Energy potential from an emerging renewable technology: Airborne wind energy systems

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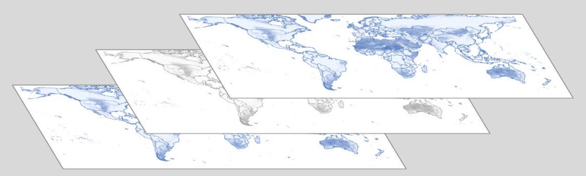
SUMMARY

- This study assessed the potential for annual electricity generation with airborne wind energy systems (AWES) for onshore applications at the global scale [1].
- AWES is an emerging wind energy technology that generates electricity from the pulling force of wind on a flying device which is attached to a generator. It operates at high altitudes (up to 400 m above the ground) to take advantage of steadier and stronger winds. Compared to conventional wind turbines, it uses less materials and has little impact on the landscape and on flying animals (birds and bats) [2].
- This study assumed an AWES based on a soft-wing kite attached to a grounded generator through a flexible tether, operating at average 200 m altitude, with a capacity of 80 kW, spaced at 800 m away from other devices.
- The energy potential from onshore AWES after considering land suitability and topographic restrictions, is equivalent to half of 2022 global electricity consumption.
- The energy potential with high grade (average capacity factor >32%) corresponded to around three quarters of the global total.

Model and parameter settings

Wind speed at 100 m altitude [4] by hour at 0.25º (~28 km) x 10 years (2015~2024)



Wind speed at 200 m altitude

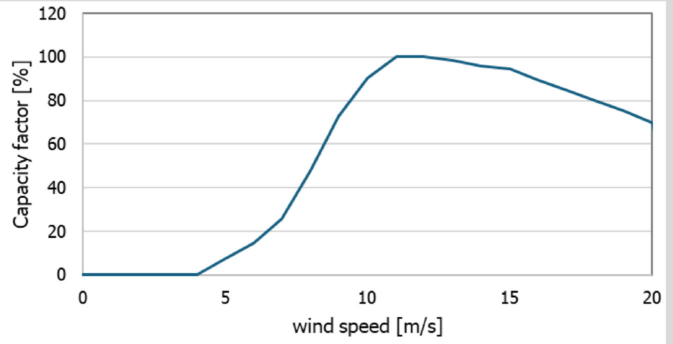
$$v_{200} = v_{100} \times (200\ m / 100\ m)^{\alpha\_lc}$$

α_lc : wind shear exponent [8]

Land cover type	[-]
Forest: closed	0.43
Forest: open	0.24
Shrubs	0.21
Herbaceous vegetation	0.16
Cropland	0.19
Urban/built up	0.31
Bare/sparse vegetation	0.1
Snow and ice	0.08
Water bodies	0.1
Wetlands	0.16
Moss and lichen	0.14
Sea	0.1

AWES technology parameters

- Power curve [5]: capacity factor = f(wind speed)



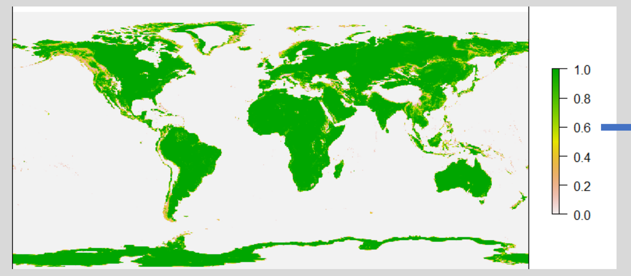
- Density of capacity: device capacity / area per device = 0.080 MW / [(0.8 km) ²] = 0.125 MW/km² [3]

$$Q_{cell} = cf \times \rho_{cpc} \times A_{cell} \times r_{lsf}$$

Annual energy potential at each grid cell [MWh/yr]

- Capacity factor grades (x15)
- 0.25º (~28km)
- Country (~180) → 17 global regions

Topographic restrictions at ~463 m (elevation <2,000 m, slope <20%) [6]



Land cover (23 categories) at 100 m [7].

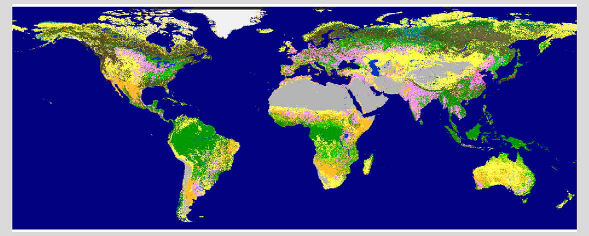


Table 1 Land suitability factor [9]

Category	[%]
Forests	0
Shrubs	30
Herbaceous vegetation	60
Cropland	30
Urban/built up	0
Bare/sparse vegetation	60
Snow and ice, water bodies, wetlands, moss and lichen, sea	0

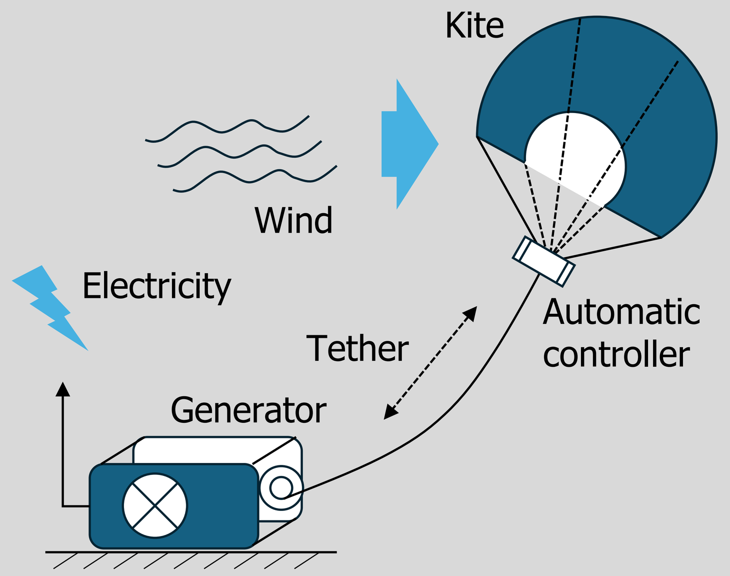


Fig.1 Schematic representation and picture of AWES using soft-wing with grounded generator (picture from [3]).

OUTCOMES

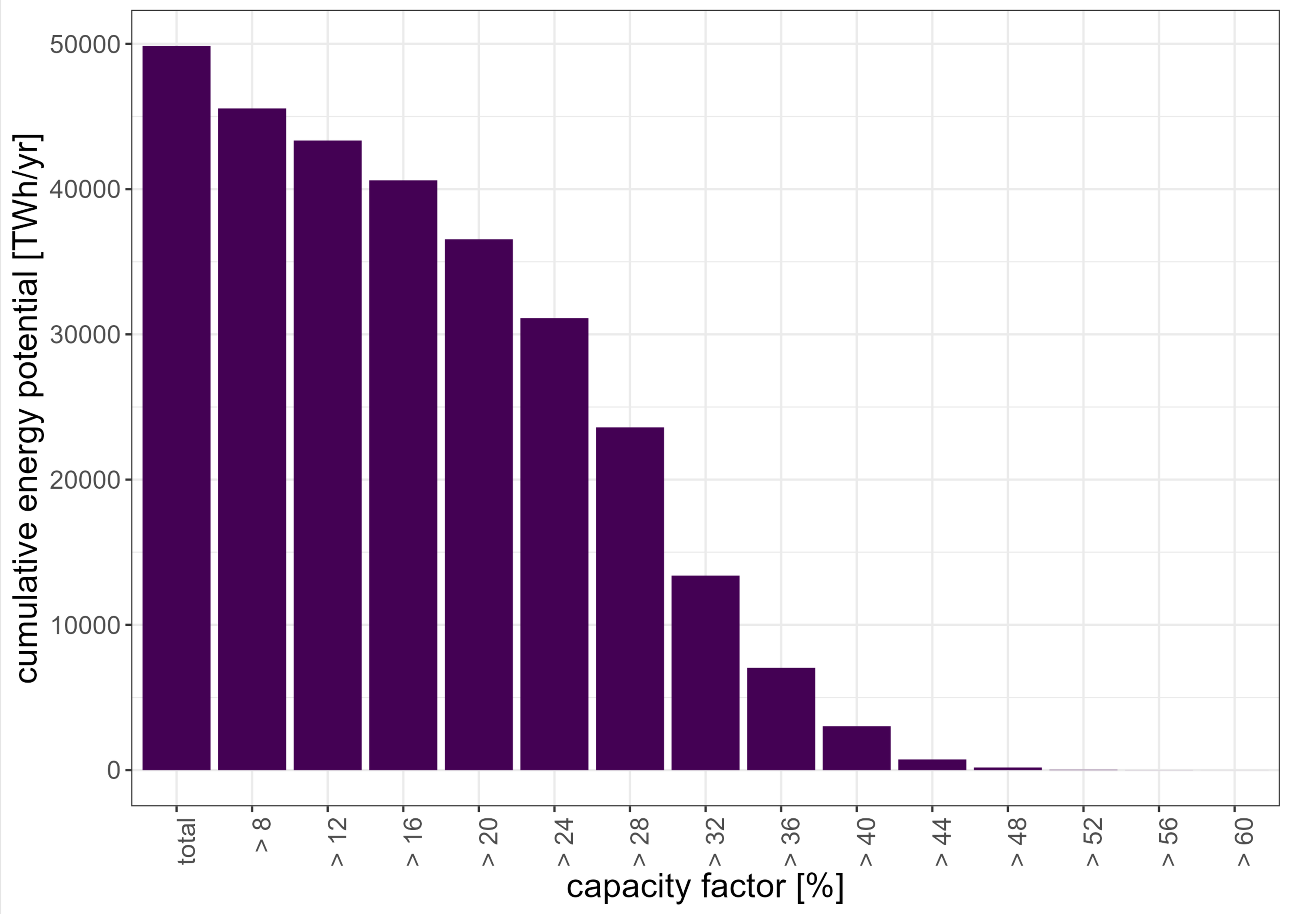


Fig. 2 Cumulative global annual energy potential (TWh/yr) in ascending order of annual capacity factor (%).

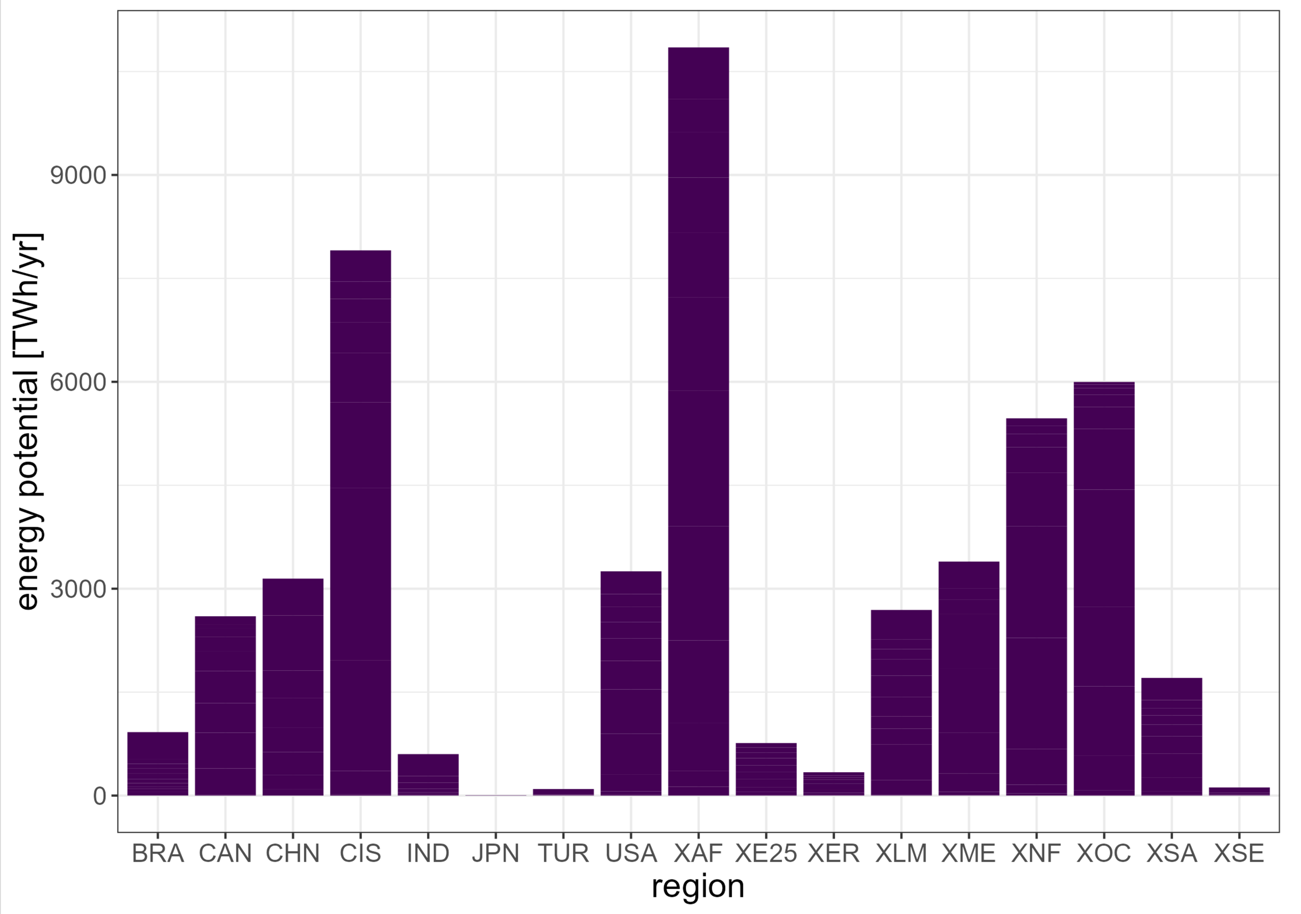


Fig. 3 Regional distribution of the global annual energy potential (TWh/yr)

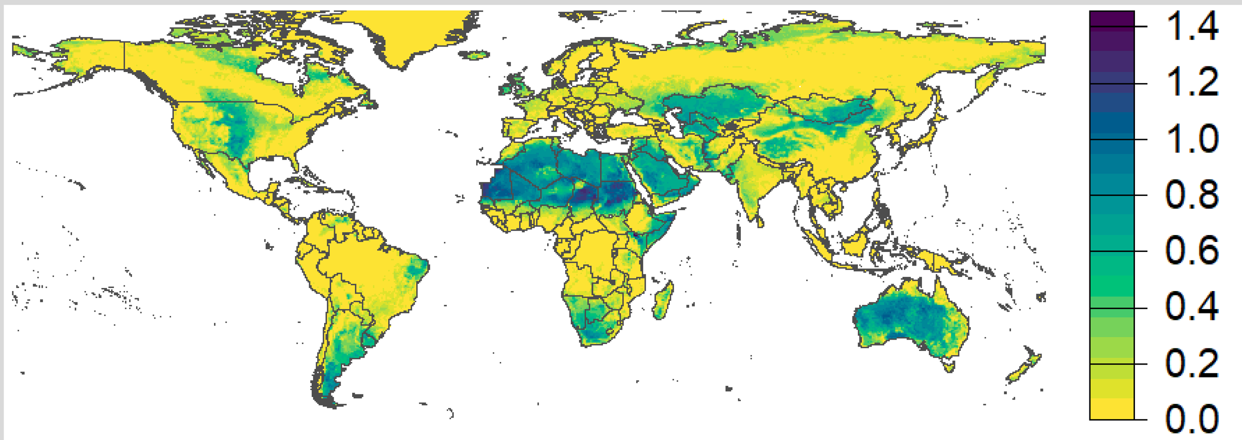


Fig. 1 Map with the spatial distribution of the global annual energy potential (MWh/yr)

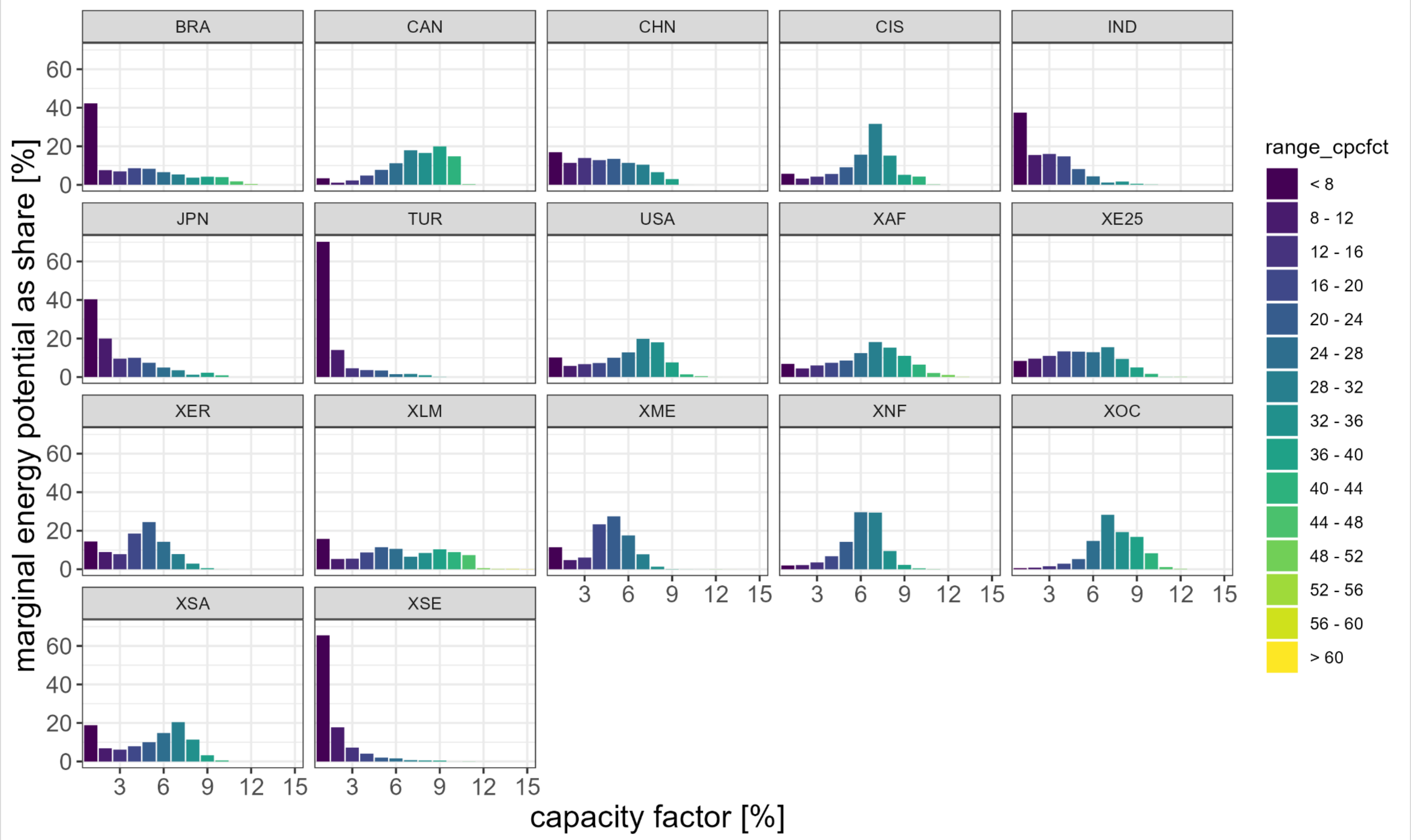


Fig. 4 Marginal energy potential (share of each region's total) by global regions in ascending order of capacity factor (%).

References

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