PO.047

Land coverage of wind energy facilities – case study of Greece

Andreas Vlamakis[1], Ioanna Eleftheriou[2], Sevi Dima[2], Efi Karra[1], Panagiotis Papastamatiou[1]

[1] Hellenic Wind Energy Association, [2] ENTEKA S.A.

Wind turbines have long “legs” but a small footprint

Other activities can co-exist in the area between wind turbines

Abstract

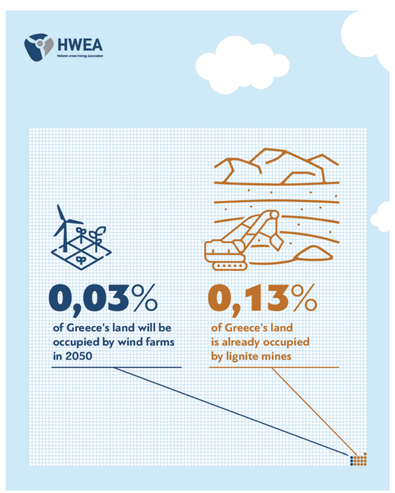
In a world of over 8,2 billion global population the land footprint of every human activity matters. Concerning wind energy plants, the land coverage concerns mainly hardstands, access roads, interconnection grids etc.

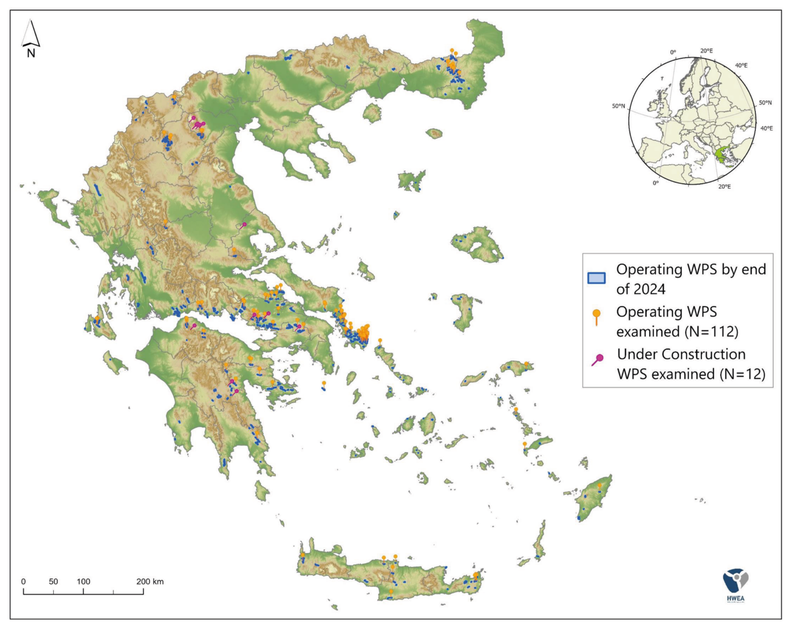
For the case of Greece, a country with complex terrain, we analyzed wind projects of a total capacity of **2,6 GW**, most of which are operating projects, together with a handful of under construction projects and we estimated an average land coverage of **0,33 ha/MW**. For 945 MW of the above sample, the energy yield was also available to express the ratio of land coverage per energy produced and we found an average value of **1,53 m²/MWh**. Both values are inside the range found in other studies.

Applying the above findings to the projections of the National Energy and Climate Plan for wind onshore in Greece for 2030 and **2050**, it arises that only 0,022% and 0,032% respectively of country’s land will be occupied by wind facilities.

However, land coverage per se cannot be assumed as an indicator of the environmental impacts of a wind farm, for which various other parameters should be considered.

Further, anthropogenic activities close to wind facilities, such as cattle breeding, beekeeping, agriculture etc. can coexist with the wind turbines. At the same time the road works facilitate not only the above activities but also help forest authorities and fire brigade to protect the forest environment.





Materials and methods

A large sample of wind power stations (WPS) was investigated which is considered representative: 38,7% of the total operating wind capacity in Greece by the end of 2024, wind turbines of various sizes (capacity: 600 kW to 6 MW, rotor: 44 m to 163 m), spatially spread, various topographies and altitudes (50 m to 2,000 m asl).

	Total numbers in Greece (end 2024)	Sample investigated
Operating		
WPS (nr)	508	112 (22,1%)
WTGs (nr)	3.014	1.136 (37,7%)
Capacity (MW)	5.354,60	2.071,19 (38,7%)
Under construction		
WPS (nr)		12
WTGs (nr)		102
Capacity (MW)		524,90

WPS: wind power station, WTG: wind turbine generator

Any land transformation caused by a wind power station was calculated (new or widened roads, hardstands, electrical works etc.).

The land coverage was estimated - in ha per MW of operational capacity – by digitizing the facilities of a WPS using satellite imagery (979 MW) or by collecting all the necessary data and permits of a project (1617 MW of the sample).

In the part of the sample where energy yield was also available, the land coverage was also expressed in m² per MWh produced.

Results

For the total 124 wind power stations investigated an average land coverage of 0,33 ha/MW was found. The results are also allocated for two main categories of wind turbines, i.e. with capacity less/greater than 3 MW. For the 35 WPS with available energy yield, the land coverage was also expressed per MWh produced and we found a value of 1,60 m²/MWh.

WTG Category	Capacity MW	Mean ha/MW	Mean m²/MWh*
>3MW	1423,66	0,31±0,11	1,68
<3MW	1172,43	0,35±0,17	1,28
Total	2596,09	0,33±0,14	1,53

** only for WPS with available energy yield (944,70 MW)*

The above values fall in the same scale size found in other studies: 0,93 ha/MW in USA (Diffendorfer J., Compton R., 2014), 0,26 ha/MW in northeastern Greece (Damianidis et al., 2022) and 0,78 ha/MW for Greece (Kati et al., 2023).

Discussion

A) Comparison with other energy sources

Applying the average land coverage value found to the projections of the Greek National Energy and Climate Plan for onshore wind in 2030 (8,9 GW) and 2050 (13 GW) it reveals that wind facilities will occupy only 0,02% and 0,03% respectively of the country’s land.

Lignite mines in Greece (not including power plants, grid & road infrastructure etc.) have a land coverage of approx. 15.500 ha, i.e. cover 0,13% of country’s area, with severe environmental & health impacts, backed by science, not at all related with the ones of wind farms.

The direct land footprint of wind energy is much less than most of the other energy sources for the same amount of energy produced. Adding the entire area between the wind turbines of WPS (the so-called “spacing”) is not fair given that WPS can support simultaneously multiple uses within the same land area (cattle breeding, agriculture etc.)

B) Best practices to further reduce land coverage of wind facilities

i) common electrical interconnection works (substations, grid lines) for neighboring WPS, as well as common main access roads

ii) For projects with large blades (length>60m), the use of blade lifter vehicles keeps the necessary interventions to the bare minimum

iii) In cases of complex terrain, the option for a “just in-time” erection of a WTG should be examined (if technically possible and no safety constraints arise)

C) Impacts and benefits

Land coverage (expressed in ha/MW or ha/MWh) per se cannot be an indicator of the actual impact of a WPS on the environment. Other parameters, such as the morphology of the area, the vegetation, the type of infrastructure involved, the assessment of the alternative solutions should be taken into consideration.

On top of harnessing climate crisis, there is one additional positive role of wind energy in sensitive areas, such as the Mediterranean countries which suffer from increasing wildfires: the road works of WPS facilitate the surveillance and protection of forest environment, as well as help the work of fire brigade during a wildfire.

References

(See here: https://shorturl.at/sSXVf)