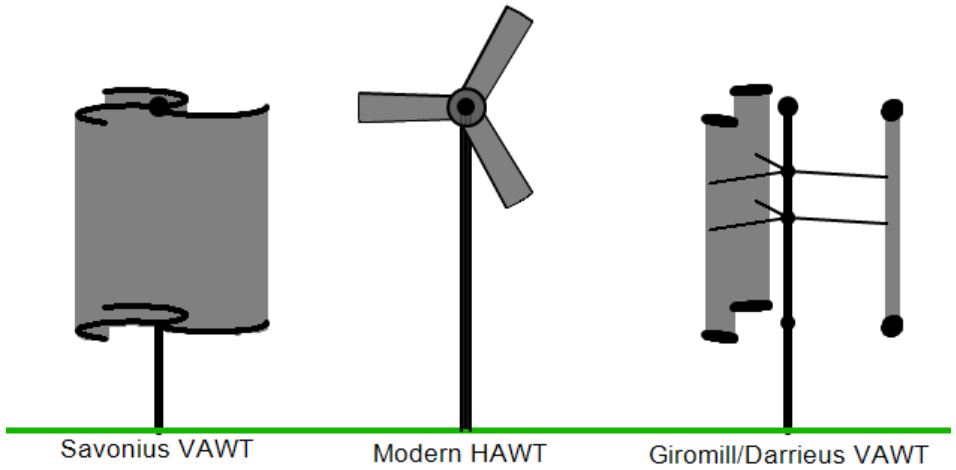
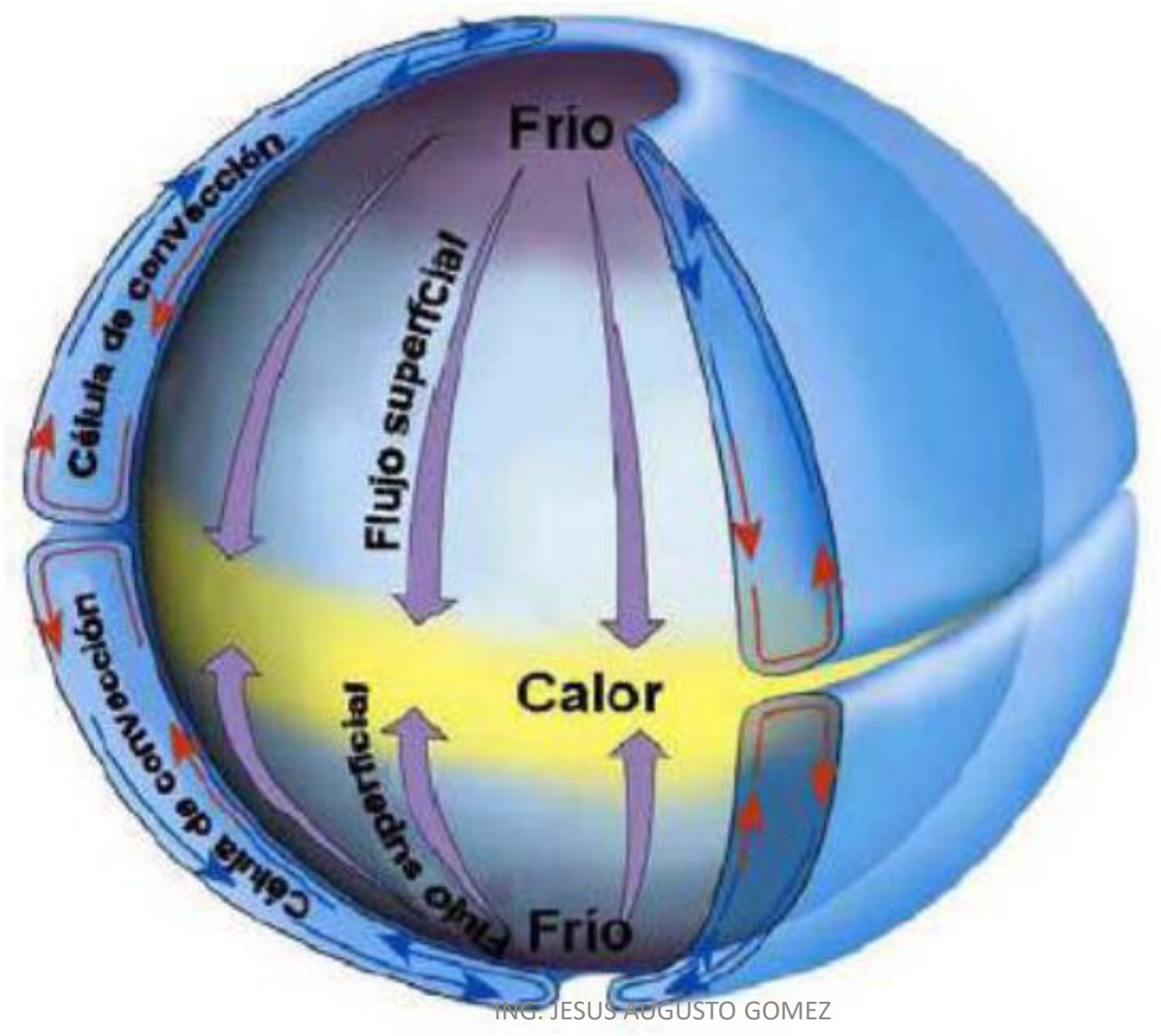


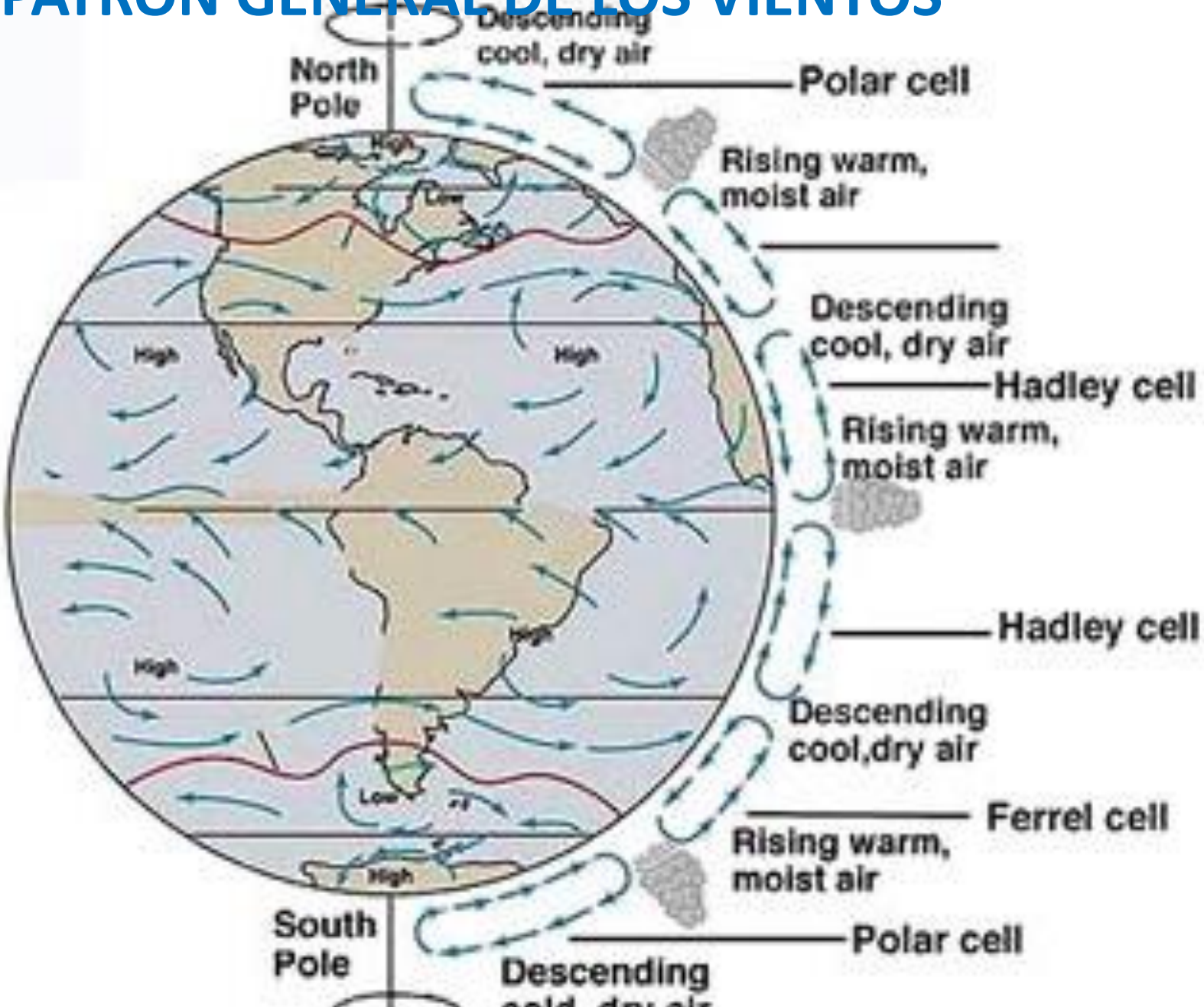
ENERGÍA EÓLICA

ING. JESUS AUGUSTO GOMEZ

0RIGEN DE LOS VIENTOS



PATRÓN GENERAL DE LOS VIENTOS



VENTAJAS DE LA GENERACION EOLICA

- Energía renovable.
- Bajo LCOE, competitivo con otras fuentes de generación
- Sin costos de combustibles.
- Energía limpia con bajo impacto ambiental.
- Libre de emisiones de CO2
- Modular y rápida de instalar.
- Libera combustibles líquidos , permite su exportación.
- Integrable con otras fuentes renovables o no

ENERGIA Y POTENCIA EOLICA.

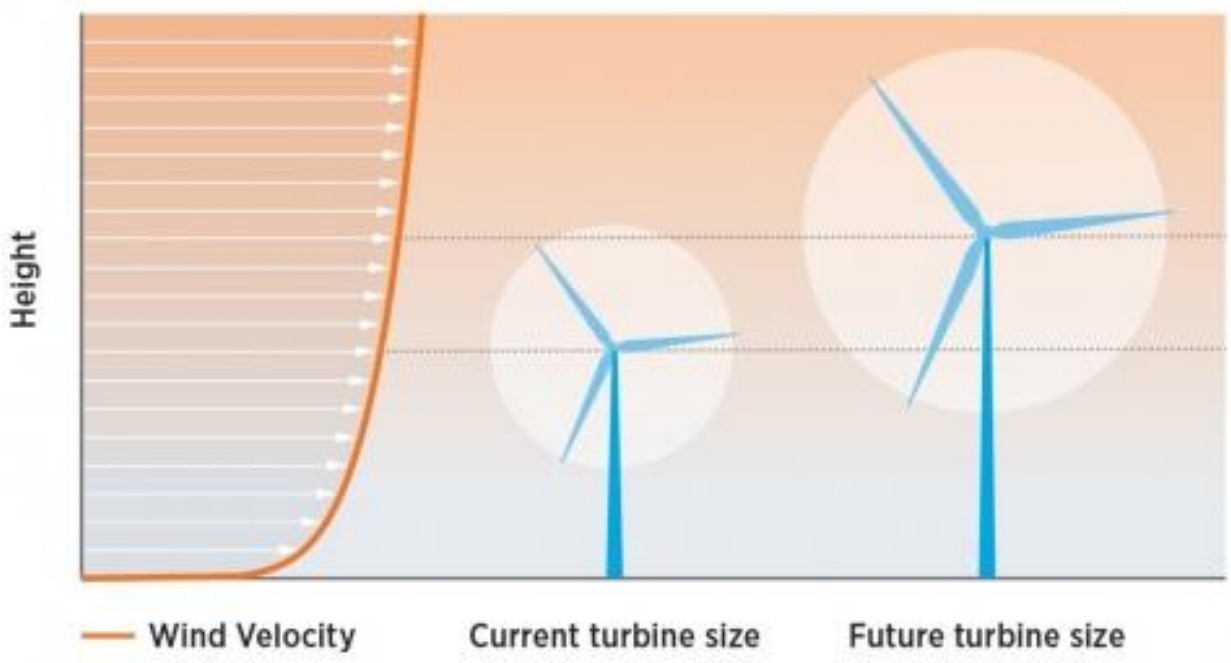
Energía cinética del viento $Ec=½*m*V^2$

Potencia eólica:

$$P = \frac{d(Ec)}{dt} = ½ * \frac{dm}{dt} * V^2$$

$dm/dt=\rho*A*V$ ➡ $P=½*\rho*A*V^3$

$\rho = 1.225*\exp((-h/8435)-(T-15)/288))$

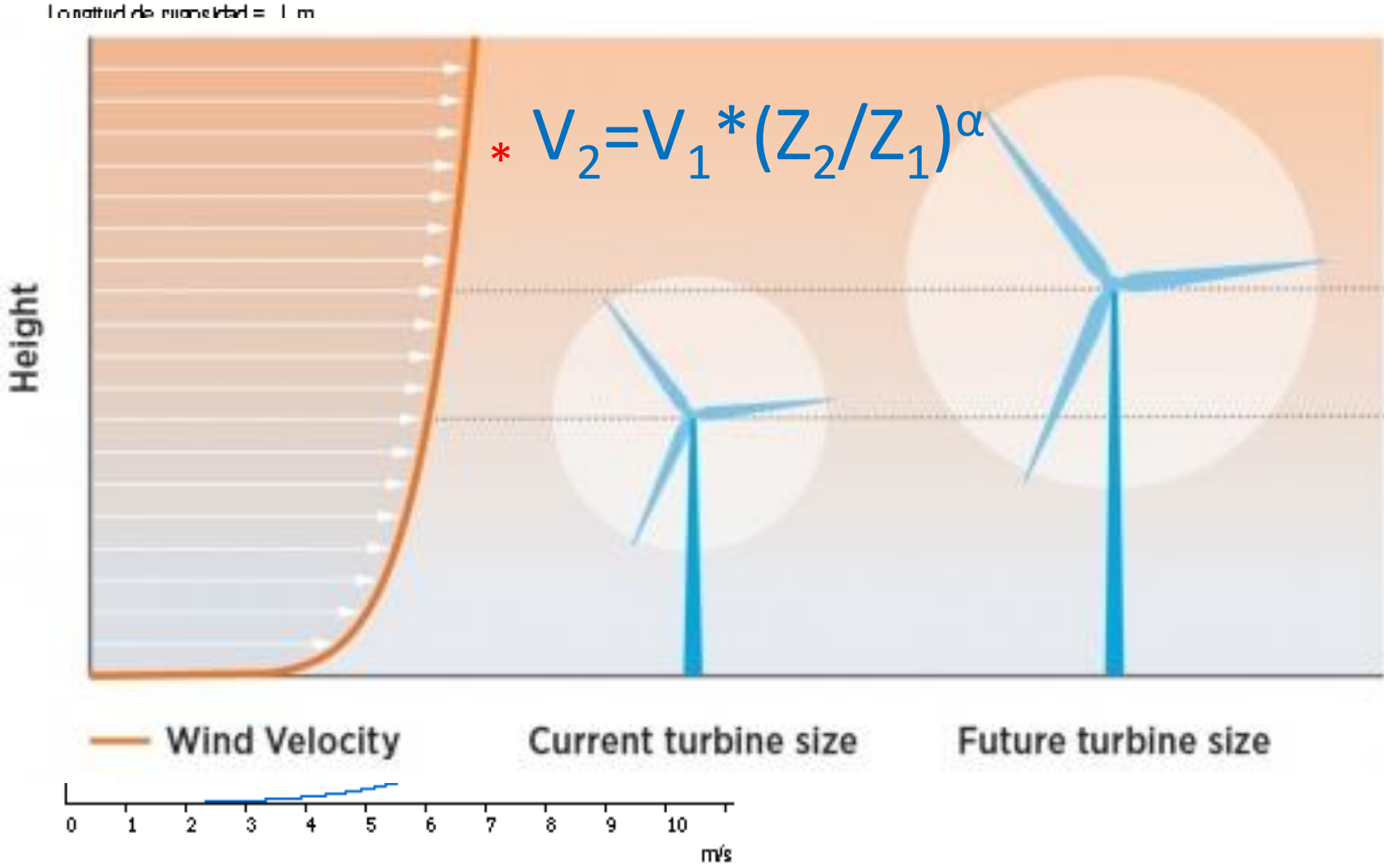


* $V_2=V_1*(Z_2/Z_1)^{\alpha}$

*HELLMAN, 1915

Perfil vertical de la velocidad del viento

Los vientos están mucho más influenciados por la superficie terrestre a altitudes de hasta 100 metros. El viento es frenado por la rugosidad de la superficie de la tierra y por los obstáculos. La velocidad del viento varia directamente proporcional con la altura, esto es, a menor altitud el viento se ve más afectado por la rugosidad y obstáculos del terreno ya que existe mayor fricción y se generan turbulencias. Para modelar el perfil vertical de la velocidad del viento existen dos métodos generales, el método de perfil logarítmico y el método de ley de potencia.

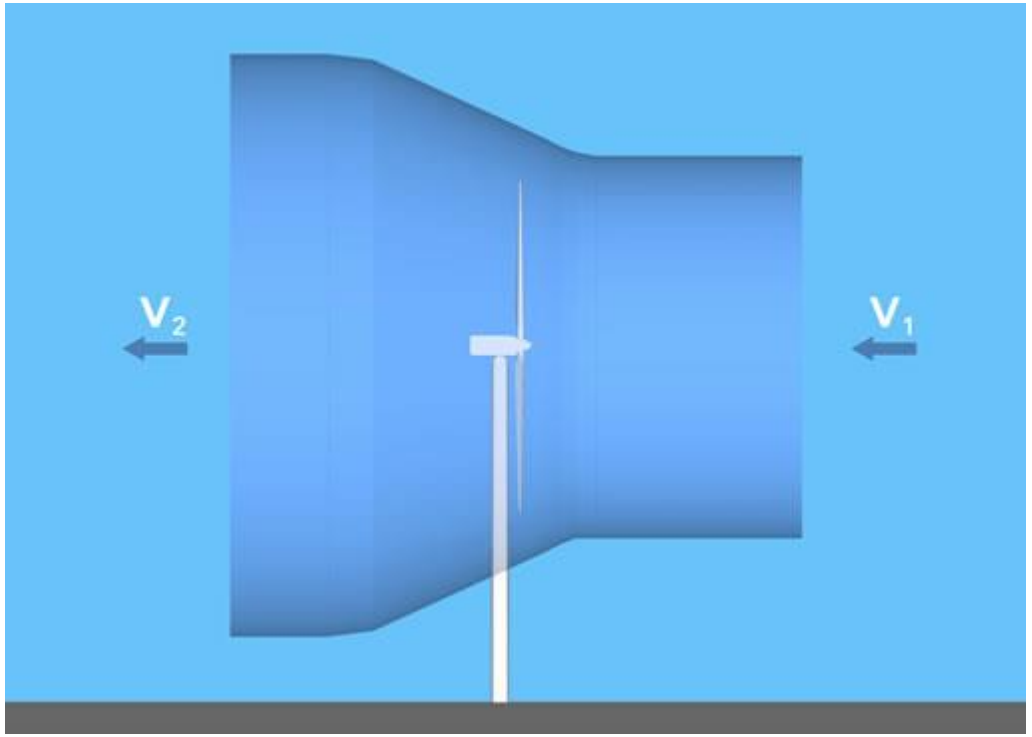


* $V_2=V_1*(Z_2/Z_1)^{\alpha}$

*HELLMAN, 1915

Límite de Betz

$$P_{util} = \left(\frac{16}{27}\right)\frac{1}{2}\rho A v_1^3$$

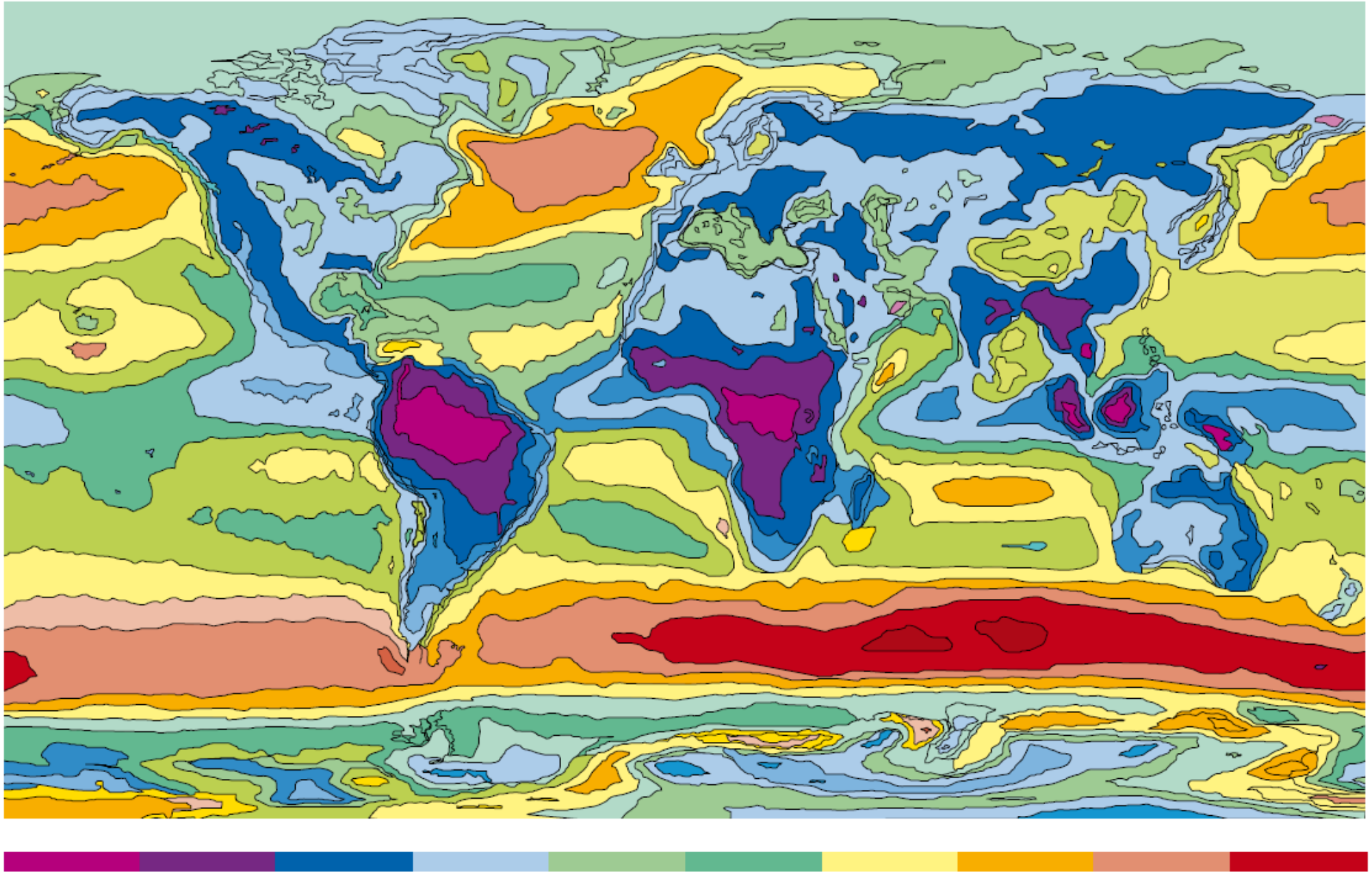


$$C_P^{Betz} = \frac{16}{27} \approx 59\ \%$$ **LIMITE DE BETZ**

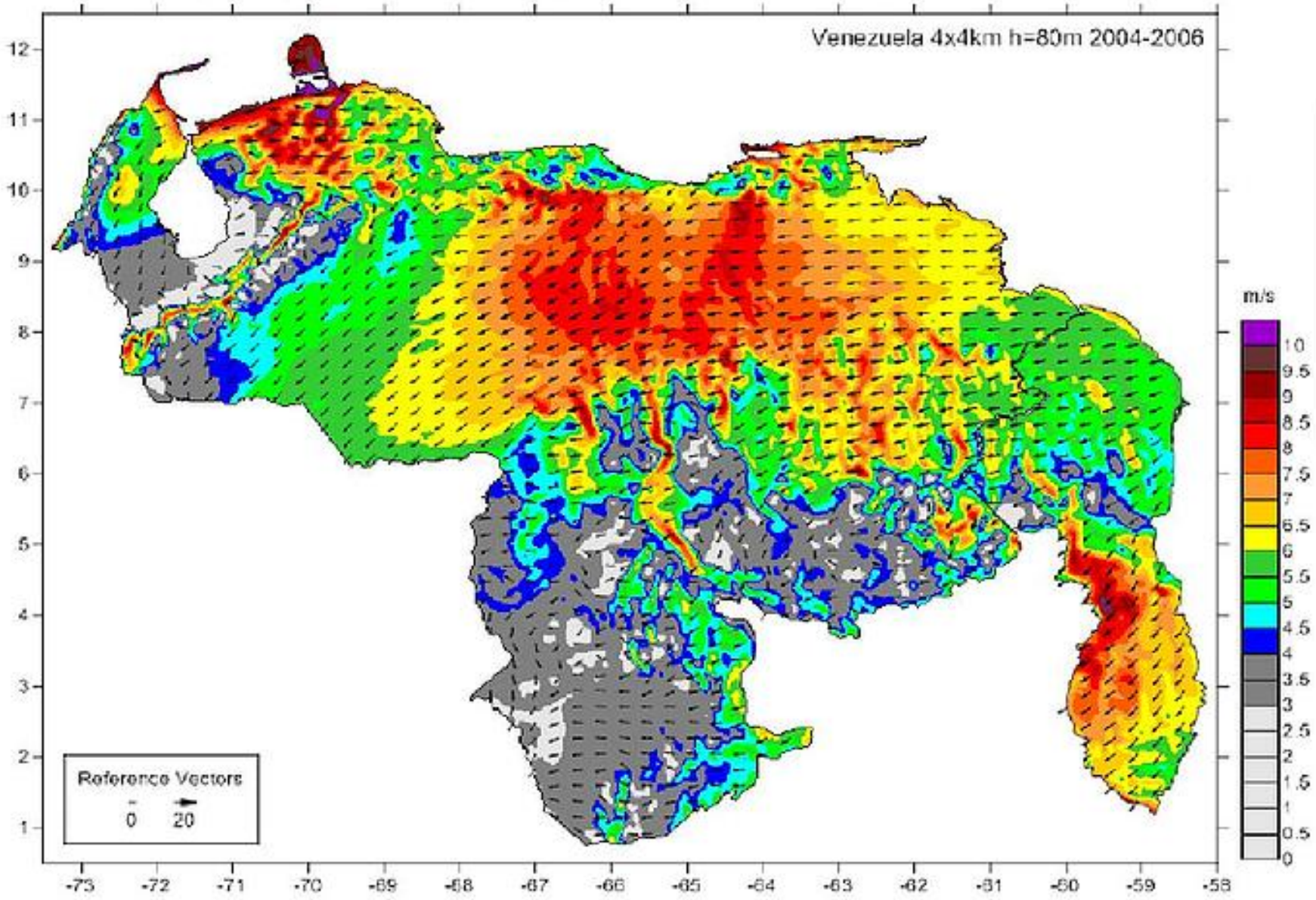
energy production from wind source does not destabilize

interval is often defined at 10min.

Figure 1.3 – Worldwide wind map: average wind speed in m/s at 10m height



MAPA EÓLICO A MESOESCALA DE VENEZUELA

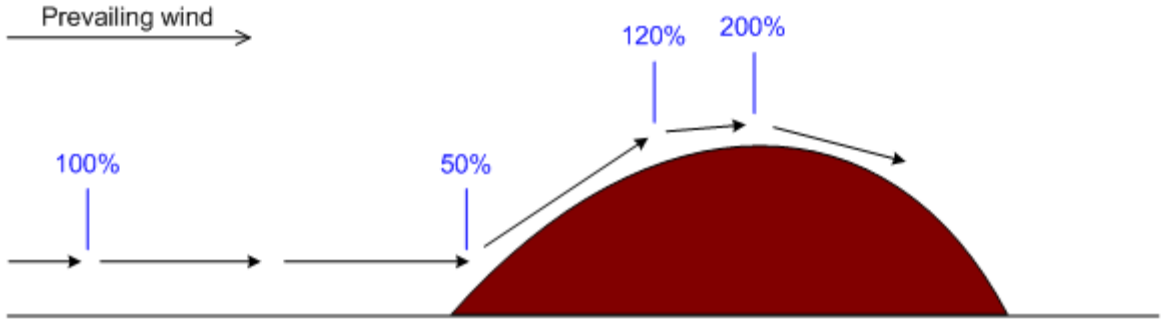


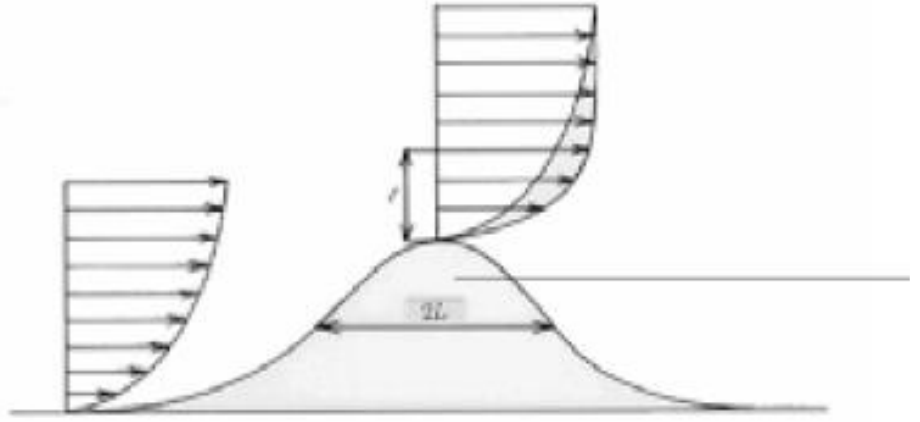
Venezuela posee una velocidad de viento promedio

$$6\ \frac{m}{s}$$

Fuente: MPPEE

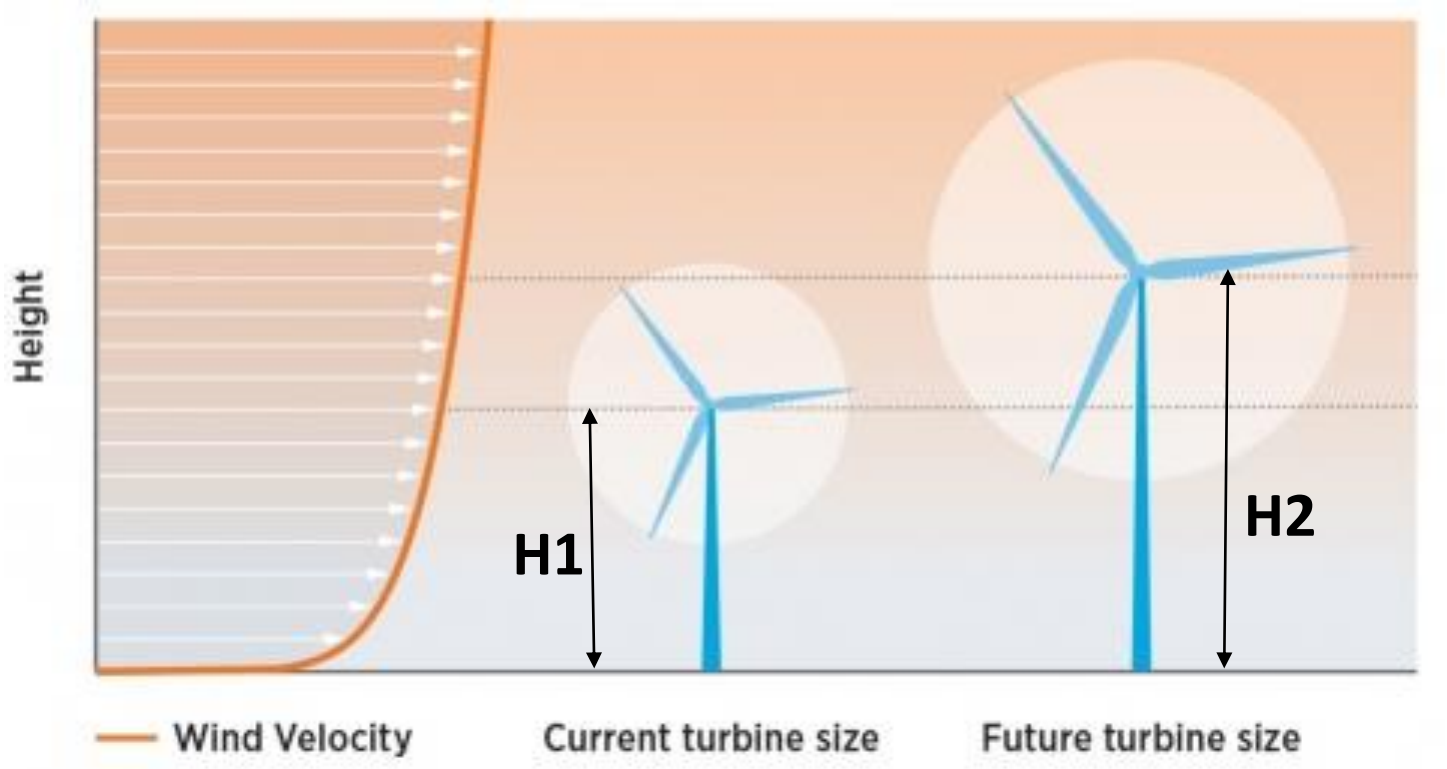
EFECTO OROGRÁFICO






EFECTO OROGRÁFICO
200%V
120%V
V
50%V

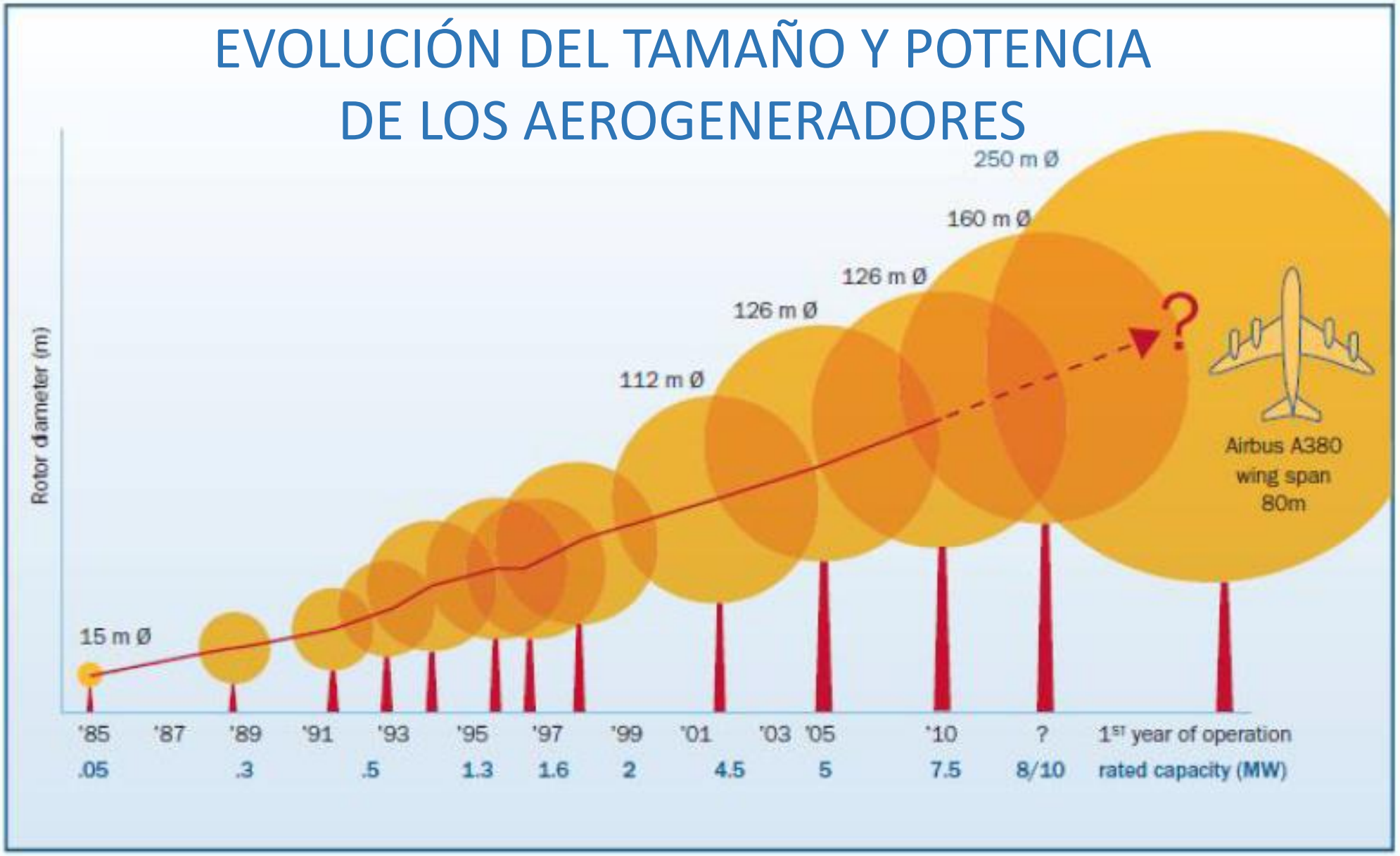
EFECTO DE LA ALTURA EN LA VELOCIDAD Y POTENCIA



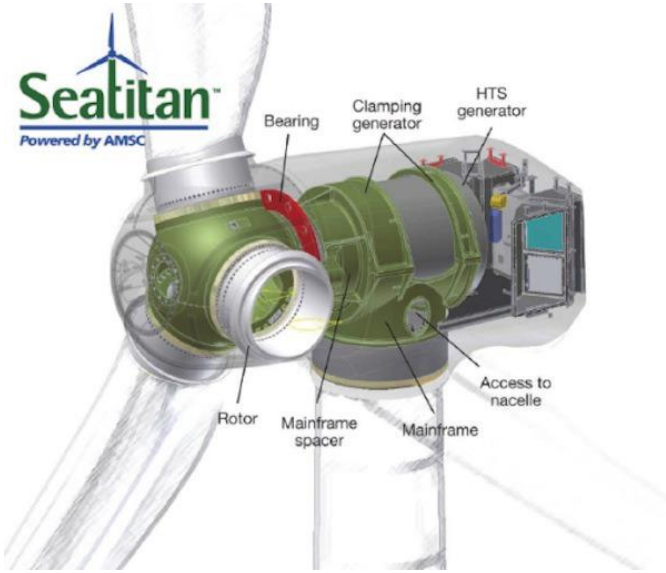
	Altura	AREA	VELOCIDAD	POTENCIA
	M	M2	mps	KW
H0	10		6.22	
H1	50	1,963.50	7.55	476.52
H2	127	12,667.69	8.44	4300.18
H2//H1	2.54	6.45	1.12	**9.02**

- The bi

EVOLUCIÓN DEL TAMAÑO Y POTENCIA DE LOS AEROGENERADORES



LOS MAYORES GENERADORES ACTUALES (2016)



SeaTitan 10 MW, h=125m, d=190m,

SWAY ST10 d=164 m, P=10 MW

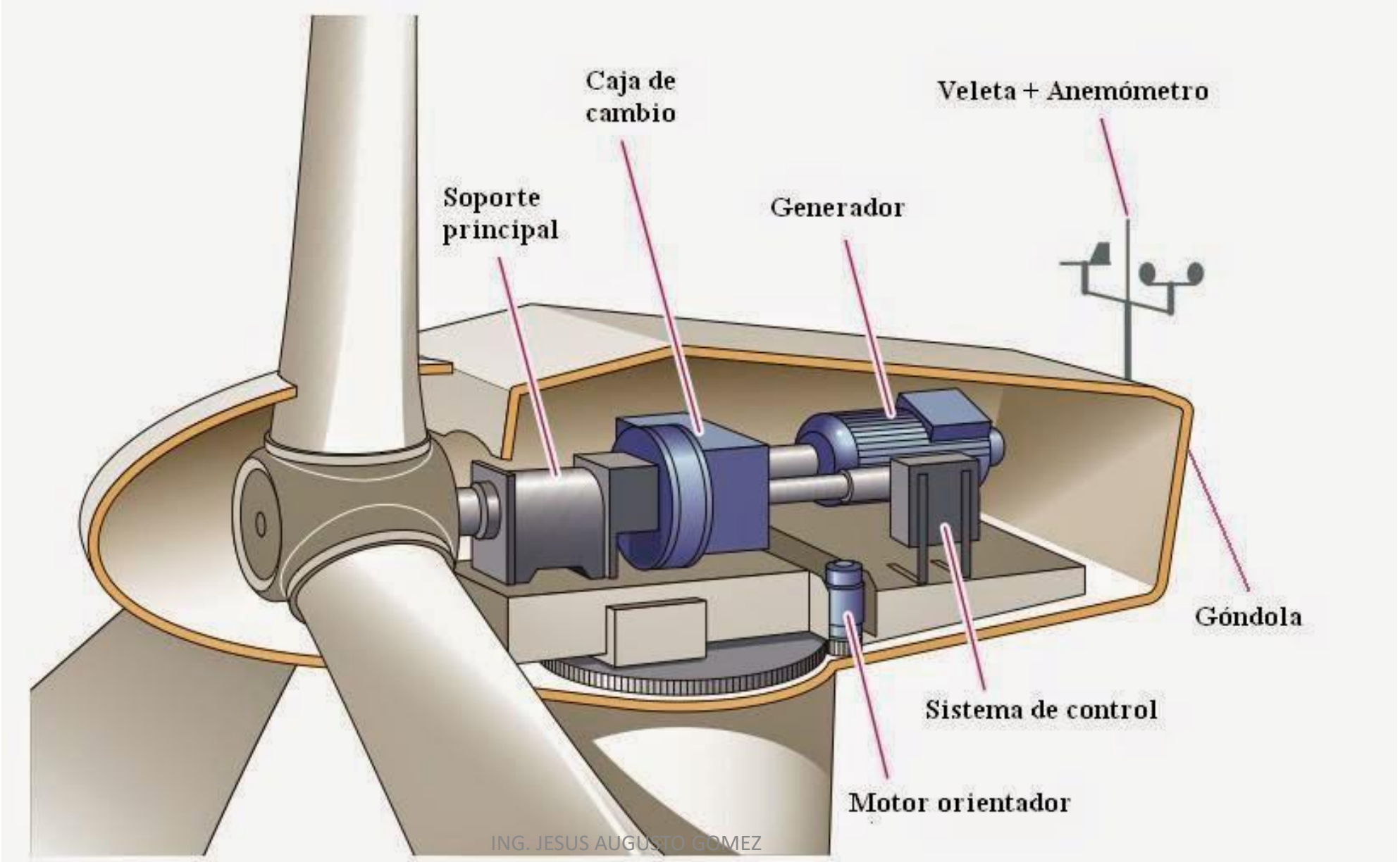
Vestas V164-8.0 MW, P8 MW y diámetro 164 m

Areva 8 MW, d= 180 m

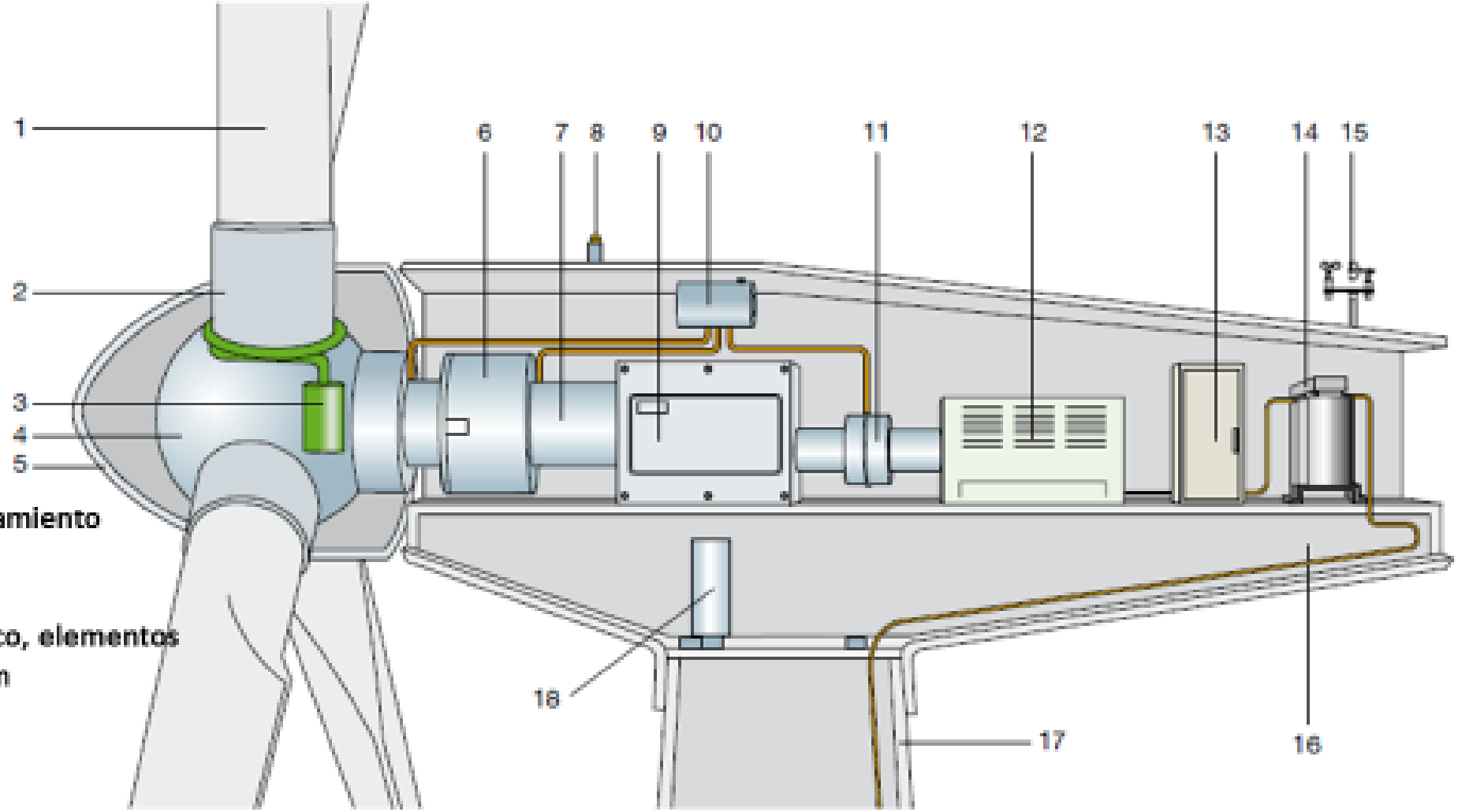
Enercon E-126/7.5 MW

Samsung S7.0-171

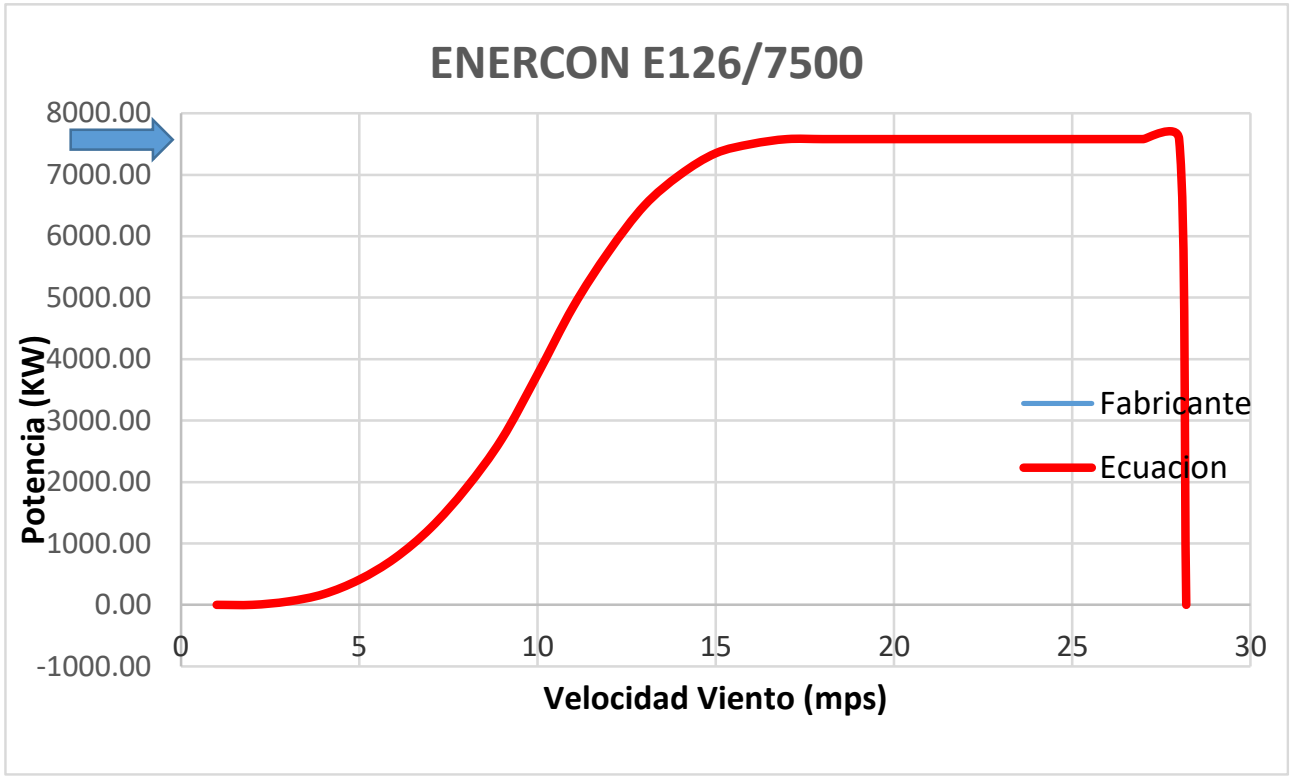
COMPONENTES DE UN AEROGENERADOR

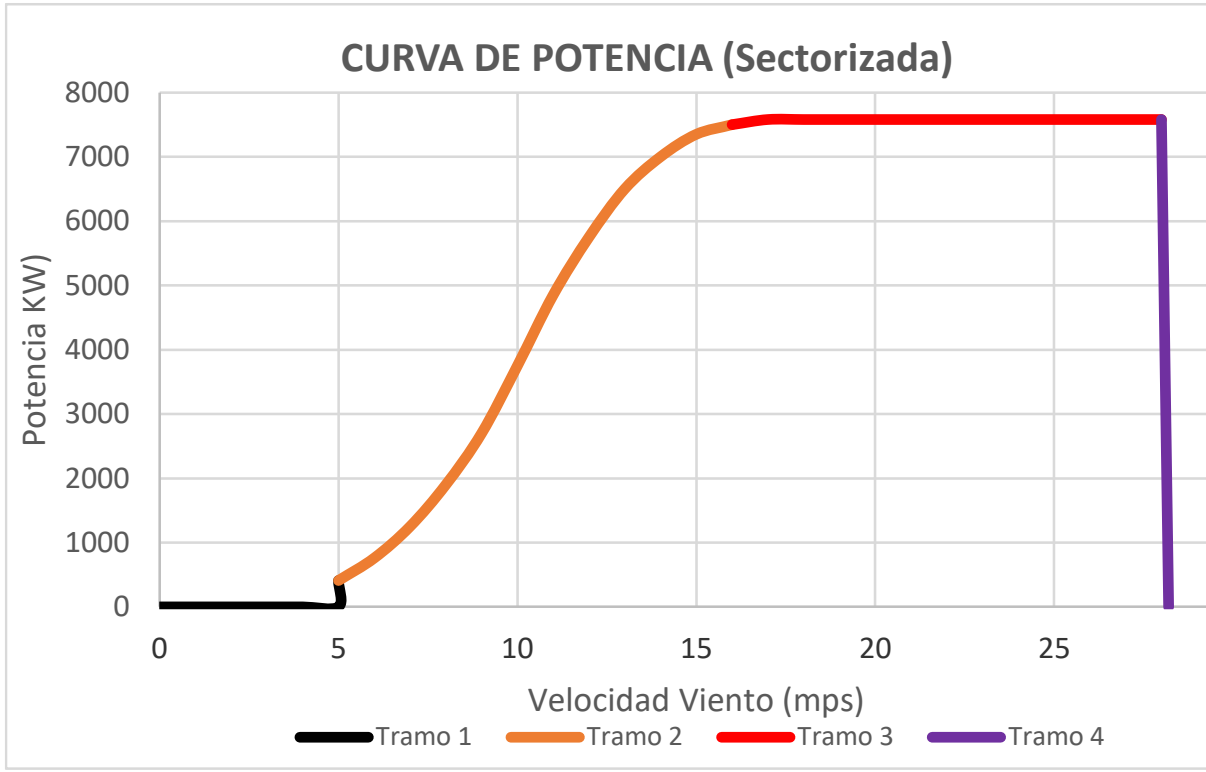


1. Aspa
2. Soporte del aspa
3. Regulador del ángulo
4. Buje (Concentrador)
5. Carena (Cascaron de proa)
6. (Soporte principal
7. Eje principal
8. Luces de posición
9. Multiplicador
10. Sistema Hidráulico de enfriamiento
11. Frenos mecánicos
12. Generador
13. Convertidor, control eléctrico, elementos de protección y desconexión
14. Transformador
15. Anemómetro
16. Chasis
17. Torre de soporte
18. Sistema de orientación

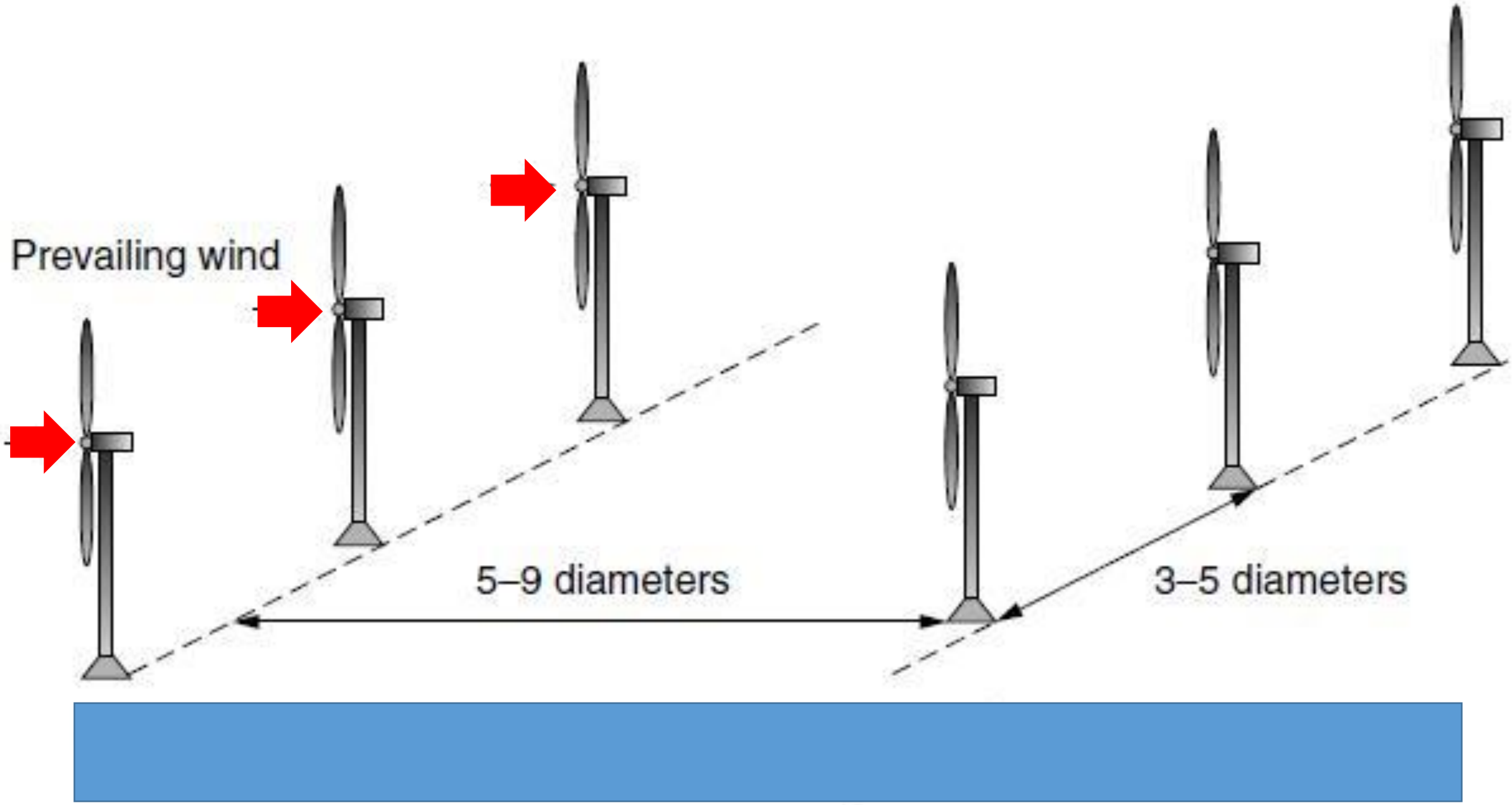


COMPONENTES DE UN GENERADOR EÓLICO

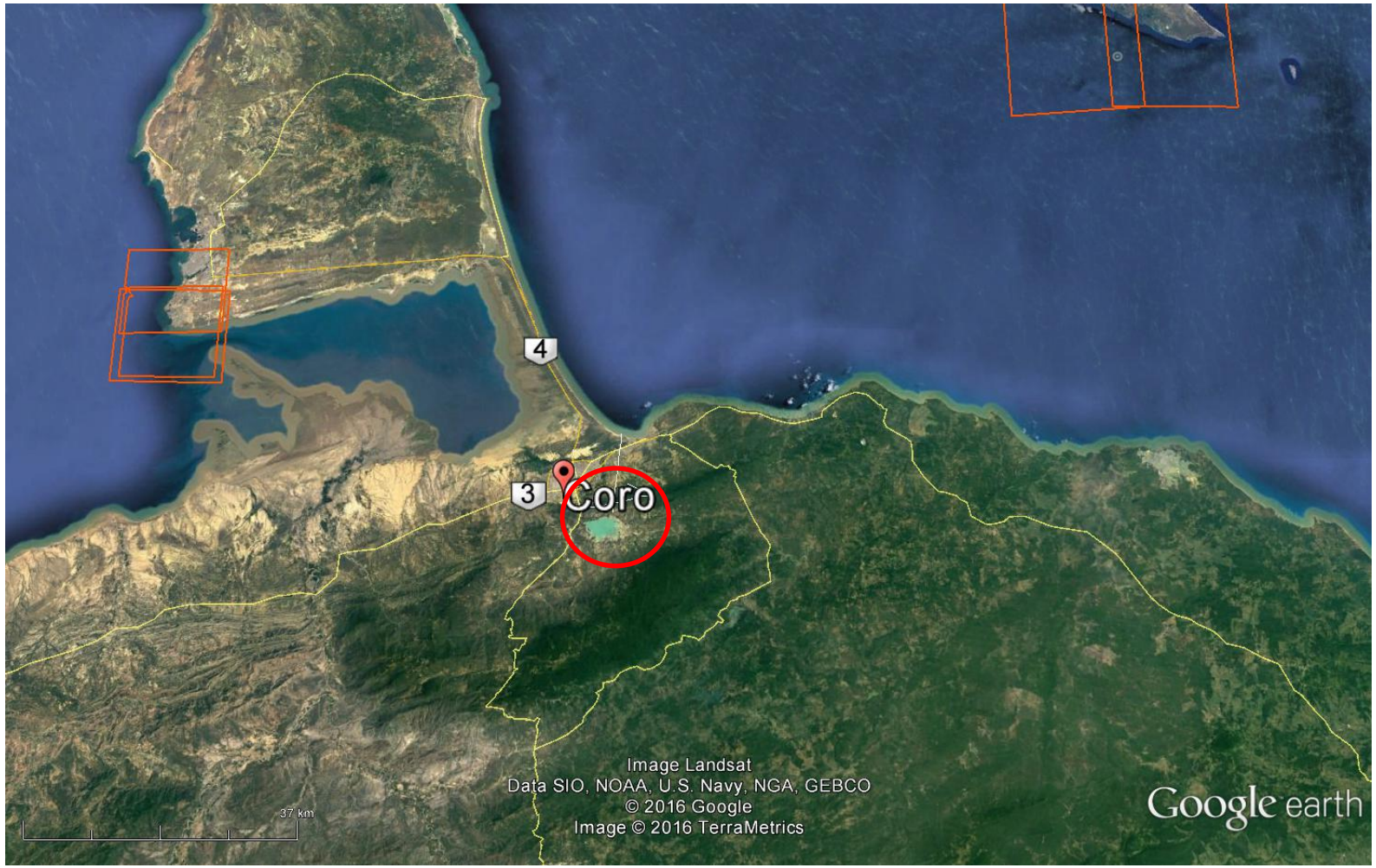

ENERCON E126/7500
8000.00
7000.00
6000.00
5000.00
4000.00
3000.00
2000.00
1000.00
0.00
-1000.00
Potencia (KW)
0
5
10
15
20
25
30
Velocidad Viento (mps)
Fabricante
Ecuacion


CURVA DE POTENCIA (Sectorizada)
8000
7000
6000
5000
4000
3000
2000
1000
0
Potencia KW)
0
5
10
15
20
25
Velocidad Viento (mps)
Tramo 1
Tramo 2
Tramo 3
Tramo 4

SEPARACIÓN OPTIMA ENTRE GENERADORES EÓLICOS

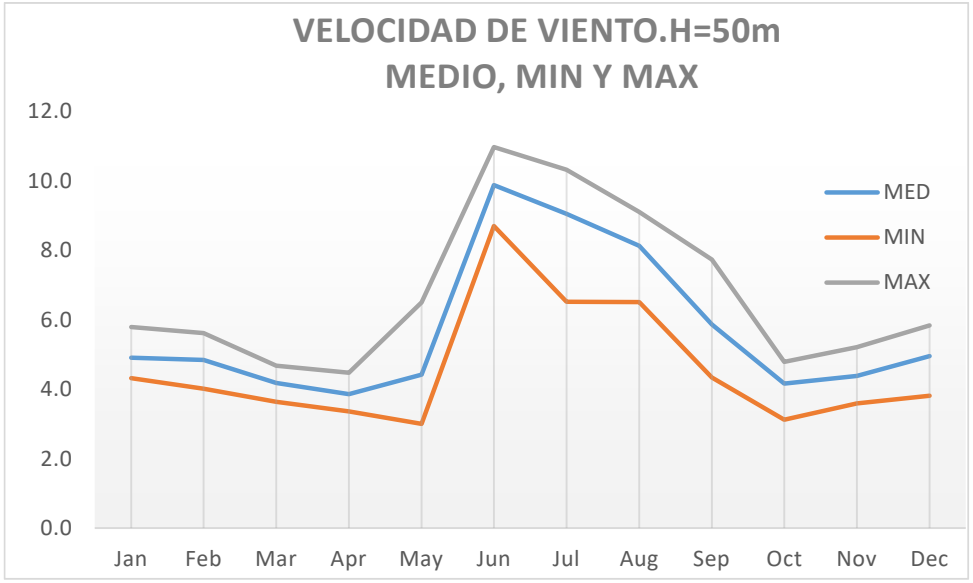


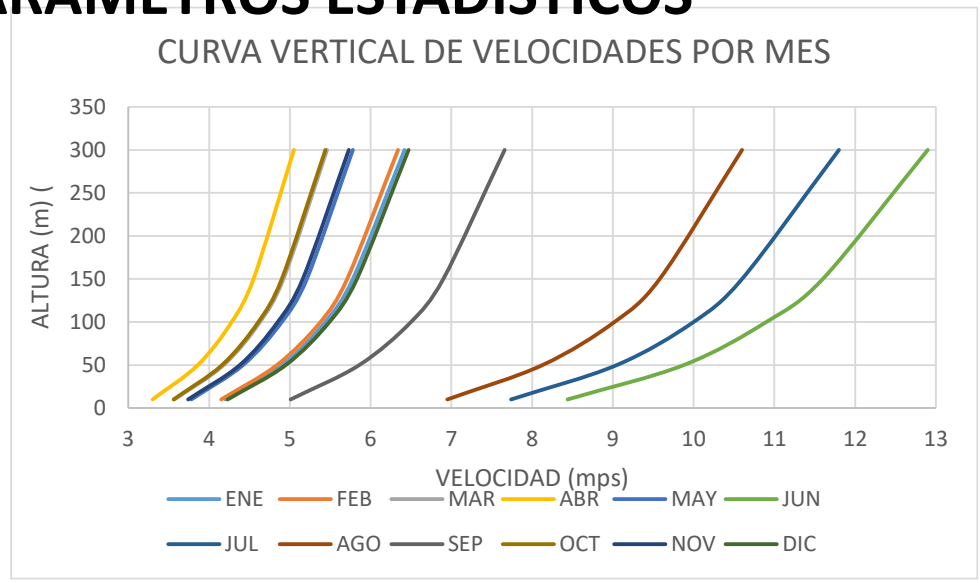
PLANTA EÓLICA EL ISIRO

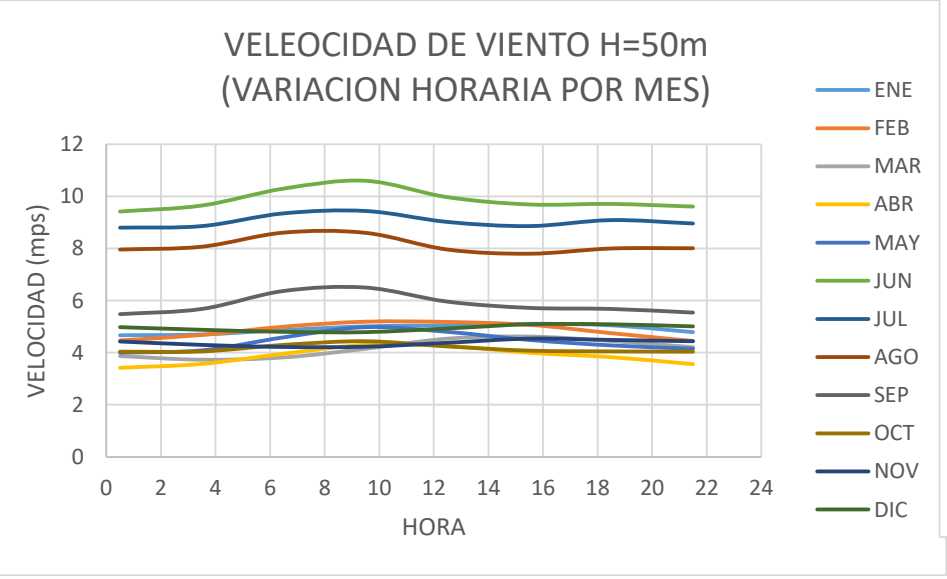


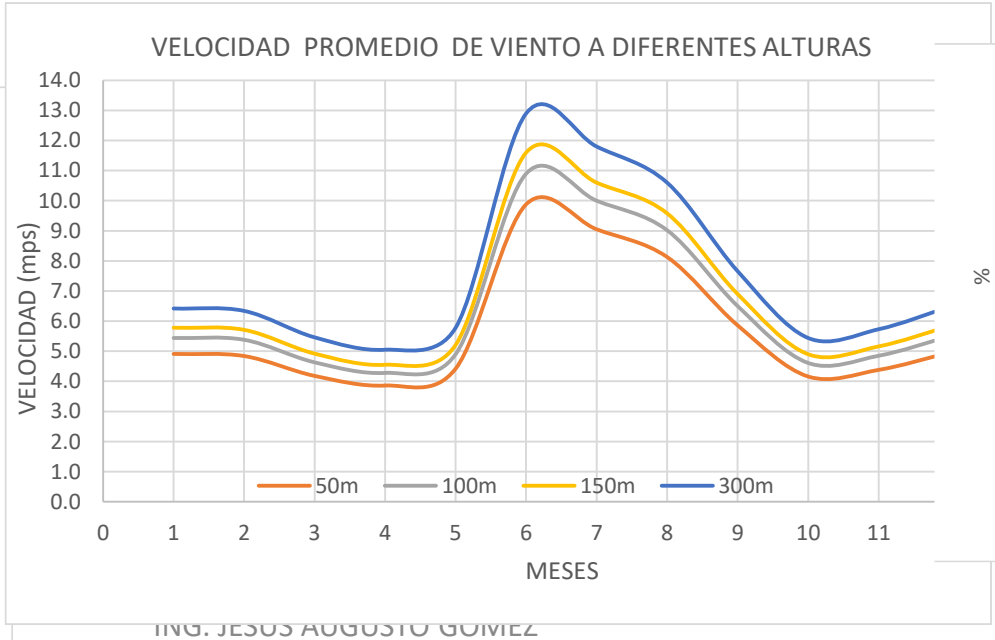
PLANTA EÓLICA EL ISIRO.

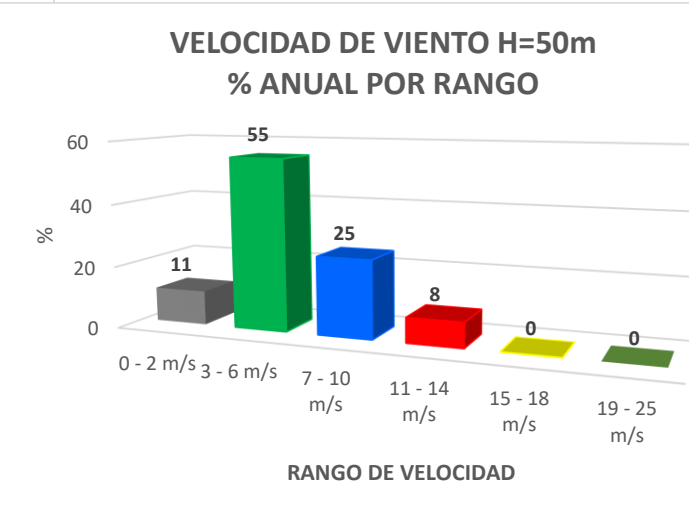
VELOCIDAD DE VIENTO. PARÁMETROS ESTADÍSTICOS

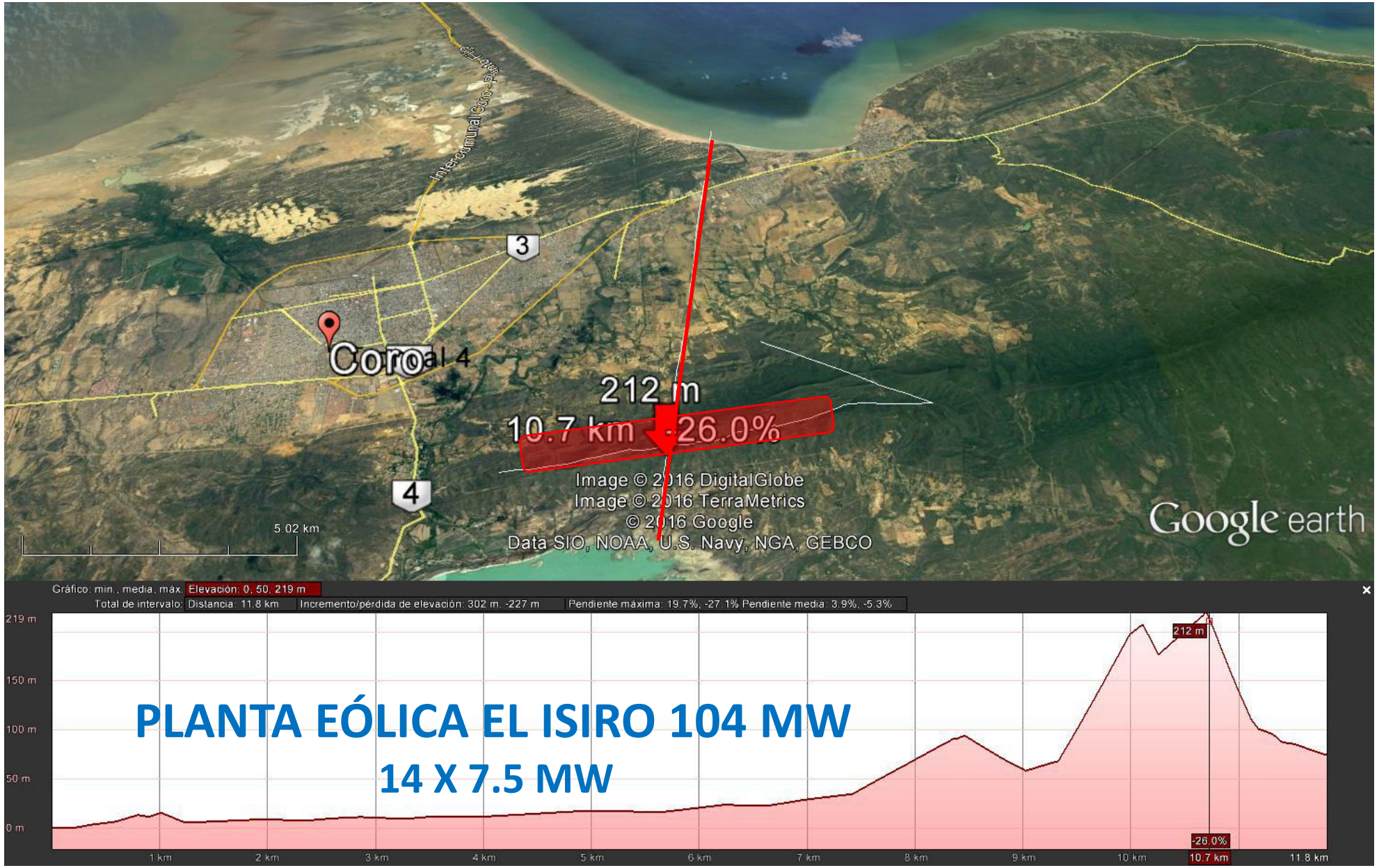






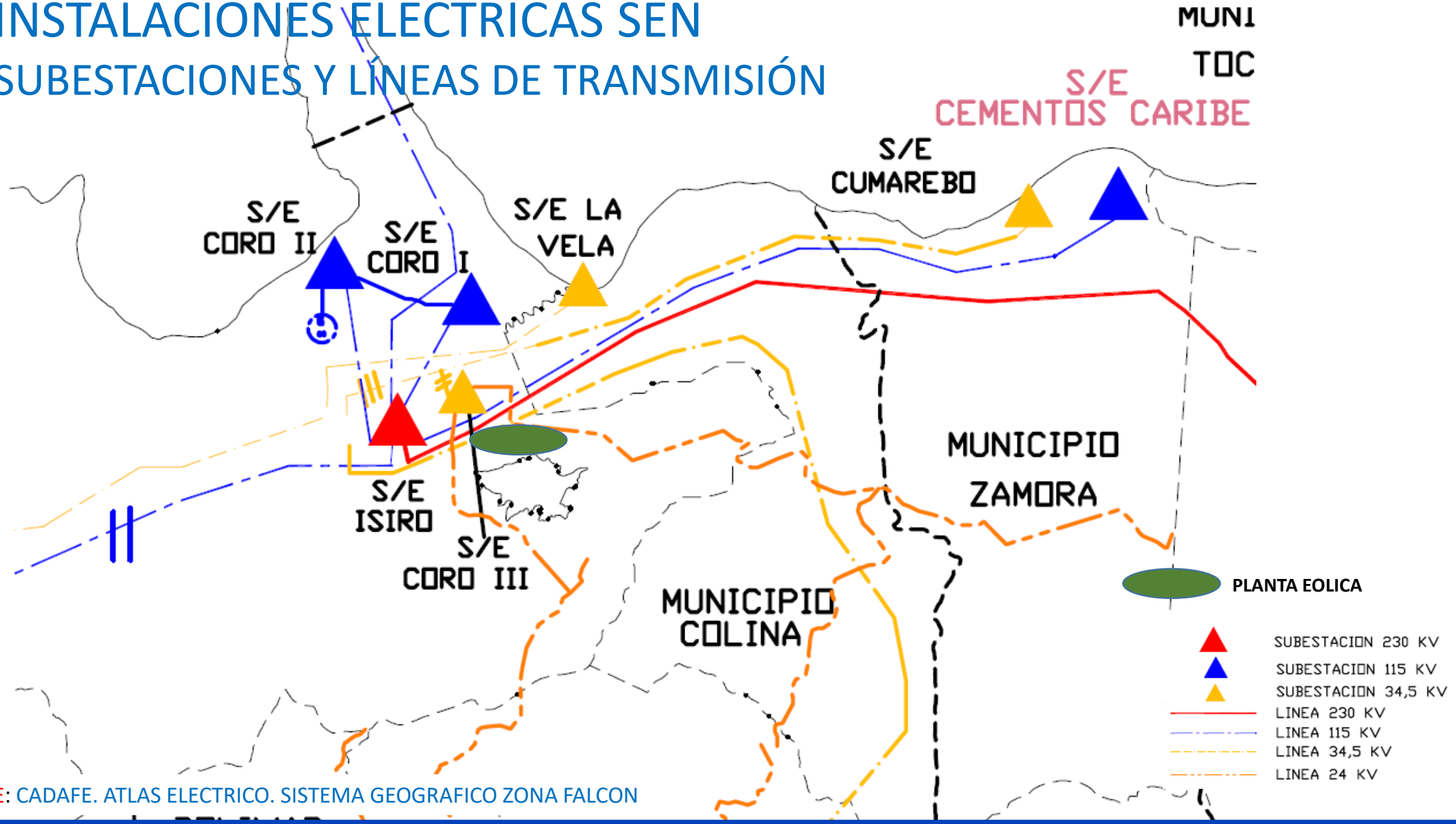




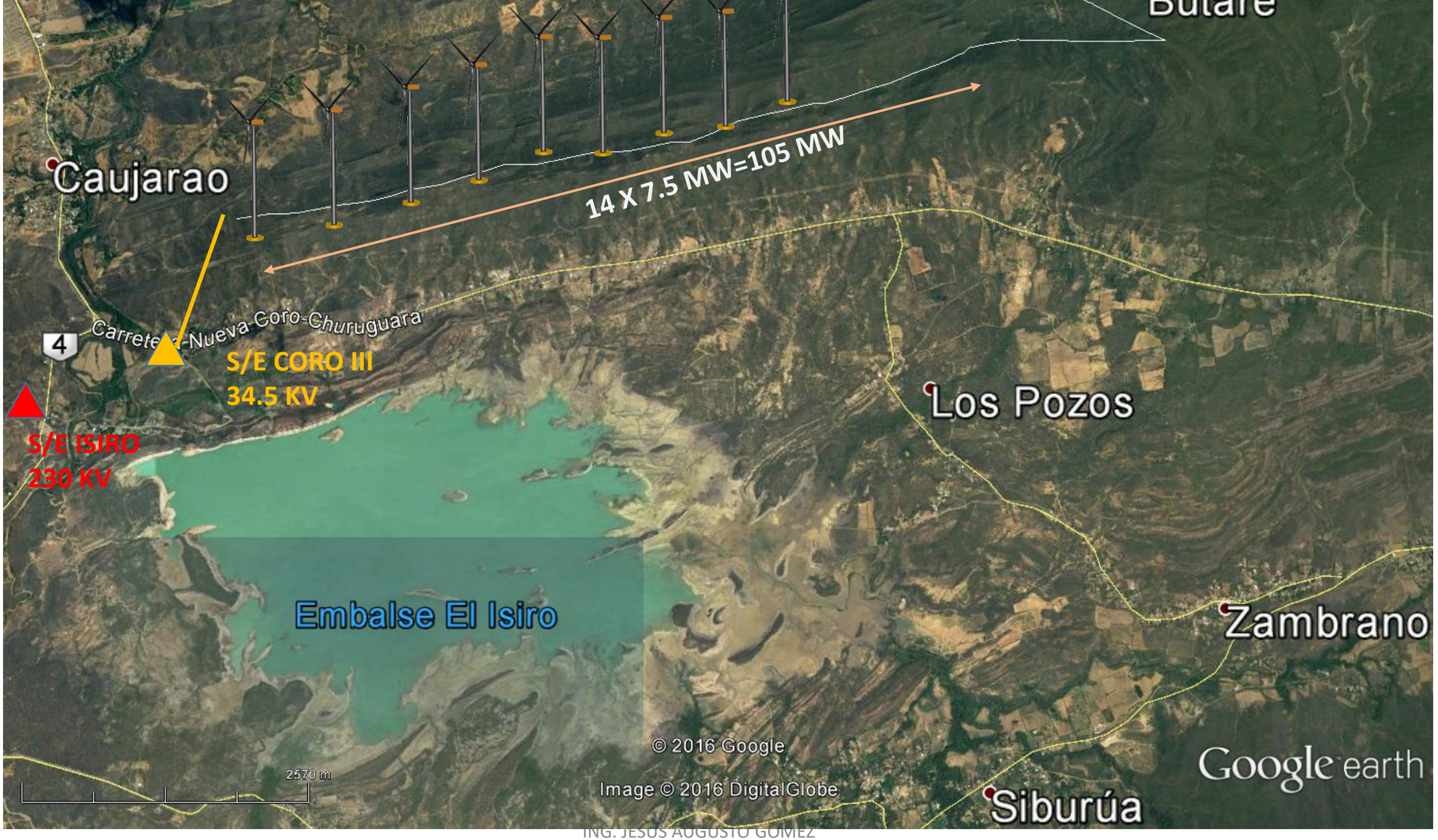

Coroal 4
212 m
10.7 km -26.0%
Image © 2016 DigitalGlobe
Image © 2016 TerraMetrics
© 2016 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
5.02 km
Gráfico: min., media, máx. Elevación: 0, 50, 219 m
Total de intervalo: Distancia: 11.8 km
Incremento/pérdida de elevación: 302 m, -227 m
Pendiente máxima: 19.7%, -27.1% Pendiente media: 3.9%, -5.3%
219 m
150 m
100 m
50 m
0 m
1 km
2 km
3 km
4 km
5 km
6 km
7 km
8 km
9 km
10 km
11.8 km
-26.0%
PLANTA EÓLICA EL ISIRO 104 MW
14 X 7.5 MW

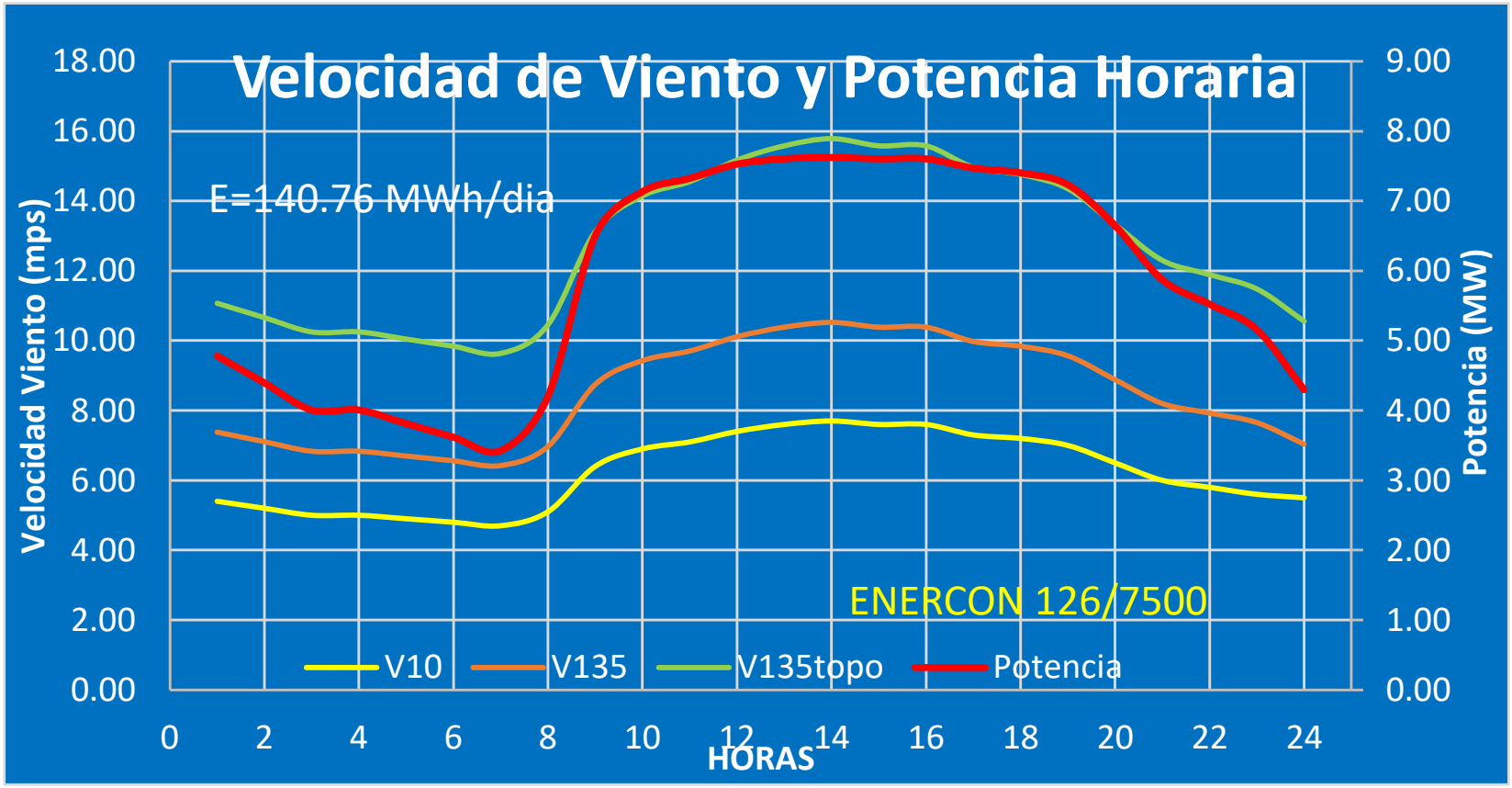
INSTALACIONES ELÉCTRICAS SEN

SUBESTACIONES Y LÍNEAS DE TRANSMISIÓN



FUENTE: CADAFE. ATLAS ELECTRICO. SISTEMA GEOGRAFICO ZONA FALCON


Caujarao
14 X 7.5 MW=105 MW
Carretera Nueva Coro-Churuguara
4
S/E CORO III
34.5 KV
S/E ISIRO
230 KV
Los Pozos
Embalse El Isiro
Zambrano
Siburúa
© 2016 Google
Image © 2016 DigitalGlobe
Google earth


Velocidad de Viento y Potencia Horaria
E=140.76 MWh/dia
ENERCON 126/7500
V10
V135
V135topo
Potencia
Velocidad Viento (mps)
Potencia (MW)
HORAS
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
2
4
6
8
10
12
14
16
18
20
22
24

PLANTA EÓLICA P-104 MW
14 GENERADORES ENERCOM 126/7500

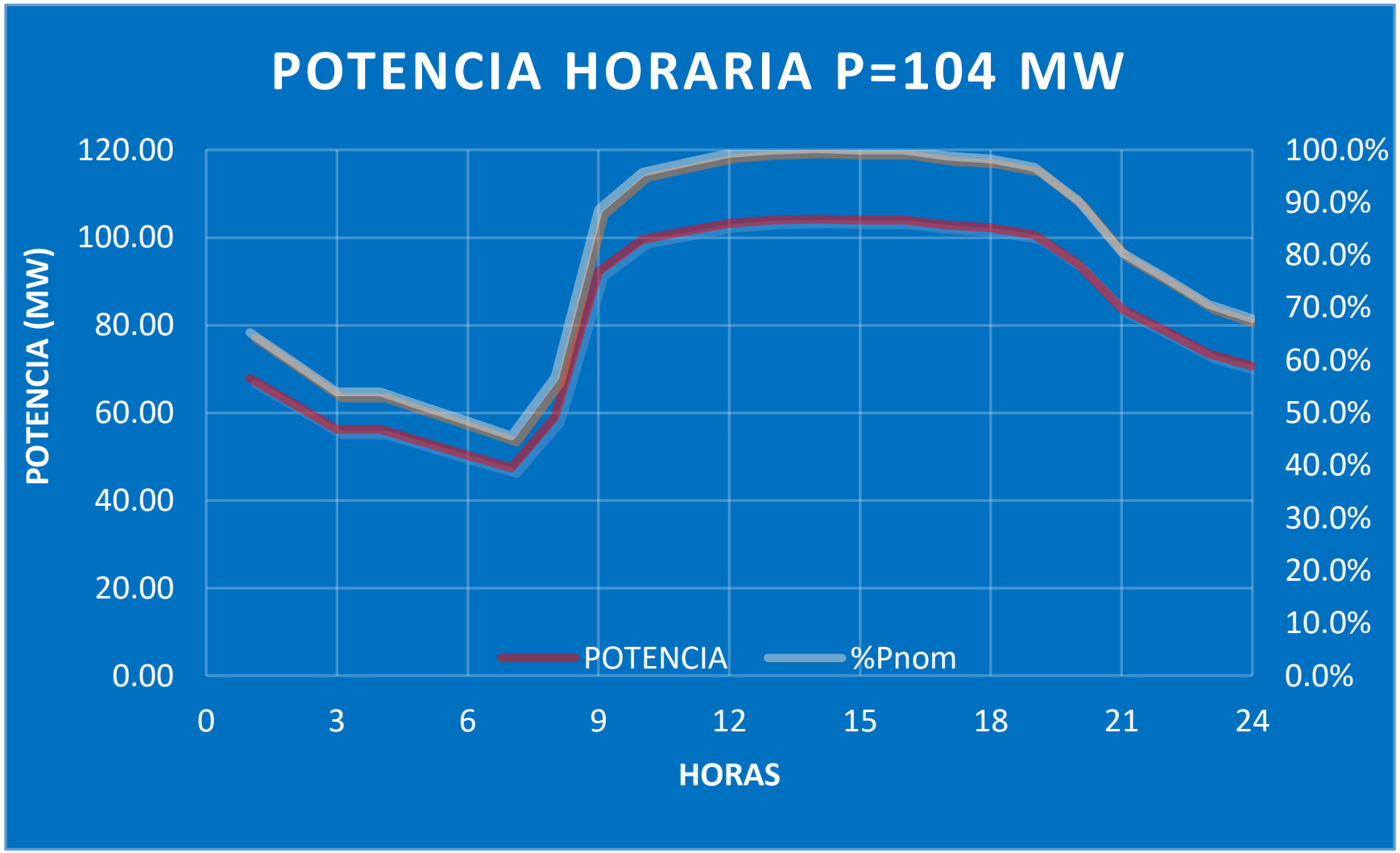
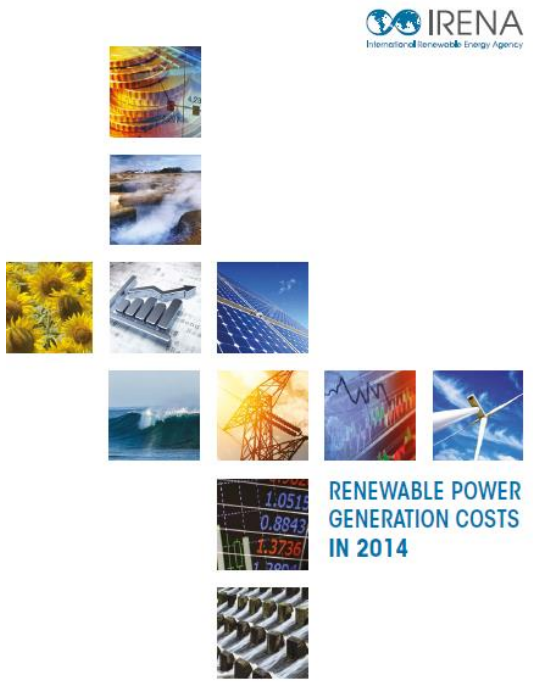


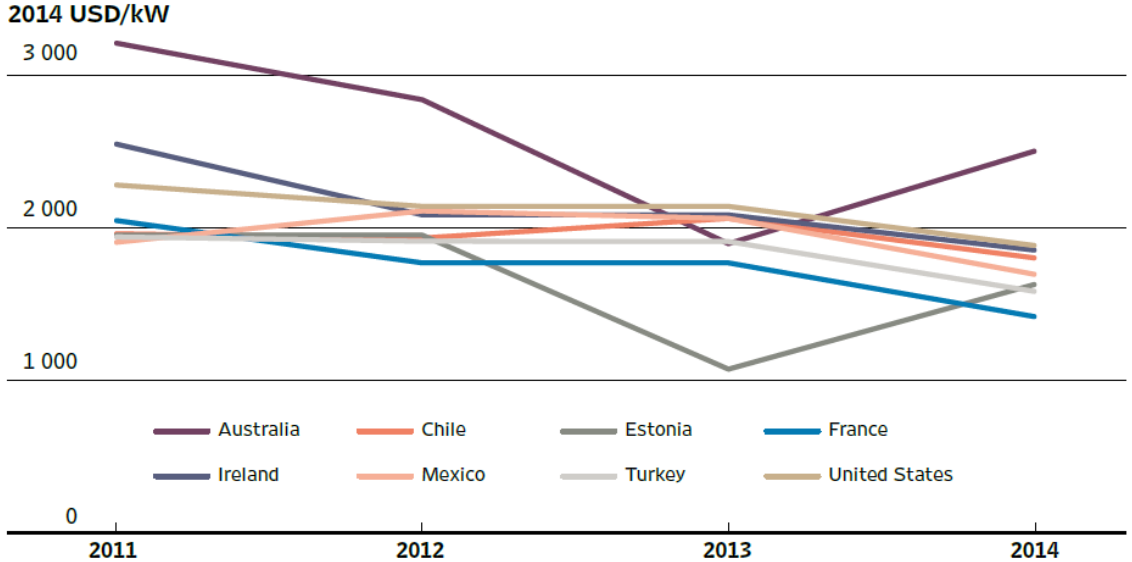
Table 4.1: Capital cost breakdown for a 20 MW onshore wind farm in Mexico

		2014 USD million	Share
Civil works and grid connection	Civil works of wind turbines	8.15	18.2%
22.0%	Measurement tower	0.09	0.2%
	Construction costs	0.31	0.7%
	Construction indirects costs	1.11	2.5%
	Land rent	0.17	0.4%
Sub-total		**17.57**	**22.0%**
Wind turbines and installation	Turbines price	20.64	46.1%
68.5%	Transportation of the wind turbines	2.27	5.1%
	Electrical infrastructure of wind turbines	7.74	17.3%
Sub-total		**22.91**	**68.5%**
Planning & management	Management cost	0.46	1.0%
9.5%	Administrative cost	3.80	8.5%
Sub-total		**4.27**	**9.5%**
TOTAL COST	2237 US$/MW	**44.74**	**100.0%**

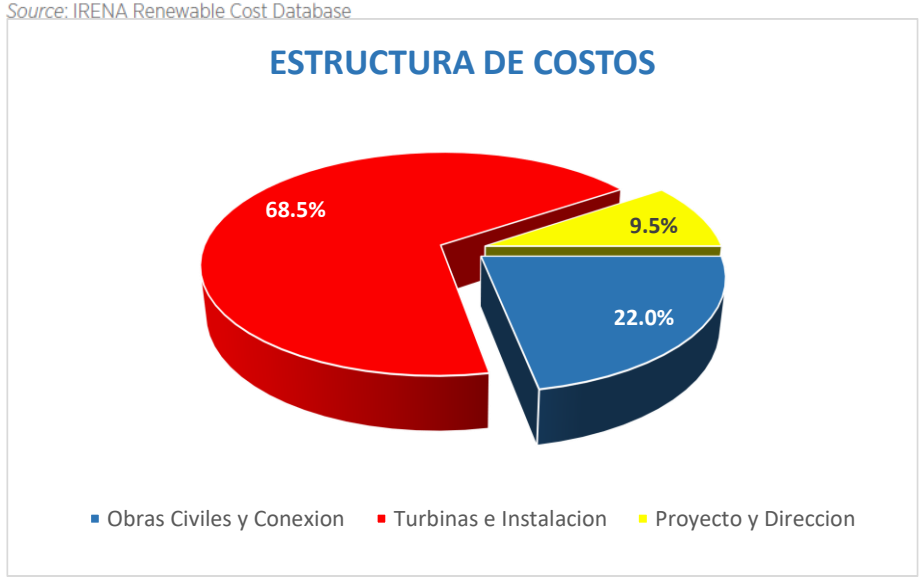
Source: IRENA Renewable Cost Database

COSTOS DE INSTALACIÓN

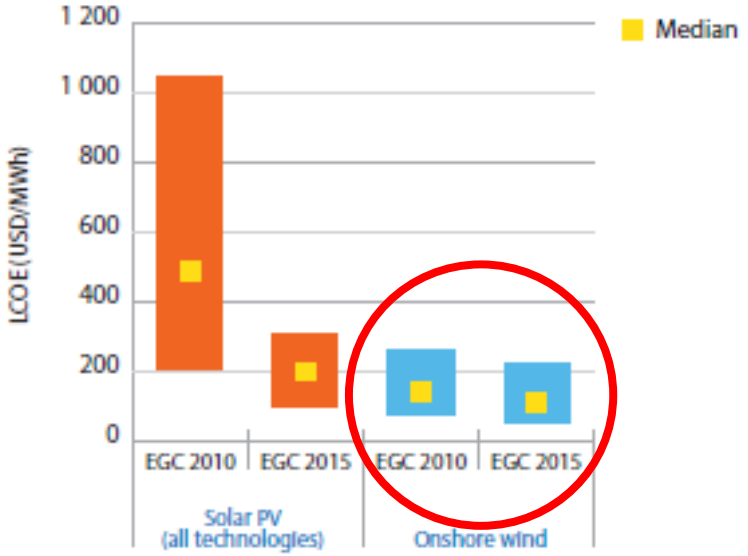




Source: IRENA Renewable Cost Database



COSTOS DE GENERACIÓN



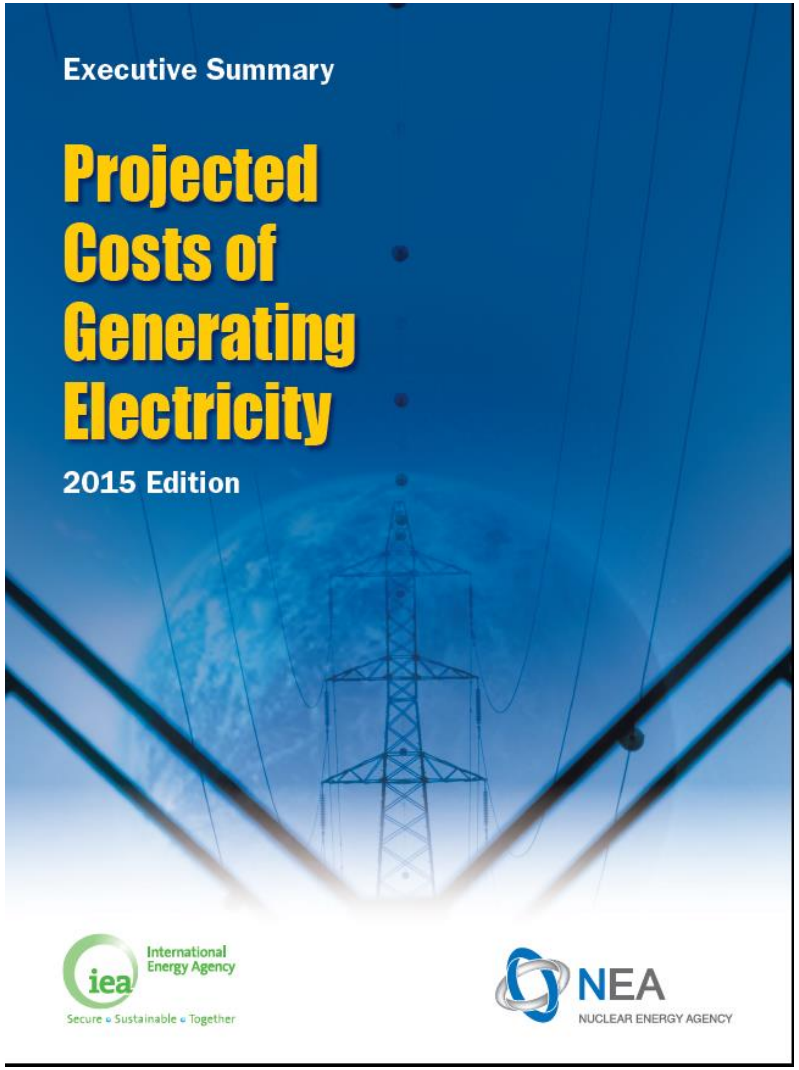
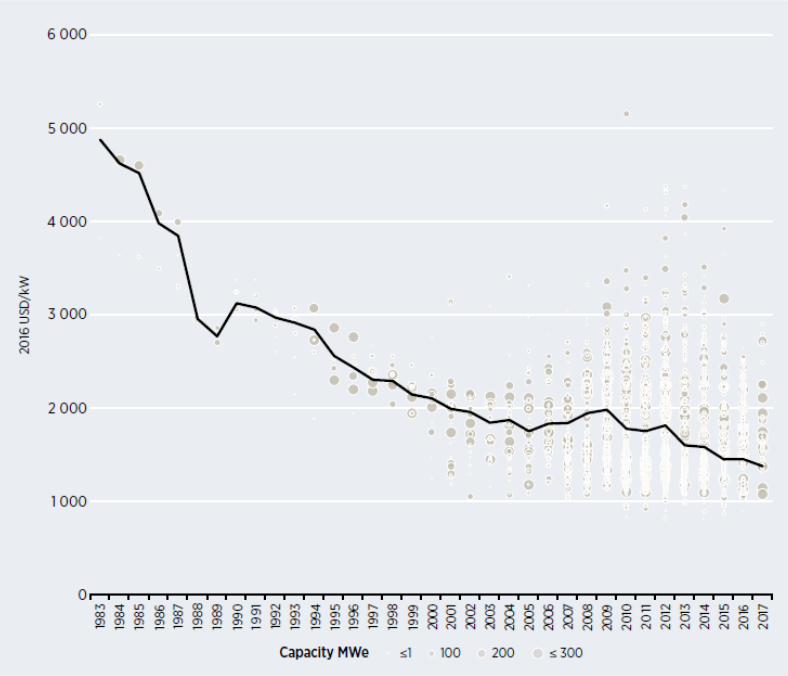
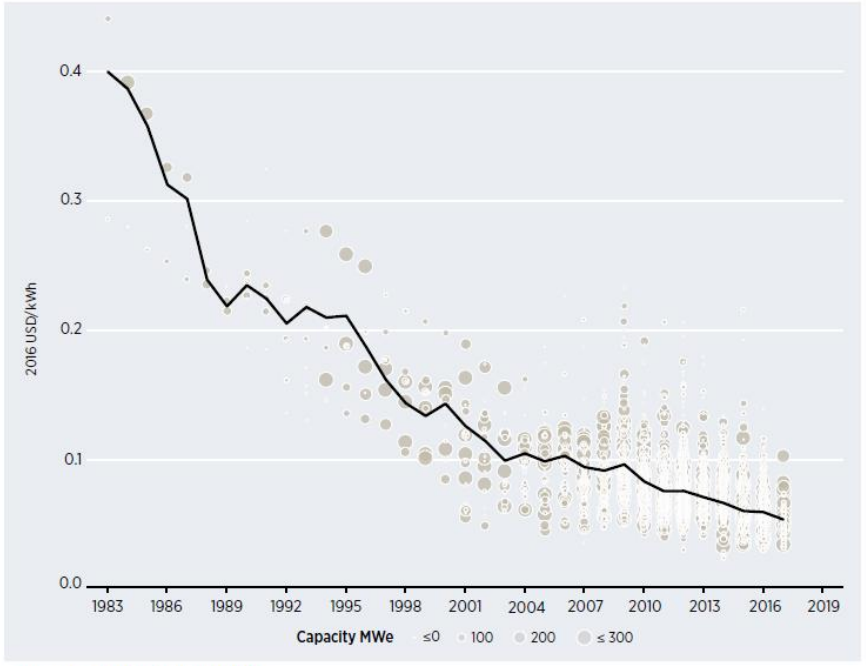


Figure 5.3 Total installed costs of onshore wind projects and global weighted average, 1983-2017

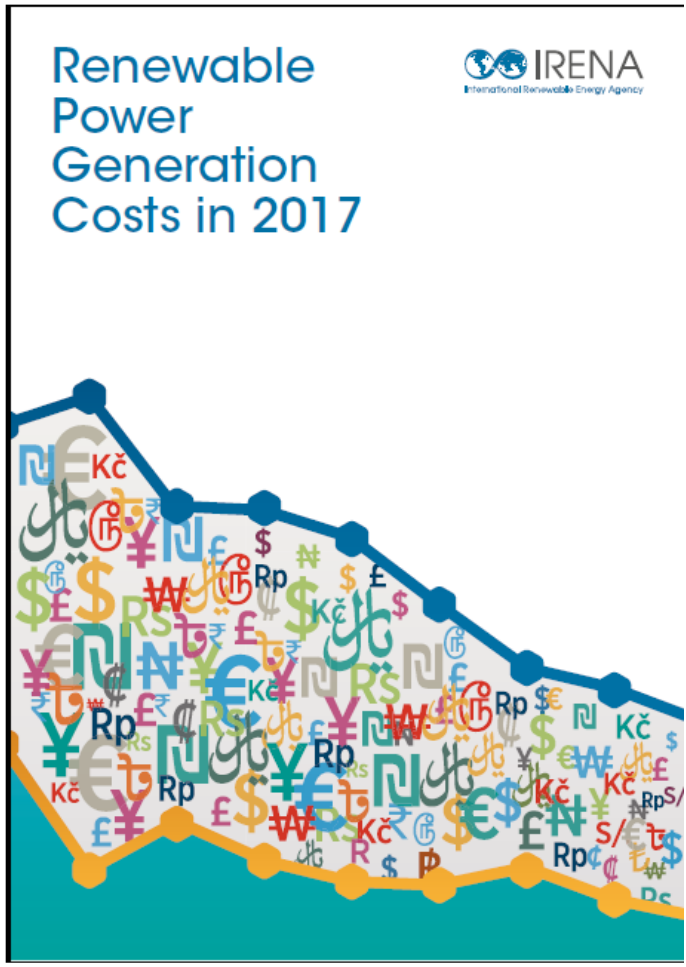


Source: IRENA Renewable Cost Database.

Figure 5.17 The global weighted average levelised cost of electricity of onshore wind, 1983-2017



Sources: IRENA Renewable Cost Database.



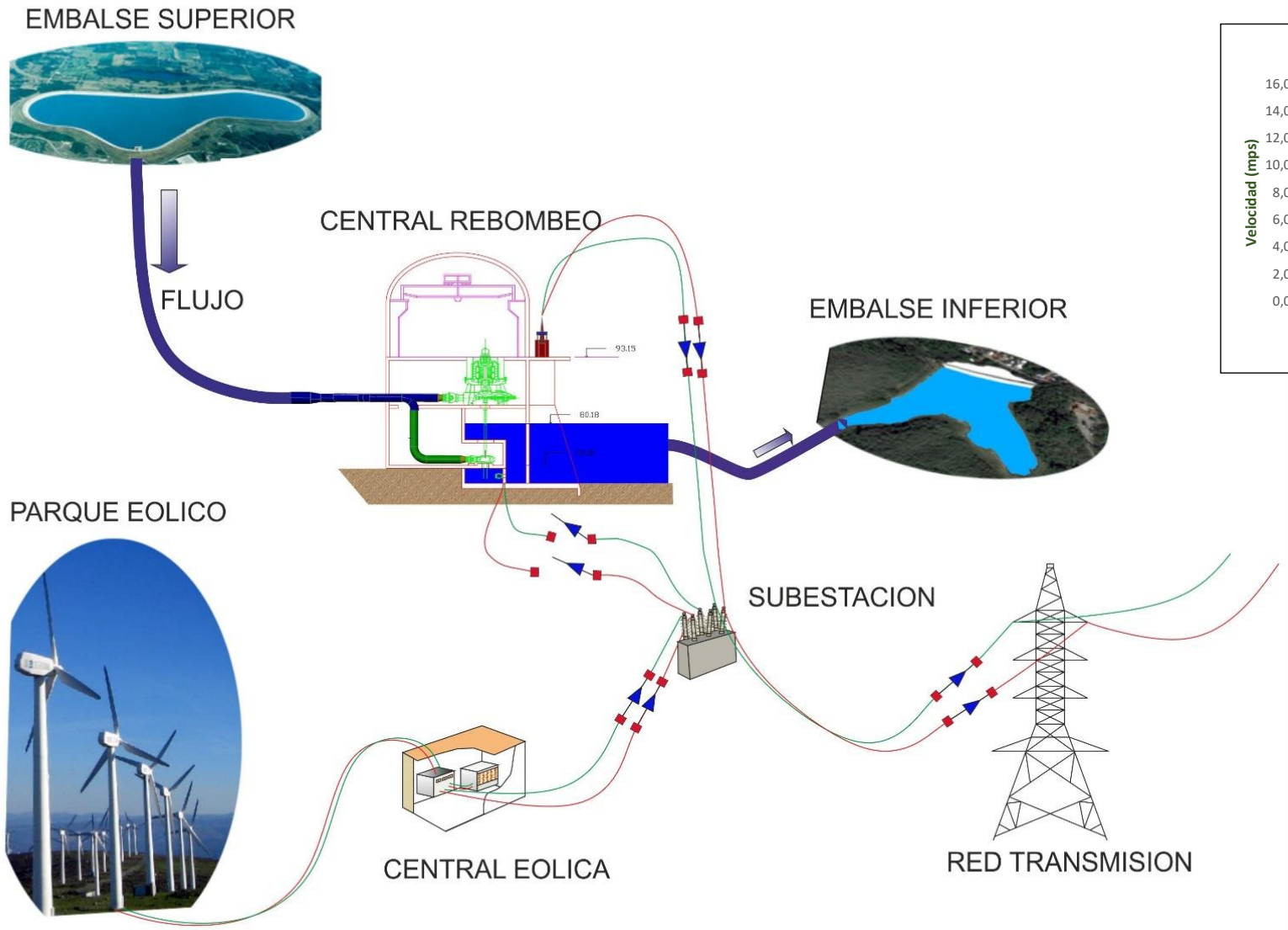
COSTOS DE INSTALACION

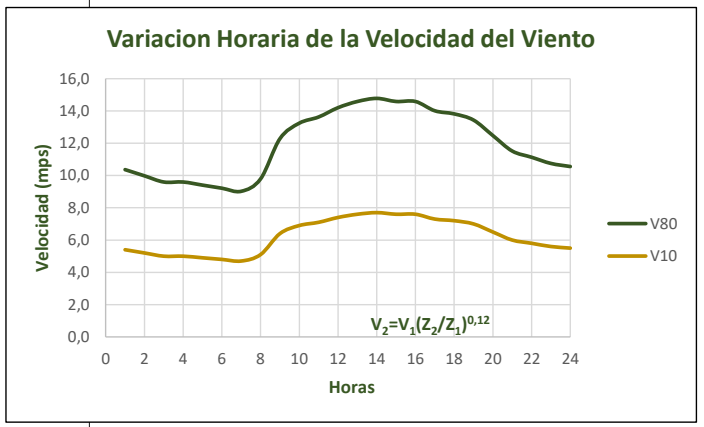
LCOE (2017)

INTEGRACION DE ENERGIAS RENOVABLES

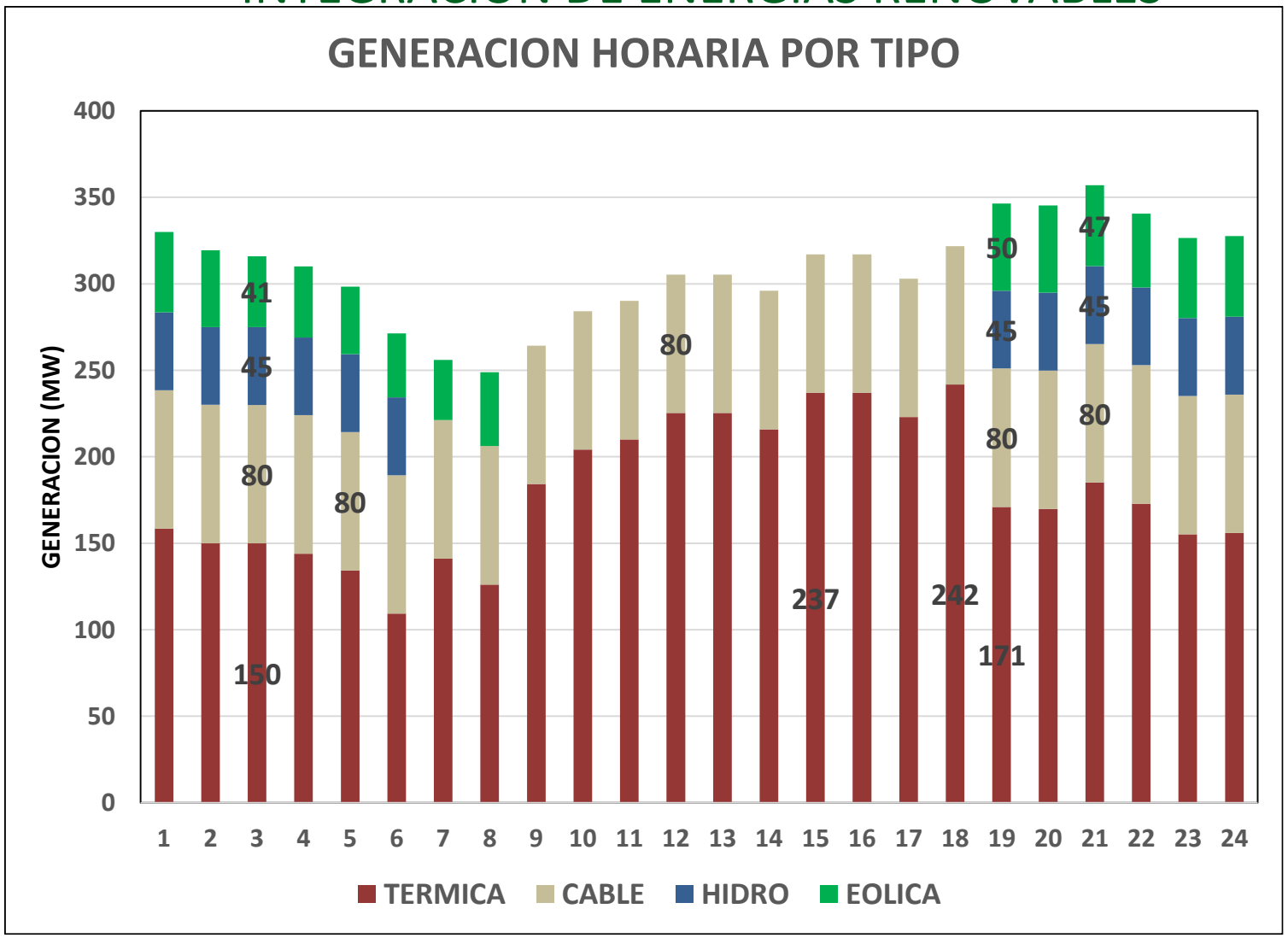
INTEGRACION DE ENERGIAS RENOVABLES

GENERACION HIDRO + EOLICA





INTEGRACION DE ENERGIAS RENOVABLES



GRUPO ORINOCO
ENERGÍA Y AMBIENTE


GRACIAS !!!