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The Parts of a Wind turbine, Construction and Integration

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Draft

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- The elements of a wind turbine
- The construction of the wind power plant
- The building procedure
- Integration of wind energy into bulk power systems

Growing unit performance

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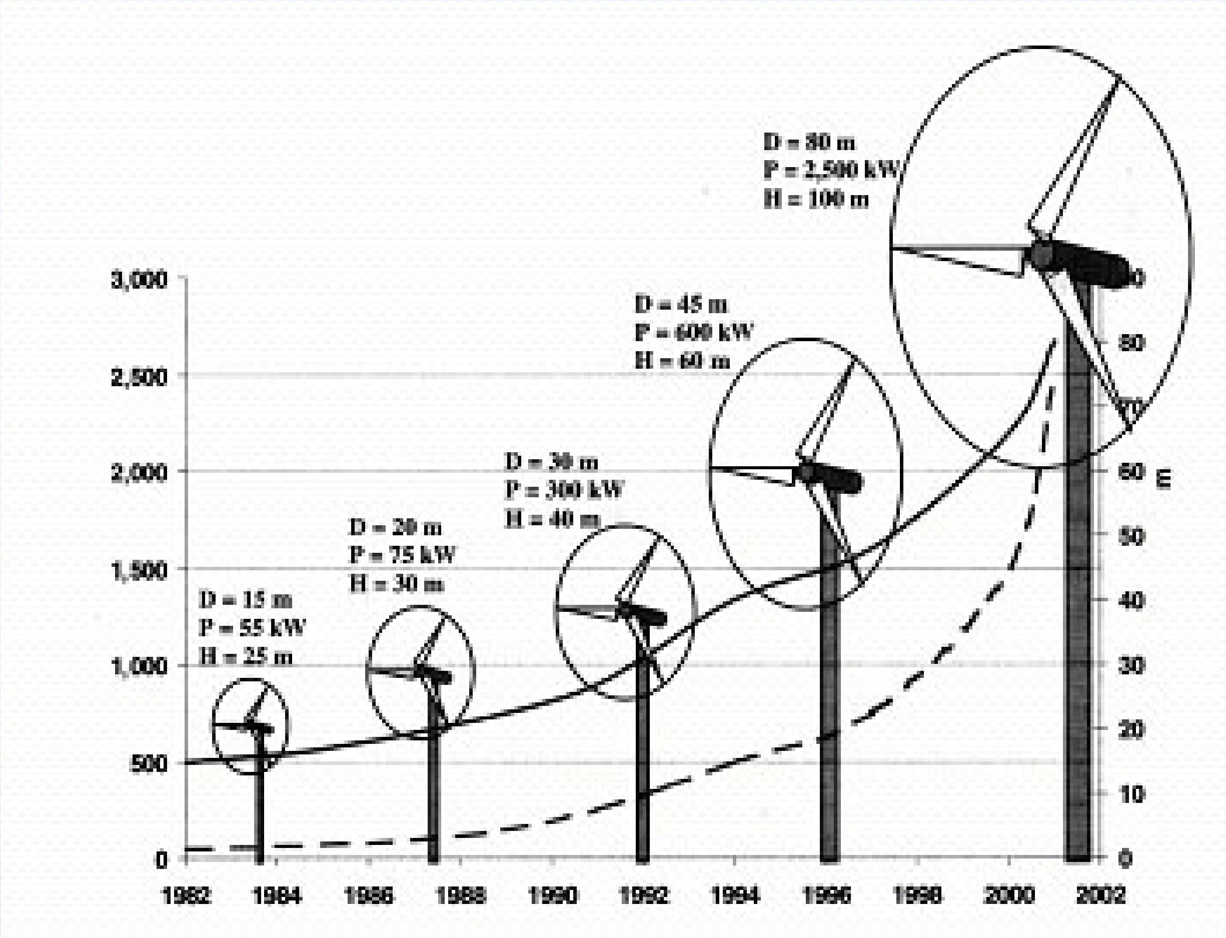

Today:

120-160 m

3,5-5 MW

Limits: the sky

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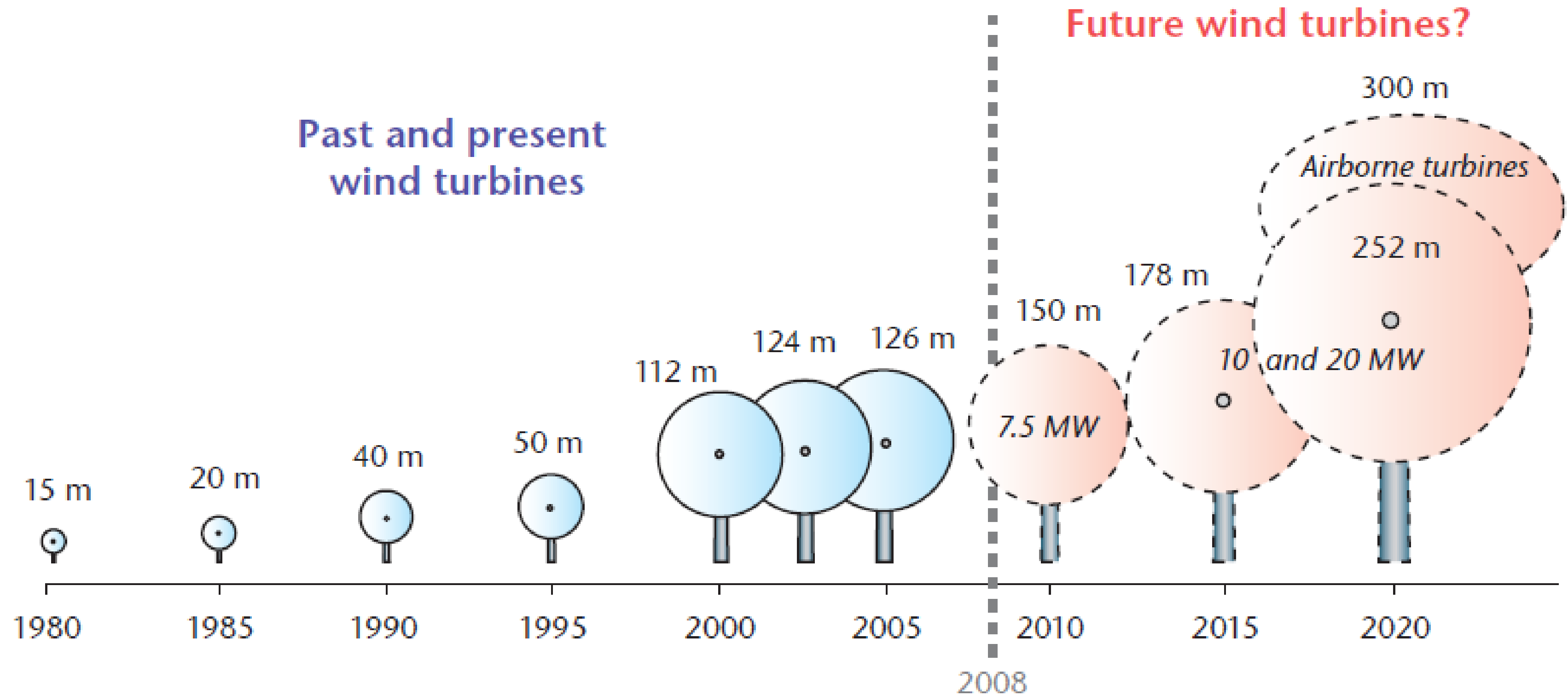
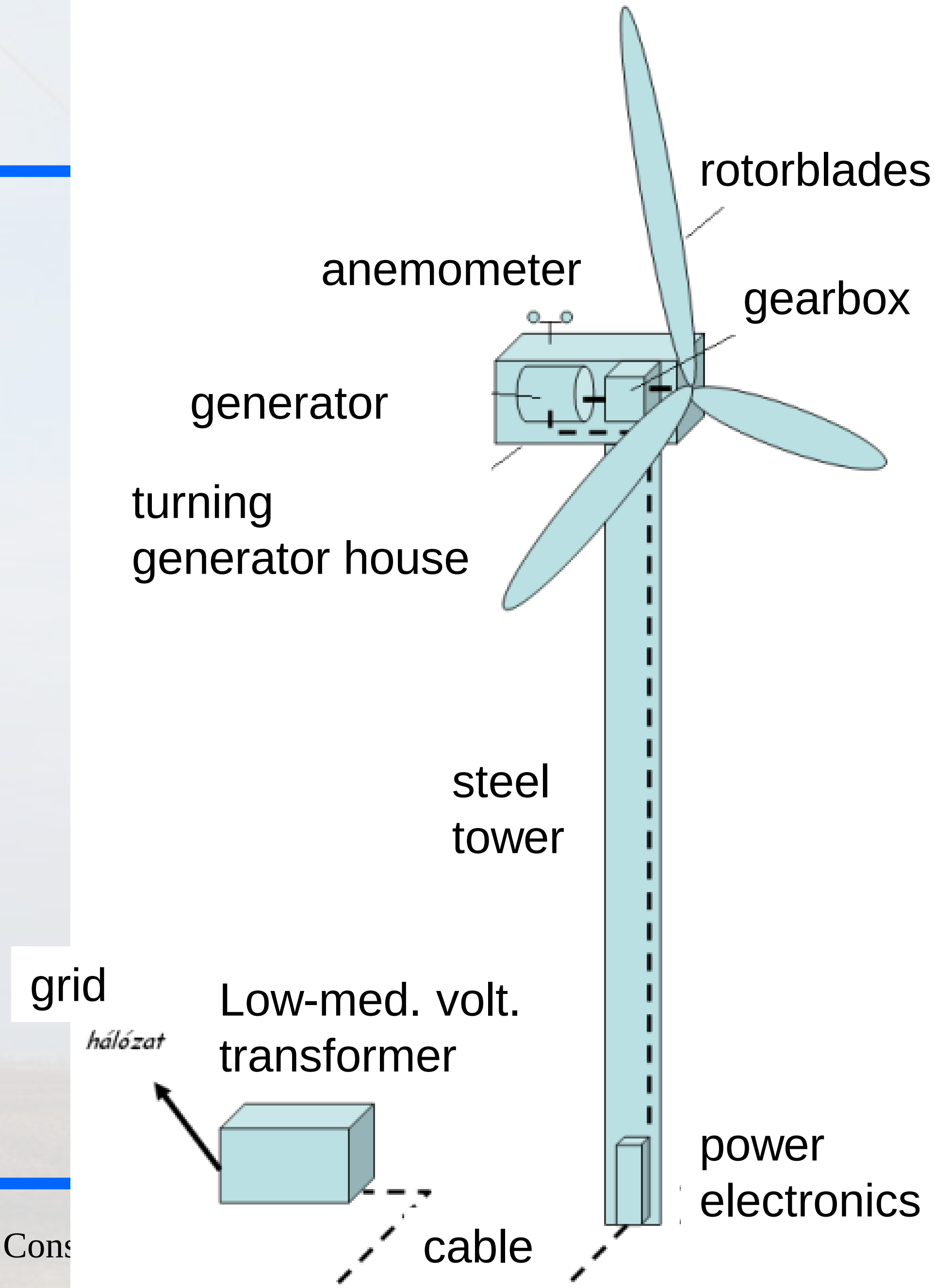


Source: Adapted from EWEA (2009).

Parts of a wind turbine



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Foundation

on-shore

- plates
- poles

off-shore

- floating
- mast weighted

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Transportation

Transportation

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Δ Α Σ Τ Α

Craning

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Nacelle

Trends

	traditional	up-to-date
Tower	steel	concrete
Height	low	high
Rpm	semi fixed speed	variable speed
Cut in	3m/s	2,5m/s

E-40 – E-82

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New control paradigm: wind priority

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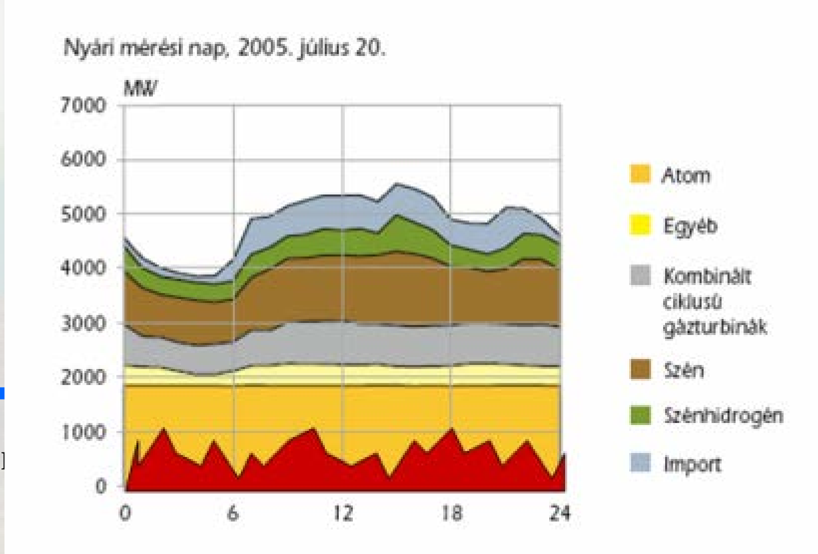
Traditional control: Load demand -> generation control on the base of the demand

Wind priority: we let generate all the wind plant, and we produce some more by the request

Future: intelligent generation and load harmonisation (Demand Side Management)



New control paradigm: wind priority

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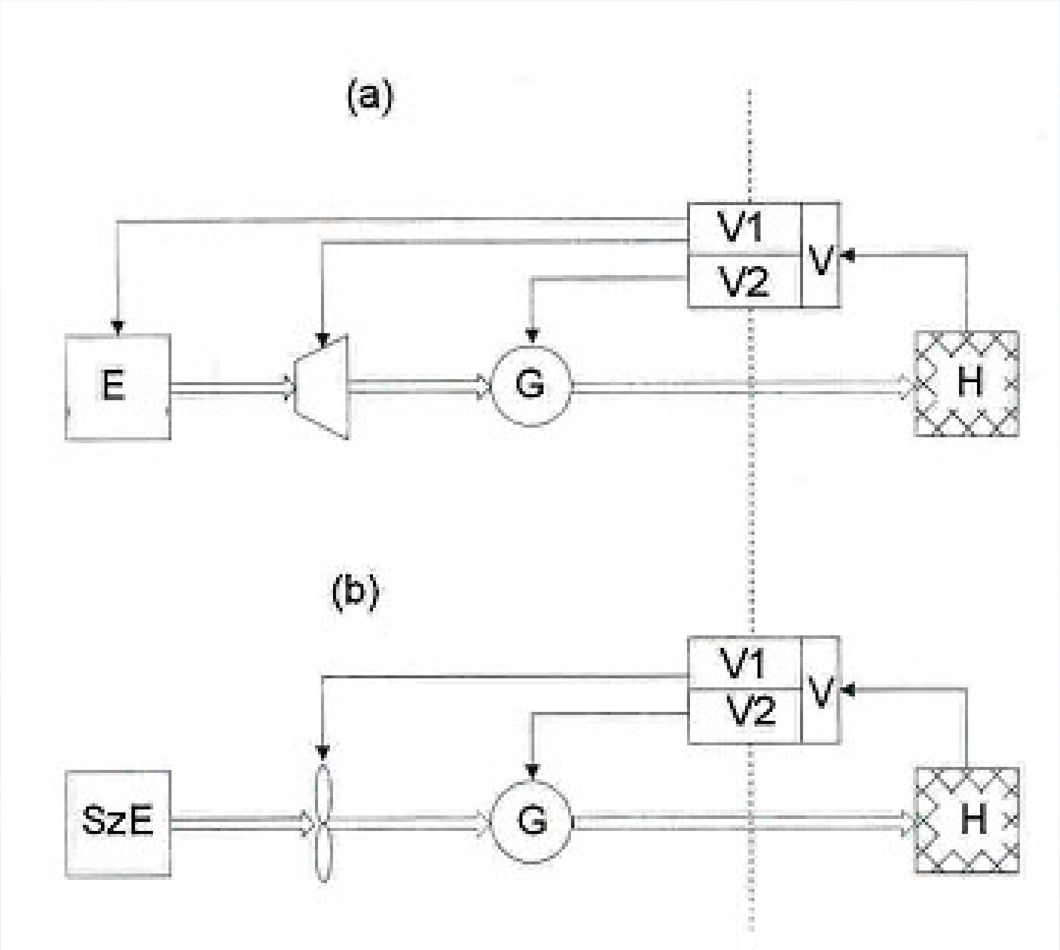

Traditional:

Control by the demand

- E.g. steam generation
- Turbine
- Generator

Wind:

Control by the wind speed and demand

- rotor blades
- generator

Indirect and direct driving

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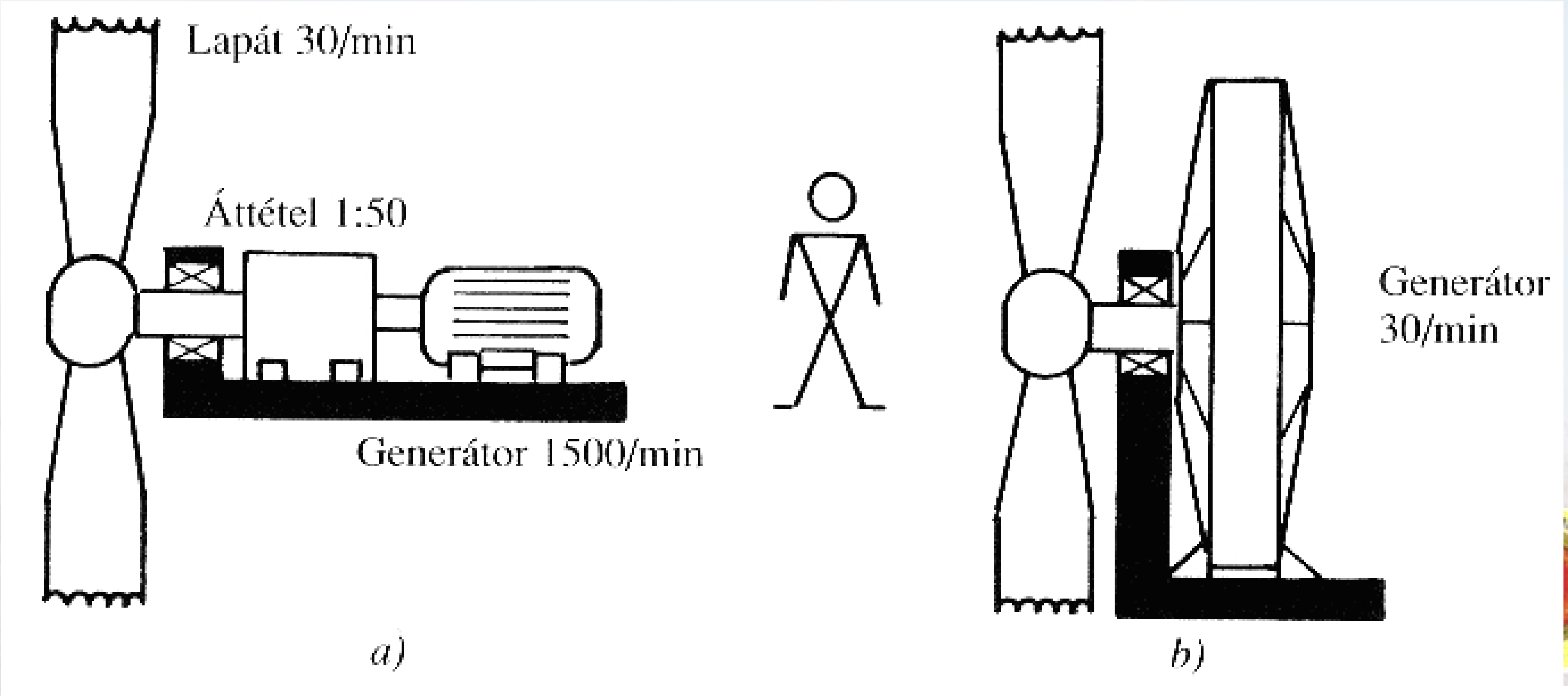

Connection of the generator to the grid

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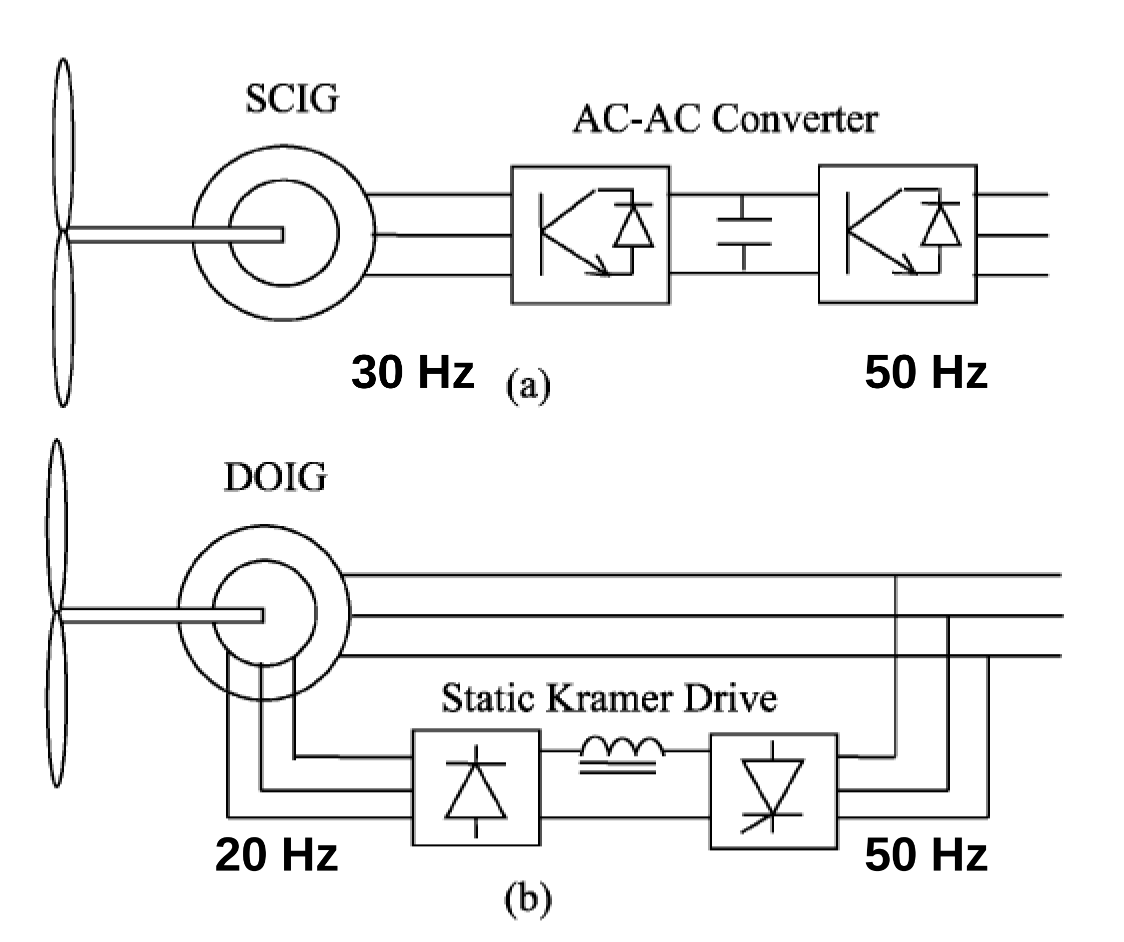
Appr. RPM

900-1000

changing



Fixed frequency (RPM)

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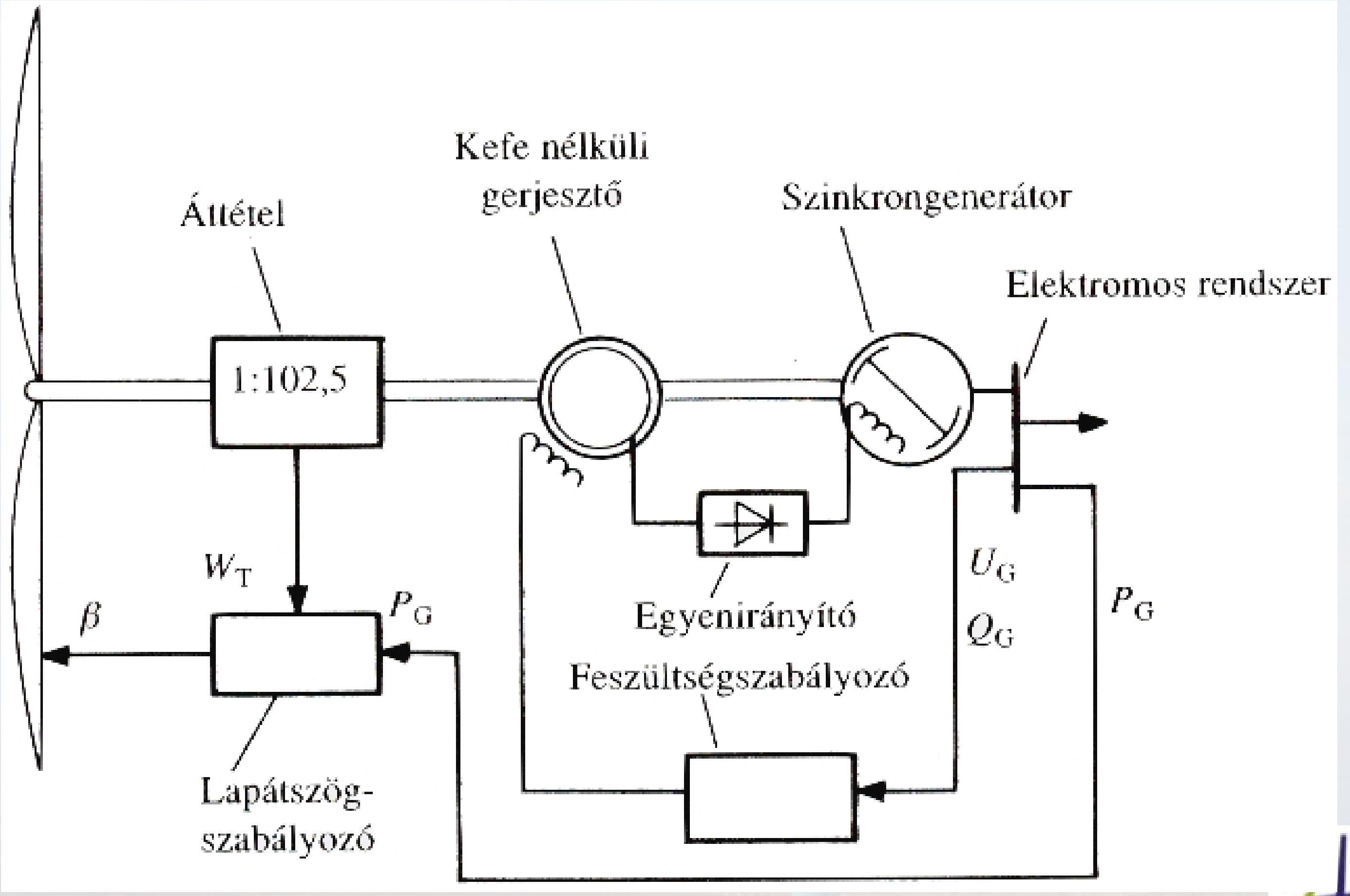
Control: pitch, P,Q

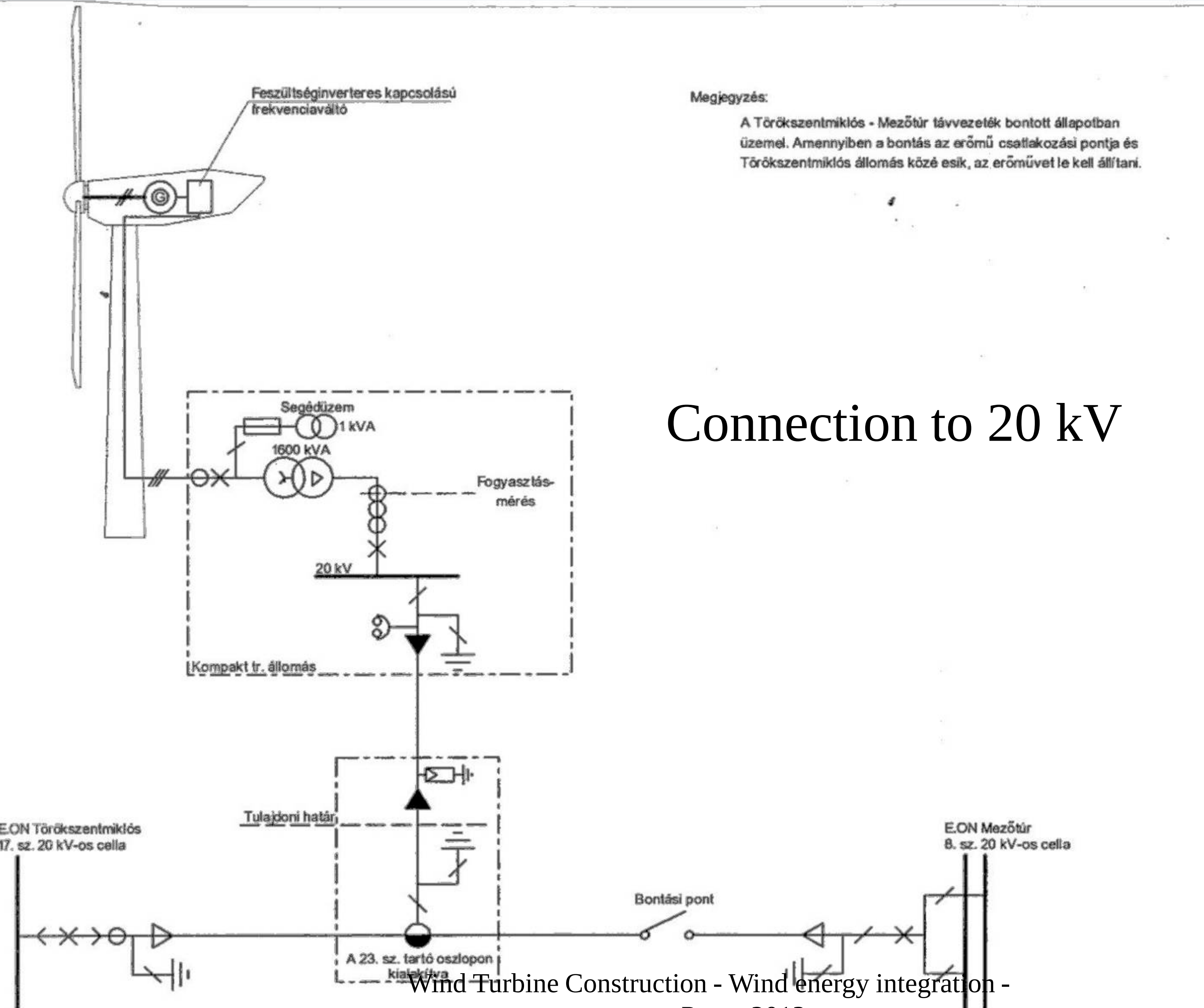


Electrical connection: compact substation

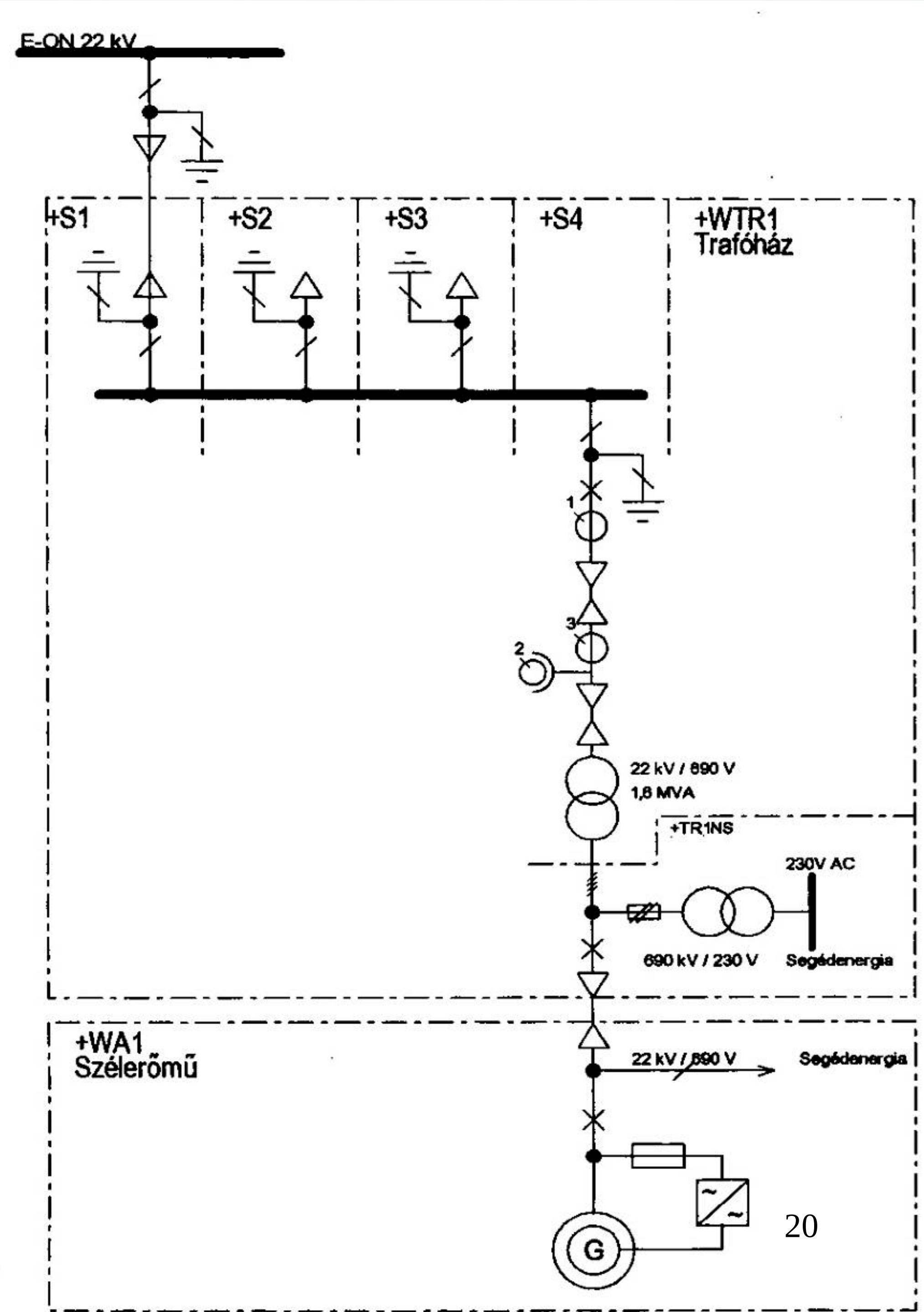


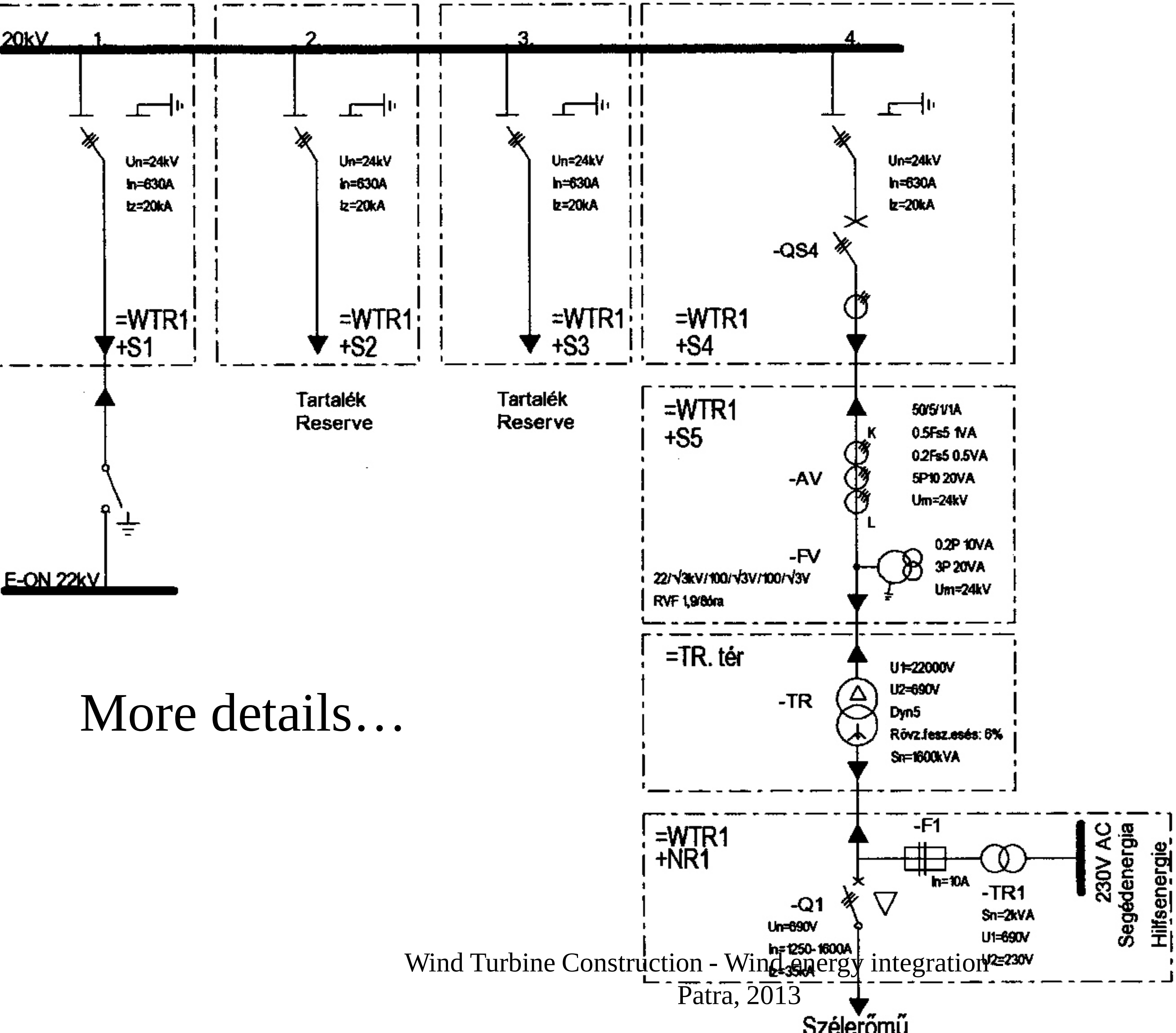



Connection to 20 kV



Single line scheme





More details…

Protection, measurements, settling, RTU

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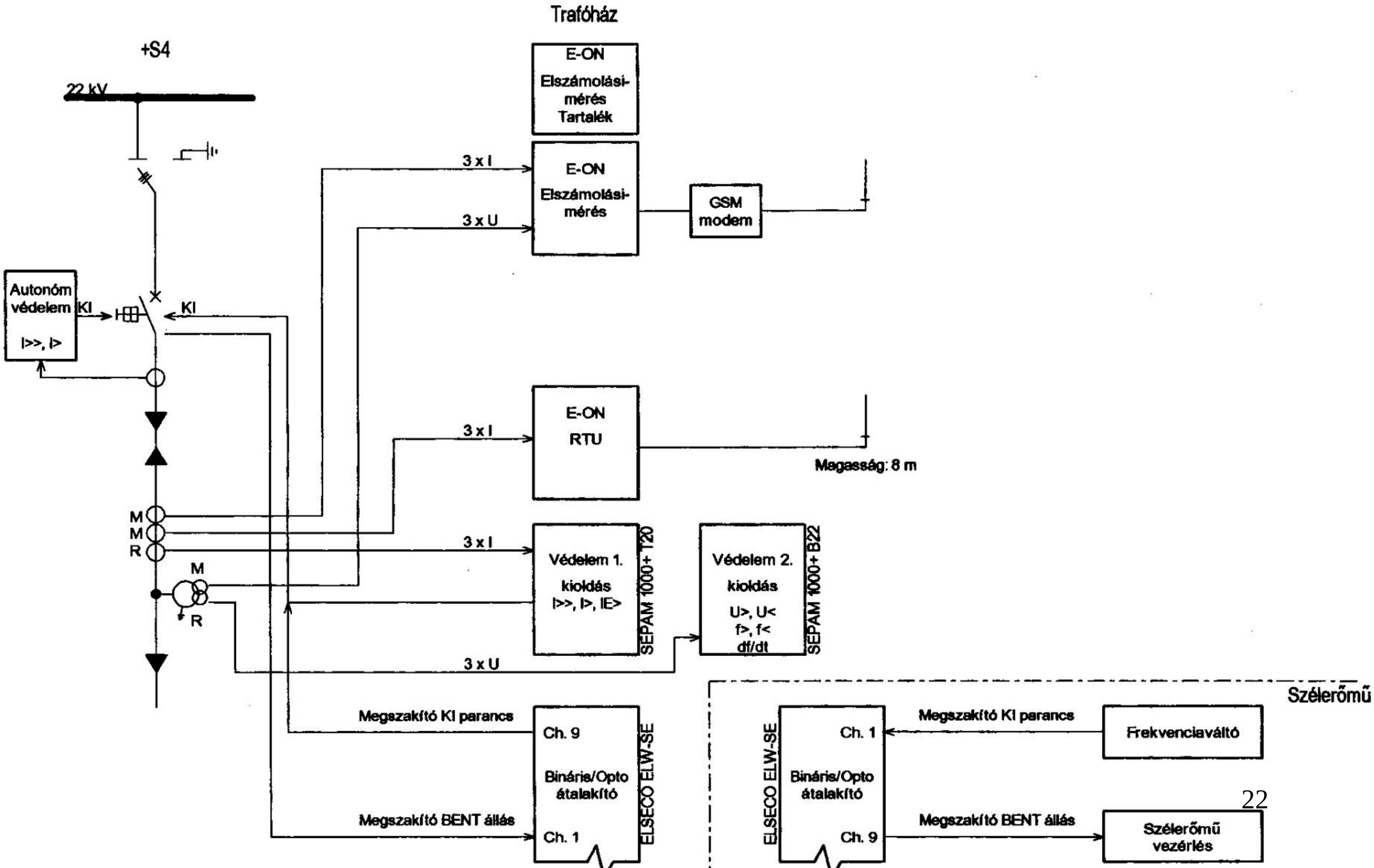

Connection between the tower and the compact substation

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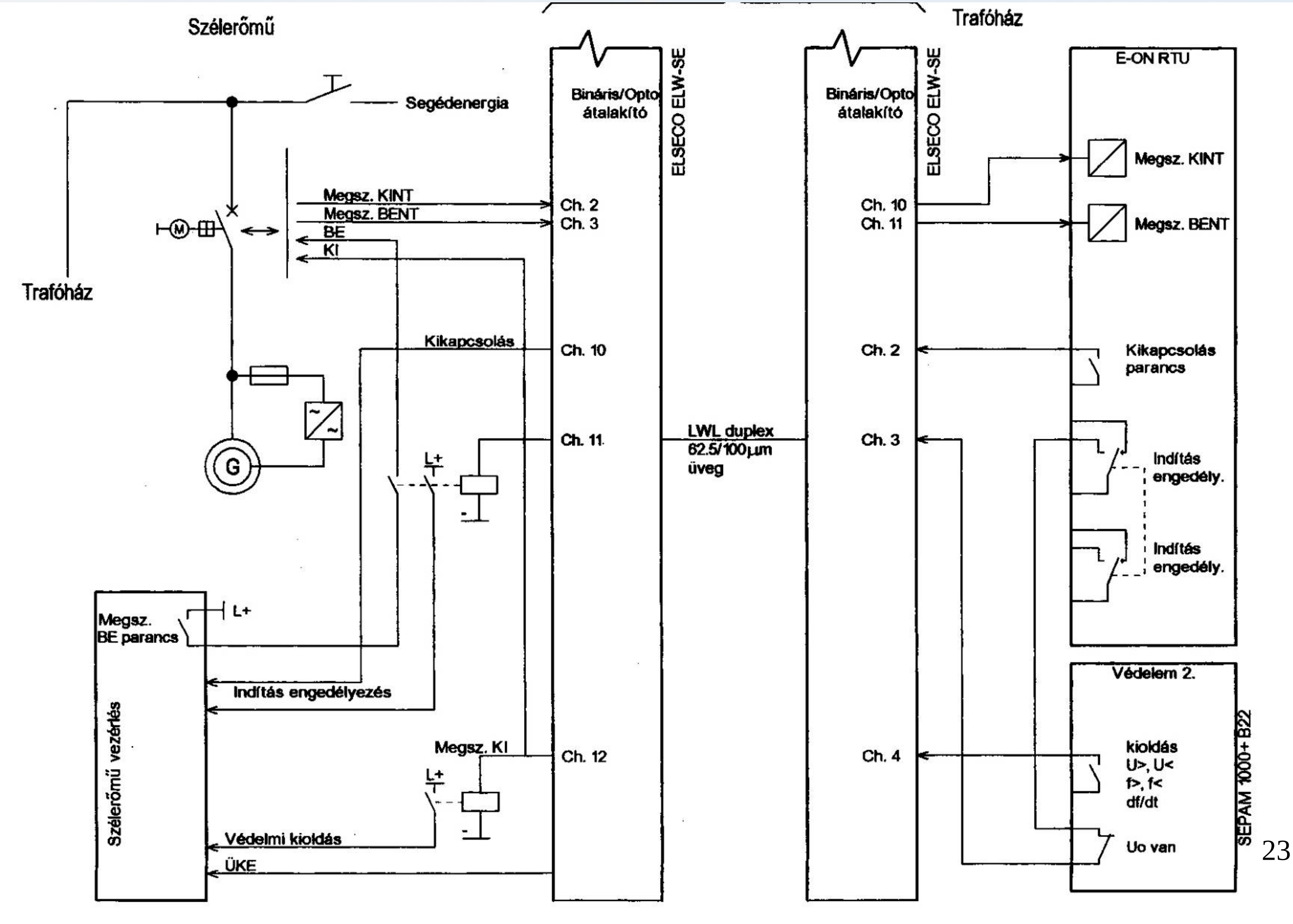

Power, voltage level and topology

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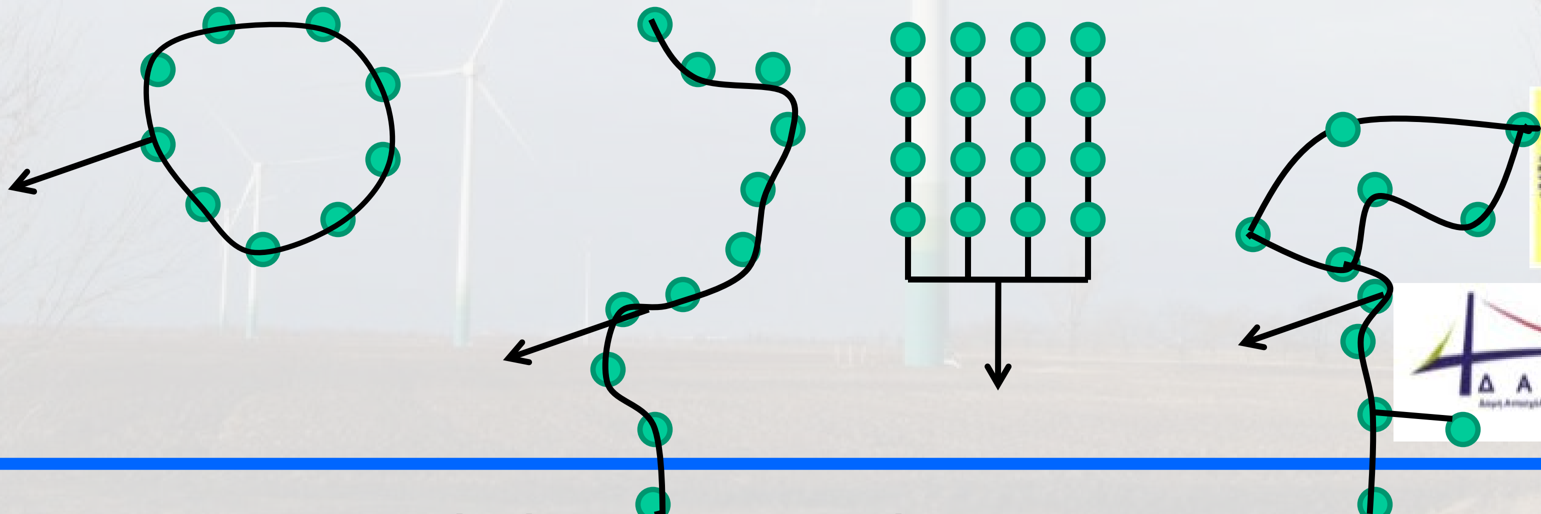
- 1 unit: cca. 2 MW (0,8 – 3,5 MW)
- 20 kV for transmission 3-8 MW
- Wind park: 20-30 units -> 110/120 kV
- Special topologies: ring, tree, quadratic, meshed, etc.
- Security – geography – economy – ecology



Wind speed changes

by Jensen

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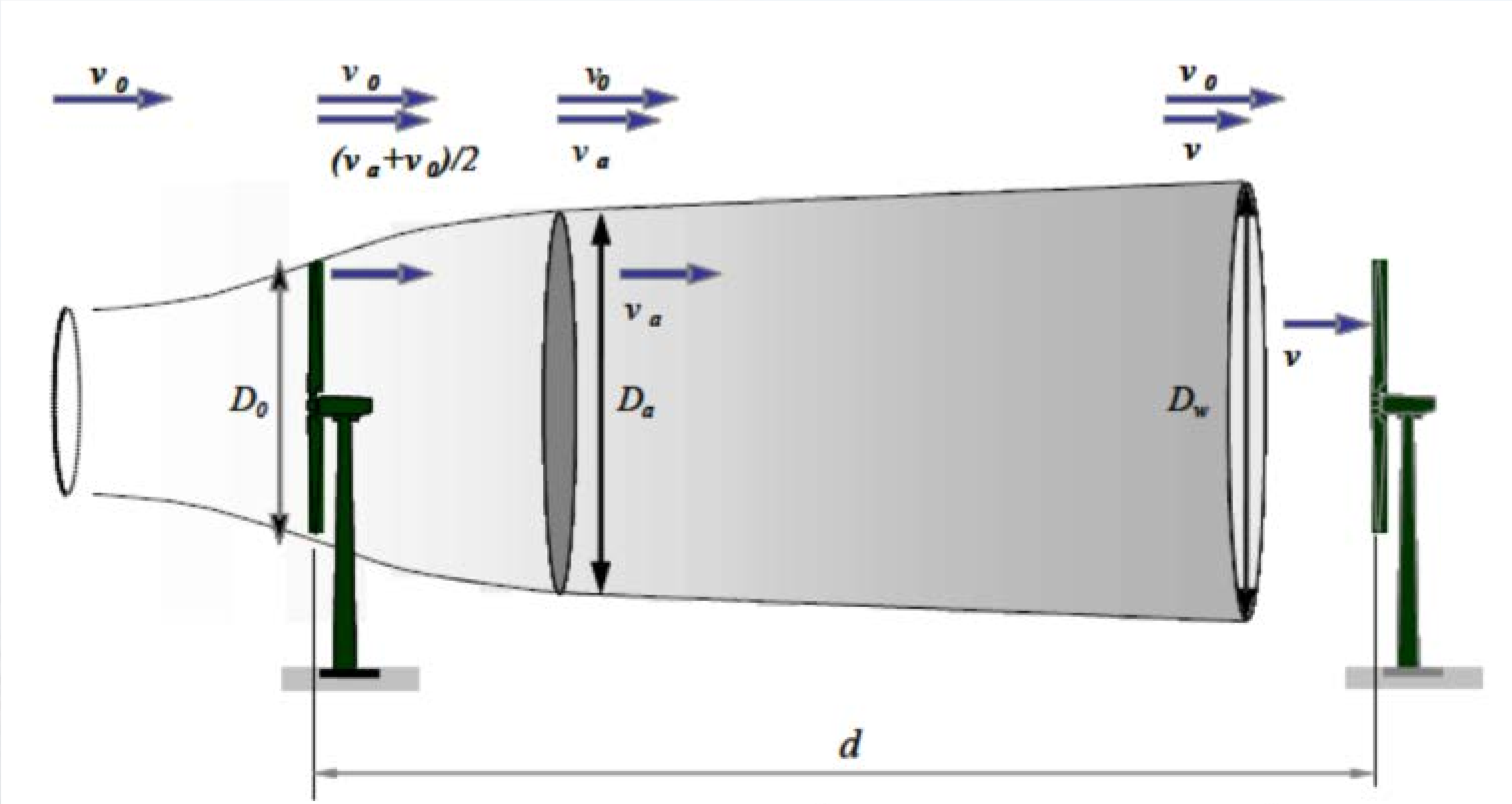

$$\frac{v_{estela}(d)}{v_0} = \frac{1}{2} + \frac{1}{2}\sqrt{1 - 2C_T(v_0)\left(\frac{D_0}{D(d)}\right)^2}$$

„Wind shadow” – Wake effect decreasig speed – decreasing energy

(work of Javier Serrano)

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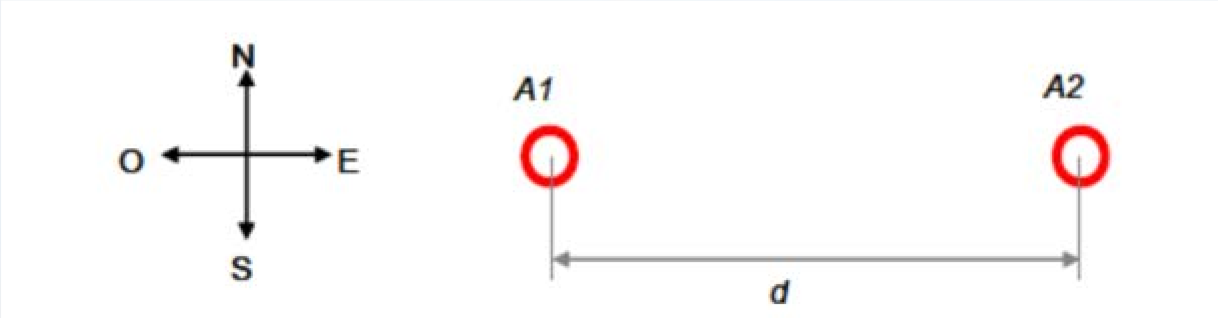

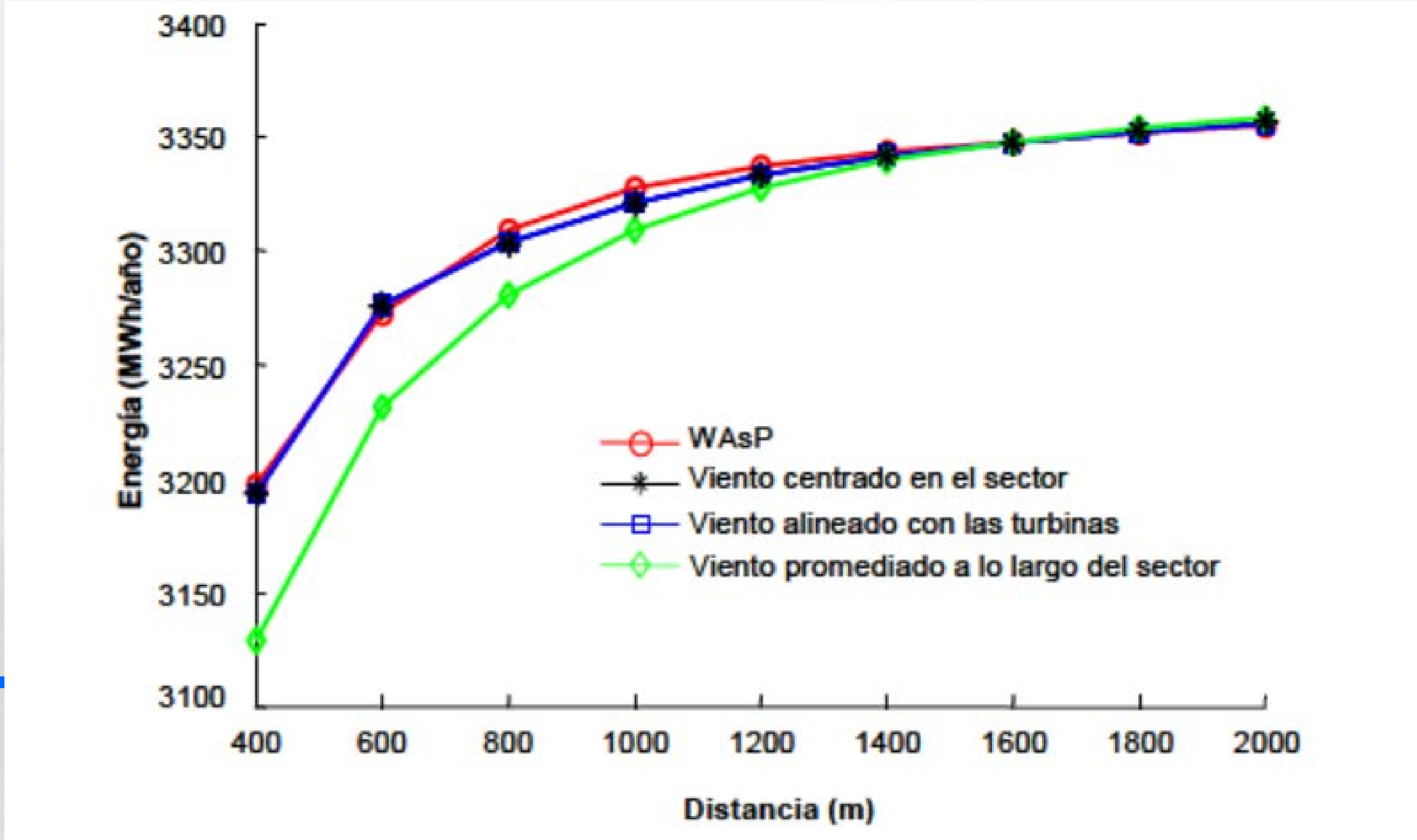

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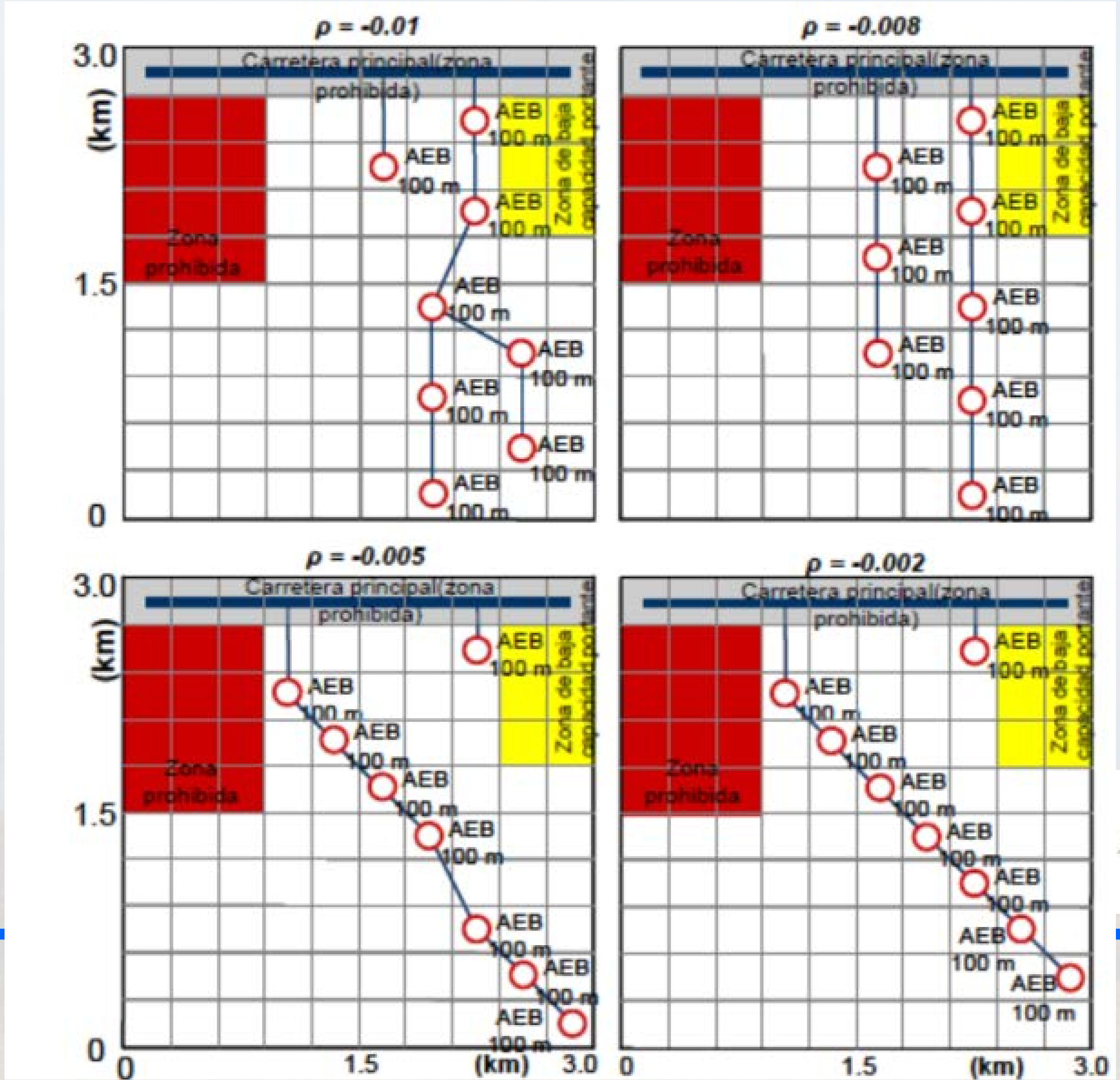
Micrositing - optimisation

(work of Javier Serrano)



Quadratic displacement, Burgenland, Austria

Line on the hill edge

Molina *moderna* de Aragón

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Wind metering tower

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Atienza, Spain

Near Calatayud, Spain

Near Calatayud, Spain

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Near Calatayud, Spain
150 towers on this picture!

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Kefalonia, Greece

Measurements
Characteristics, RPM, output power

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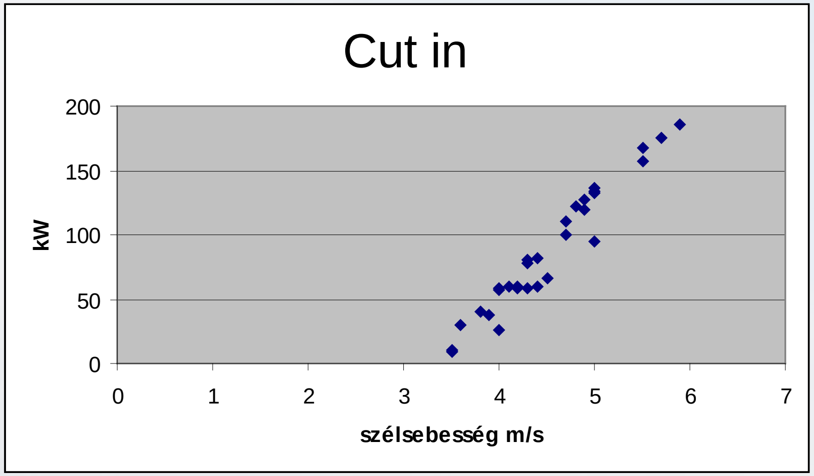

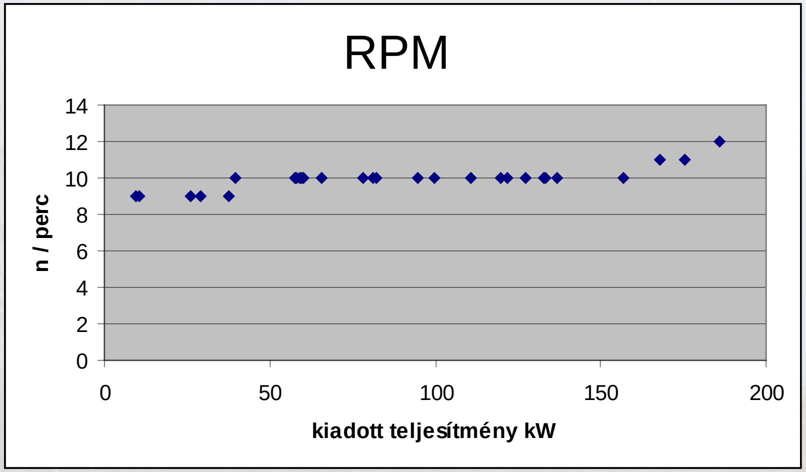

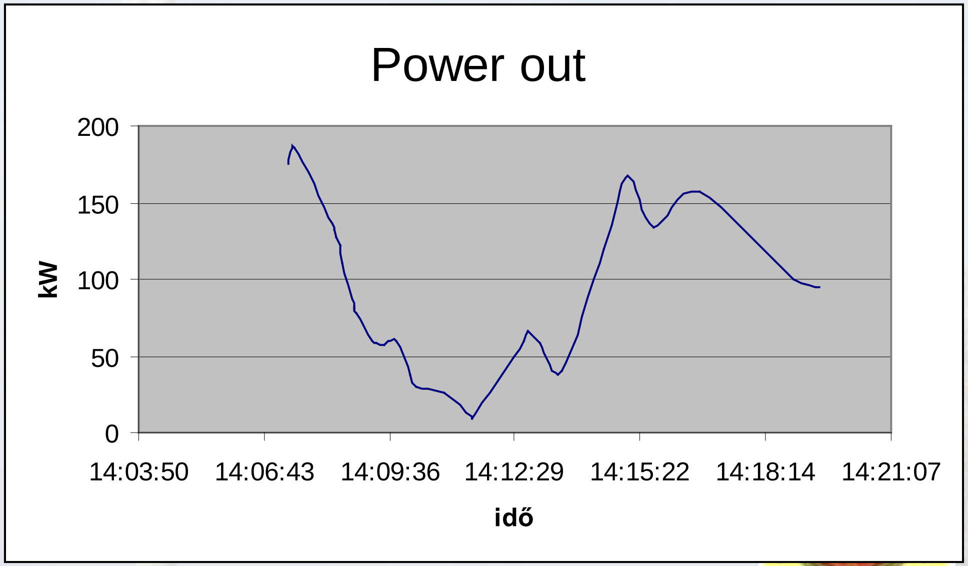

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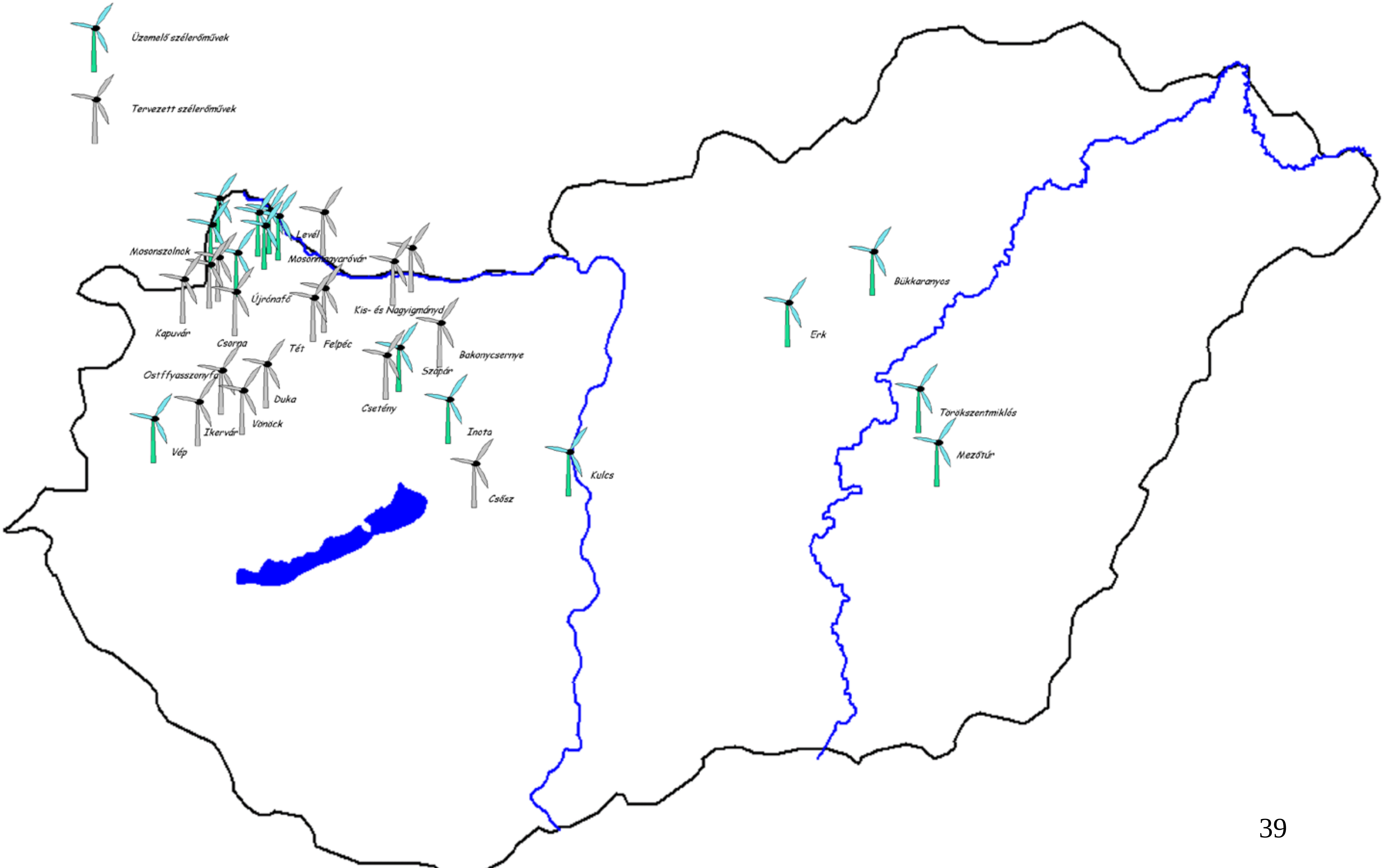
Niederland , Cabo Verde, Burgenland (A), Portugal

Windpower plants in Hungary, 2006



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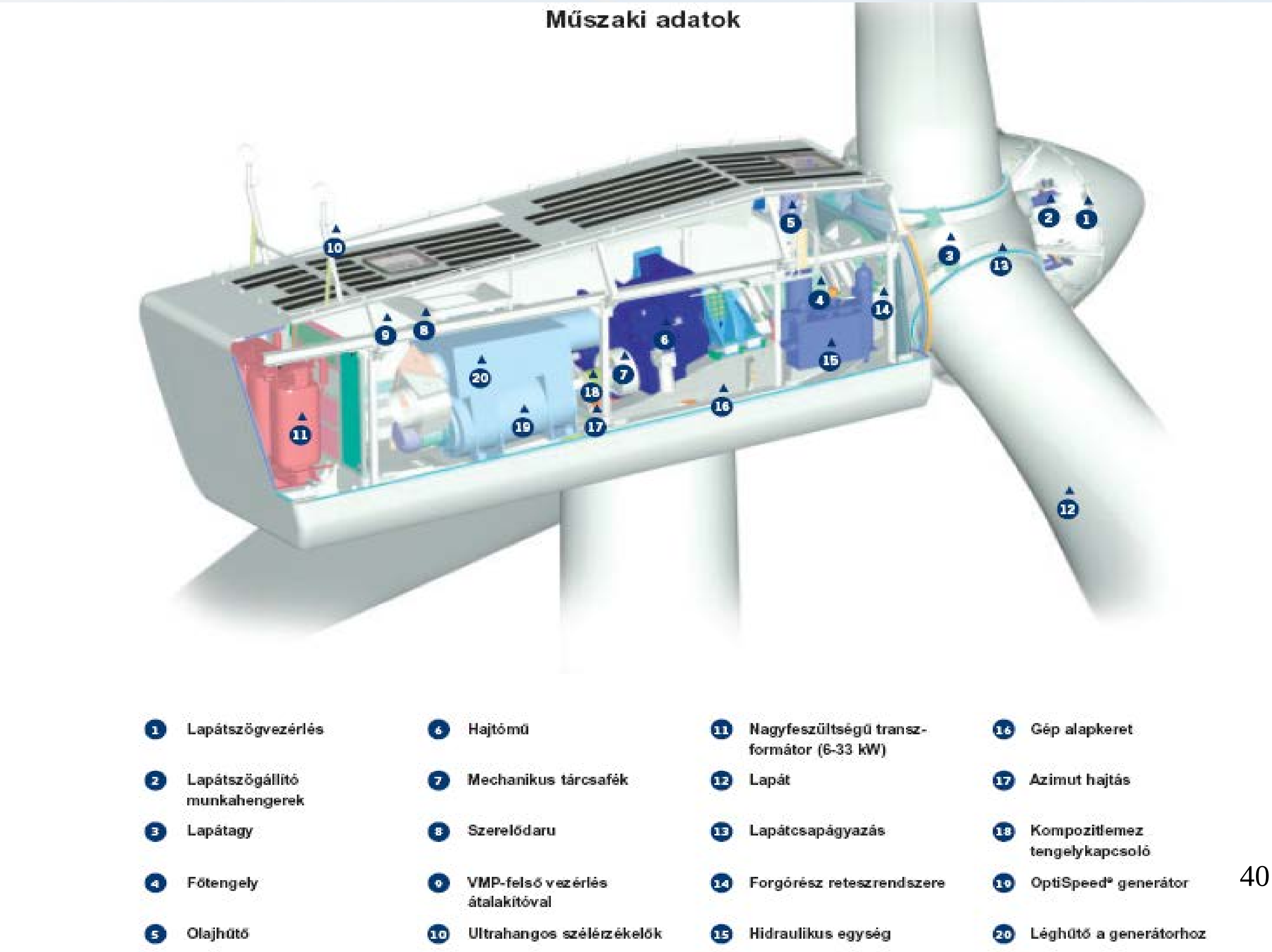
V90



Characteristics

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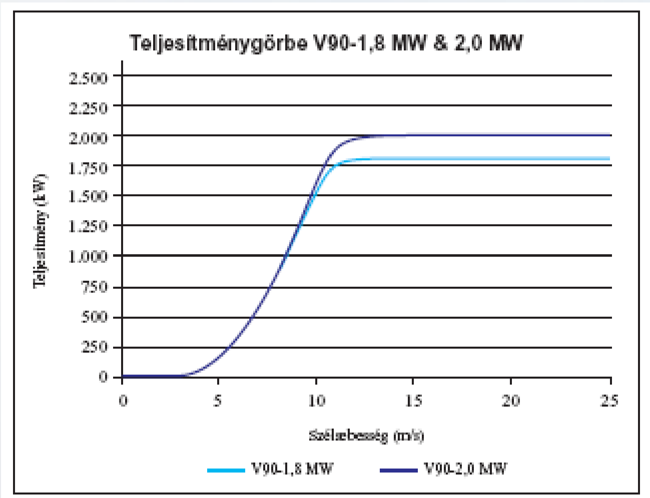

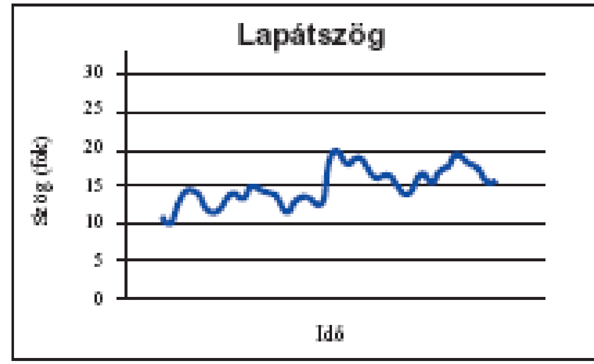

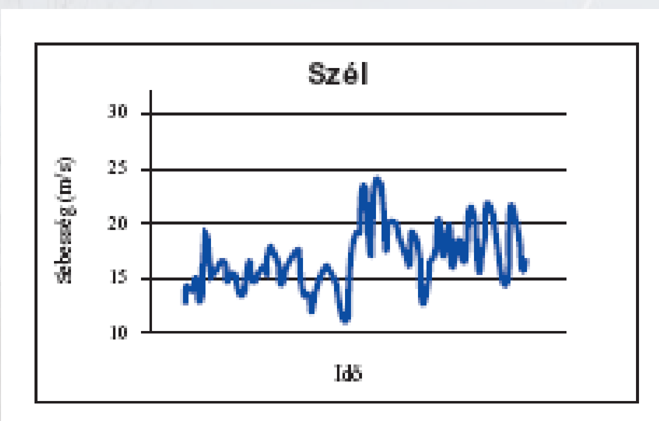

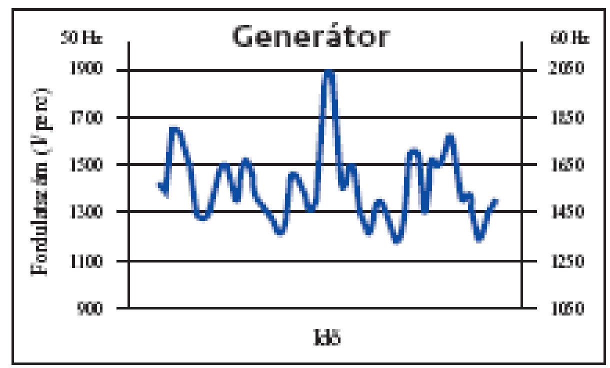

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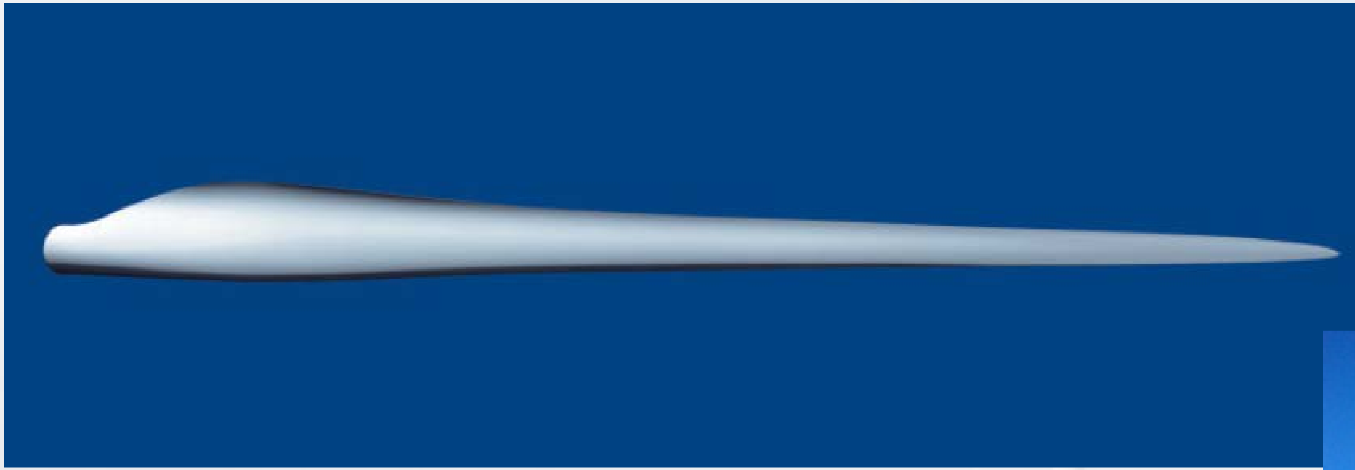
Rotor blade



V90 (~44 m)

MD 77 (37,5 m)

6,5 t!

Glassfiber – epoxi

Grafit fiber

Damage on Crete island

- It happens

FL MD77

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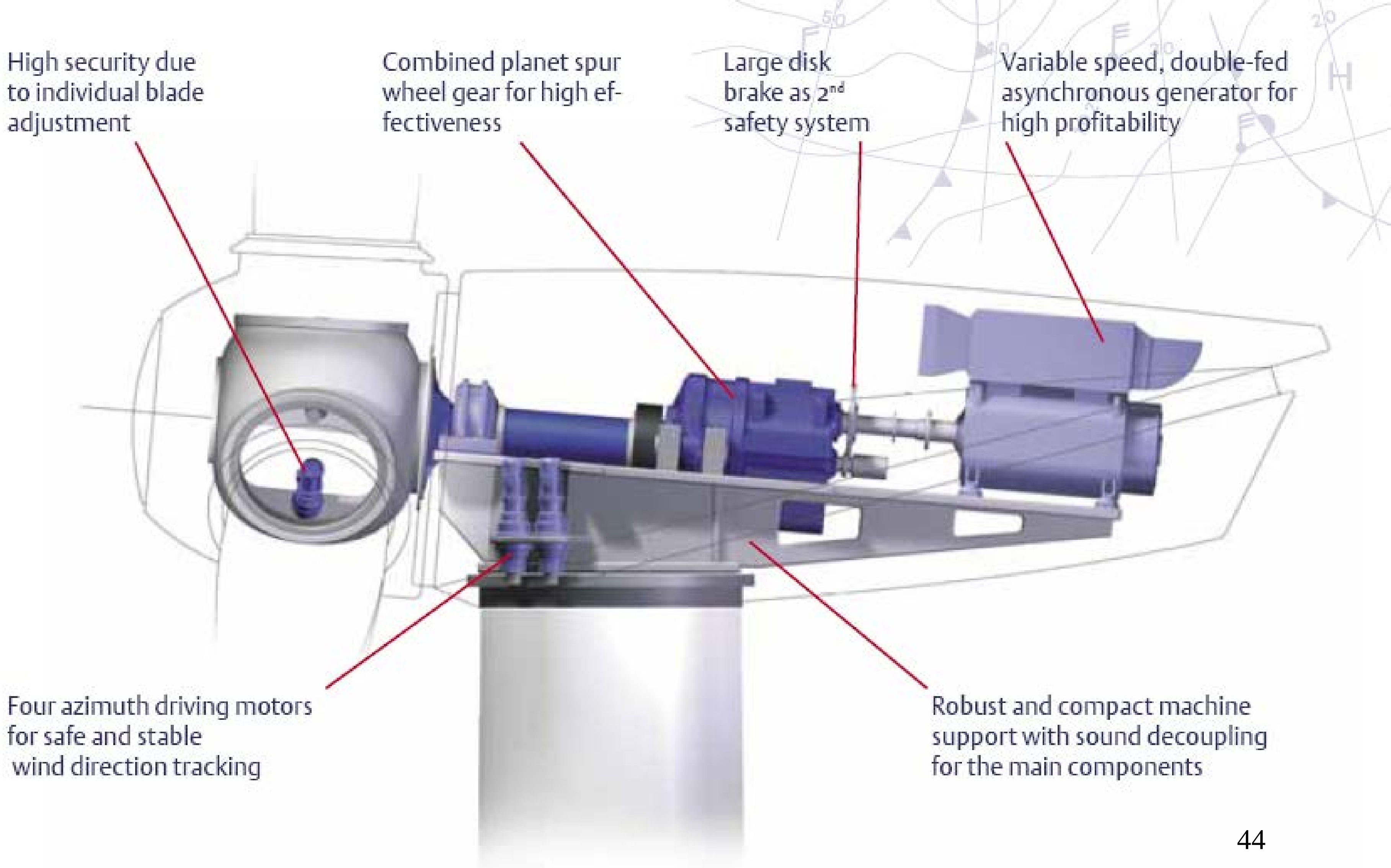

MD 77

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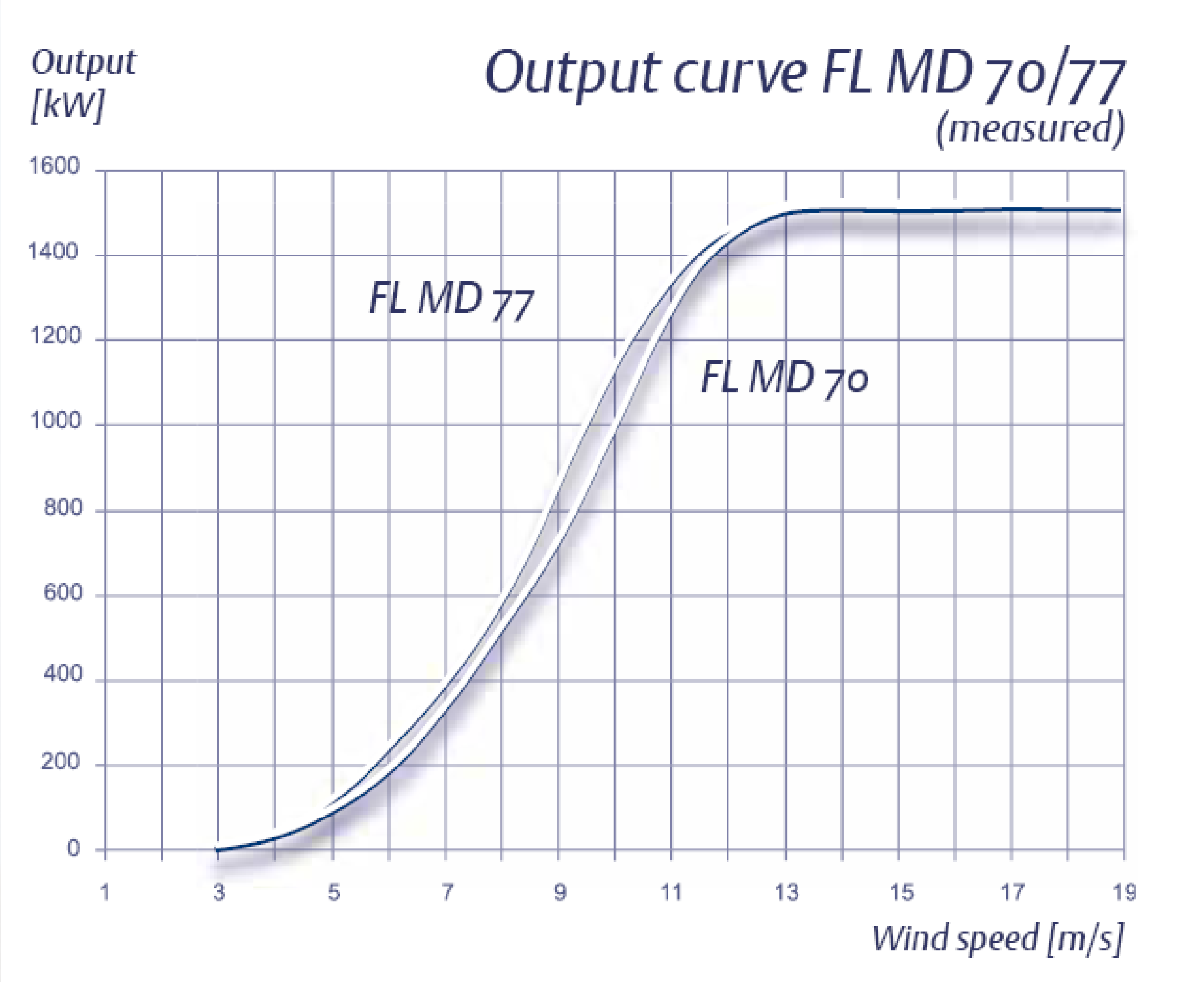
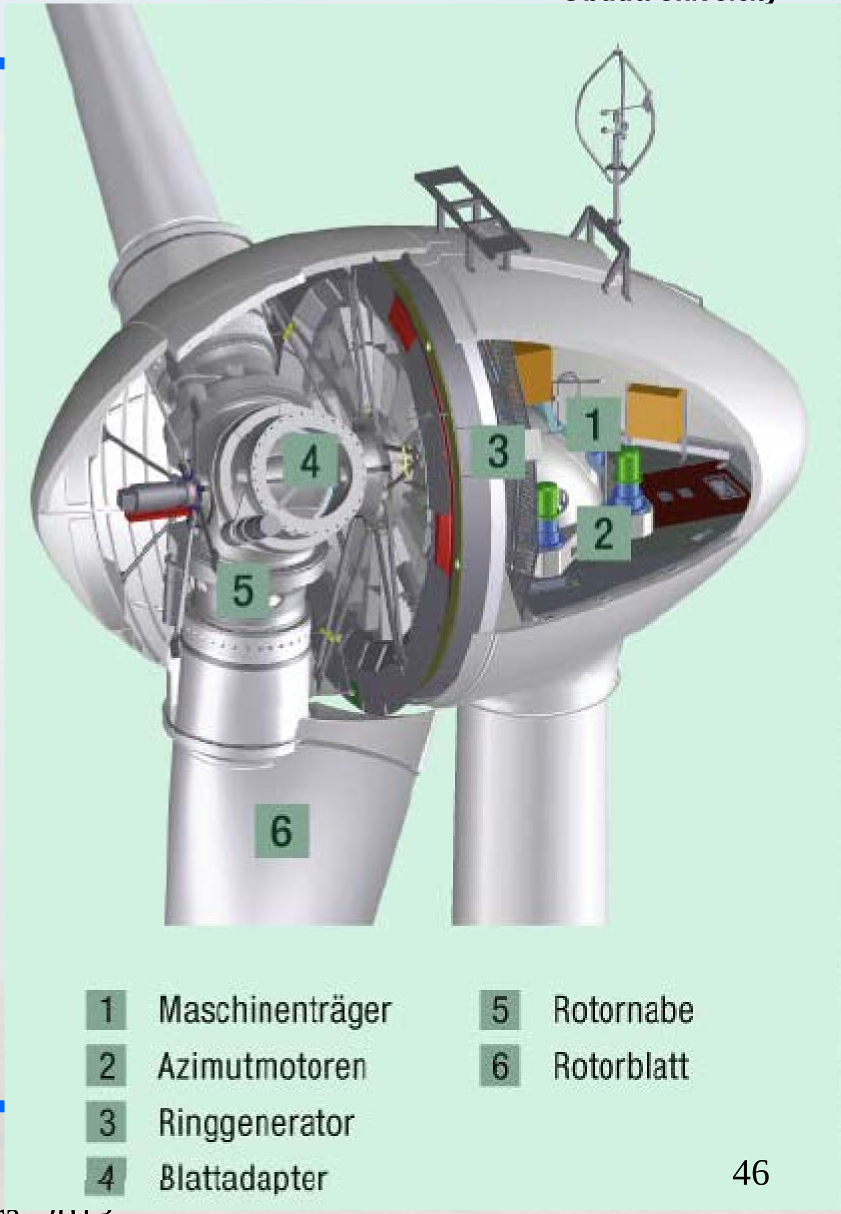


E 48


1
2
3
4
5
6
1 Maschinenträger
2 Azimutmotoren
3 Ringgenerator
4 Blattadapter
5 Rotornabe
6 Rotorblatt

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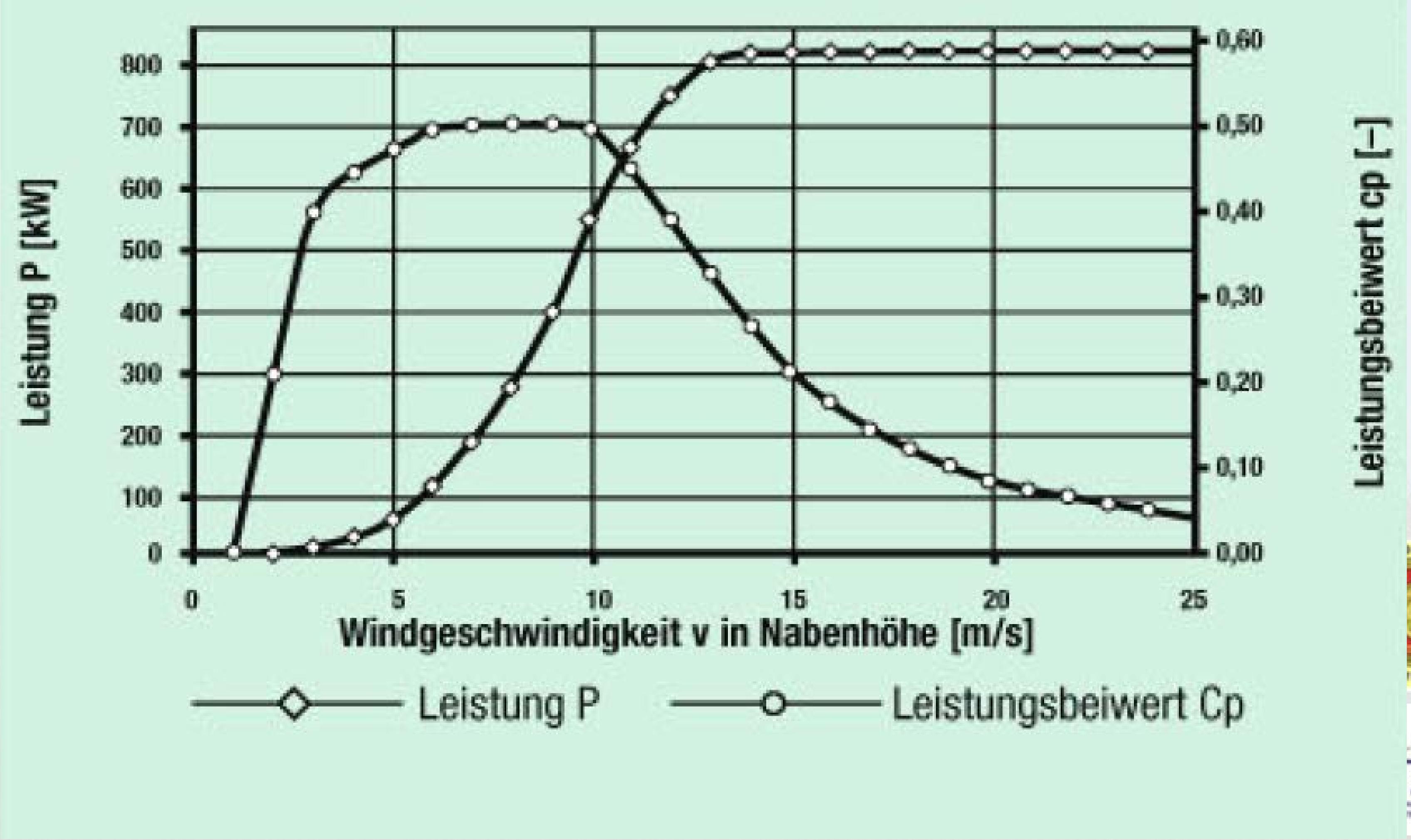
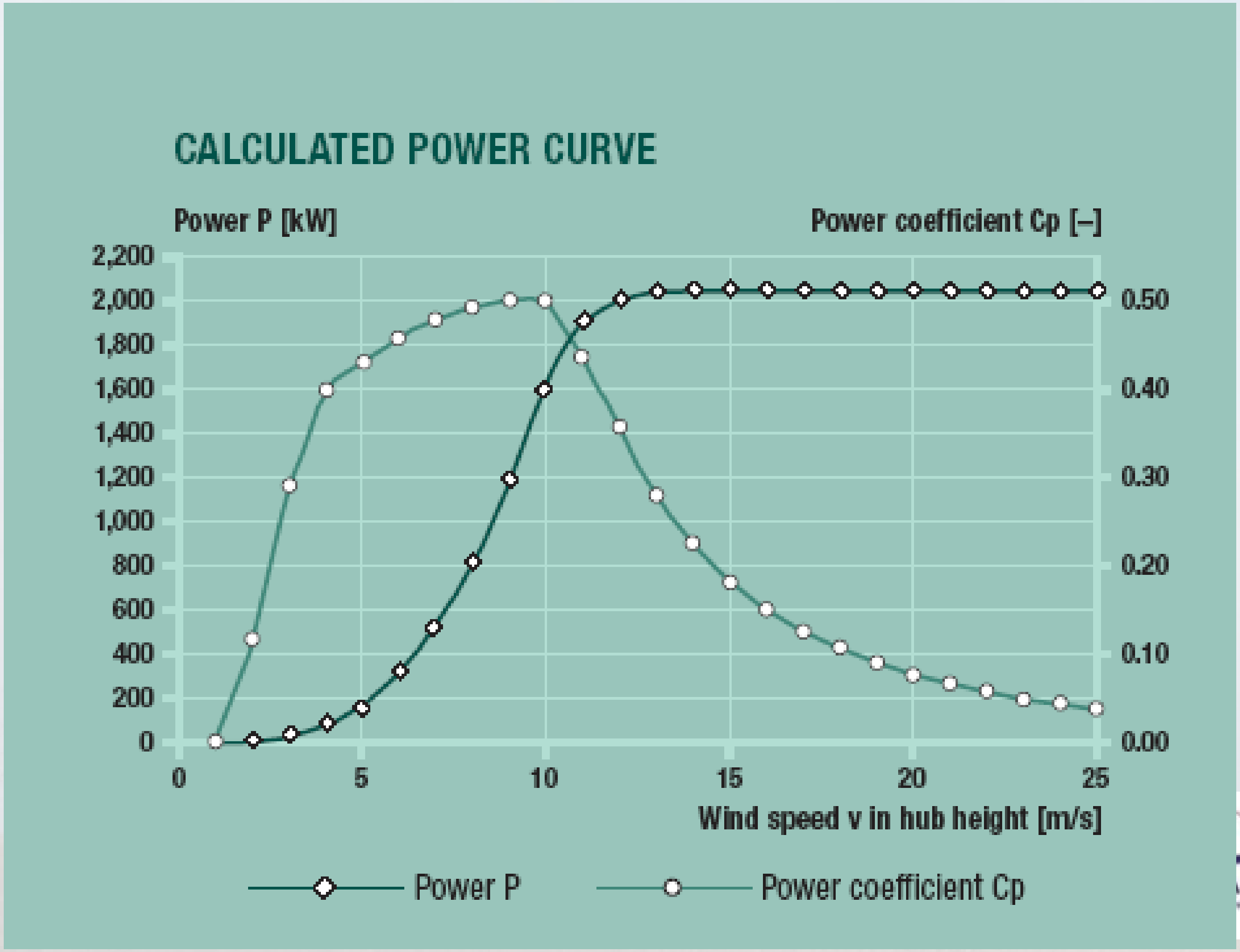
E 48



E82


CALCULATED POWER CURVE
Power P [kW]
Power coefficient Cp [–]
2,200
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
0.50
0.40
0.30
0.20
0.10
0.00
0
5
10
15
20
25
Wind speed v in hub height [m/s]
Power P
Power coefficient Cp

Characteristics measurements

Wind [m/s]	Power P [kW]	Power coefficient Cp [-]
1	0.0	0.00
2	3.0	0.12
3	25.0	0.29
4	82.0	0.40
5	174.0	0.43
6	321.0	0.46
7	532.0	0.48
8	815.0	0.49
9	1,180.0	0.50
10	1,612.0	0.50
11	1,890.0	0.44
12	2,000.0	0.36
13	2,050.0	0.29
14	2,050.0	0.23
15	2,050.0	0.19
16	2,050.0	0.15
17	2,050.0	0.13
18	2,050.0	0.11
19	2,050.0	0.09
20	2,050.0	0.08
21	2,050.0	0.07
22	2,050.0	0.06
23	2,050.0	0.05
24	2,050.0	0.05
25	2,050.0	0.04

$\rho = 1.225\ kg/m^3$

„Storm control”

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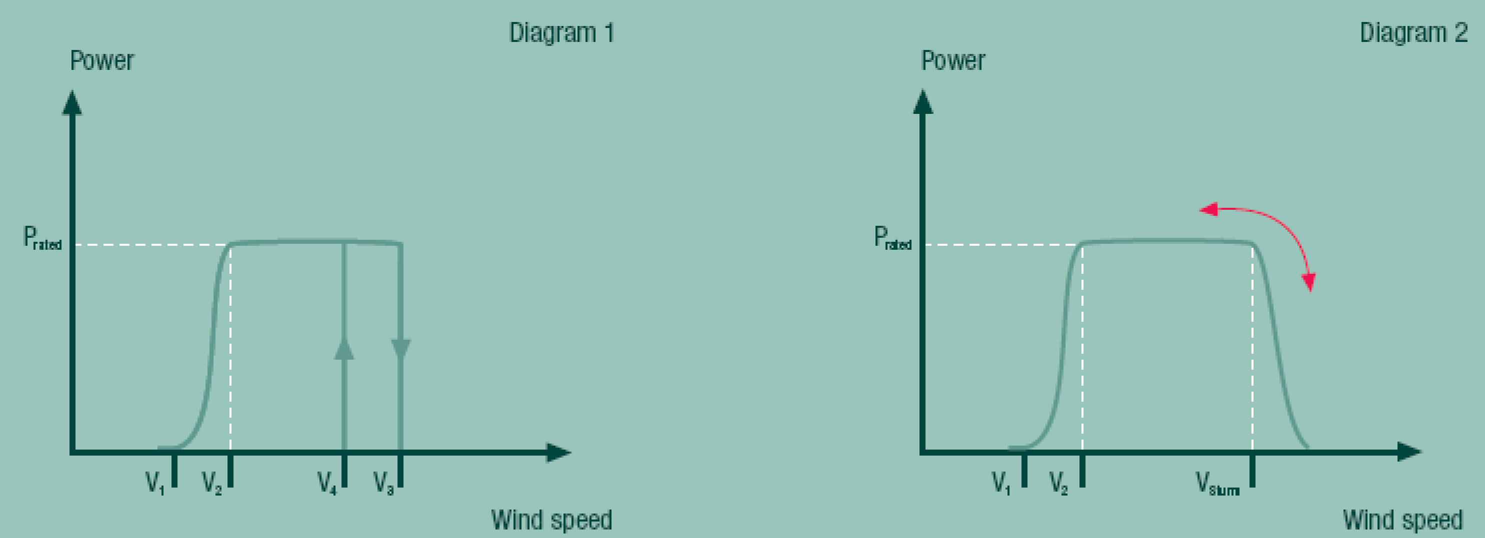

Power curve of a wind turbine without ENERCON storm control

Power curve of a wind turbine with ENERCON storm control

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Comparison

NÉHÁNY SZÉLERŐMŰ LEGFONTOSABB MŰSZAKI JELLEMZŐJE ([261]; 484)

Szélerőmű típusa		NORDEX	ENERCON	NORDEX	NORDEX	ENERCON
Megnevezés	M.e.	N29/250	E-40	N43/600	N64/1000	E-112
Névleges teljesítmény	kW	250	600	600	1100	4500
Indulási szélsebesség	m/s	3-4	2,5	3-4	3-4	
Leállítási szélsebesség	m/s	25	25	25	25	
Lapátszám	db	3	3	3	3	3
Lapáthossz	m	13,4	19	19,1	26	52
Járókerék átmérője	m	29,7	44	43	54	112
Megfúvott felület	m2	693		1452	2290	10000
Tengelymagasság	m	30/40/50	65	43/50/60	60	124
Járókerék fordulatszáma	1/min	39,5–29,5	34–18	26,9–17,9	22–16	

Bükkaranyos

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Erk

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Inota

Kulcs

Mezőtúr

Mosonmagyaróvár -Levél

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Mosonszolnok

Szápár

Törökszentmiklós

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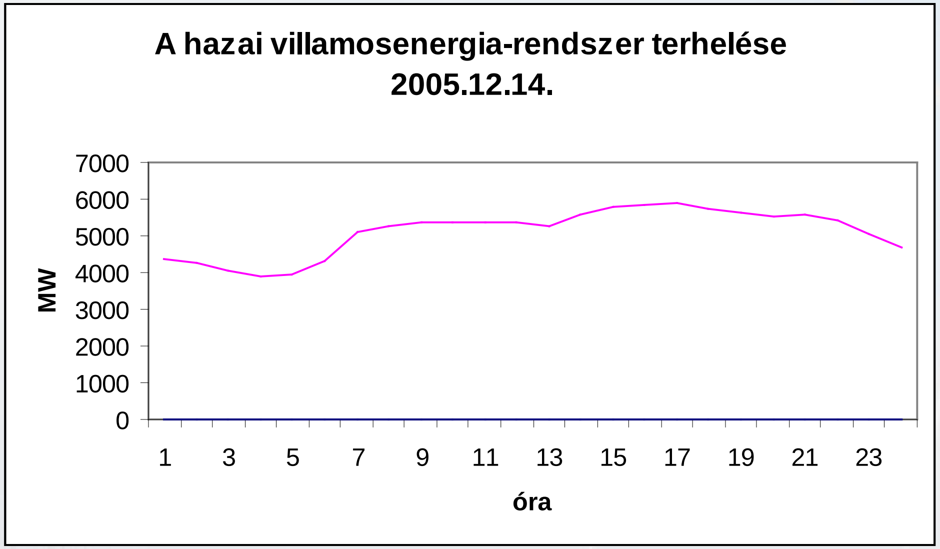
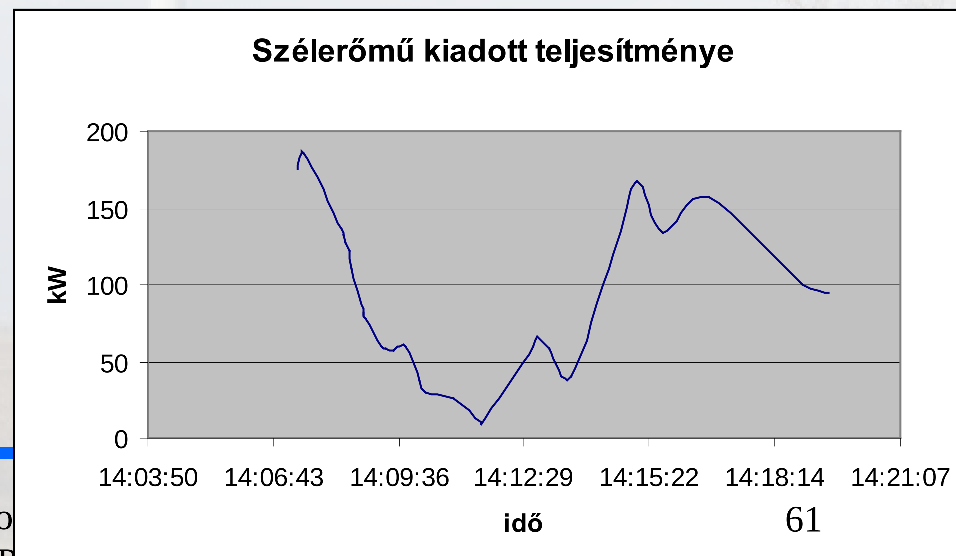
System load <–> wind production





Balancing with CO_2

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Feel the measure!

V27 – 225 kW

E-40 600 kW

E-48 800 kW

Feel the measure!

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MD-77 1,5 MW V-90 1,8 MW E-70 2 MW

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How many tower represents 1000 MW?

• V27	225 kW	4444 pcs
• E-40	600 kW	1666 pcs
• E-48	800 kW	1250 pcs
• MD-77	1,5 MW	666 pcs
• V-90	1,8 MW	555 pcs
• E-70	2 MW	500 pcs

A lot.

Wind energy integration

Energy production calculation

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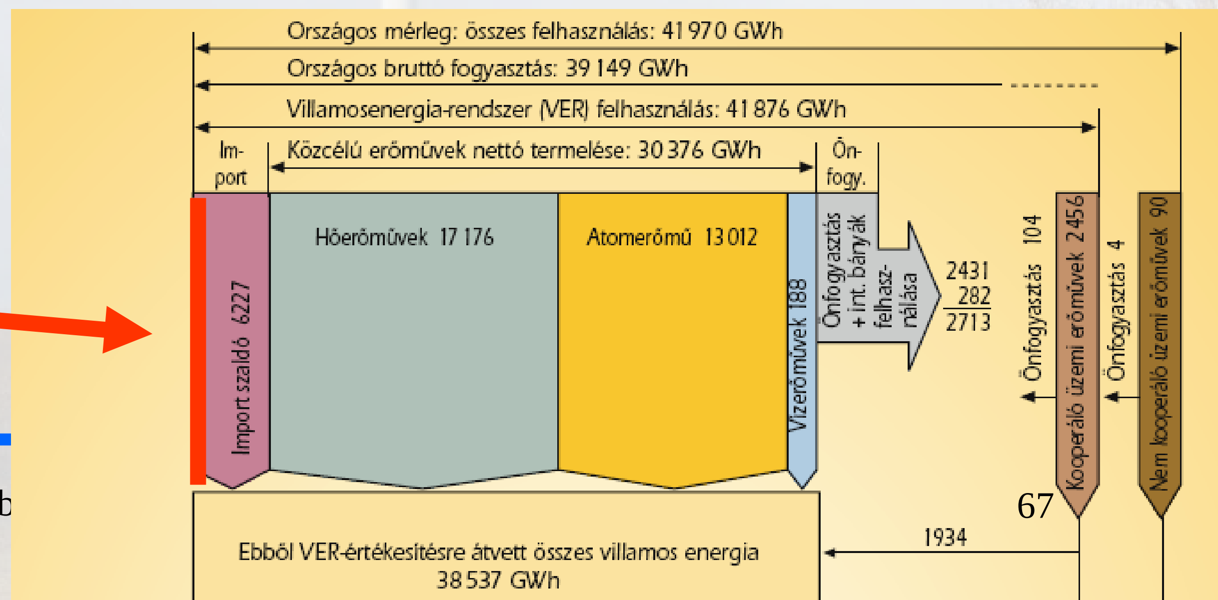
- If 1000 MW built in capacity operates in 1 year with 20 % usage ratio
- 365 days x 24 hours x 1000 MW x 0,2 % = 1.752.000 [MWh] = 1,752 TWh
- In Hungary it is only 4,47 % of the total consumption
- Not too much



Power ratio

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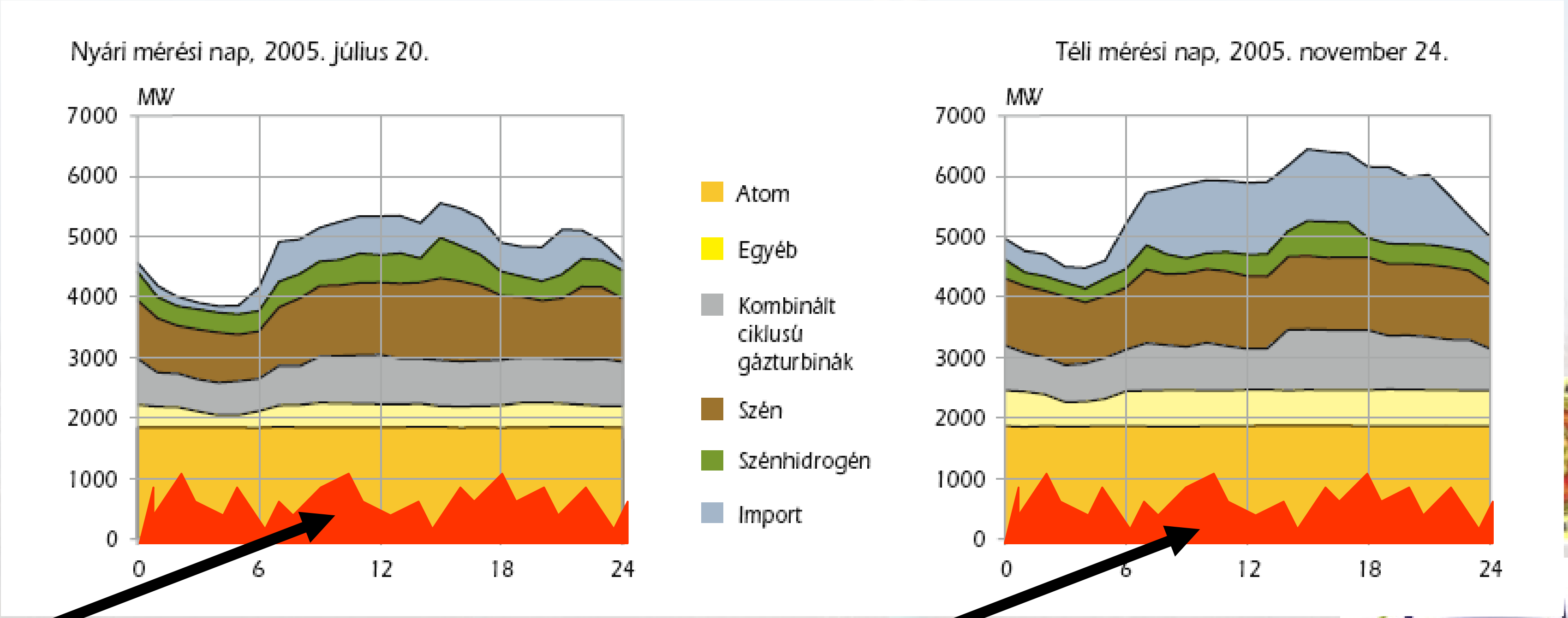
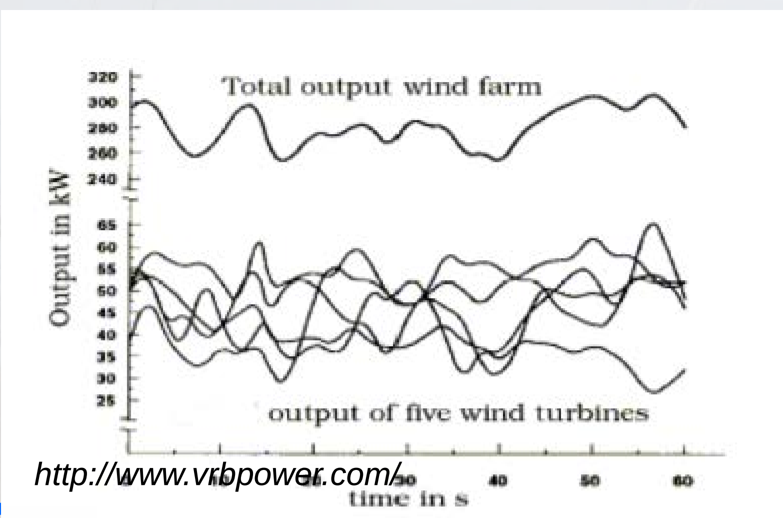


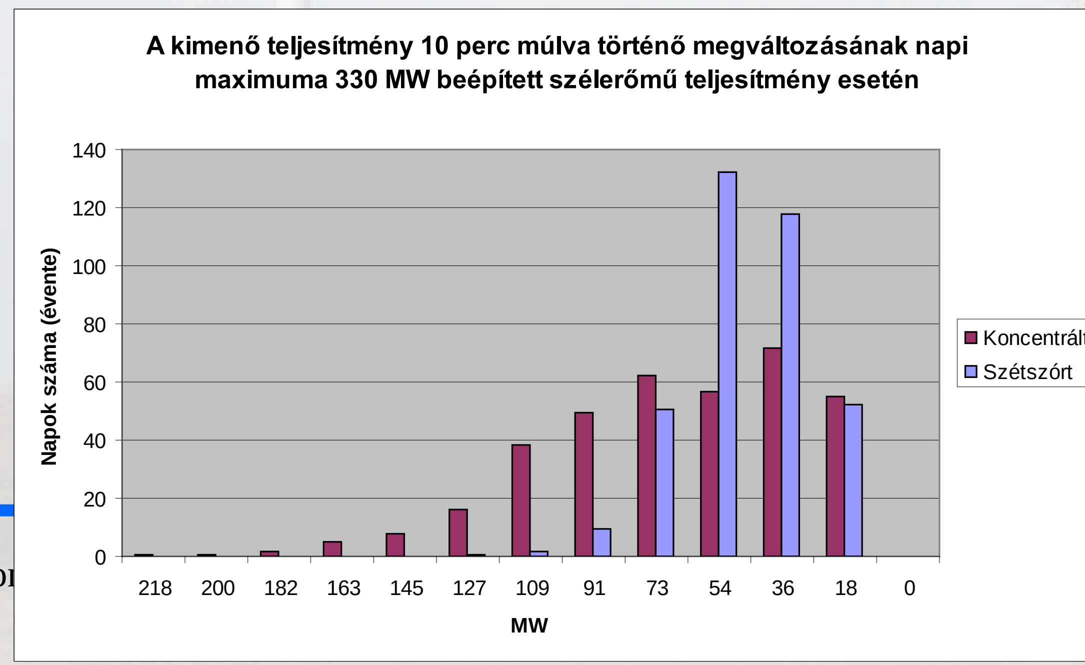
It is much!

Forrás: A magyar villamosenergia-rendszer 2005. évi statisztikai adatai, MVM Zrt., 2006

How the wind blows

- BEWAG experiences: gradient 60 MW/h
- 3 areas - 3 different wind blows
- Local autobalancing in the windpark
- Balancing between different areas





Sudden stop of wind power plants

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- Too strong wind (over 25-30 m/s)
- Network faults
- Frequency problems

Is it really problem to loose 200 MW? – daily events

The network flexibility must be raised!

- Diversification
- Forecast

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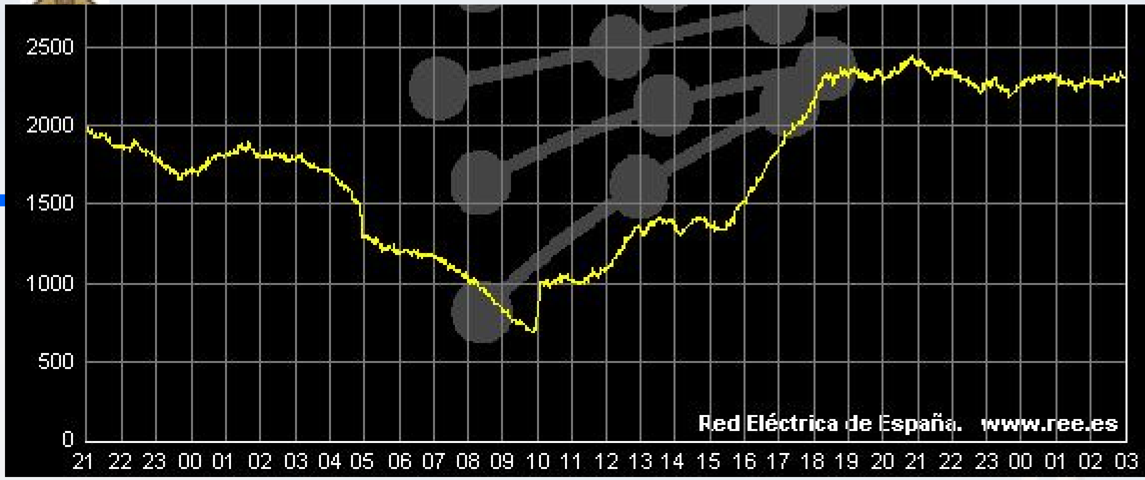
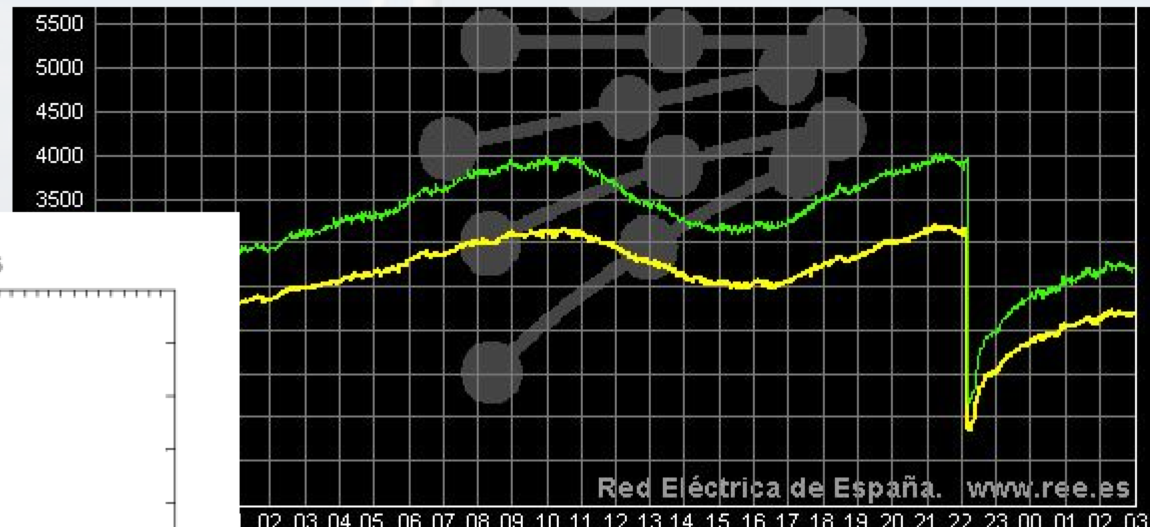
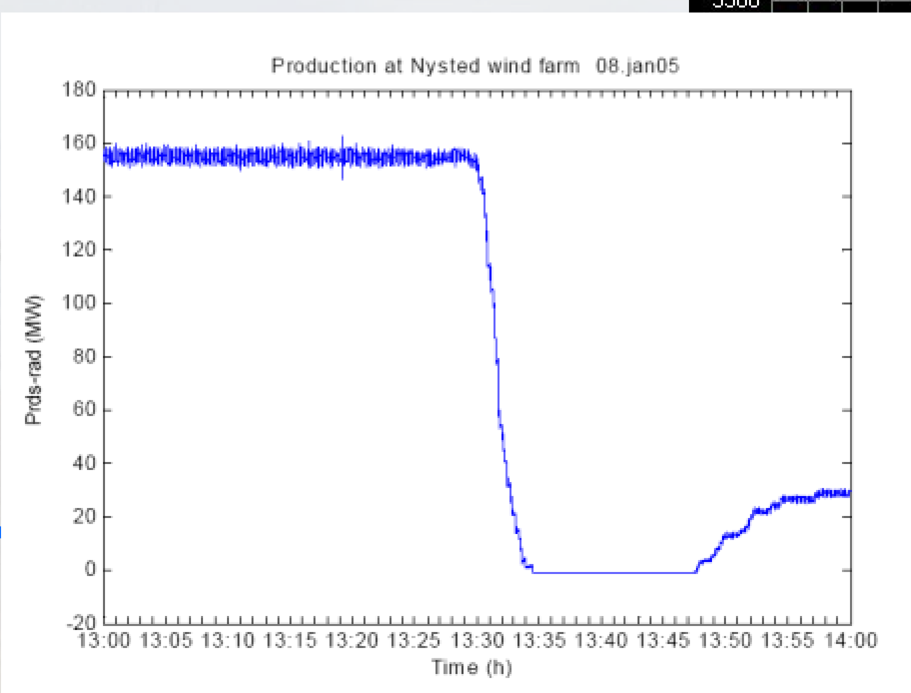


- Fault in Spain

- 2006.11.04.





- Storm in Denmark

2008. 04.01. operation - BEWAG

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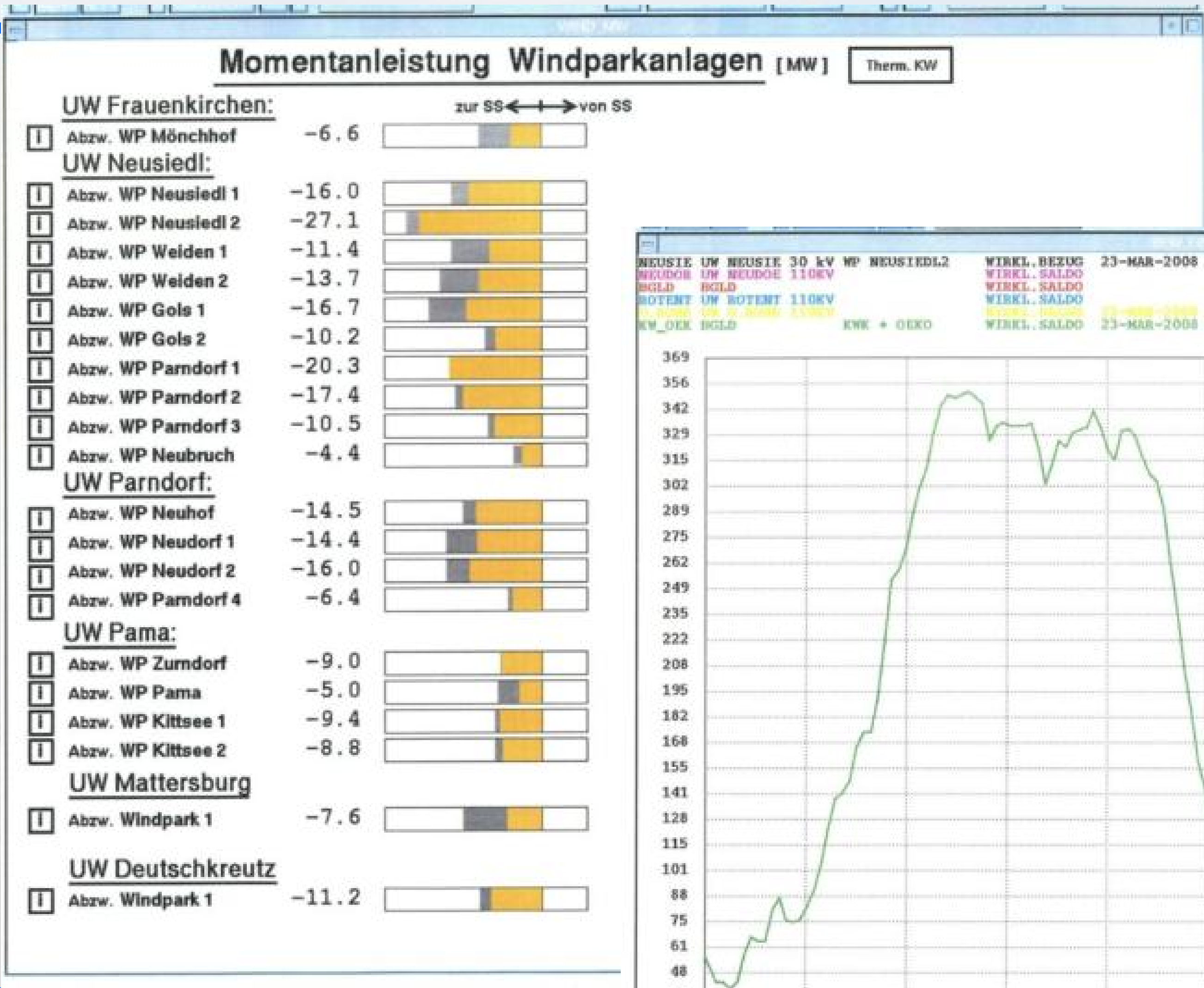

The UTSIRA project

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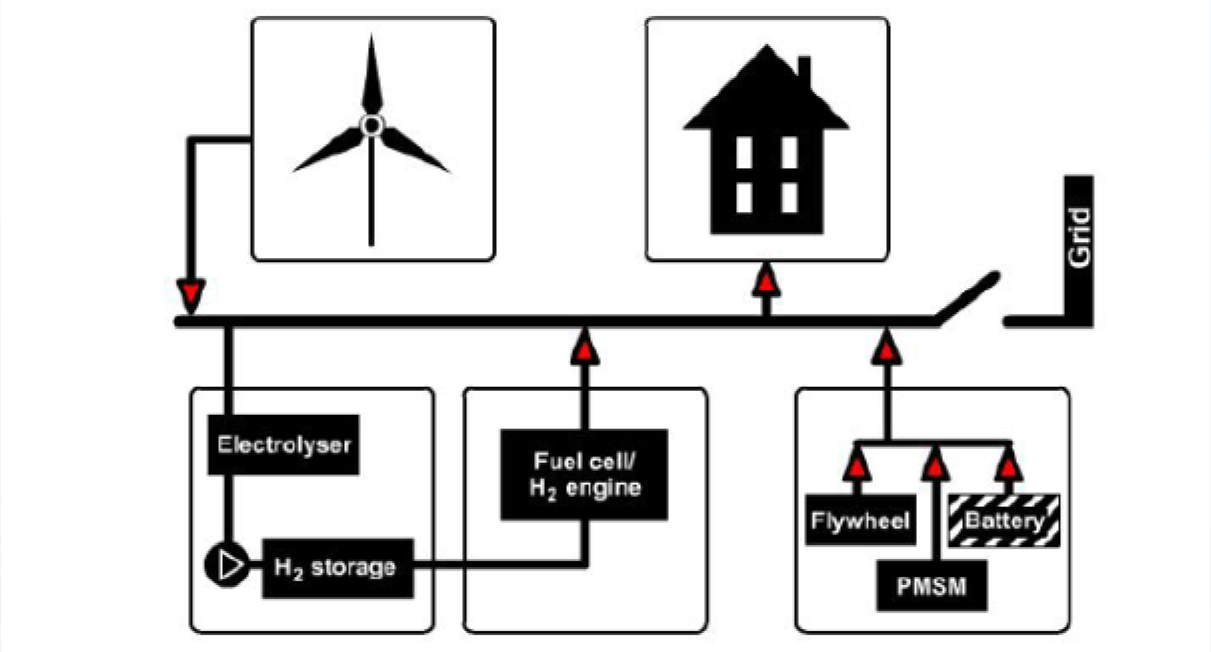

Hydrogen generation

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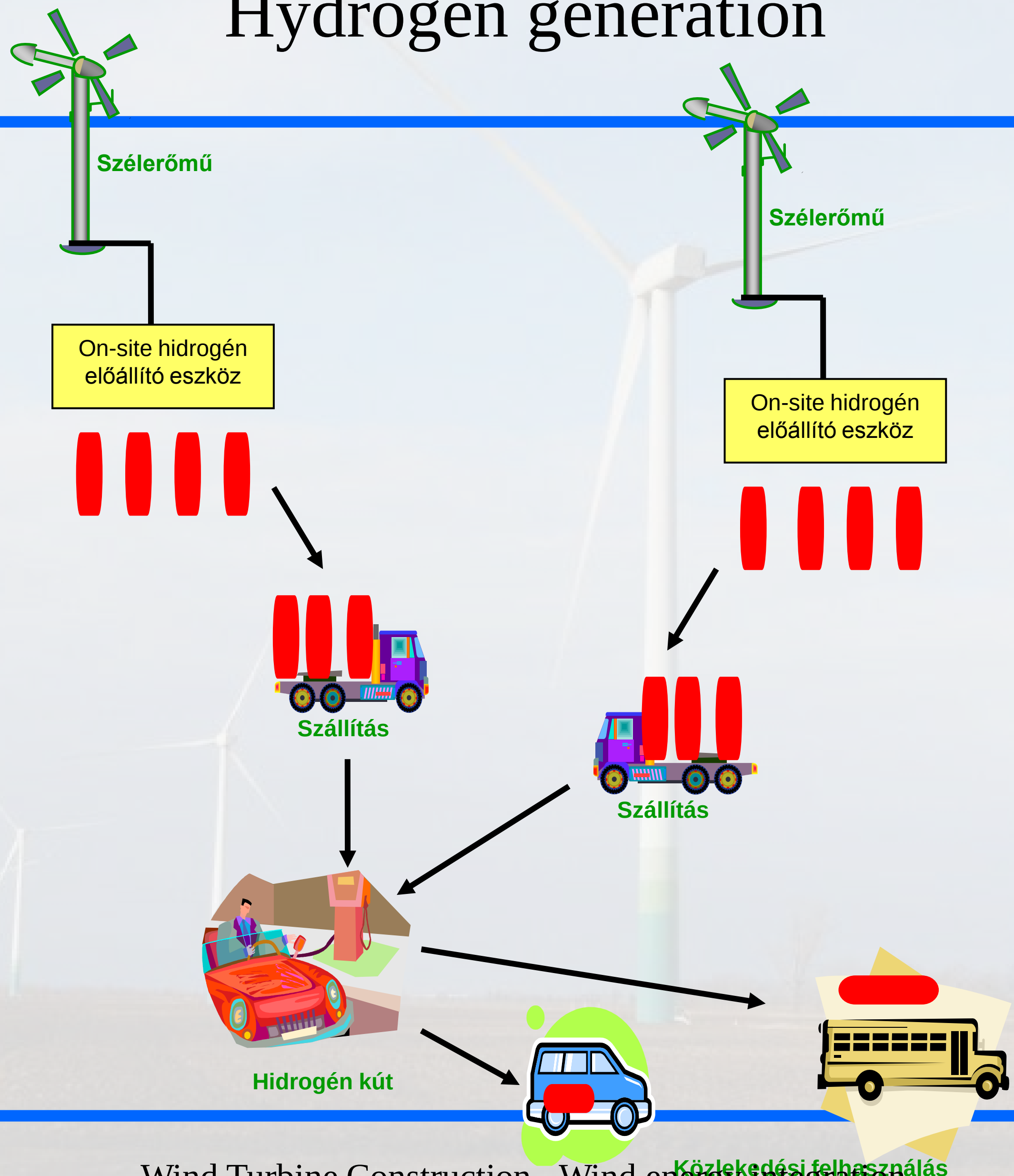

Central hydrogen generation – system operatior control

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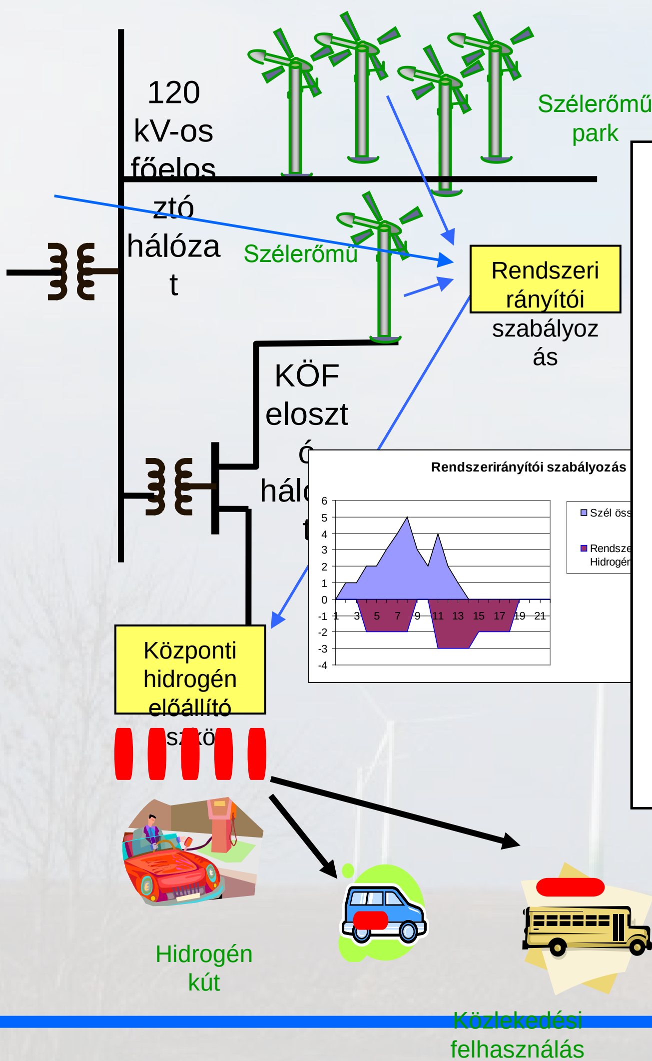

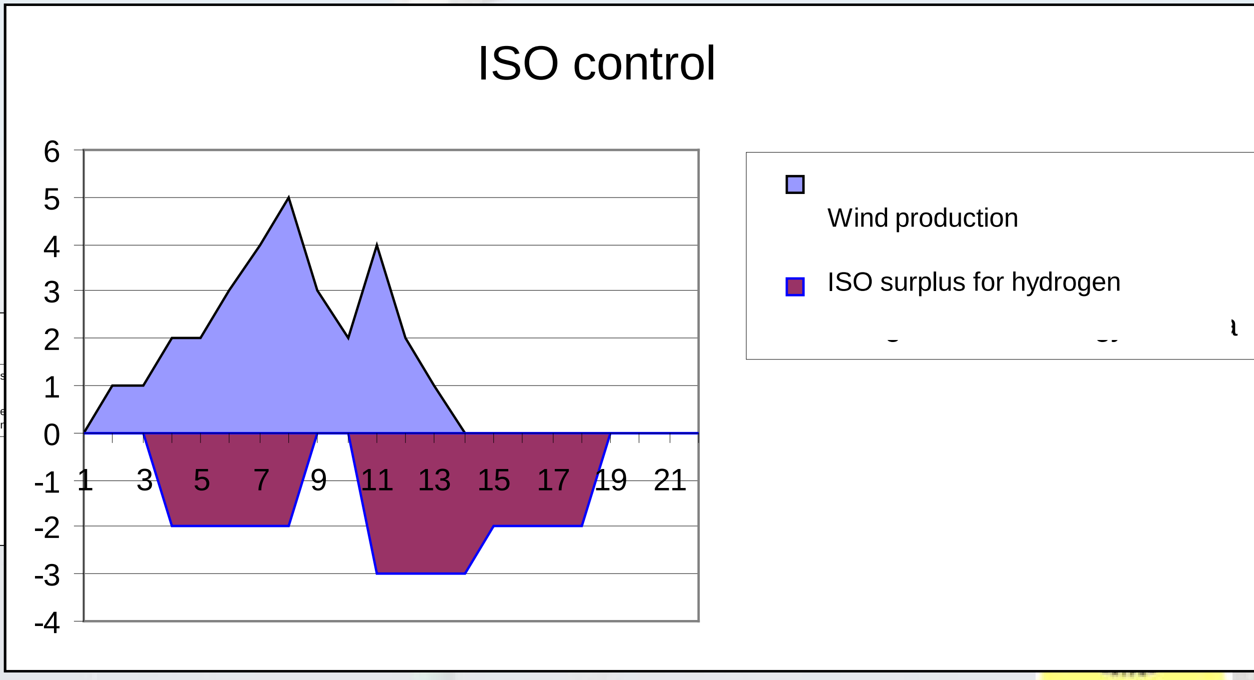

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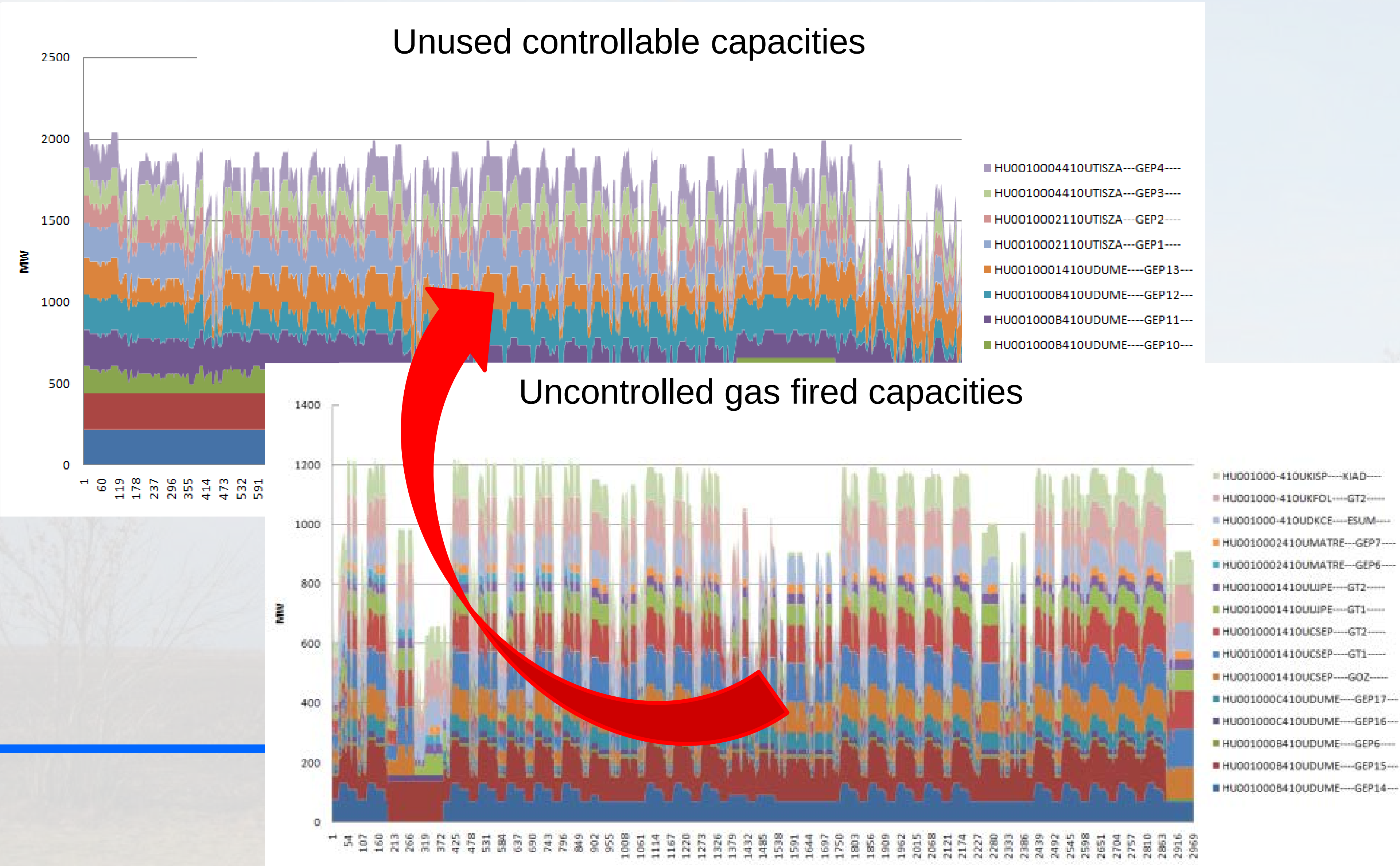
Where to find the control capacities?



Co-control of gas engines and wind turbines

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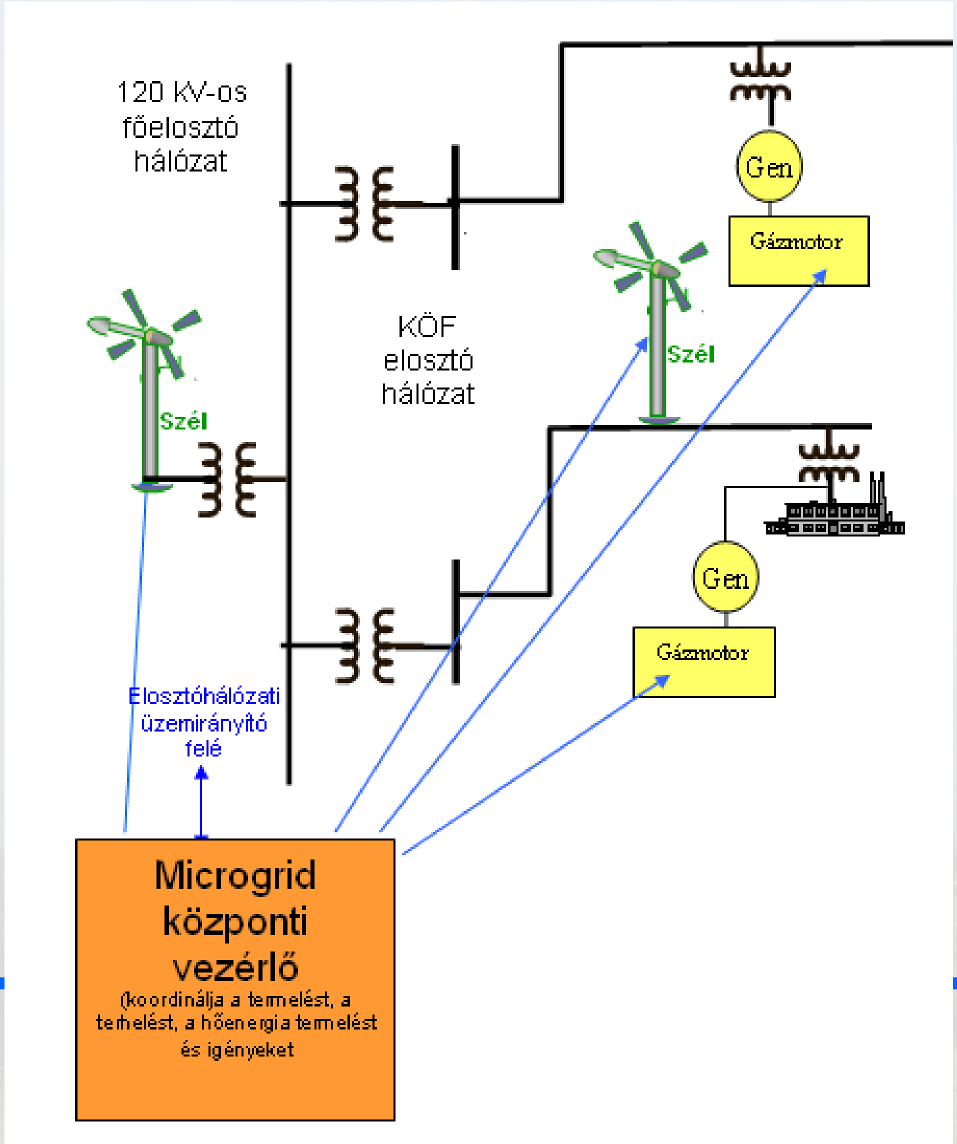

Wind generation + gas engine generation + balancing

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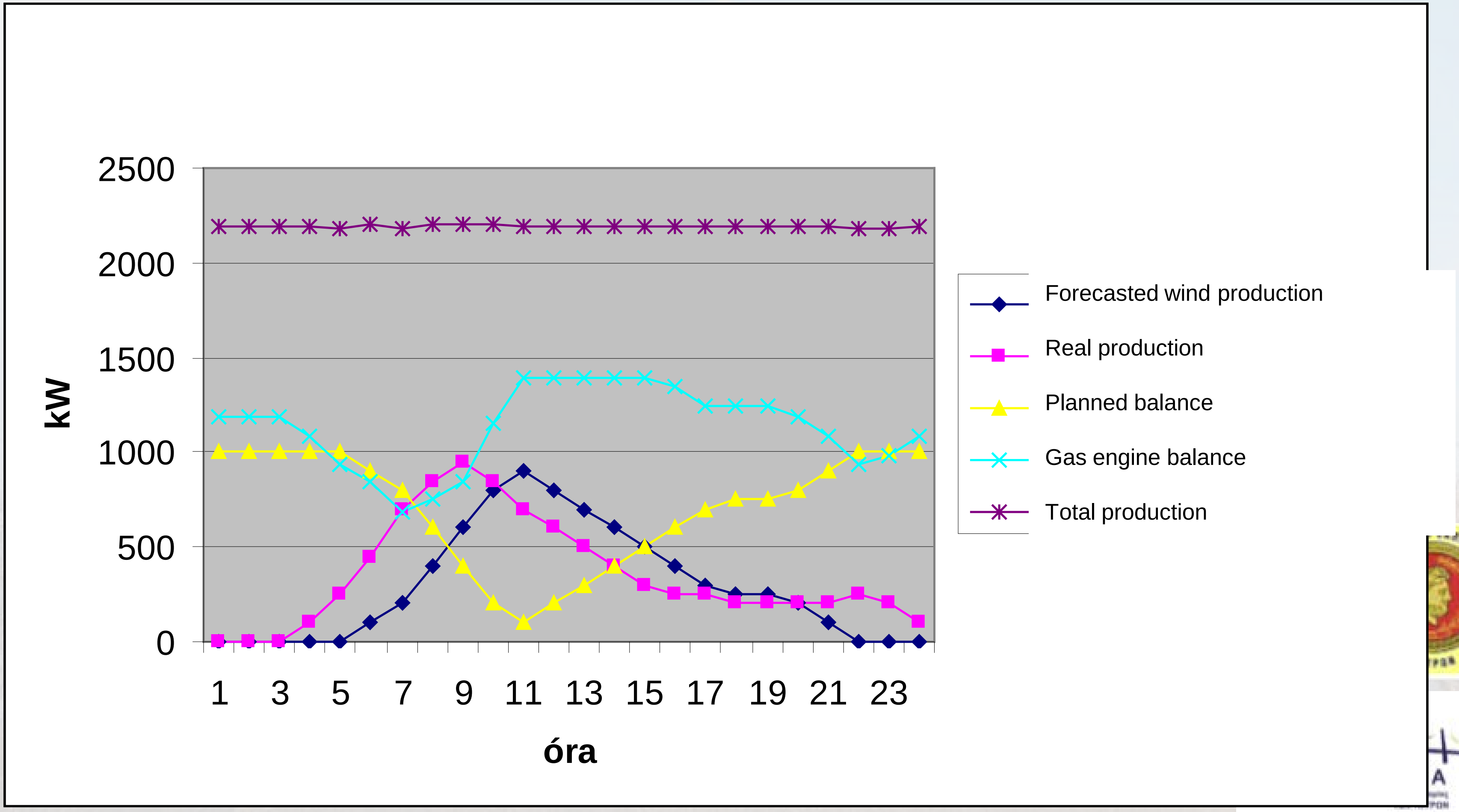

Load of the gas engine

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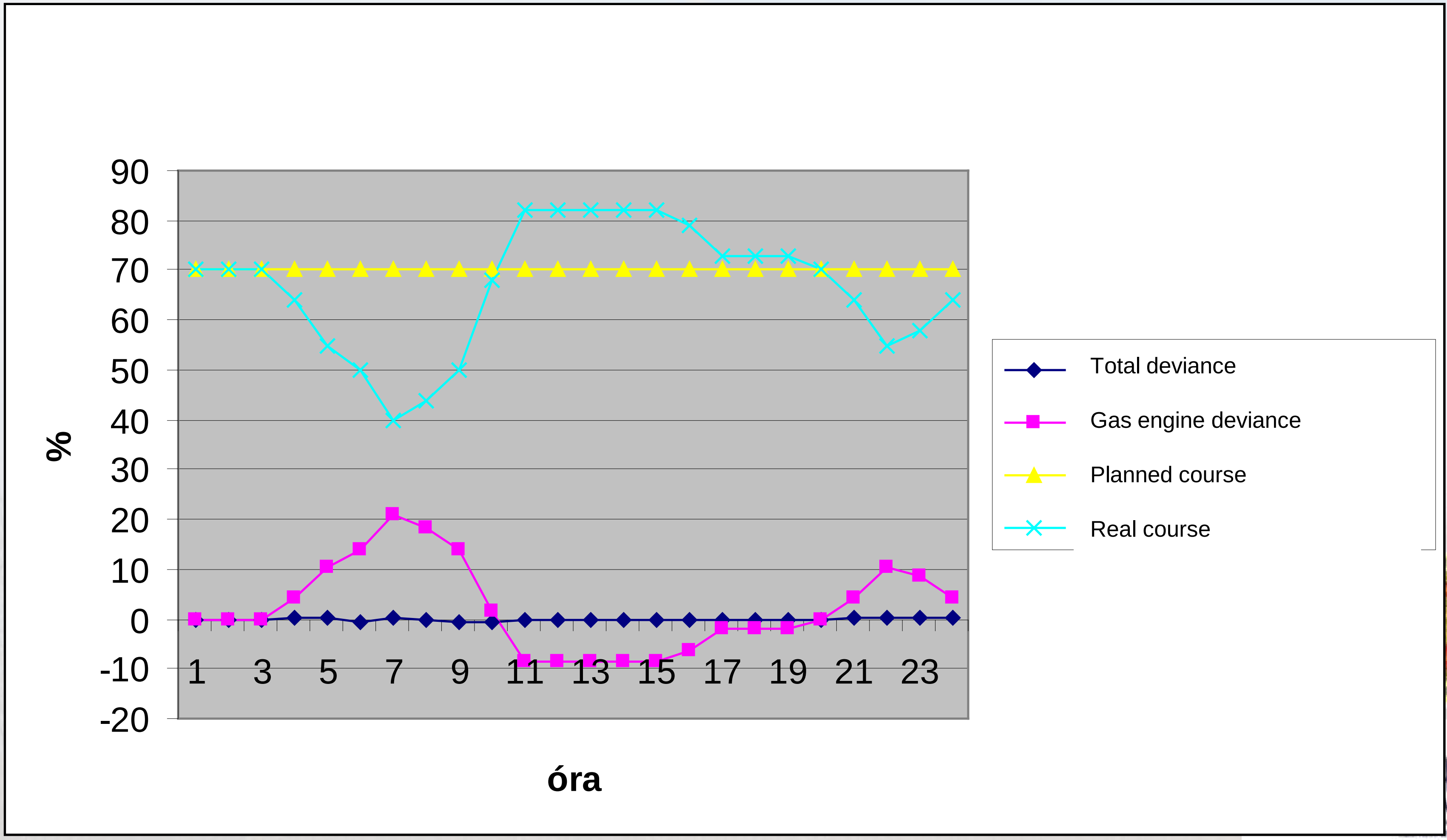

Control Center for Renewable Energy (CORE)

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- Iberdrola
- Toledo, Spain
- Virtual power plant
- Connection to the ISO
- On-line control of the wind towers
- Maitenance control

What helps the integration?

- Control of the windpark output
- Diversification
- Local control centers
- Intraday power exchange

American plans…

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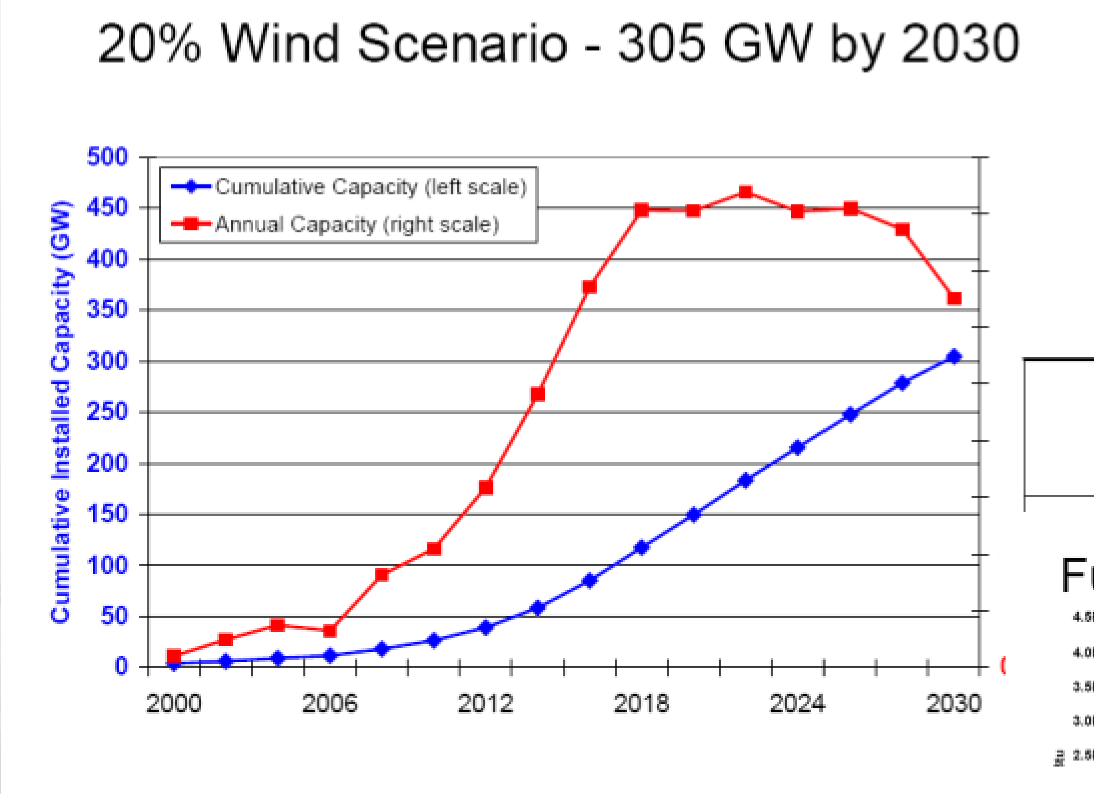
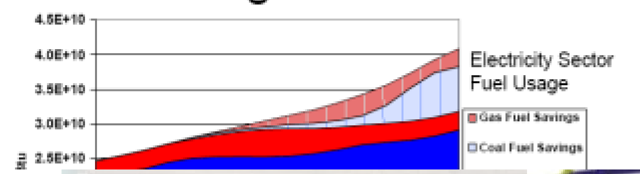


Incremental Direct Costs of 20% Wind Vision Scenario

	Present Value Direct Costs (billion 2006$)*	Average Incremental Levelized Cost of Wind ($/MWh-Wind)*	Average Incremental Levelized Rate Impact ($/MWh-Total)*	Impact on Average Household Customer ($/month)**
				$0.5/month



source: Ed DeMeo, Renewable Energy Consulting Services, Inc. UWIG techn. Workshop, 24 July, 2007, Anchorage, Alaska

Conclusion

- The wind technology is cleared, this is the high time of the **application**
- The hot topics are the **off shore** plants
- The integration of the wind energy is the question of **decision**
- The present **network structures was not planned** and implemented for the trade and renewable generation

Have a good work!

Thanks for the attention!