Course name: Wind and Ocean Energy Plants

Project name: Repowering Frosolone Wind Farm

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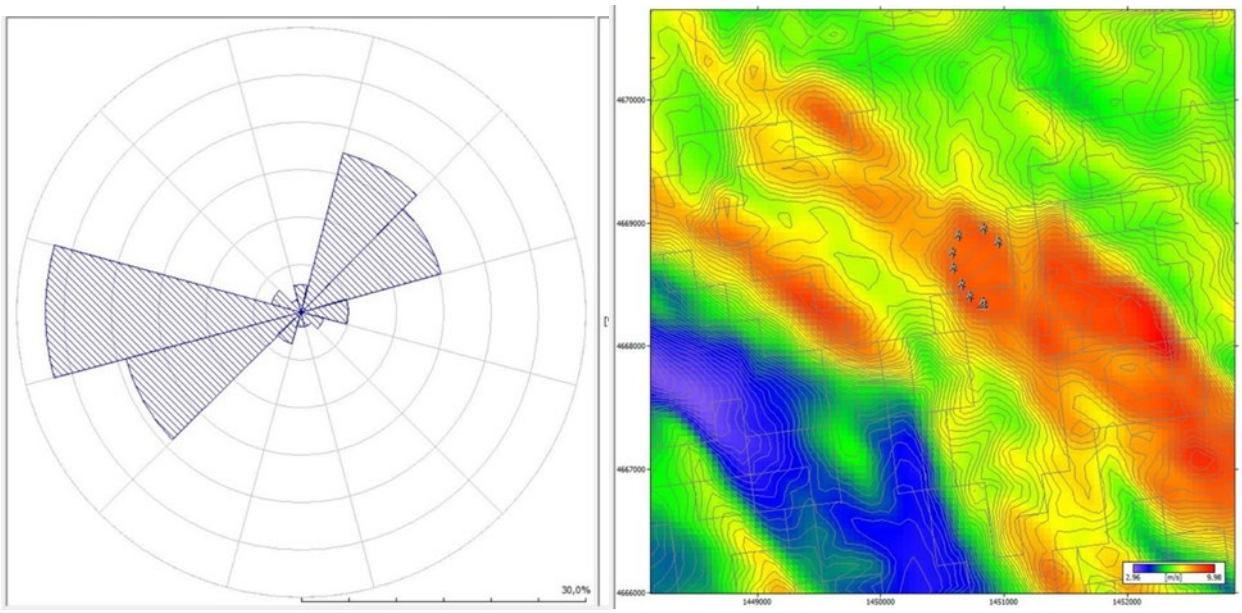
Abstract:

The goal of this project is to repower an old wind farm in Frosolone in the province of Isernia, Italy. The current wind farm is built in 2006 with a capacity of 7 MW. To achieve this aim WaSP software was used extensively. This study comprised of three main sections:

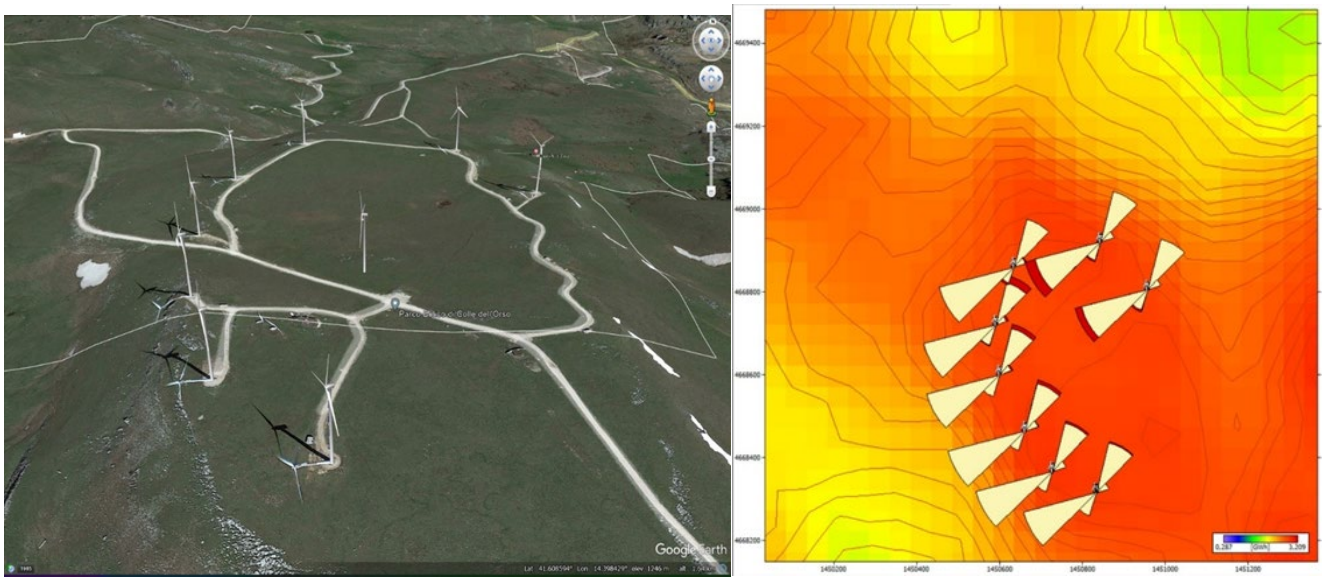
1- **Wind Climate and Productivity Estimation:** Prediction of the wind climate, assessment of the wind farm layout, and estimation of the productivity of individual turbines.
2- **Repowering and Productivity Re-estimation:** Redesigning the wind farm layout and re-evaluating the productivity of individual turbines in the new setup.
3- **Grid Connection and Economic Feasibility:** Analysis of the Frosolone wind farm's grid connection and evaluation of the economic feasibility of repowering to determine its financial viability.

The results showed the repowered wind farm, with fewer turbines (5 instead of 8) and taller structures (80 m instead of 44 m), which reduces wake effects and soil roughness impacts. It has higher nominal power (10 MW vs. 6.8 MW), leading to increased energy production. Economically, it offers a lower LCOE (50.20 €/MWh vs. 56.15 €/MWh) and higher NPV (16.44 million € vs. 9.64 million €), making it a profitable investment. The repowering of the Frosolone wind farm is feasible and beneficial.

Wind Climate and Productivity Estimation:



Left: Turbine Wind Rose Graph; Right: Mean Wind Speed map in the location of wind farm.

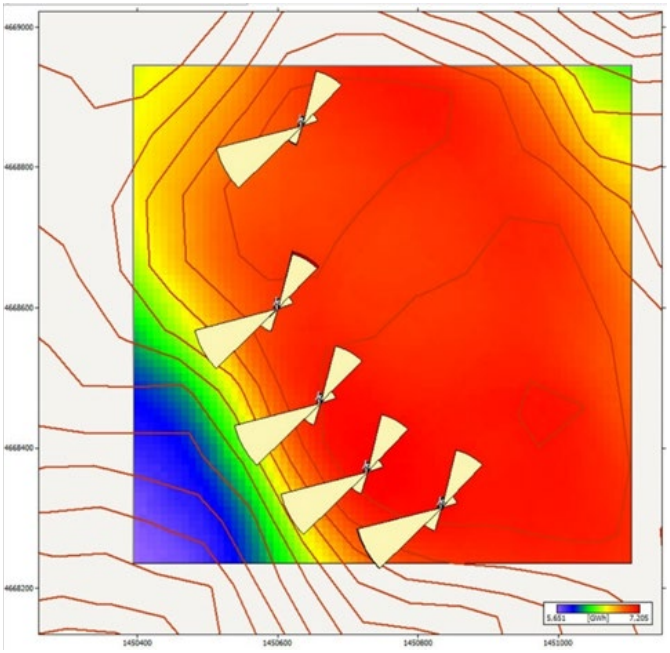


Left: Current Wind Farm turbine placement; Right: wake effect on turbines.

Variable	Unit	Total	Mean	Min	Max
Total gross AEP	GWh	22.79	2.85	2.79	2.91
Total net AEP	GWh	21.90	2.74	2.62	2.85
Proportional wake loss	%	3.90	-	0.99	7.29
Capacity factor	%	36.3	-	34.8	37.8
Mean speed	m/s	-	8.73	8.56	8.91
Mean speed (wake reduce)	m/s	-	8.55	8.29	8.82
Air density	kg/m3	-	1.06	1.059	1.06
Power density	W/m2	-	1024	959	1089

Overall Wind farm production.

Repowering and Productivity Re-estimation:

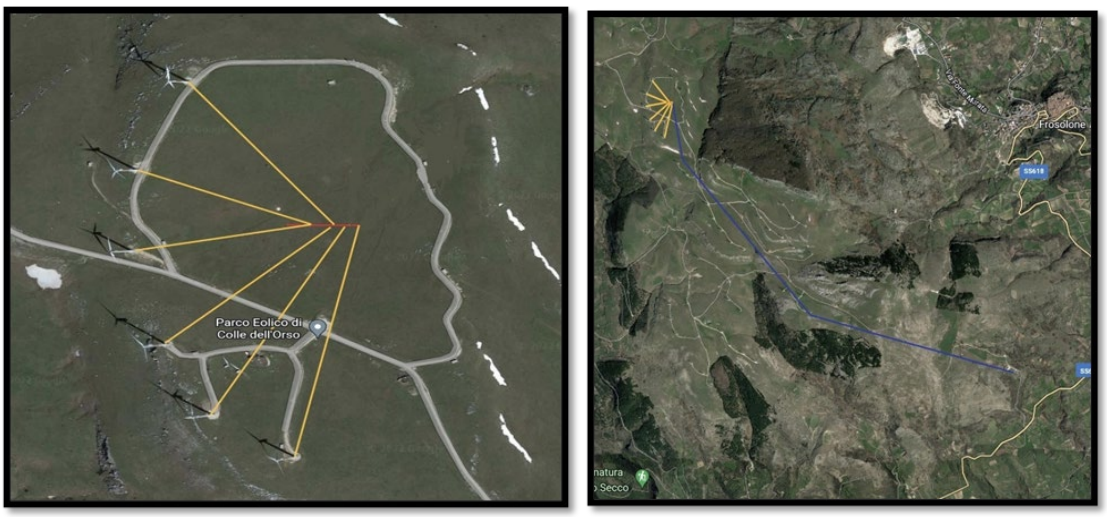


Wind Farm turbine placement and Wind Rose with Wake effect.

Variable	Unit	Total	Mean	Min	Max
Total gross AEP	GWh	35.53	7.11	7	7.18
Total net AEP	GWh	35.06	7.01	6.87	7.11
Proportional wake loss	%	1.32	-	0.75	2.29
Capacity factor	%	40	-	39.2	40.6
Mean speed	m/s	-	9	8.86	9.09
Mean speed (wake reduce)	m/s	-	8.93	8.81	9.03
Air density	kg/m3	-	1.05	1.05	1.06
Power density	W/m2	-	1021	970	1052

Overall Repowered Wind farm production.

Grid connection and Economic Feasibility:



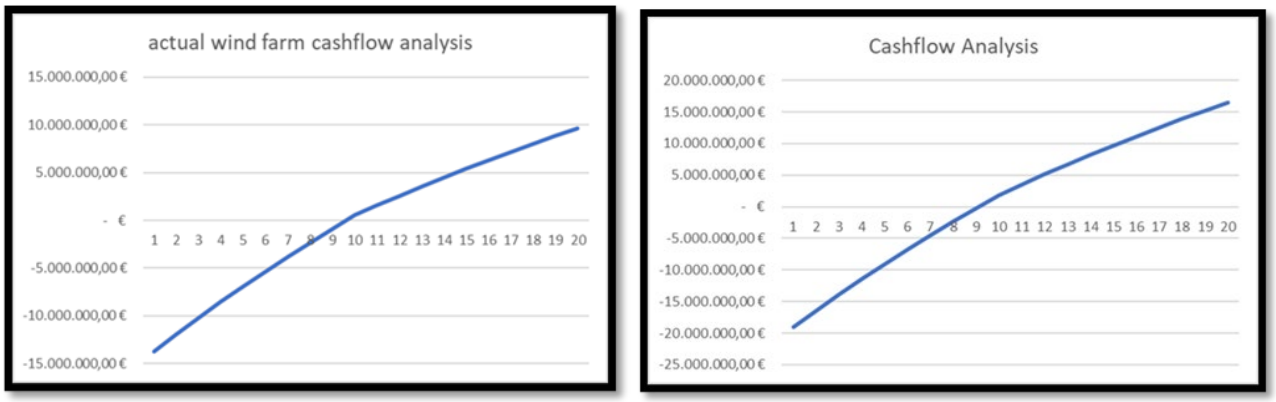
Left: Repowered Wind Farm connections. Right: Farm connection to the grid.

FROM	TO	Distance (m)	Pin (MW)	Qin (MW)	Sin(Phi)	Cos(Phi)	Iphase	Acable (mm2)	Iz (A)	Rcable (Ω)	Xcable (Ω)	Pcable (W)	Qcable (var)	DeltaV/V (%)
Turbine3	Bus1	270	0,85	0,1897	0,8709	0,976	16,7605	70	187	0,1196	0,0359	100,8006	30,2629	0,0121
Turbine5	Bus1	209	0,85	0,1897	0,8709	0,976	16,7605	70	187	0,0926	0,0278	78,0271	23,4258	0,0093
Turbine6	Bus1	266	0,85	0,1897	0,8709	0,976	16,7605	70	187	0,1178	0,0354	99,3073	29,8146	0,0119
Turbine7	Bus1	320	0,85	0,1897	0,8709	0,976	16,7605	70	187	0,1418	0,0426	119,4674	35,8672	0,0143
Turbine8	Bus1	357	0,85	0,1897	0,8709	0,976	16,7605	70	187	0,1582	0,0475	133,2808	40,0143	0,0159
bus1	HV/MV TR	4762	5,1	1,1379	5,2254	0,976	100,5631	95	222	1,5238	0,5905	46231,4566	17914,6894	0,9382

Repowered wind farm cable information

	investment (€ 1000/MW) [2012]		investment (€ 1000/MW) [2022]
turbine	928,00 €	turbine	1.295,80 €
substructure	80,00 €	substructure	111,71 €
electric installations	18,00 €	electric installations	25,13 €
grid connection	109,00 €	grid connection	152,20 €
control systems	4,00 €	control systems	5,59 €
consultancy fees	15,00 €	consultancy fees	20,95 €
land cost	48,00 €	land cost	67,02 €
financial costs	15,00 €	financial costs	20,95 €
general connection	11,00 €	general connection	15,36 €
total	1.228,00 €	total	1.714,70 €

Left: CAPEX and OPEX for 2012 wind farm. Right: CAPEX and OPEX for 2022 wind farm.



Left: Cash flow of current wind farm. Right: Cash flow of repowered wind farm.