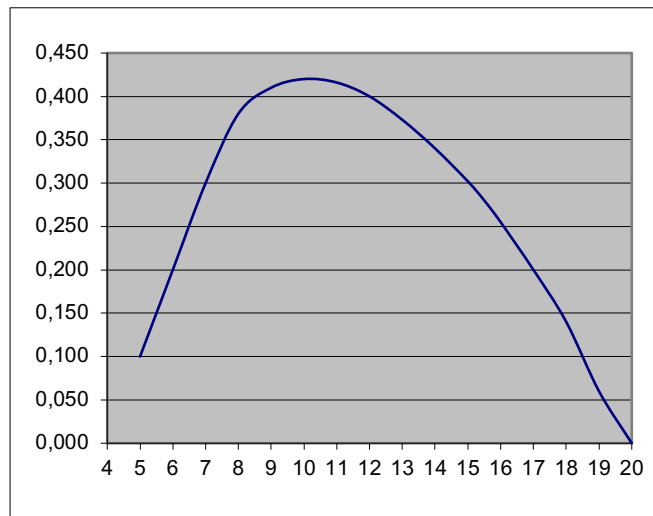


**Determine operating parameters of a wind turbine, rotating at variable angular speed, from the Cp-λ characteristic**

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* ( $v_{\text{rated}}$ ). 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 ( $\dot{W}_{\text{rated}}$ ) 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]	$\omega$ [rad/s]	λ [-]	T [kN]	W [kWh]
5						
...						
v <sub>rated</sub>	0.42	310		10		
...						
17						
Total →						