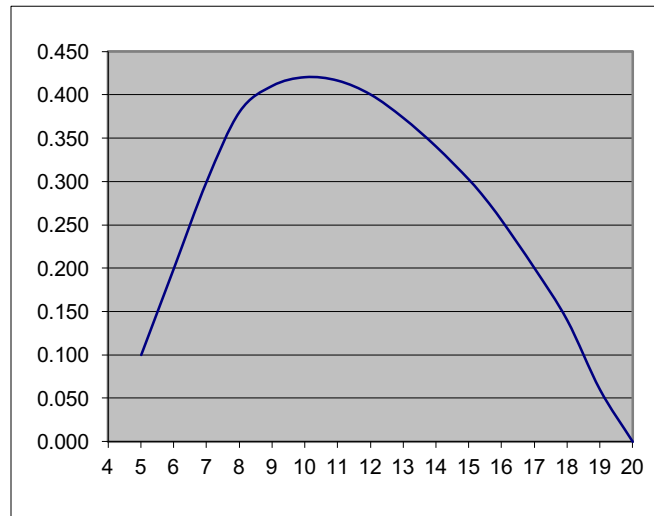


Determine operating parameters of a wind turbine, rotating at variable angular speed, from the Cp-λ characteristic

Consider a wind turbine designed to operate at **variable angular speeds** in order to maximize the energy extracted from the wind ($C_p = \text{const.} = C_{p, \text{max}}$) between the *start-up speed* ($v_{\text{cut-in}} = 5 \text{ m/s}$) and the *nominal speed* (v_{rated}). The power from the rated speed onwards remains then constant (rated power) up to the *maximal admissible speed* ($v_{\text{cut-out}} = 17 \text{ m/s}$). The diameter of the wind turbine is 34 m and its rated power (\dot{W}_{rated}) 310 kW. The C_p -λ curve is given below (remember that the power extracted by the turbine is expressed as : $\dot{W} = \frac{1}{2} \cdot \rho \cdot \pi R^2 \cdot C_p \cdot v^3$; and that $\lambda = \text{tip speed ratio} = \omega R / v$). $C_{p, \text{max}} = C_p (\lambda=10) = 0.42$.



λ	5,0	6,0	7,0	8,0	9,0	10,0	11,0	12,0	13,0	14,0	15,0	15,5	16,0	17,0	18,0	19,0	20,0
Cp	0,10	0,20	0,30	0,38	0,41	0,42	0,416	0,40	0,373	0,340	0,302	0,28	0,255	0,20	0,14	0,06	0,0

The exploited wind regime (5-17 m/s, operating hours) is given below.

v[m/s]	5	6	7	8	9	10	11	12	13	14	15	16	17
t[h/yr]	1212	1200	1092	948	780	600	480	312	240	144	96	60	36

Air density: $\rho = 1.22 \text{ kg/m}^3$.

Question:

Determine the *rated speed* (such as $C_p = C_{p, \text{max}}$ at the rated power), then complete the table below (T is the couple (*Torque*) obtained from the wind) :

v [m/s]	Cp [-]	\dot{W} [kW]	ω [rad/s]	λ [-]	T [kN]	W [kWh]
5						
...						
v _{rated}	0.42	310		10		
...						
17						
Total →						