Assessment of the global wind energy potential considering technical and sustainability boundaries

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LOCOMOTION
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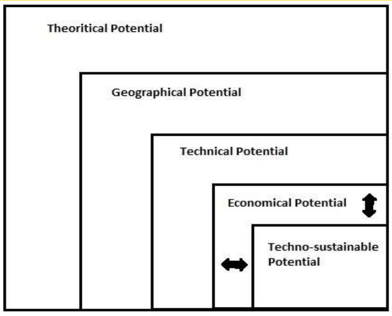
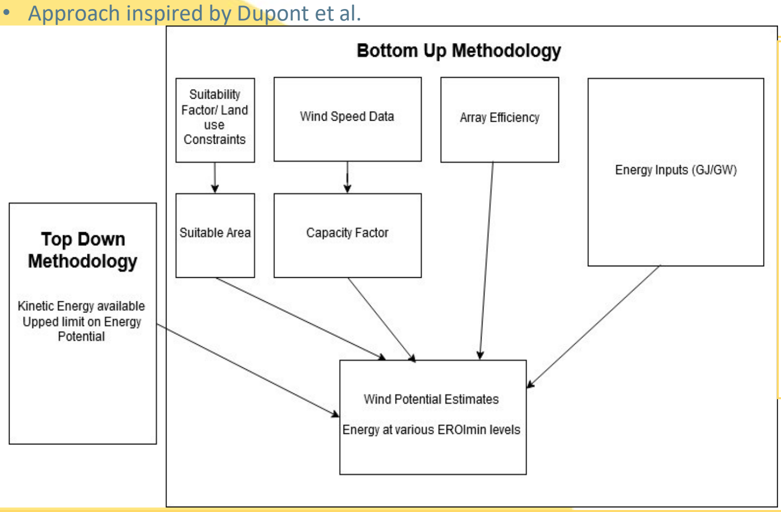
- Estimating the energy potential from wind is important to be able to identify the expected energy contribution from wind energy and accurately design energy policies
- Theoretical potential is the physical upper limit of the energy from a certain source without restrictions.
- Topographic and local constraints reduce it to the geographical potential.
- The technical potential takes into account technology characteristics and losses during conversion to electricity.
- The economic potential is the economically viable potential based on economic constraints.
- The term techno-sustainable is the potential that takes into account sustainability, ecological and socio-economic aspects
- Approach inspired by Dupont et al.





- Approach utilises Geographical Information Systems (GIS).
- Grid cells on a global scale
- Land and techno-sustainable constraints
- Wind speed data and performance characteristics
- Derived energy from wind at each location for different levels of EROI.
- Grid size of the model is 0.5o x 0.5o (~2500 km2)
- 258480 grid cells on a global scale 48028 of which are on land.
- The CCILC database for land cover types.
- Suitability factor (see table below) was assigned to each land cover type
- Bottom up and Top down methodologies followed

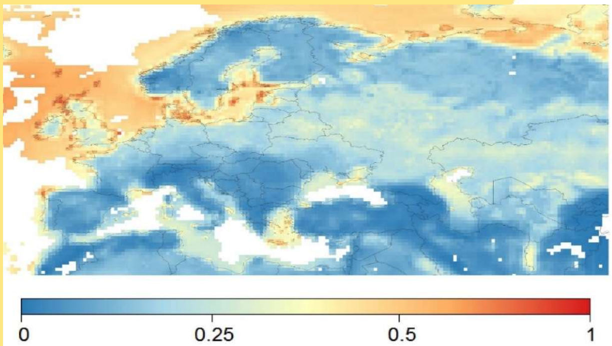
- Wind turbine capacity factor in each grid cell was estimated using the following empirical equation.

$$CF = -\exp\left[-\left(\frac{v_f}{c}\right)^k\right] + \frac{3c^3\Gamma\left(\frac{3}{k}\right)}{k(v_r^3 - v_c^3)}\left(\gamma\left(\left(\frac{v_r}{c}\right)^k, \frac{3}{k}\right) - \gamma\left(\left(\frac{v_c}{c}\right)^k, \frac{3}{k}\right)\right)$$

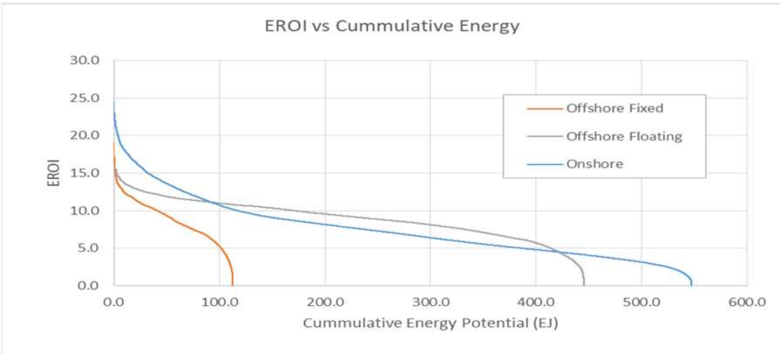
where v_c, v_r, v_f are the wind turbine cut-in, rated and cut-out speed and γ the incomplete gamma function. Common values for Vc = 3-4 m/s , Vr = 11 m/s , Vf = 25 m/s

- The wake effect generated by another wind turbine is considered with the array placement efficiency.

Land Suitability Factor		
	Range in studies	Used in this study
Cropland, rainfed	0-100	70
Cropland, irrigated	0-90	0
Forest	0-50	10
Grassland	10-100	80
Shrubland	10-100	50
Sparce vegetation and bare areas	10-100	90
Flooded vegetation	0	0
Water bodies, snow and ice	0	0
Urban areas	0	0



Map showing the capacity factor variation in Europe



EROI function representation relative to global cumulative energy potential with no EROImin

- The resulting global techno-sustainable energy potential in this study for minimum level of EROIst 5 and 15 is respectively 385.5 / 32.3 EJ for onshore wind energy and 515.0/4.0 EJ for offshore
- For comparison the EU27 electricity consumption is added in the table

	Electricity Consumption 2019 (PJ)	EU27 annual wind Potential for $EROI_{st}$ min 0 (PJ)			EU27 annual wind Potential for $EROI_{st}$ min 10 (PJ)		
		Onshore	Offshore Fixed	Offshore Floating	Onshore	Offshore Fixed	Offshore Floating
EU27	8956	13698	4899	15532	1334	1115	1850

References
1. Dupont, E., Koppelaar, R., Jeanmart, H., 2018. Global available wind energy with physical and energy return on investment constraints. Applied Energy 209, 322–338.

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