applying an export cable grid connection limit of 200MW the now constrained AEC is 647,331MWh. This is a constrained loss of 6,009MWh. Note that this calculation is done on hourly time series data. Applying a 3% transmission loss gives a total combined ADE of 633,740MWh, which is the power that can be sold to the grid annually.

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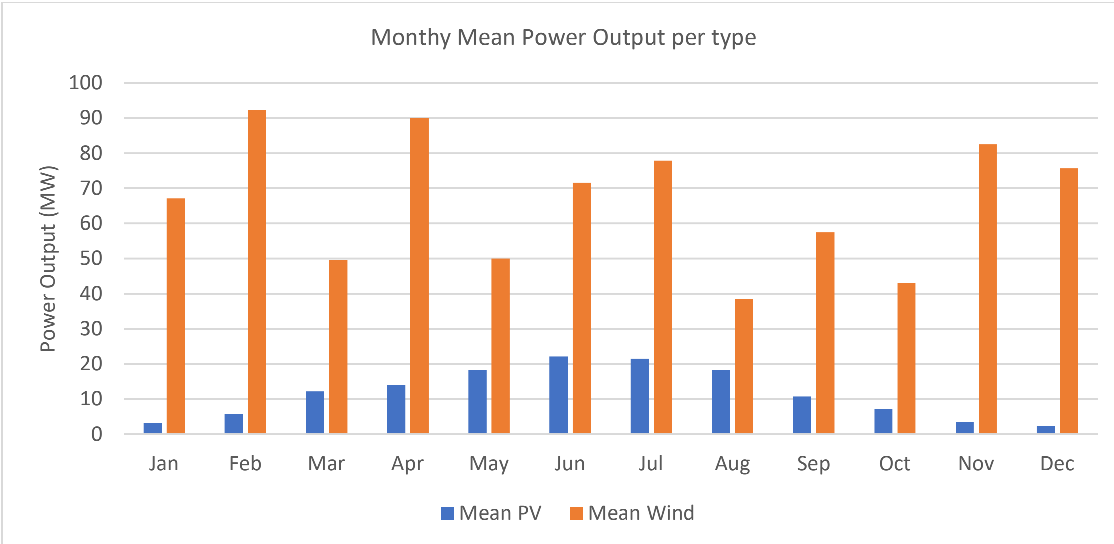

Figure 12: Monthly power output for wind and offshore solar

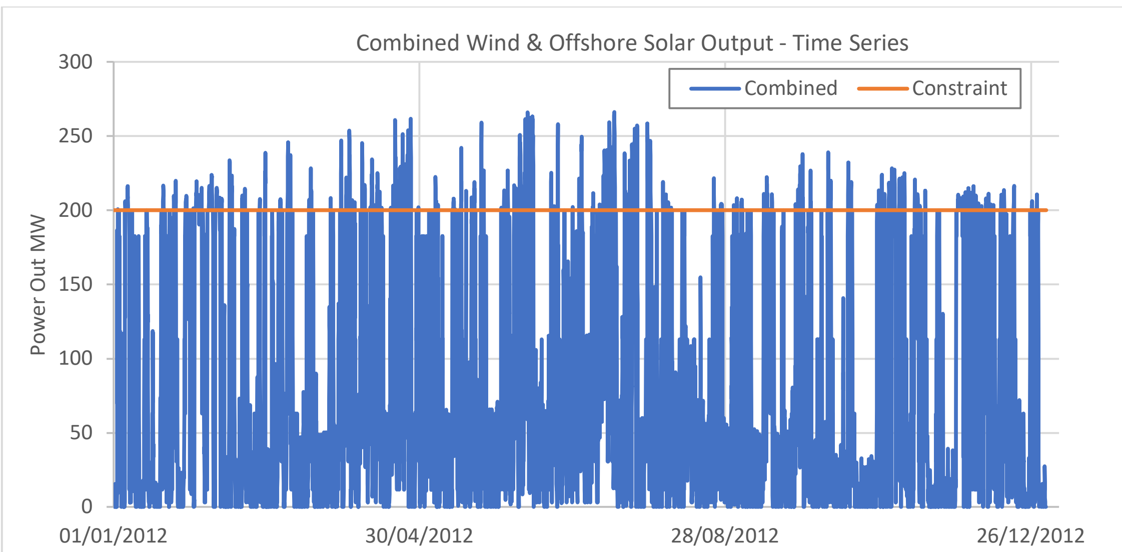

Figure 13: power output over one year in time series for wind and offshore solar showing the combined power and the constraint

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Table 6: Estimated combined ADE for 200MW wind and 100MWp offshore solar

Technology	Wind	Offshore Solar	Combined
Farm size	200MW	100MWp	300MW
AEC	551,348MWh	101,991MWh	653,340
Capacity Factor	33.13%	11.6%	29.8%
Constrained AEC			647,331MWh
Constrained loss			6,009MWh
Transmission loss	3%		
ADE			633,740MWh

5.2 Combining Project Inputs Offshore Wind and Solar

The cost inputs (CAPEX and OPEX) for Offshore Solar are taken from the World Bank Group[24], converted to EUR and inflated from Jan 2018 to Jan 2025. The costs have been further adjusted for offshore solar as the costs in the World Bank Group are for onshore floating solar. In discussion with DMEC, the total CAPEX for offshore solar is currently estimated to be between 1 to 1.5 M€/MW. The costs and financial inputs for the baseline wind farm and the offshore solar are shown side by side in Table 7. When combining the CAPEX items for wind and offshore solar, the items listed for wind and offshore solar are technology specific. The items indicated by a dash (-) in the offshore solar list, are cost items that are shared between the two technologies.

[24] World Bank Group, ESMAP and SERIS. 2019. Where Sun Meets Water: Floating Solar Market Report. Washington, DC: World Bank.

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Table 7: Project Inputs for Offshore Wind and Solar

	Offshore Wind		Offshore Solar
Lifetime	**30 years**		**20 yrs**
CAPEX	**2,800,000€/MW**	**CAPEX items (offshore Solar)**	**1,130,000 €/MW**
Dev &PM	140,000€/MW		-
Wind Turbine Generator	1,085,000€/MW	Modules	390,000€/MW
Export Cable	240,000€/MW	Inverters	90,000€/MW
Offshore Substation	215,000€/MW	Mounting System	235,000€/MW
Onshore Substation	40,000€/MW		-
Balance of Plant (rest)	490,000€/MW	Balance of Plant (including array cables, and solar dynamic cables)	200,000€/MW
Export Cable installation onshore	8,000€/MW		-
Offshore Substation installation	40,000€/MW		-
Onshore Substation installation	27,000€/MW		-
Installation and Commissioning (rest)	515,000€/MW	Design, construction, T&C	215,000€/MW
OPEX	**41,000€/MW/year**		**17,800 €/MW/year**
Decommissioning	**500,000€/MW**		**55,000€/MW**
Revenue / FiT*	**105€/MWh**		**105 €/MWh**
WACC	**7%**		**9%**
Escalation on OPEX	**2%**		**2%**
Debt/Equity	**80/20**		**50/50**
Loan term	**20 years**		**10 years**
Interest Rate	**5%**		**5%**

5.3 Combined Financial KPIs

Using Exfin and the methodology for combining projects described in more detail in the public EU-SCORES deliverable D7.8, a financial model is built separately for each of the technologies since the underlying drivers are different; lifetime, WACC, debt/equity, etc. Once the cashflow is generated for each project, the resulting combined financial KPIs can be calculated, as shown in the project summary in Figure 14 and the delta in Table 8.

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14 July 2025

Version: 3.0.0.2

Project name: **EU-SCORES 7.11 DETAIL Combined**

Project Summary

Main Project Detail		Resource Details	Wind	Offshore Solar
Farm Technology	Wind & Offshore Solar	Country	Italy	
Final Farm Size (MW)	300MW	Location Name	Romagna 1	Romagna 1
Operating Years	30 Years	Data Years	2012	2012
Development Years	0 years	Water Depth		
Decommissioning Years	1 years	Comments	for EU-SCORES D7.11	
Project Currency	EUR - Euro [€]	Measuring height		

Device Details

#	Renewable Technology	Manufacturer	Device Name	Development Depth/Height (m	Power Rating (kW)	Capacity Factor (%)
1	Wind		Fixed Offshore	170m	8,000	33.1%
2	Offshore Solar		Offshore Solar		1,000	11.6%

Farm Energy Output Results		Cost Information	EUR[€]	EUR [€]/MW
Farm Annual Energy Production (MWh	671,119	**CAPEX**	€ 673,000,000	€ 2,243,333
Farm Actual Energy Capture (MWh)	647,331	**OPEX (Annual)**	€ 9,980,000	€ 33,267
Farm Annual Delivered Energy (MWh)	633,740	**Decommisioning**	€ 100,000,000	€ 333,333

Financial Inputs	Wind	Offshore Solar
Total Revenue Rate	105	105
Discount Rate	7%	9%
Inflation Rate	0	0
Debt Equity Ratio	80/20	50/50
Borrowing Rate (%)	5%	5%
Tax Rate (%)		
Revenue Indexation Rate (%)		
Opex Escalation Rate (%)	2%	2%
Borrowing Term	20 years	10 years

Combined Results		
Levelised Cost of Energy (EUR [€]/MWh)	€	99.1
Net Present Value [NPV] (EUR[€])	€	22,073,389
Internal Rate of Return [IRR] (%)		8.5%
Net Present Value [NPV] per MW (EUR[€])	€	73,578
Farm Capacity Factor		29.7%
Payback Period (simple)		13 years
Payback Period (discounted)		23 years

Figure 14: Project Summary for the combined project fixed offshore wind (200MW) and offshore solar (100MWp)

Table 8: The baseline KPIs alongside the KPIs for combined offshore wind + solar

	Wind	Combined Wind + Offshore Solar
ADE	534,808MWh	18.5%
MWh constrained	-	0.9%
CAPEX	560M€	20.2%
OPEX	8.2M€	21.7%
REVENUE	56M€	18.5%
LCOE	**94.2€/MWh**	**99.1€/MWh)**
IRR	**10.7%**	**8.6%**
NPV	**49.5M€**	**22.1M€**
Payback period (simple)	**10 years**	**13 years**
Payback period (discounted)	**18 years**	**23 years**

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Although adding 100MWp increases overall CAPEX and OPEX by approximately 20%, the LCOE only increases by approximately 5%. Due to the complementarity of offshore wind and offshore solar in this location, only 0.9% of the combined power output is constrained. Noteworthy to mention is that the feed-in tariff has been kept constant at 105€/MWh from the baseline, showcased in the IRR dropping approximately 2 percentage points. This is however, still within the acceptable range of 8 to 12% as discussed in Chapter 3. With a slightly higher feed-in tariff, the IRR and NPV will both increase, which will be discussed in the next section along with sensitivity analysis on a few of the other parameters.

5.4 Sensitivity Analysis

Outlined below is the suite of sensitivity analysis conducted on a number of the parameters to assess the robustness of the resulting LCOE and IRR. Each item is tested in turn, whilst keeping all the other inputs constant to the original fixed offshore wind/offshore solar combination base cases.

- Lifetime for offshore solar increases from 20 to 25 years. The overall combination project lifetime is 30 years, determined by the wind project lifetime. However, the combination project now gets 5 extra years of power from the offshore solar farm.
- Total CAPEX for fixed offshore wind increases or decreases by 10%. This also has a follow-on impact on the EUR amount of debt/equity. However, the debt/equity ratio, loan term and interest rate are kept the same.
- Total CAPEX for offshore solar increases or decreases by 10%. This also has a follow-on impact on the EUR amount of debt/equity. However, the debt/equity ratio, loan term and interest rate are kept the same.
- Total annual OPEX for fixed offshore wind increases by 10%.
- Tota annual OPEX for offshore solar increases by 10%.
- WACC for each of the technologies increases by 1% unit
- Inflation on OPEX for both technologies increases by 1%
- Revenue increases by 5€/MWh (from 105 to 110€/MWh)

As can be seen from the resulting numbers presented in Table 9, the top three key cost drivers are related to specifically offshore wind in order CAPEX, OPEX and WACC. Although the change in CAPEX by +/- 10% has the biggest impact on LCOE and IRR, it is worth remembering that the overall farm size and cost envelope for offshore wind as presented in Table 7 is larger than for offshore solar and that the costs for the export cable, and offshore & onshore substations are also included in the offshore wind cost envelope. Additionally, the same items CAPEX, OPEX and

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WACC that have specifically been adjusted for offshore solar only has marginal impact on LCOE and IRR. Another interesting takeaway, is that a 1% increase in the combined Inflation has a larger impact on LCOE and IRR than a 10% increase in Offshore Solar CAPEX or OPEX. Furthermore, the increase in revenue shows a positive impact on IRR. As the Italian government has set a maximum cap on feed-in tariff of 185€/MWh for 25 years, there is likely some leeway with revenue as well. In this combination base case the sensitivity analysis conducted on offshore wind, offshore solar and some combined items, shows that offshore solar has the least impact on LCOE and IRR and that the key cost drivers are all related to the offshore wind.

Table 9: Sensitivity analysis for combination project fixed offshore wind and offshore solar

Sensitivity	LCOE (€/MWh)	IRR (%)
Combination base case	99.1	8.6%
Lifetime offshore solar 25 years	98.4	8.9%
CAPEX offshore wind +10%	105.6	6.0%
CAPEX offshore solar +10%	100.5	7.9%
CAPEX offshore wind -10%	86.8	15.4%
CAPEX offshore solar -10%	97.8	9.2%
Annual OPEX offshore wind +10%	100.8	7.9%
Annual OPEX offshore solar +10%	99.4	8.4%
WACC offshore wind +1%	101.7	8.5%
WACC offshore solar +1%	99.5	8.5%
Inflation combination +1%	101.3	7.7%
Revenue increases to 110€MWh	99.1	10.4%

6. Conclusions

The Romagna 1 is a planned 200MW fixed offshore wind farm approximately 22km off the coast of Italy. In further phases this project will consider the addition of further wind turbines, 100MWp offshore solar, as well as storage.

Exceedence use their financial software Exfin, along with their methodology developed to combine two different technologies with different financial drivers to conduct the analysis presented. Some sensitivity analysis has also been conducted; however, further optimisation of the scenarios has been outside the scope of this work.

For the purpose of this report a Romagna 1 Baseline of 200MW wind farm has been built using publicly available information to conduct techno/financial modelling of the project. Next two different scenarios have been investigated: 1) overplanting

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with additional wind turbines and 2) a combination project of wind and 100MWp offshore solar. The summary metrics are shown in Table 10, along with the main financial KPIs. Although Scenario 1 also investigated overplanting with 1, 6 and 12 additional turbines, the most reasonable for comparison was 2 and 3 additional turbines which are shown in the table below.

The aim of this study was to determine if one of the scenarios made better use of the 200MW capacity export cable, and at the same time to not have an adverse impact on the financial KPIs.

Inspecting the numbers closer in Table 10, Scenario 1 overplanting with 2 x 8MW turbines (216MW) and Scenario 2 are very similar from a financial KPI perspective. However, from the perspective of utilising the export cable better, delivering more renewable power to the grid, as well as likely lower overall system costs, due to the complementarity of wind and offshore solar, then Scenario 2 offshore wind and offshore solar is clearly the better option.

Table 10: Summar of metrics and financial KPIs for the Romagna 1 Baseline, Scenario 1 and 2.

	Baseline	Scenario 1: overplanting		Scenario 2: wind/solar
	200MW wind	200+16MW wind	200+24MW wind	200MW wind + 100MWp Offshore Solar
Annual Delivered Energy	534,808MWh	3%	5%	18.5%
MWh curtailed	-	5%	7%	0.9%
CAPEX	560M€	7%	11%	20.2%
OPEX	8.2M€	8%	12%	21.7%
DECOM	100M€	8%	12%	11%
REVENUE	51.2M€	3%	5%	18.5%
LCOE	**94.2€/MWh**	**98.3€/MWh**	**99.7€/MWh**	**99.1€/MWh**
IRR	**10.8%**	**8.7%**	**7.9%**	**8.6%**
NPV	**49.5M€**	**23.1M€**	**13.3M€**	**22.1M€**
Payback period (simple)	**10 years**	**13 years**	**14 years**	**13 years**
Payback period (discounted)	**18 years**	**22 years**	**23 years**	**23 years**

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