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Power System Department

The Parts of a Wind turbine, Construction and Integration

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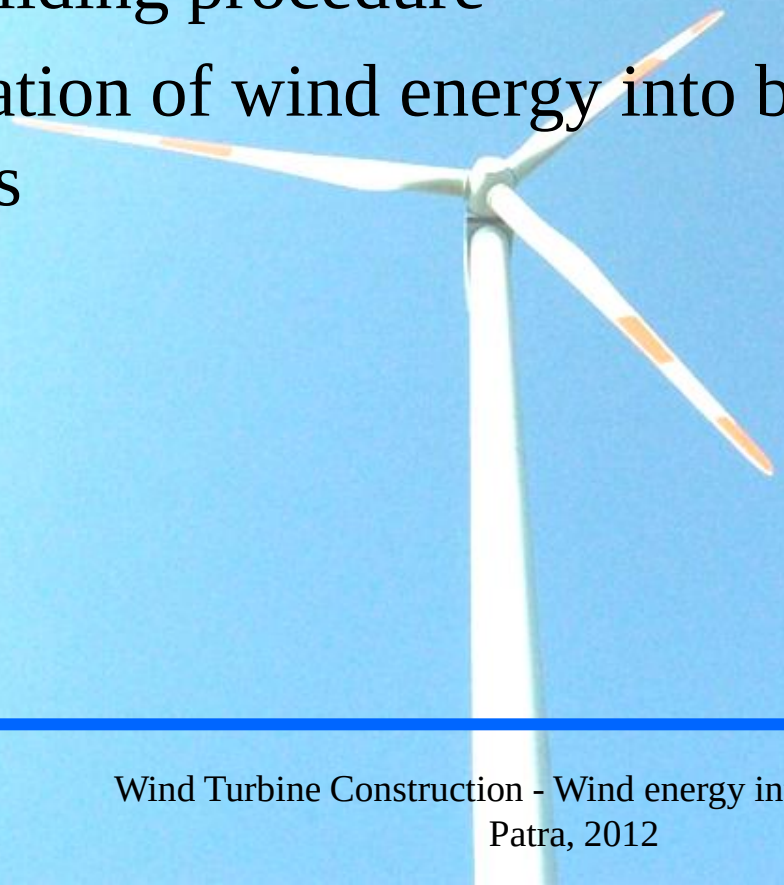
Draft

- 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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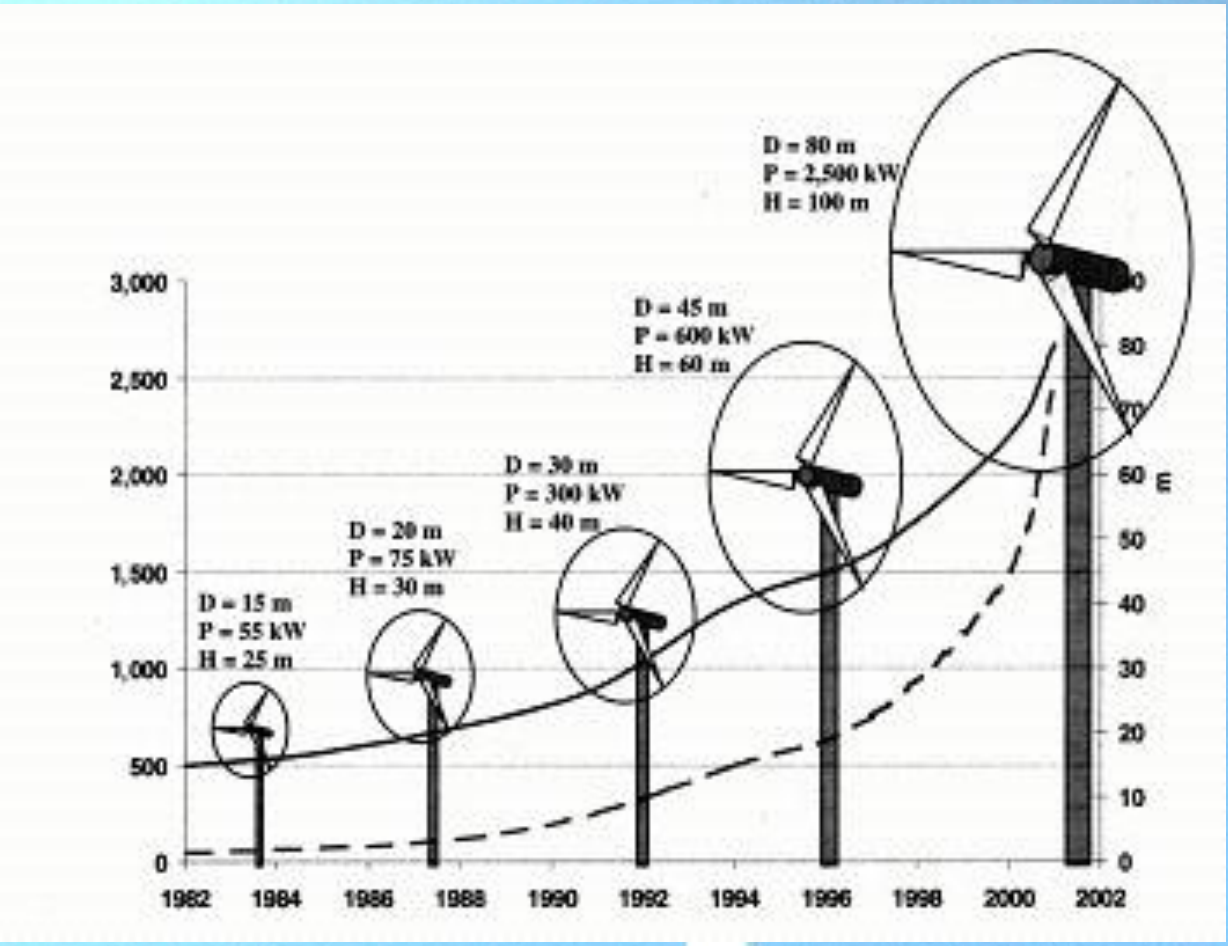

Today:

120-160 m

3,5-5 MW

Limits: the sky

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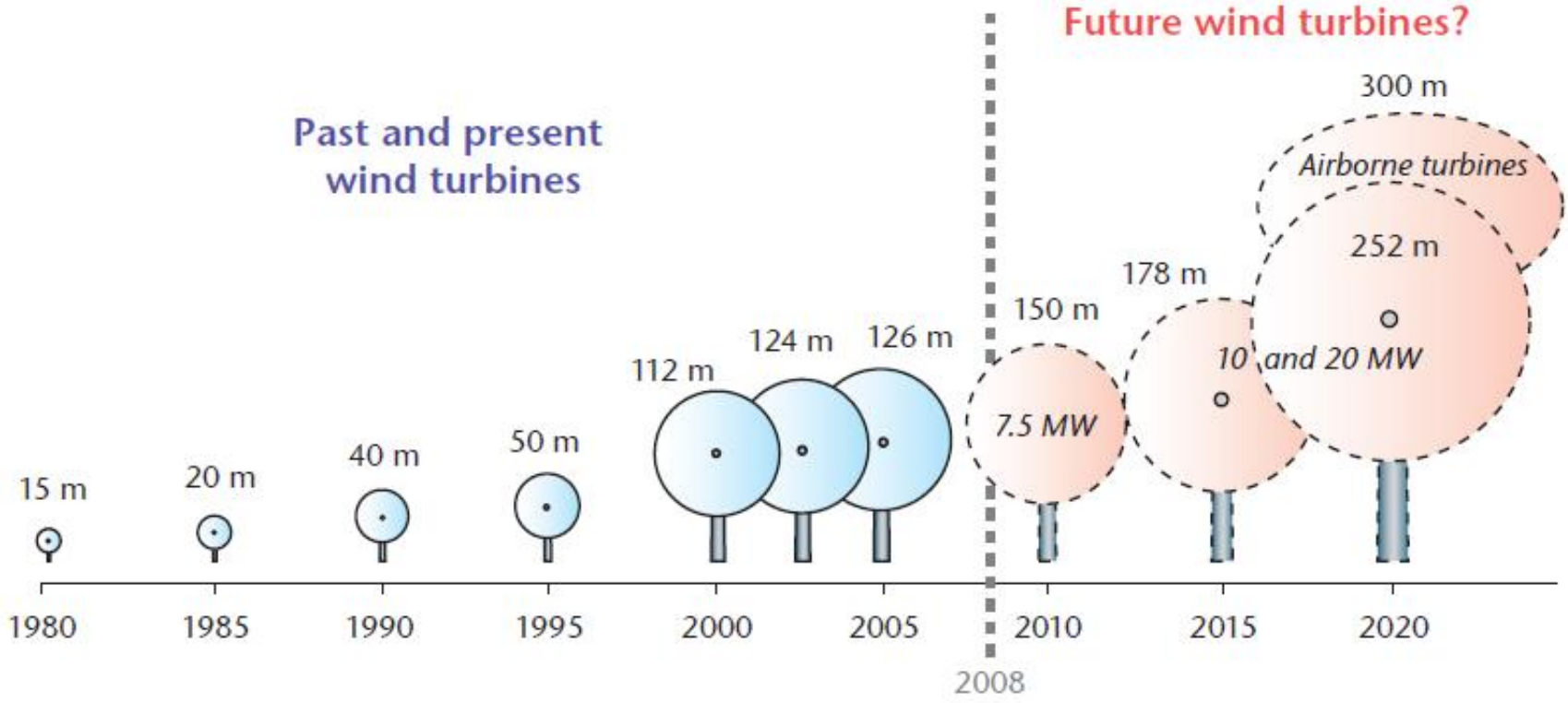
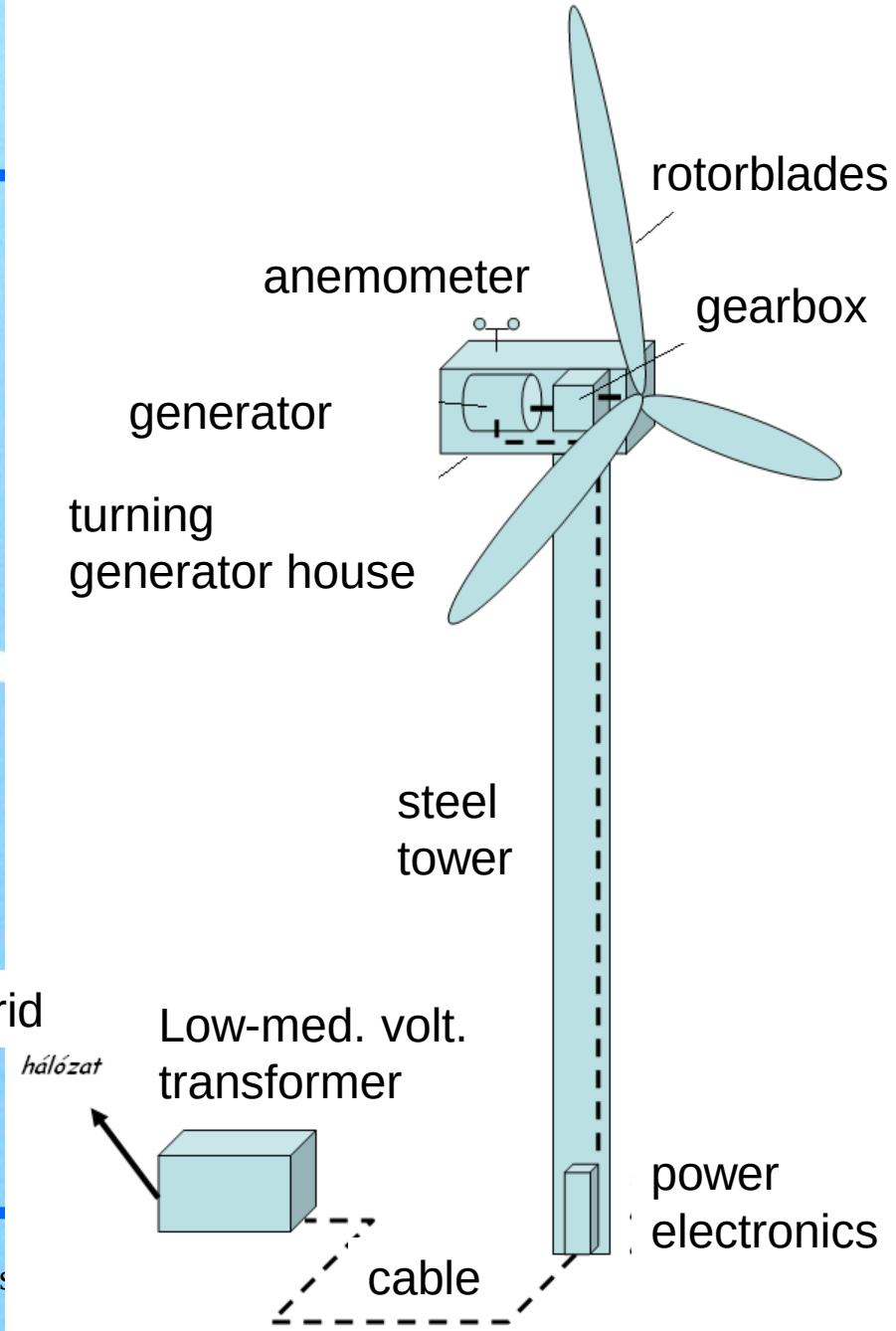


Source: Adapted from EWEA (2009).

Parts of a wind turbine



Foundation

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Transportation

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Transportation

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Craning

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Nacelle

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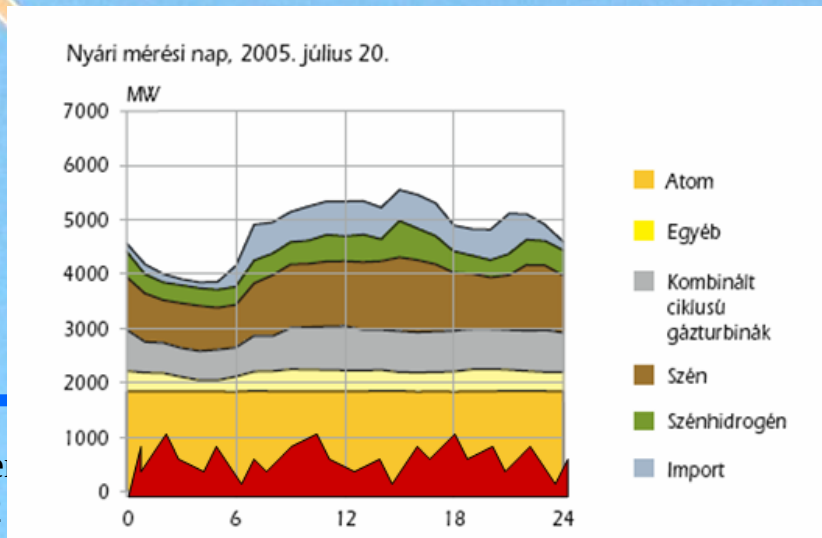
Traditional control: Load demand -> generation control on the base of the demand

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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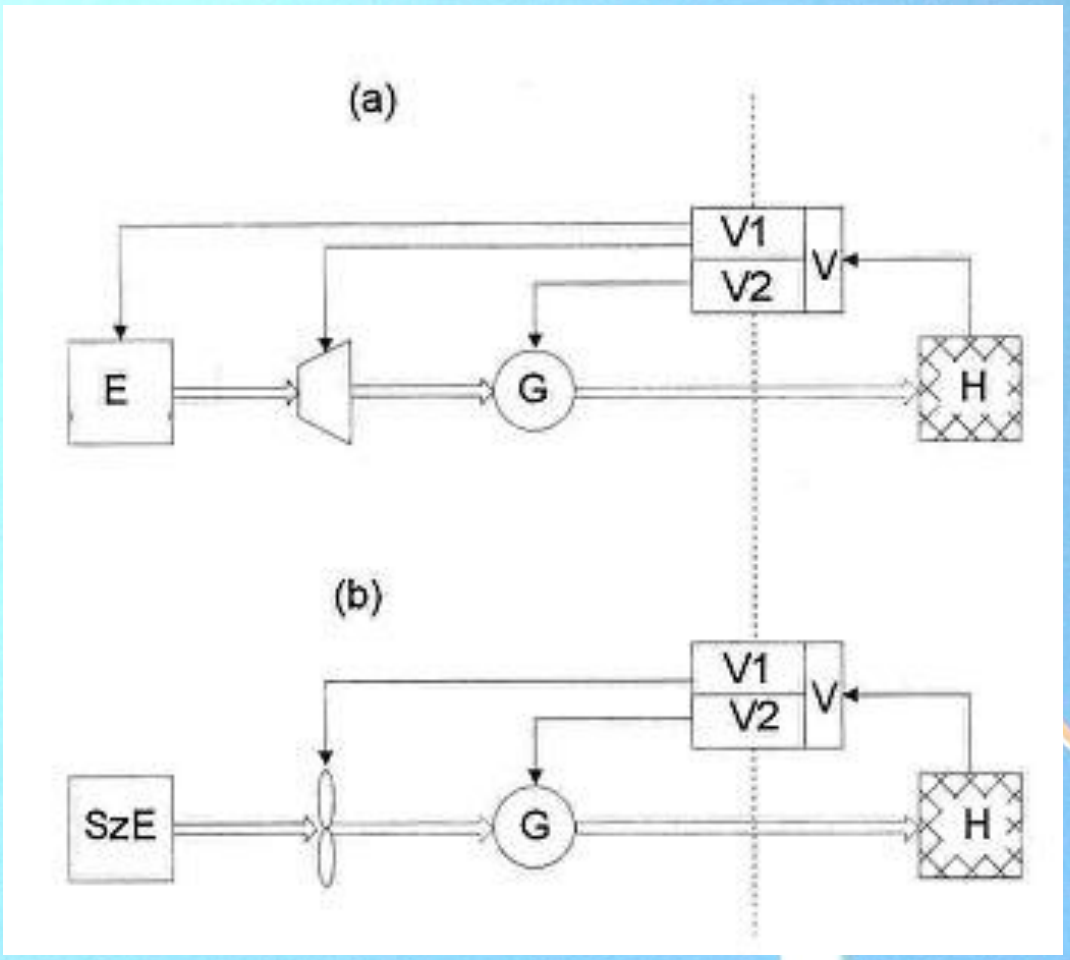

Traditional:

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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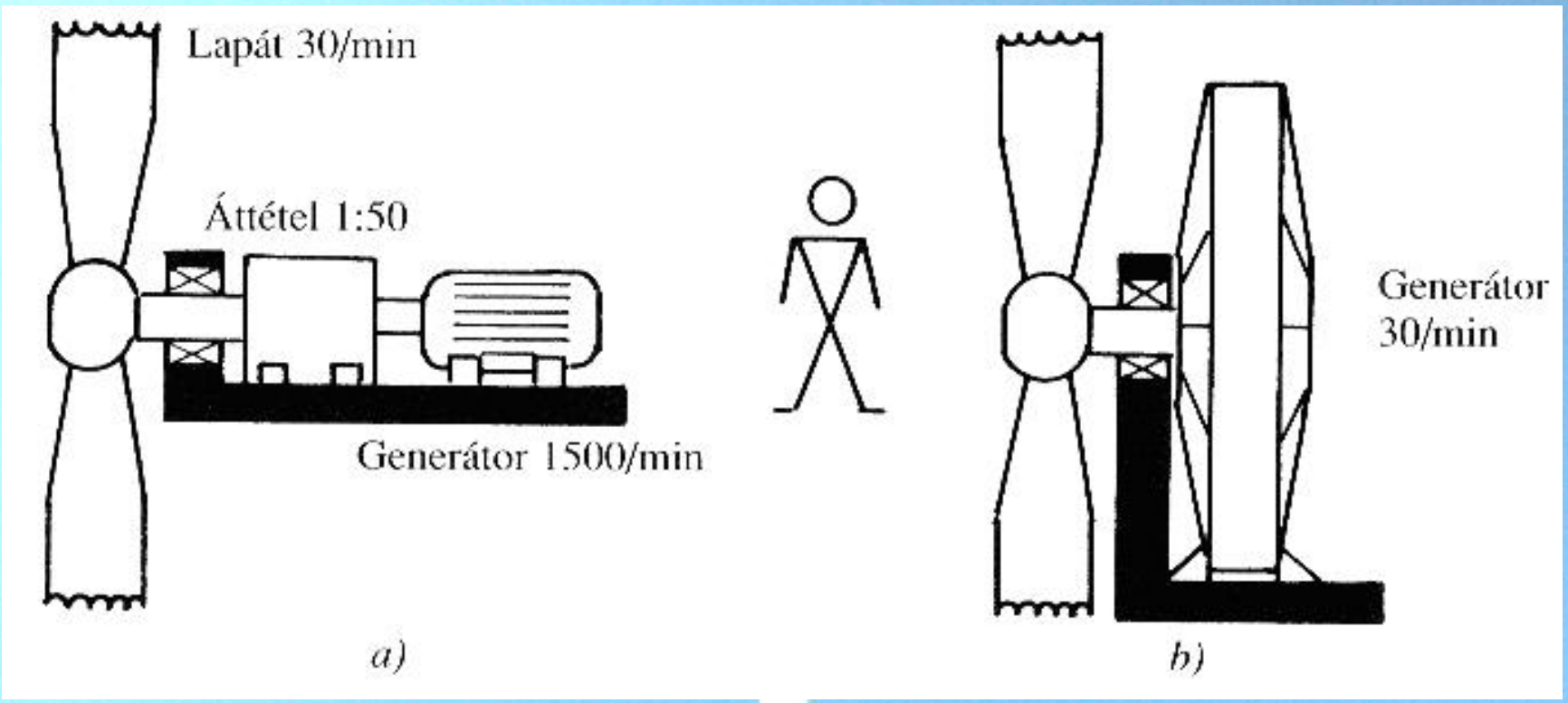

Connection of the generator to the grid

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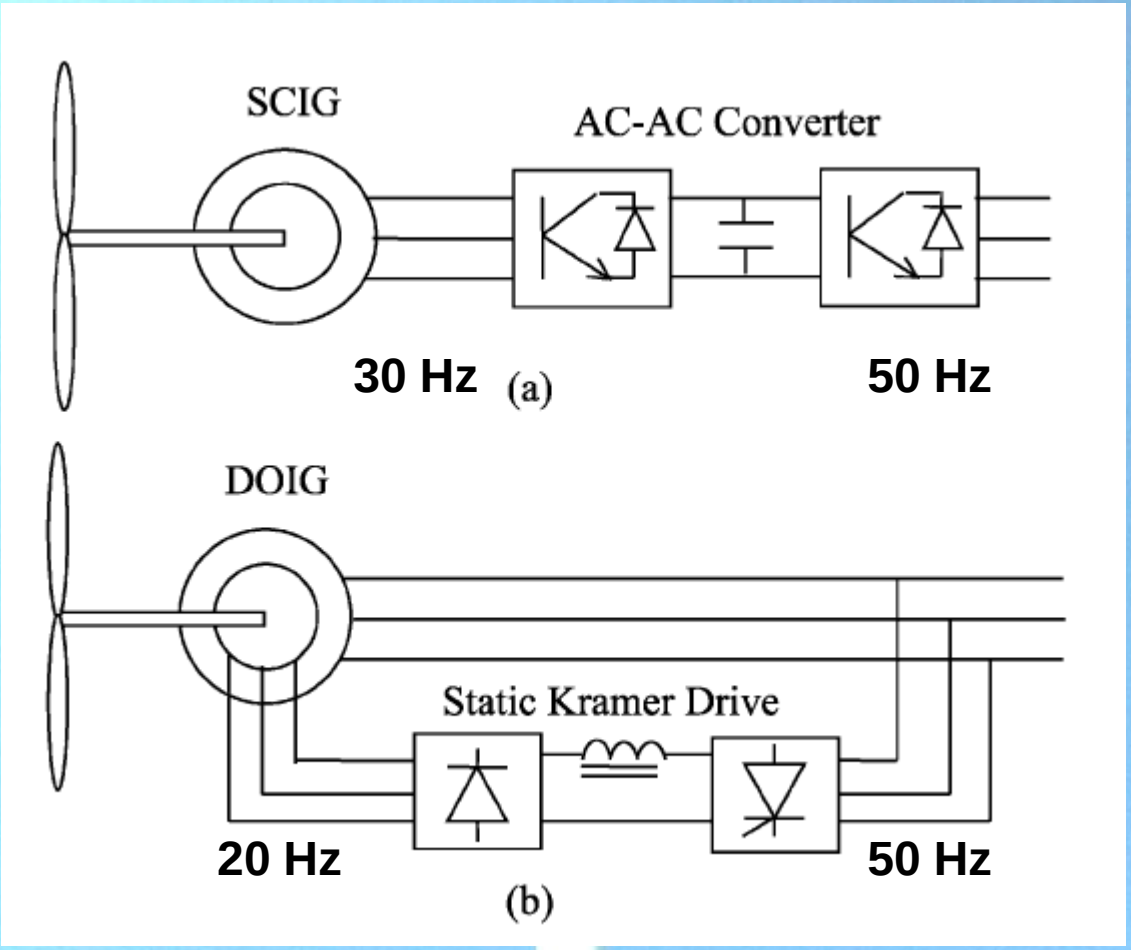
Appr. RPM

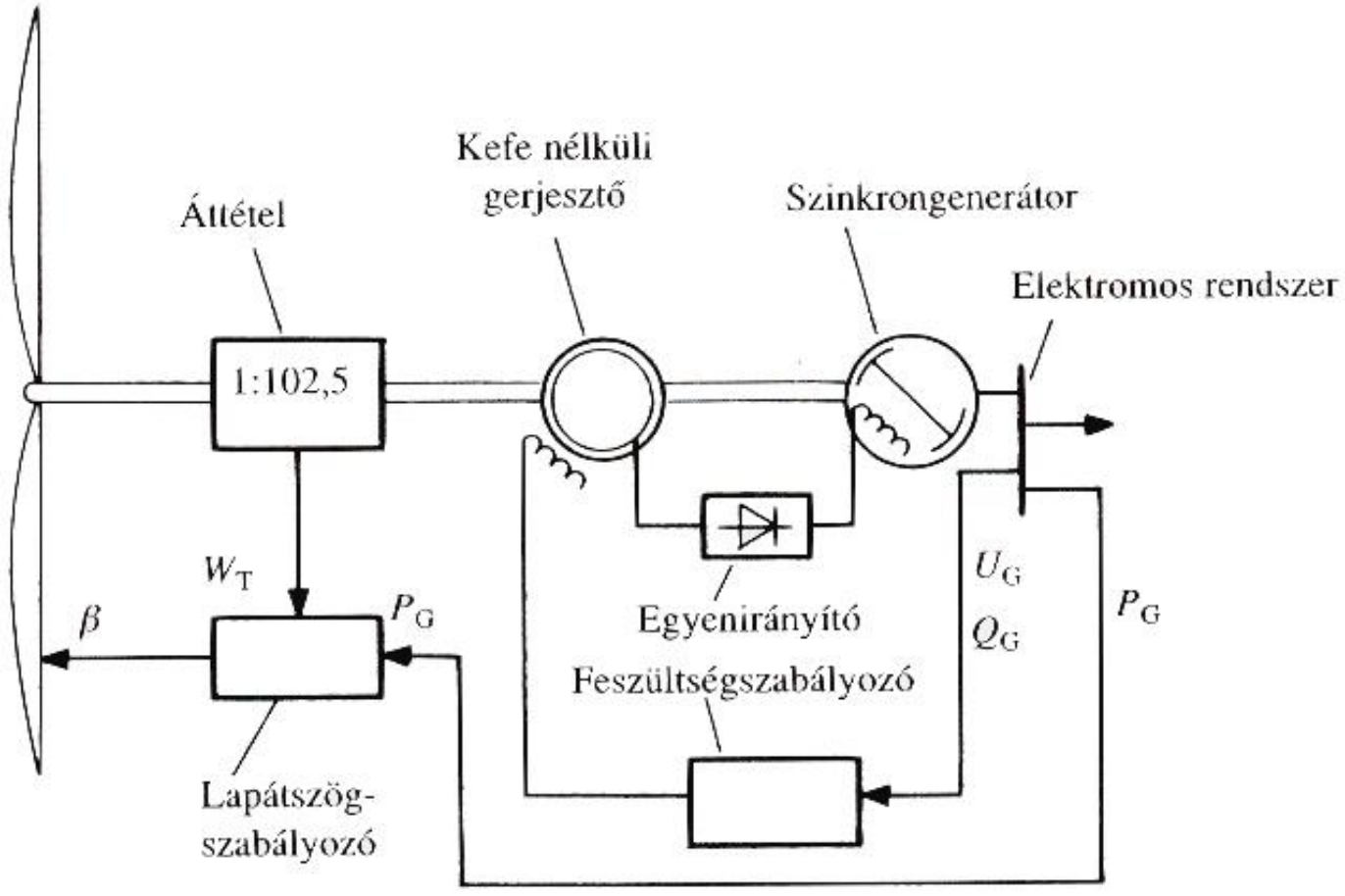
900-1000

changing



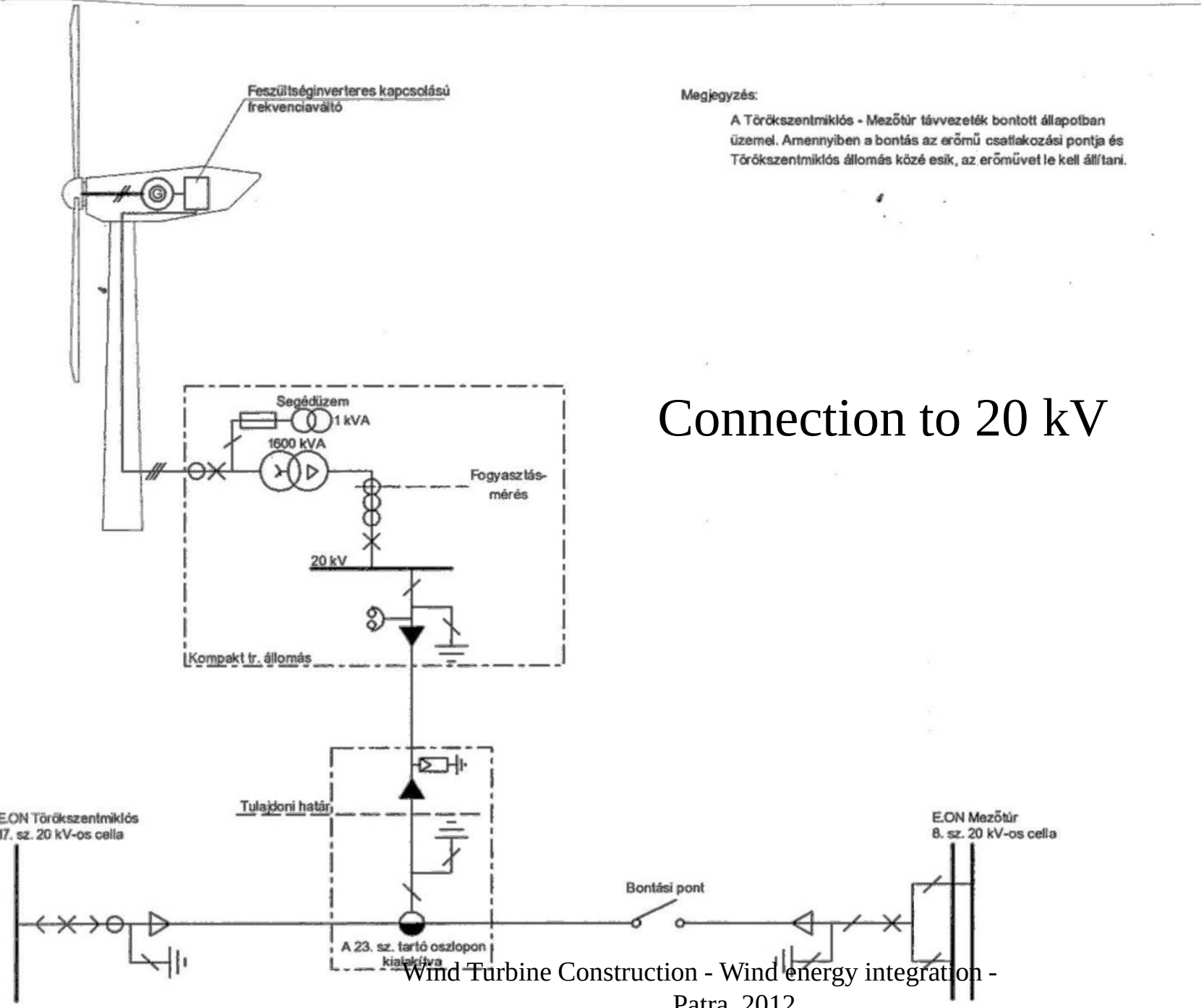
Fixed frequency (RPM)

Control: pitch, P,Q

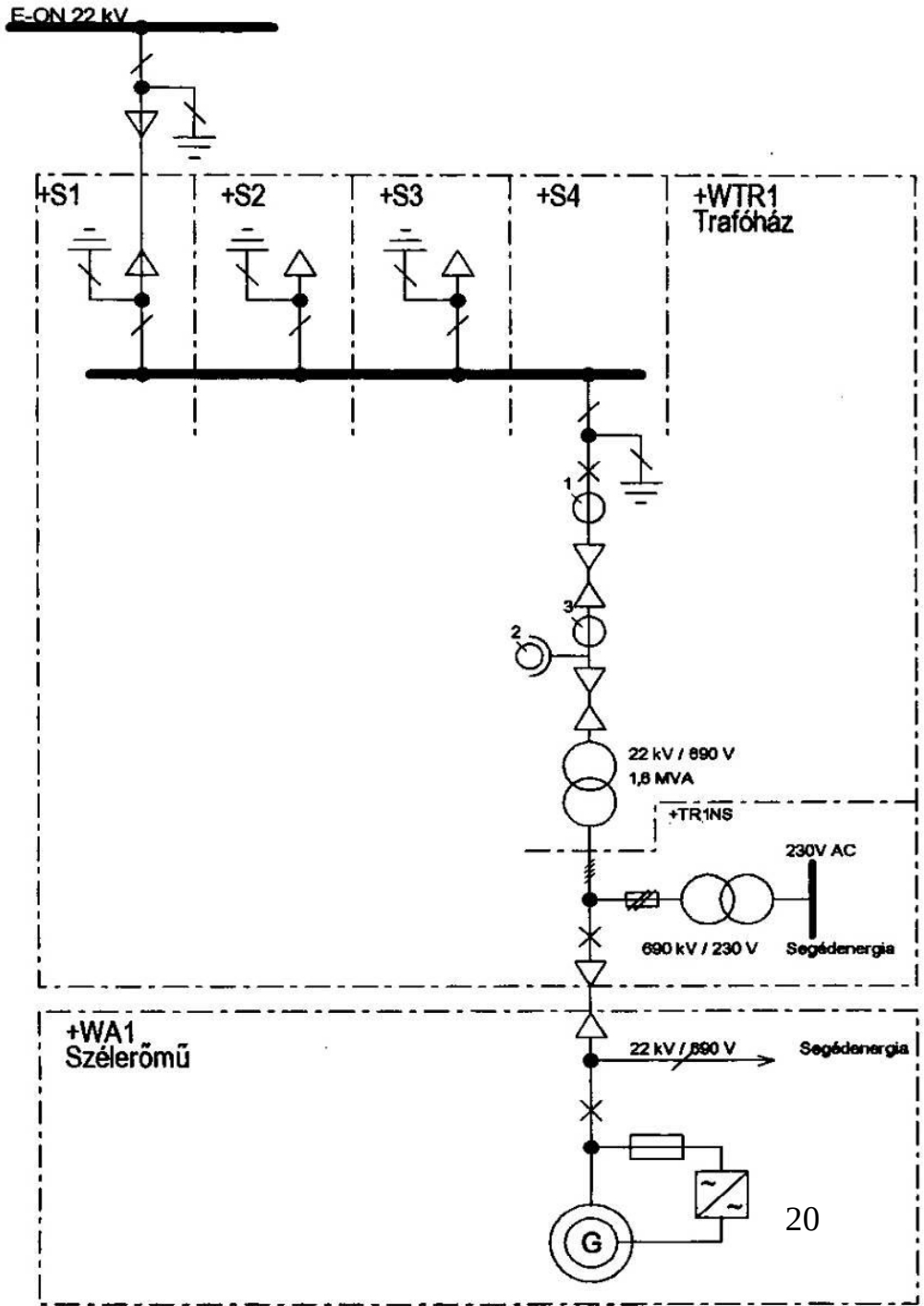


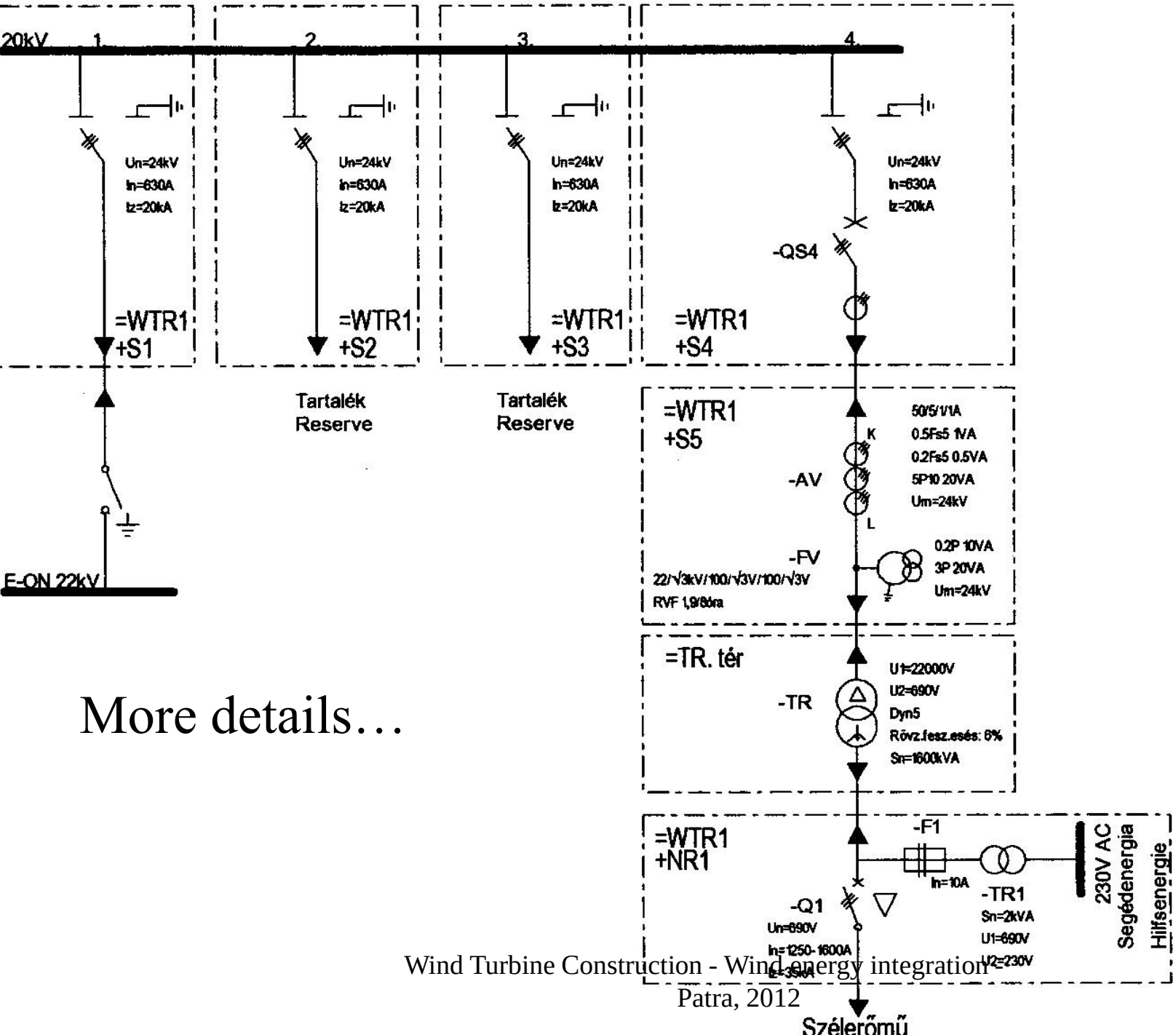
Electrical connection: compact substation

Connection to 20 kV



Single line scheme





More details…

Protection, measurements, settling, RTU

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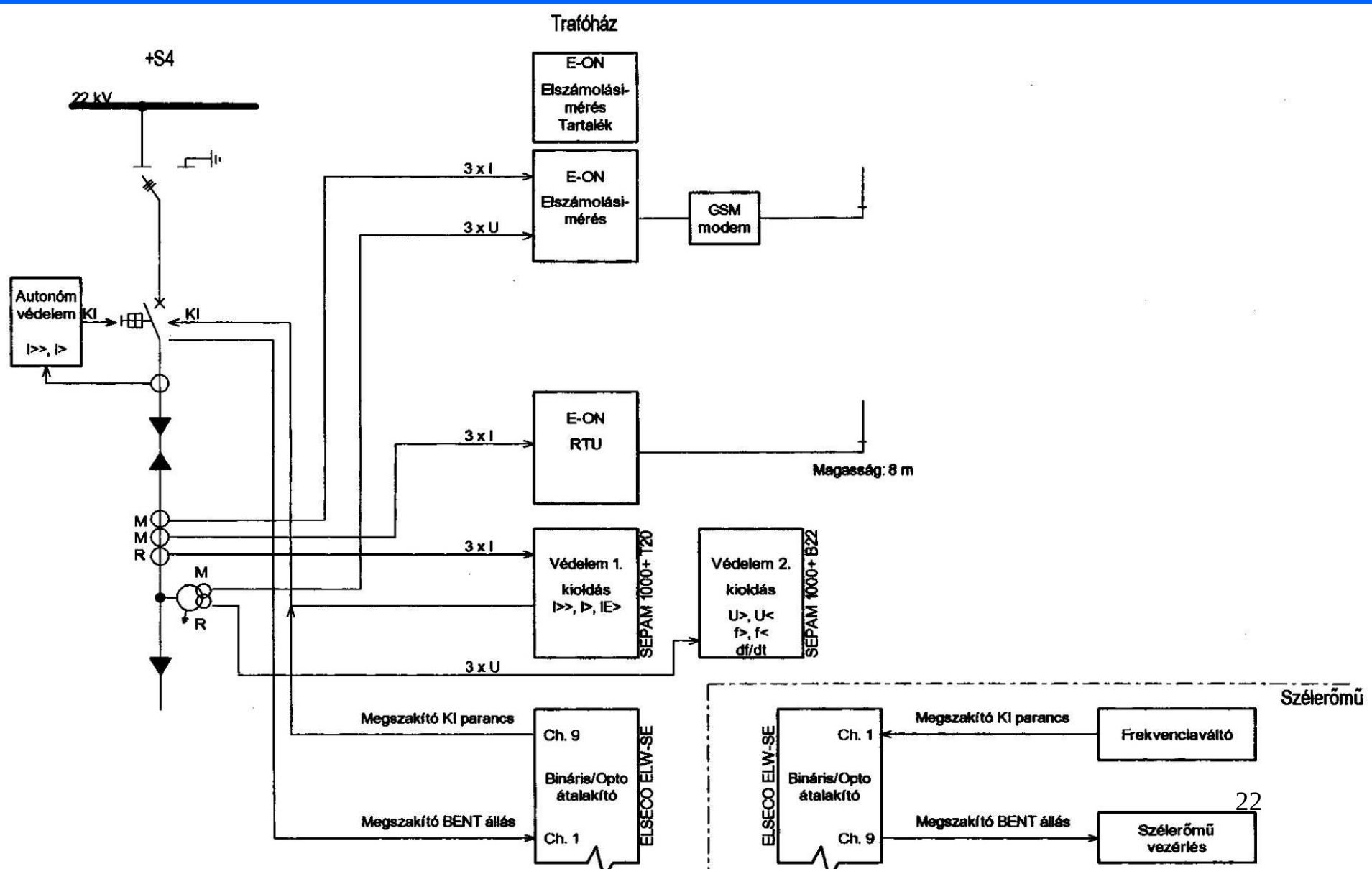

Connection between the tower and the compact substation

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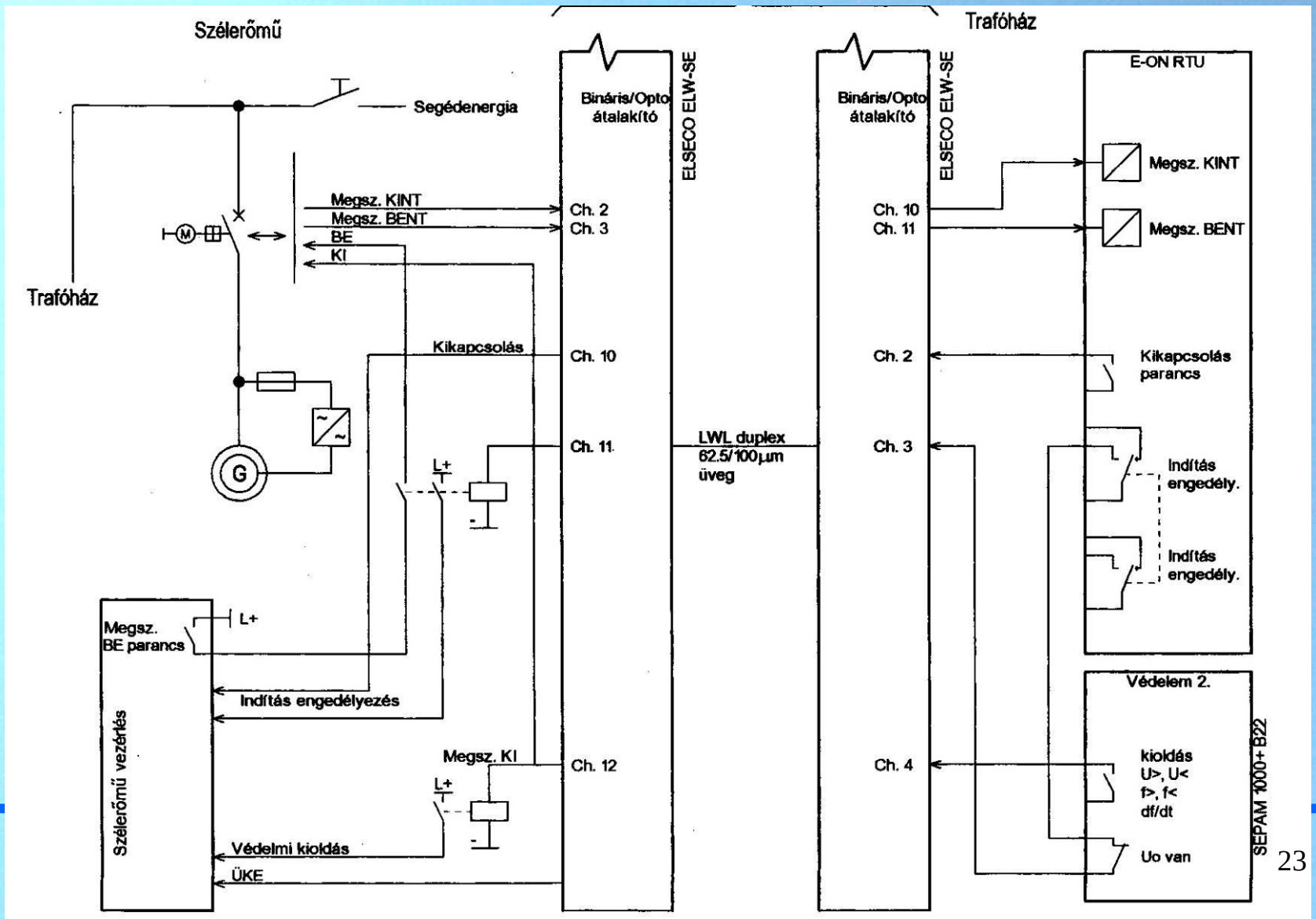

Power, voltage level and topology

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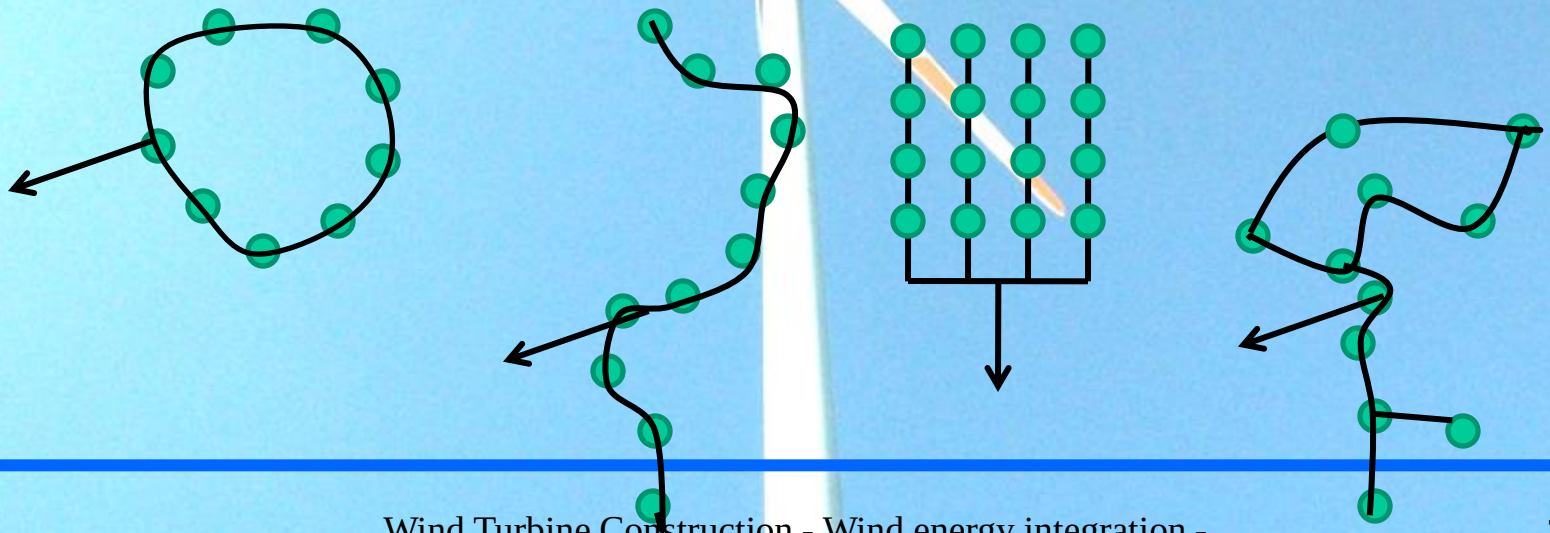
- 1 unit: cca. 2 MW (0,8 – 3,5 MW)
- 20 kV for transmission 3-8 MW
- Wind park: 20-30 units -> 110/120 kV
- Special topologies: ring, tree, quadratic, meshed, etc.
- Security – geography – economy – ecology



Wind speed changes

by Jensen

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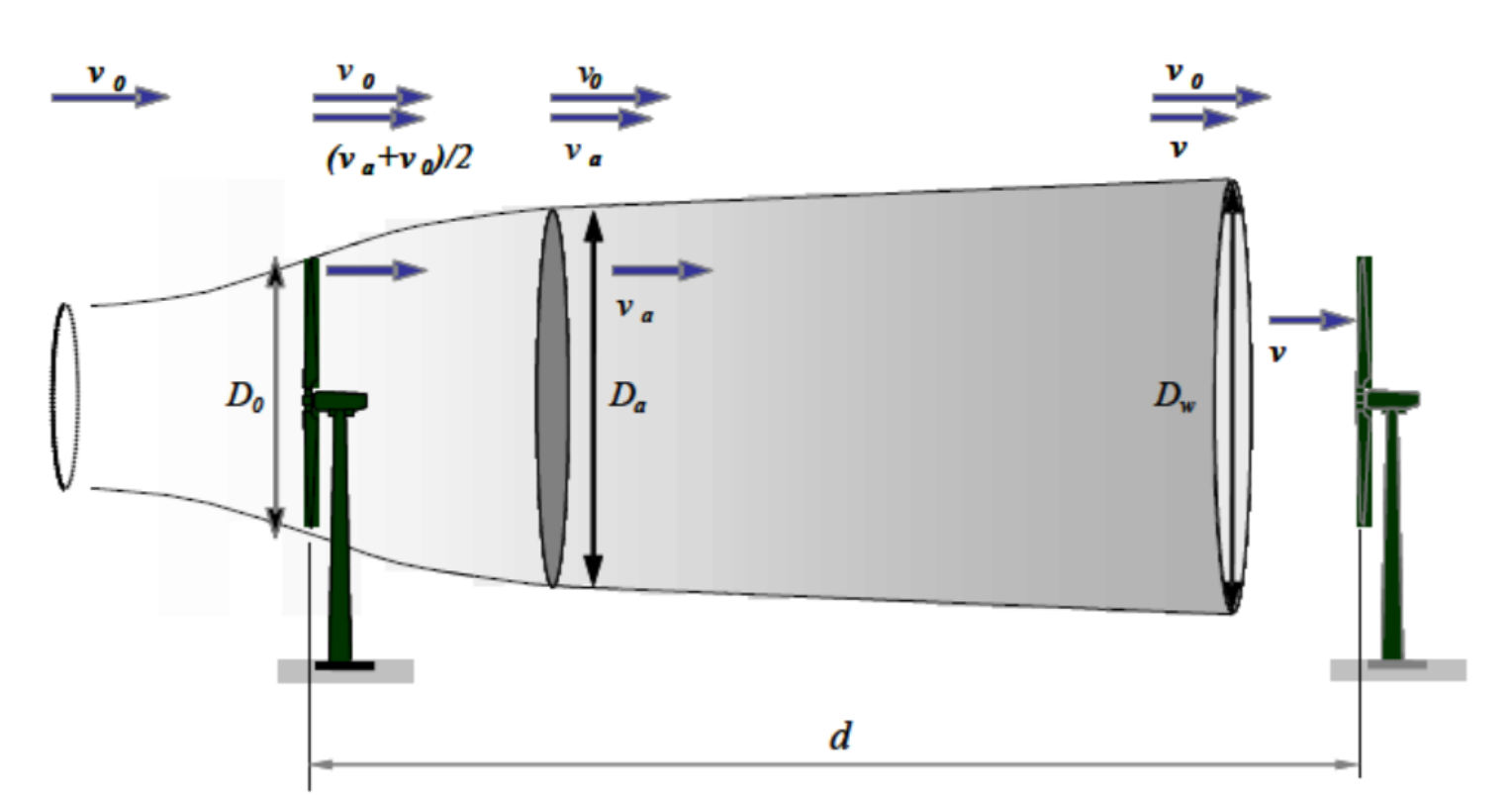

$$\frac{v_{estela}(d)}{v_0} = \frac{1}{2} + \frac{1}{2}\sqrt{1 - 2C_T(v_0)\left(\frac{D_0}{D(d)}\right)^2}$$

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

(work of Javier Serrano)

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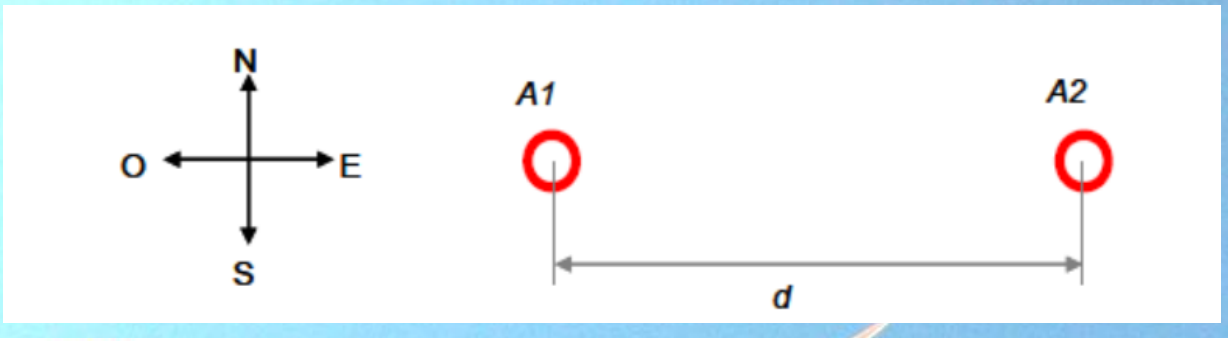

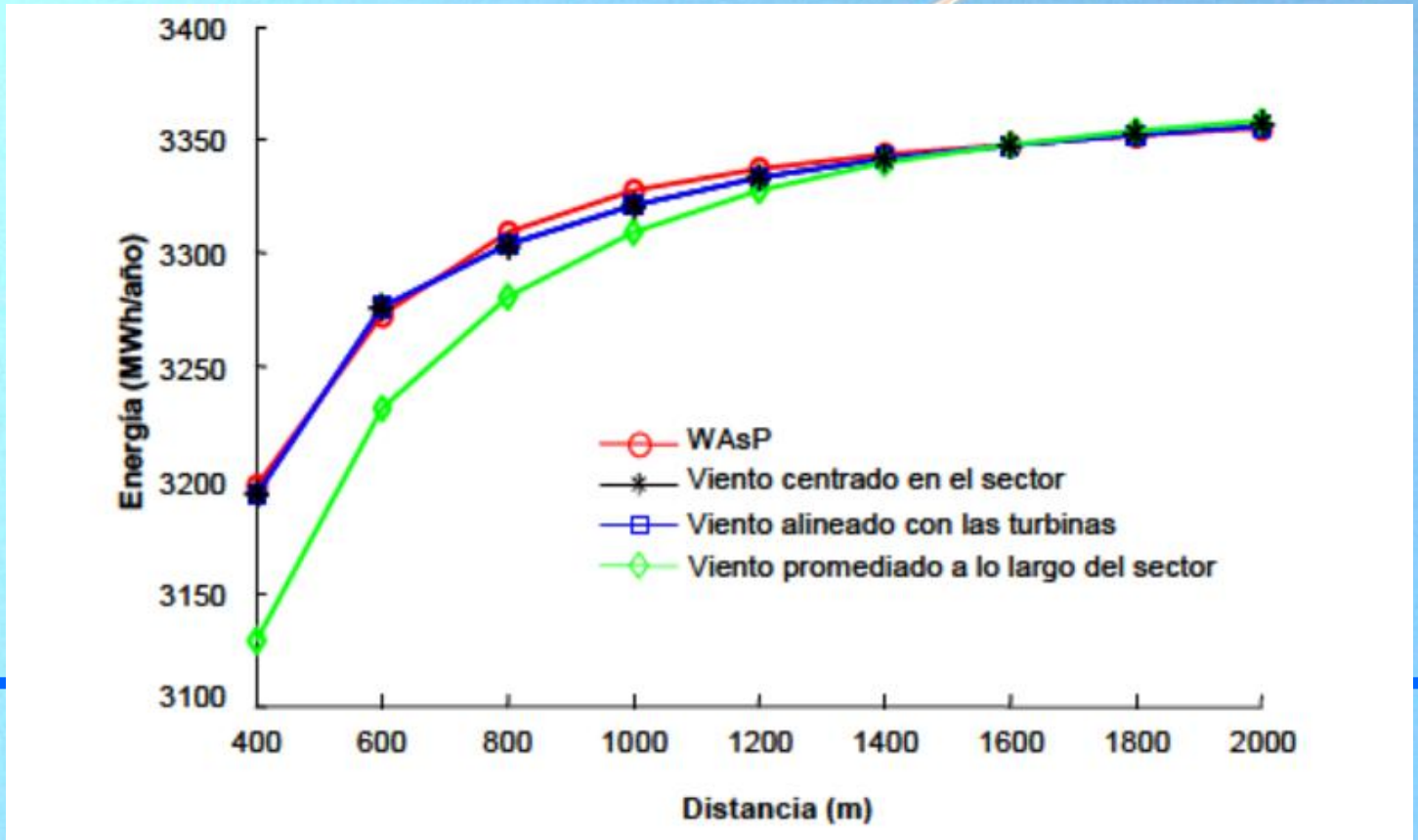

Micrositing - optimisation

(work of Javier Serrano)

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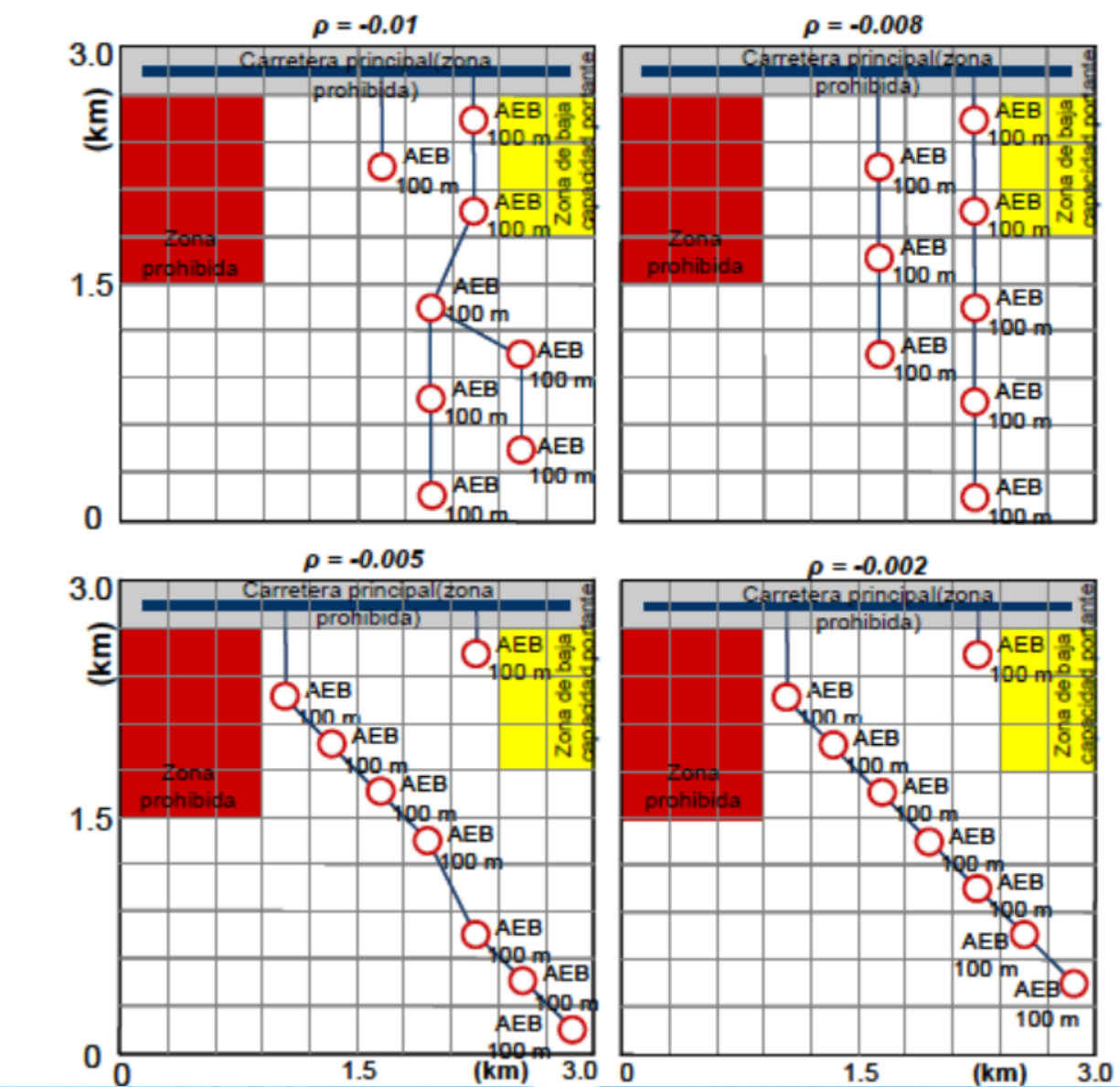

Quadratic displacement, Burgenland, Austria

Line on the hill edge

Molina ***moderna*** de Aragón

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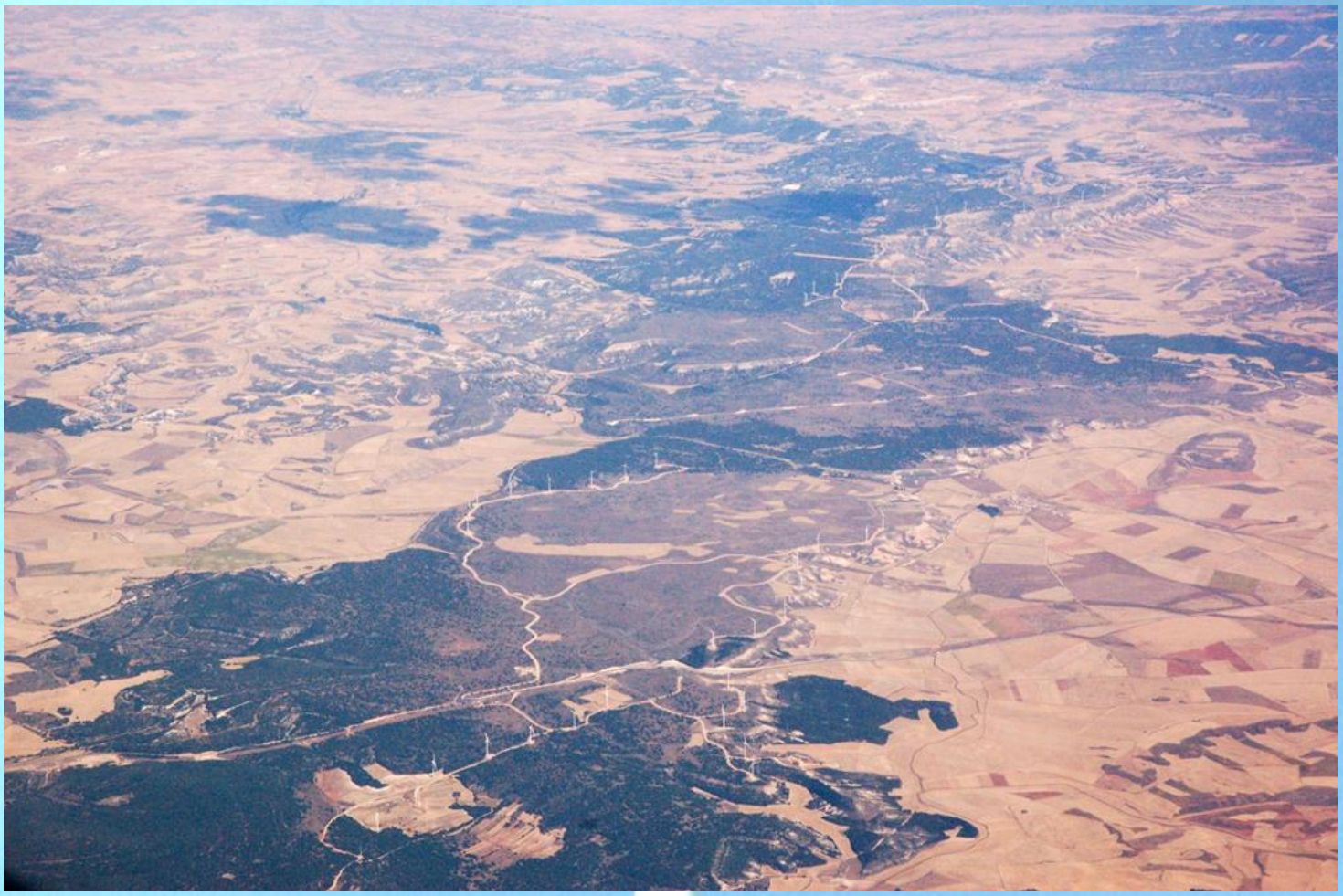
Wind metering tower

Atienza, Spain



Near Calatayud, Spain

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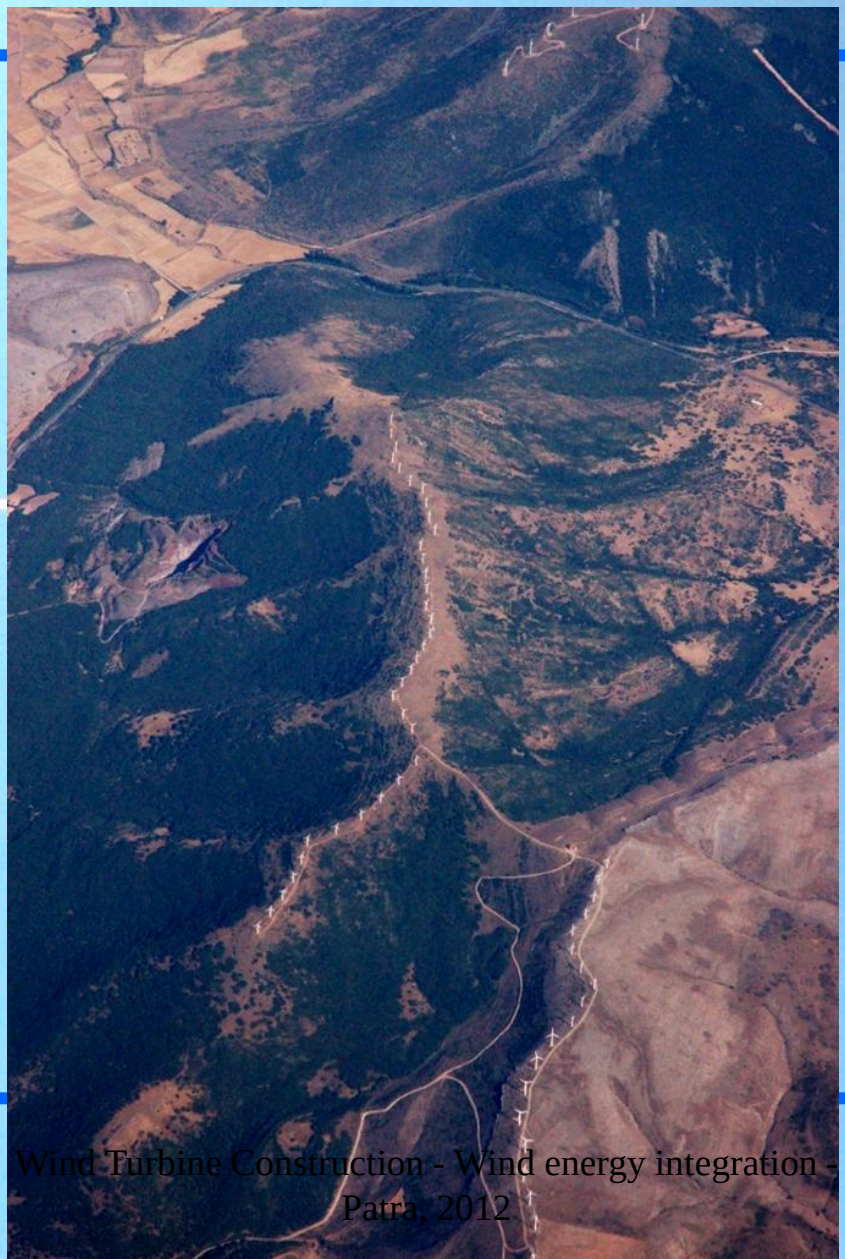
Near Calatayud, Spain



Near Calatayud, Spain
150 towers on this picture!

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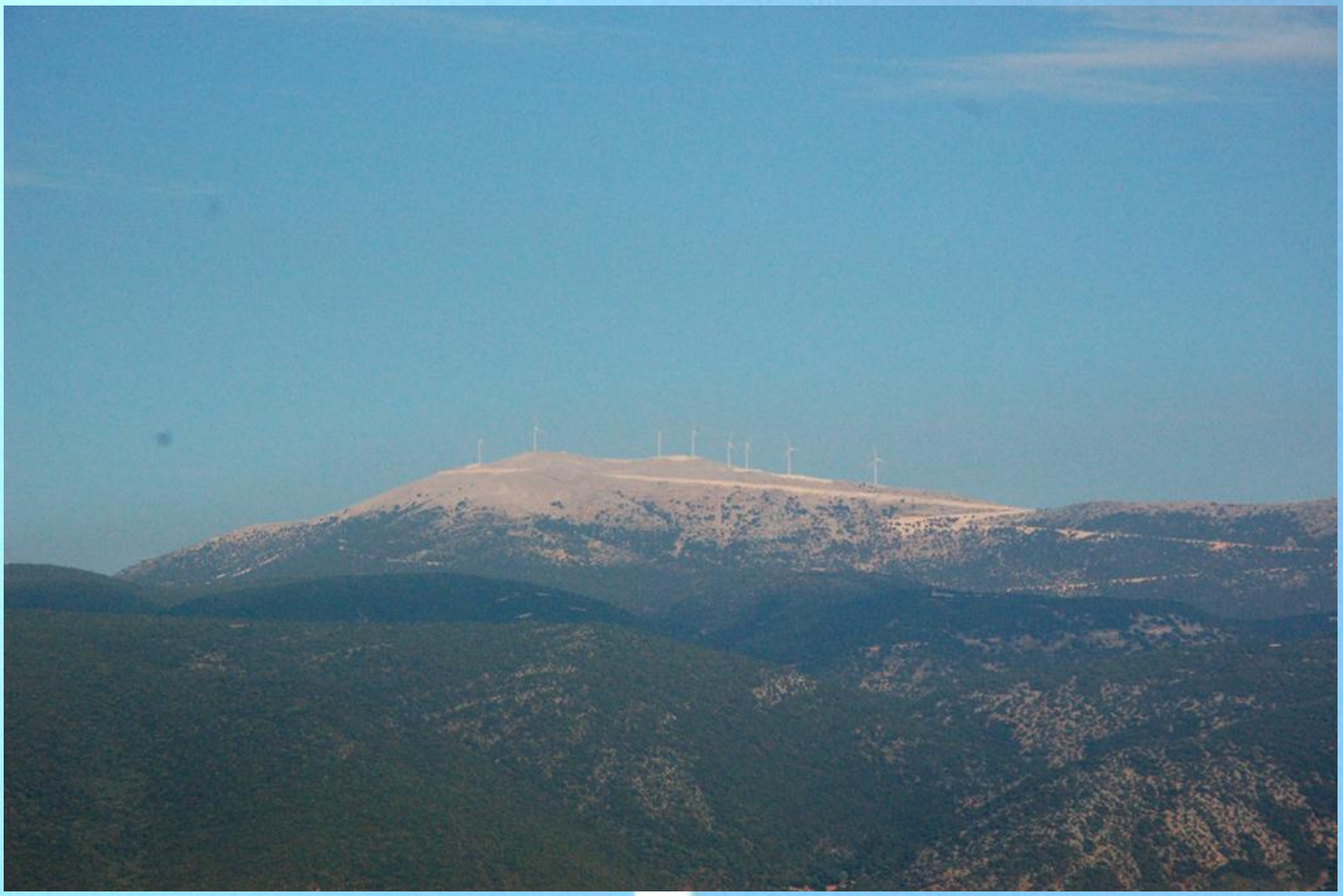
Kefalonia, Greece



Measurements
Characteristics, RPM, output power

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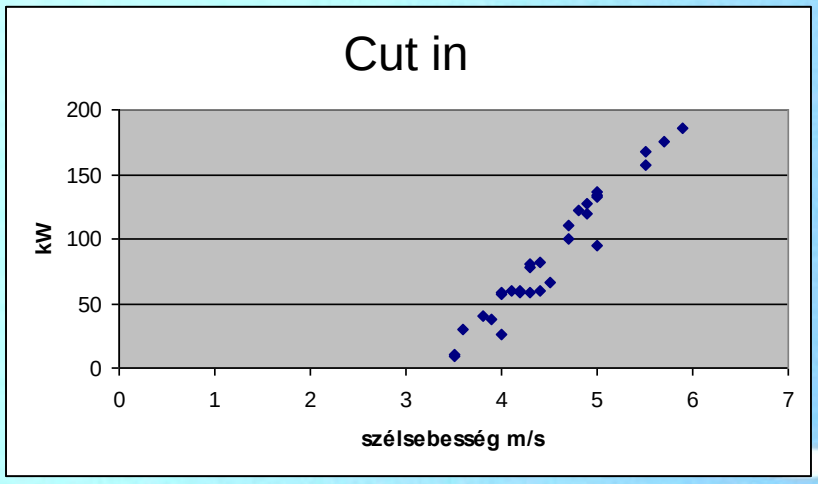

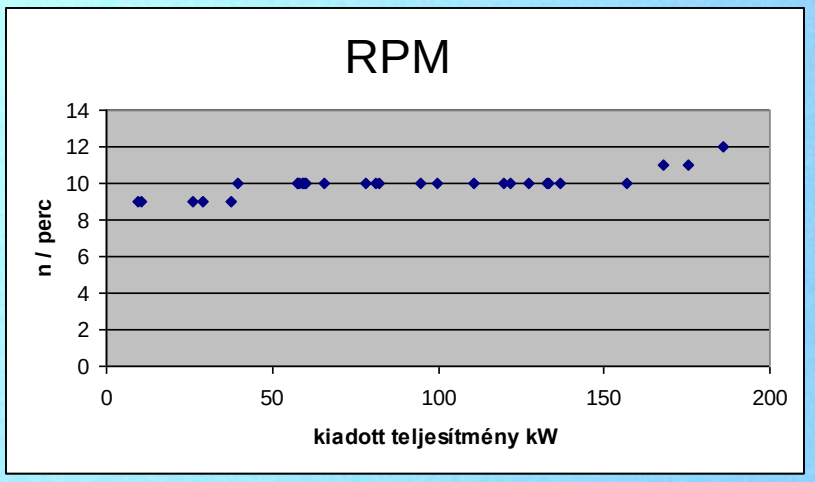

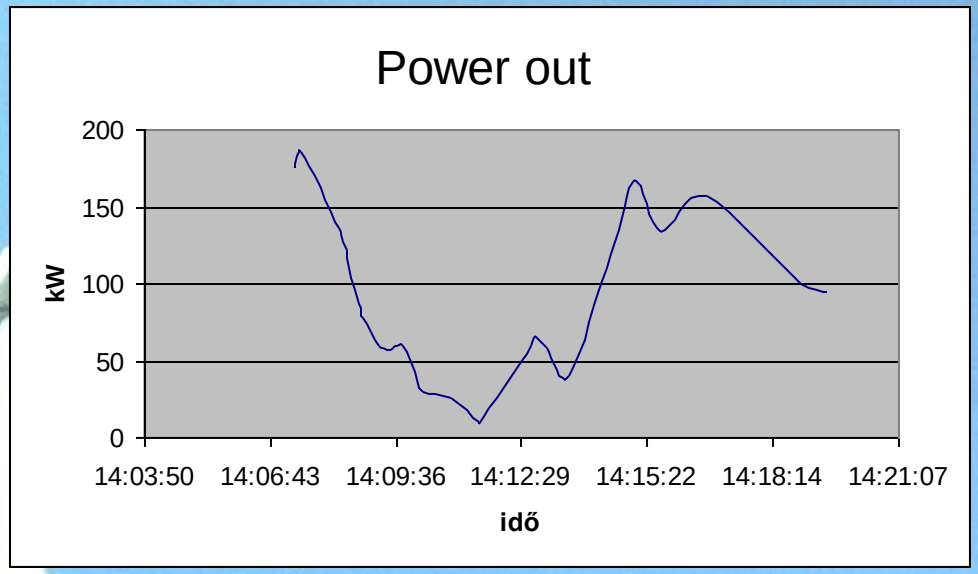

Niederland , Cabo Verde, Burgenland (A), Portugal

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Windpower plants in Hungary, 2006

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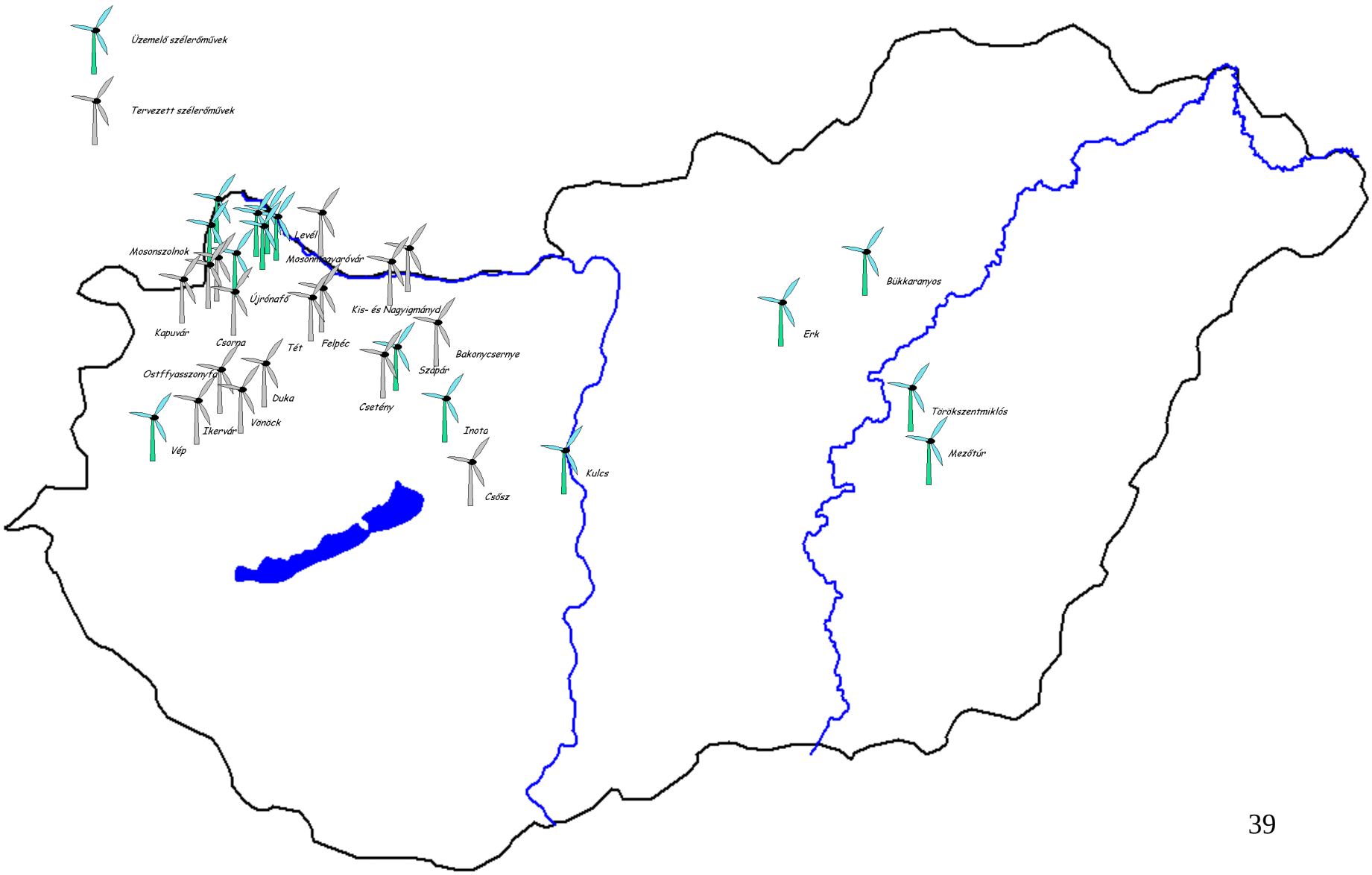
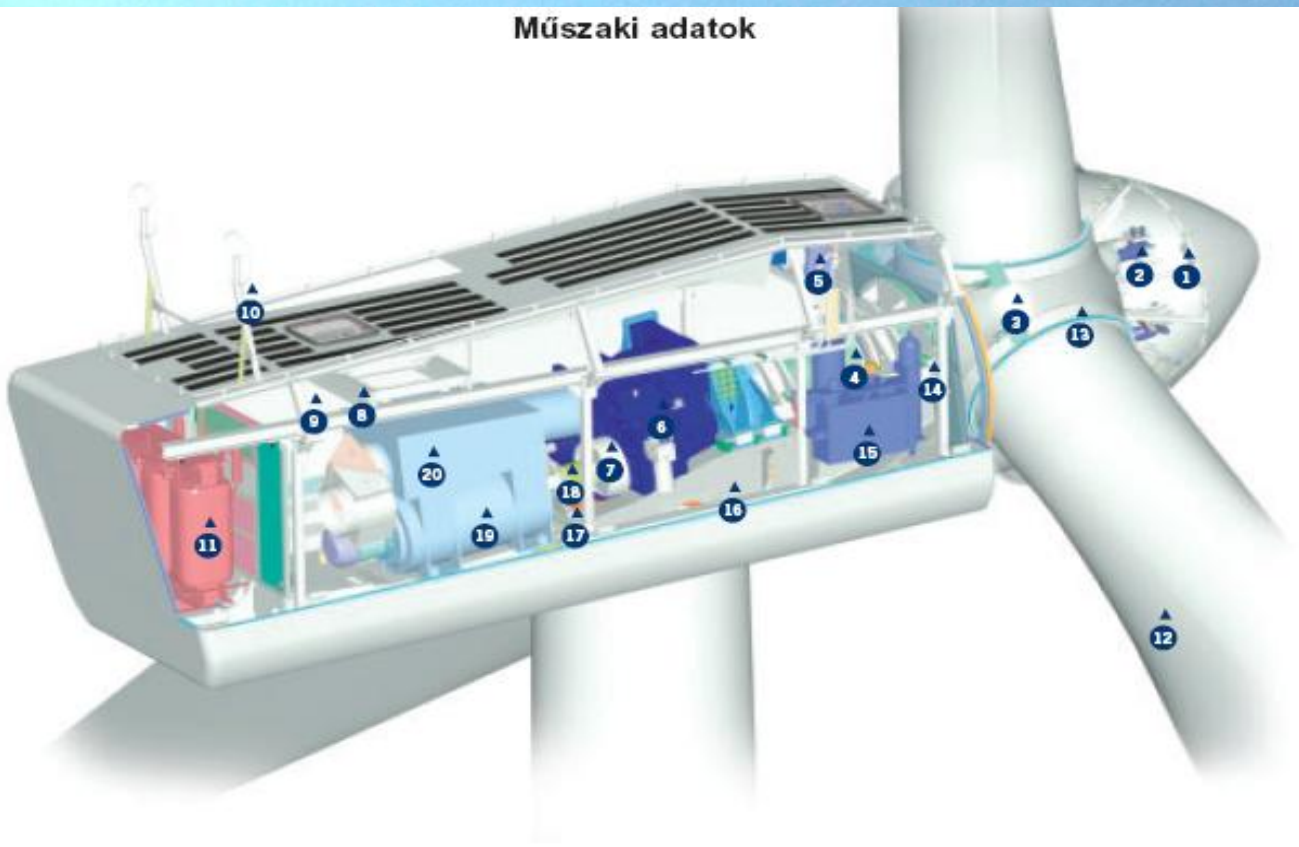


V90

Műszaki adatok



1 Lapátszögvezérlés
2 Lapátszögállító munkahengerek
3 Lapátagy
4 Főtengely
5 Olajhűtő
6 Hajtómű
7 Mechanikus tárcsafék
8 Szerelődaru
9 VMP-felső vezérlés átalakítóval
10 Ultrahangos szélérzékelők
11 Nagyfeszültségű transzformátor (6-33 kW)
12 Lapát
13 Lapátcsapágyazás
14 Forgórész reteszrendszere
15 Hidraulikus egység
16 Gép alapkeret
17 Azimut hajtás
18 Kompozitlemez tengelykapcsoló
19 OptiSpeed® generátor
20 Léghűtő a generátorhoz

Characteristics

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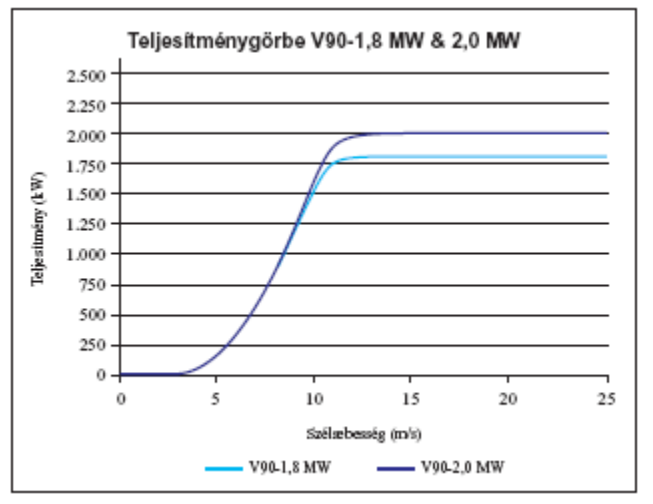

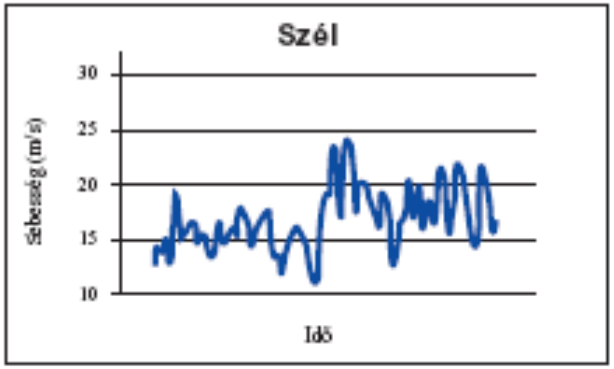

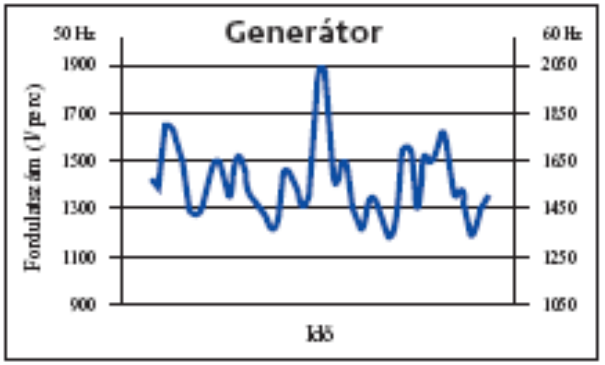

Rotor blade

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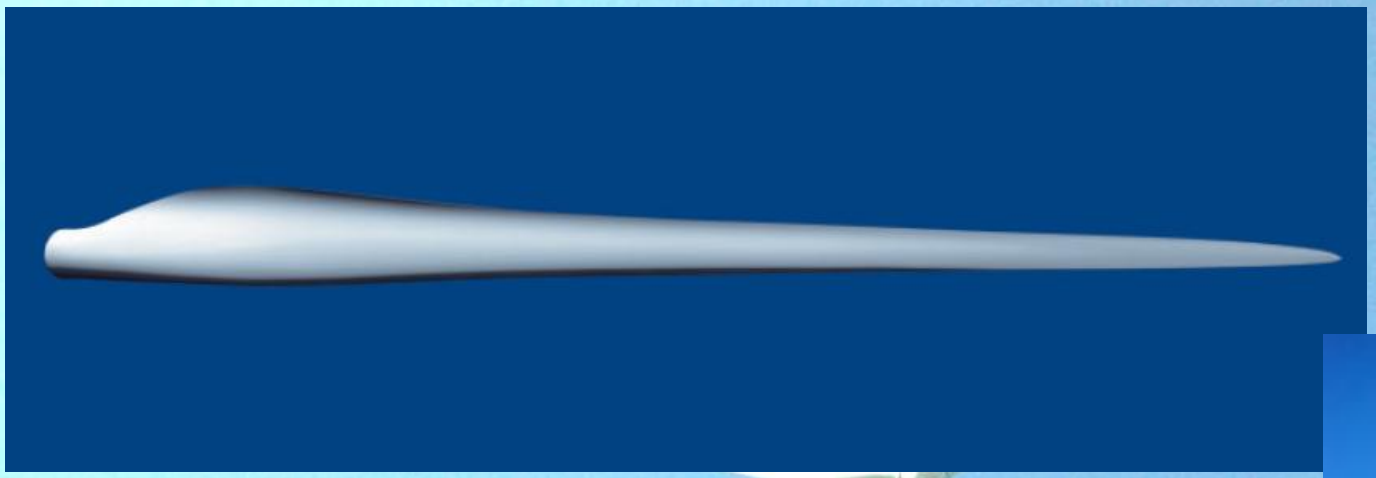


V90 (~44 m)

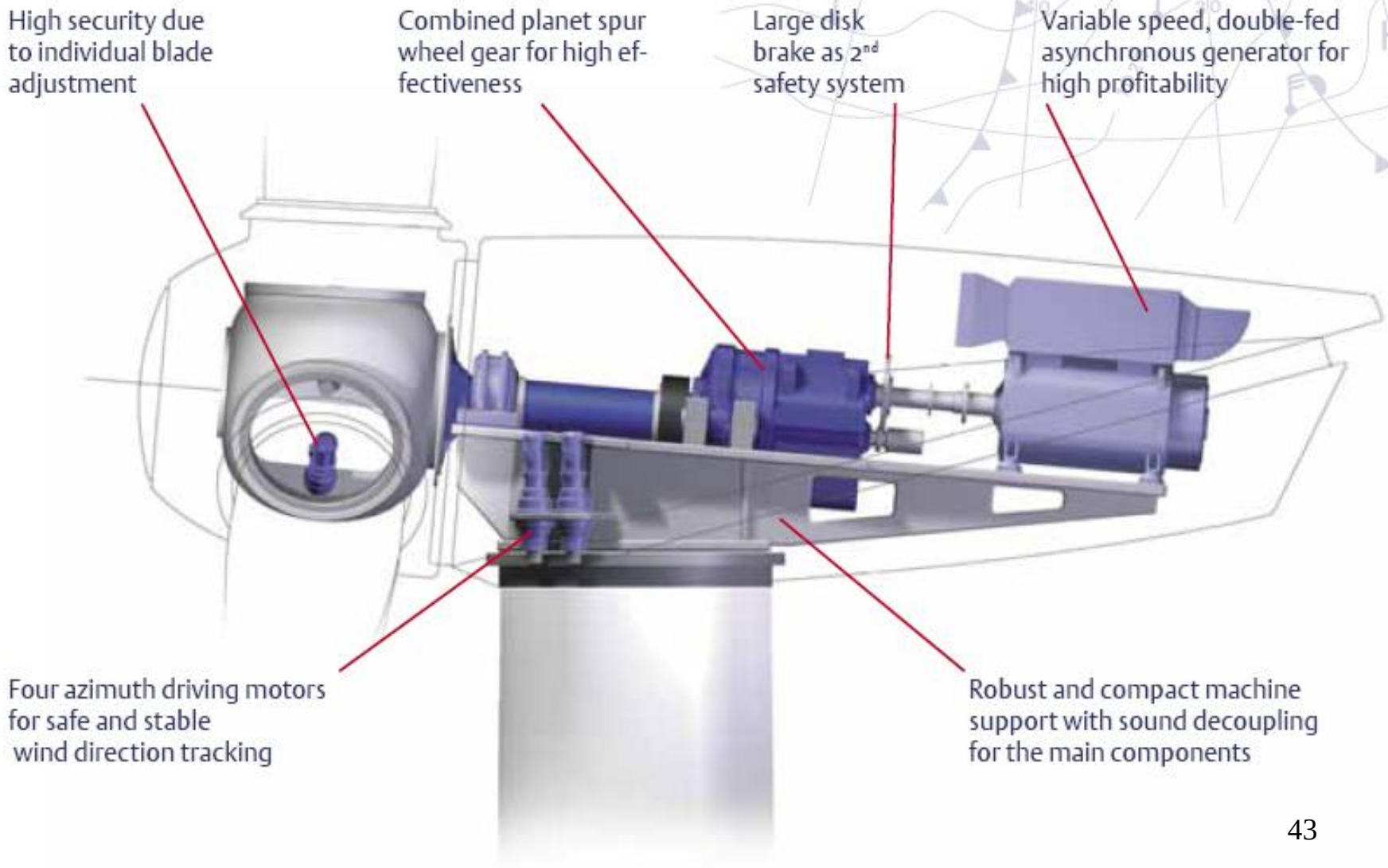
MD 77 (37,5 m)

6,5 t!

Glassfiber – epoxi

Grafit fiber

FL MD77


High security due to individual blade adjustment
Combined planet spur wheel gear for high effectiveness
Large disk brake as 2nd safety system
Variable speed, double-fed asynchronous generator for high profitability
Four azimuth driving motors for safe and stable wind direction tracking
Robust and compact machine support with sound decoupling for the main components

MD 77

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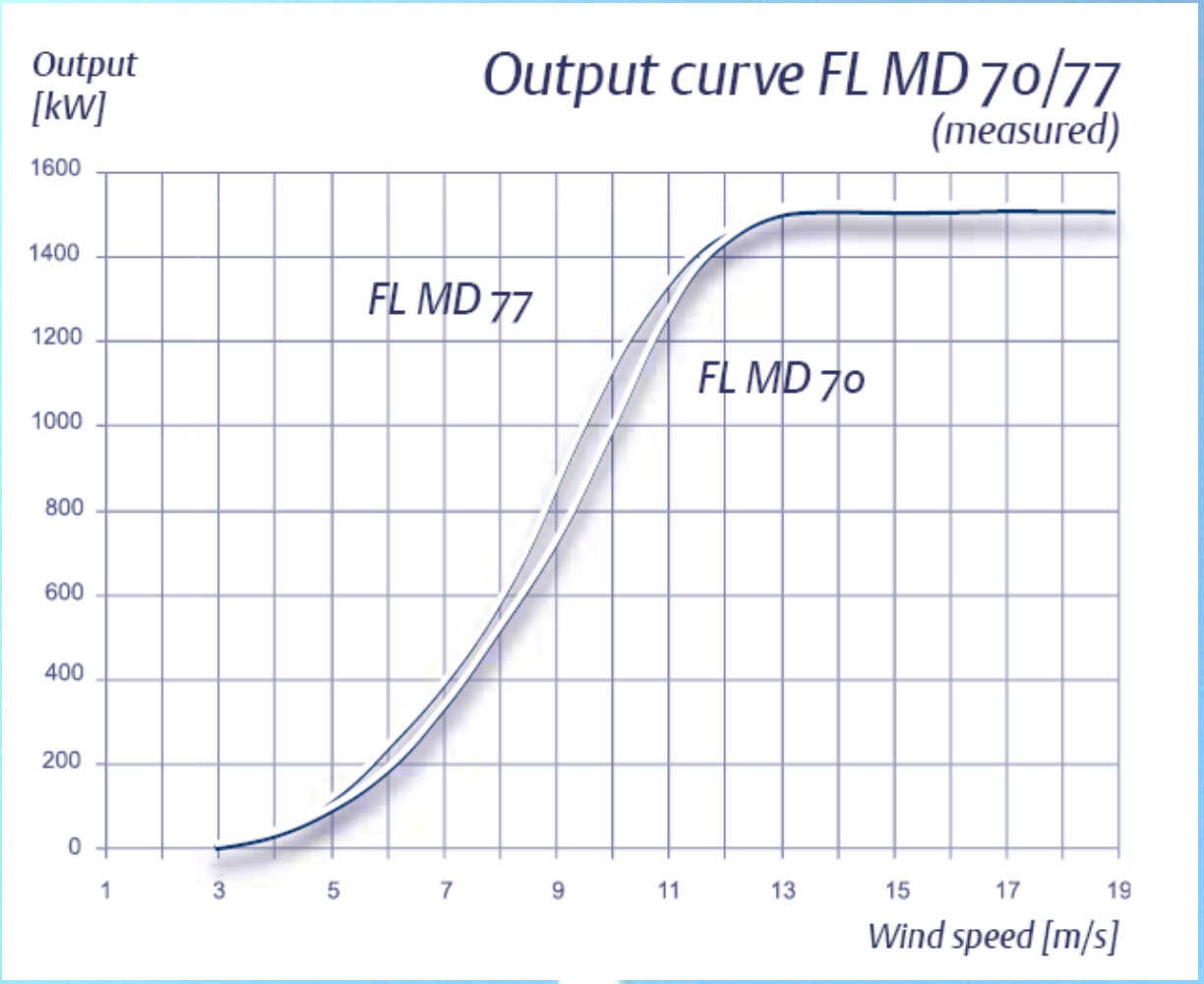

E 48

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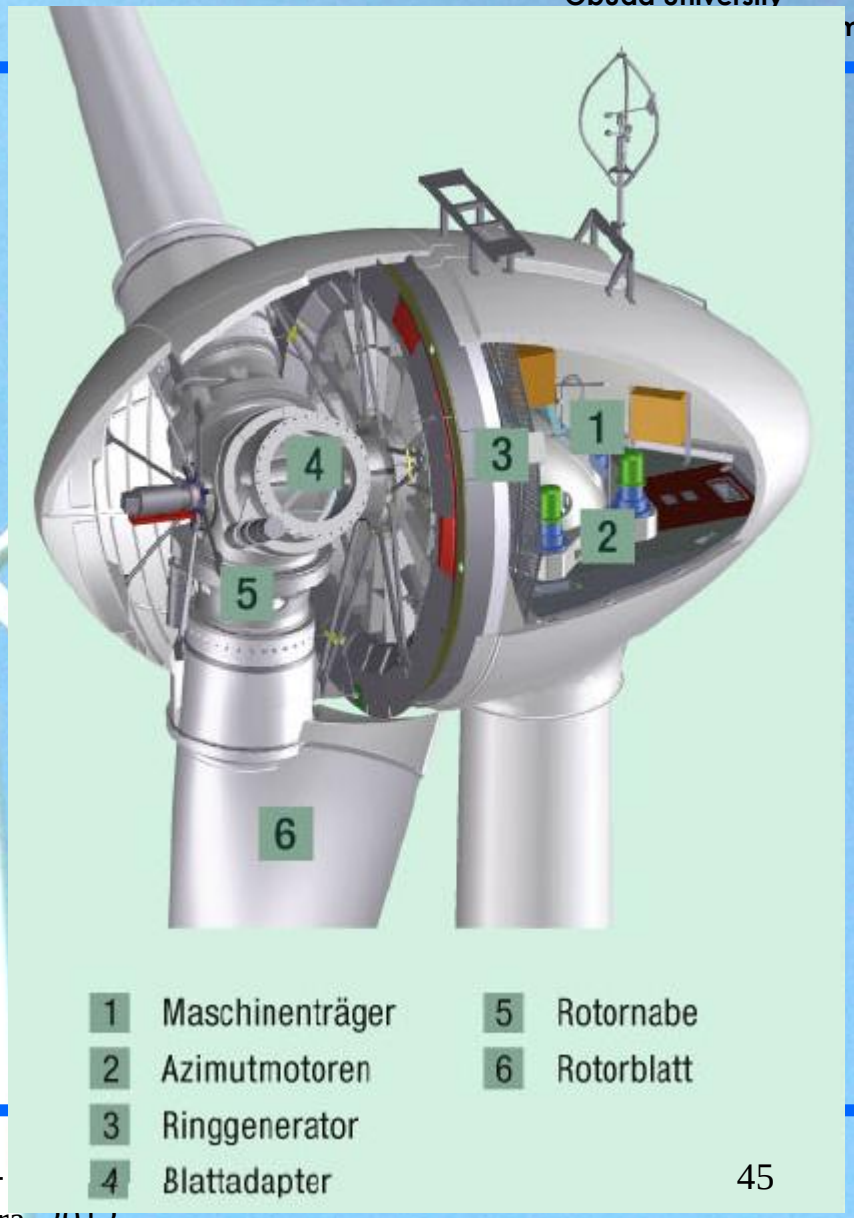
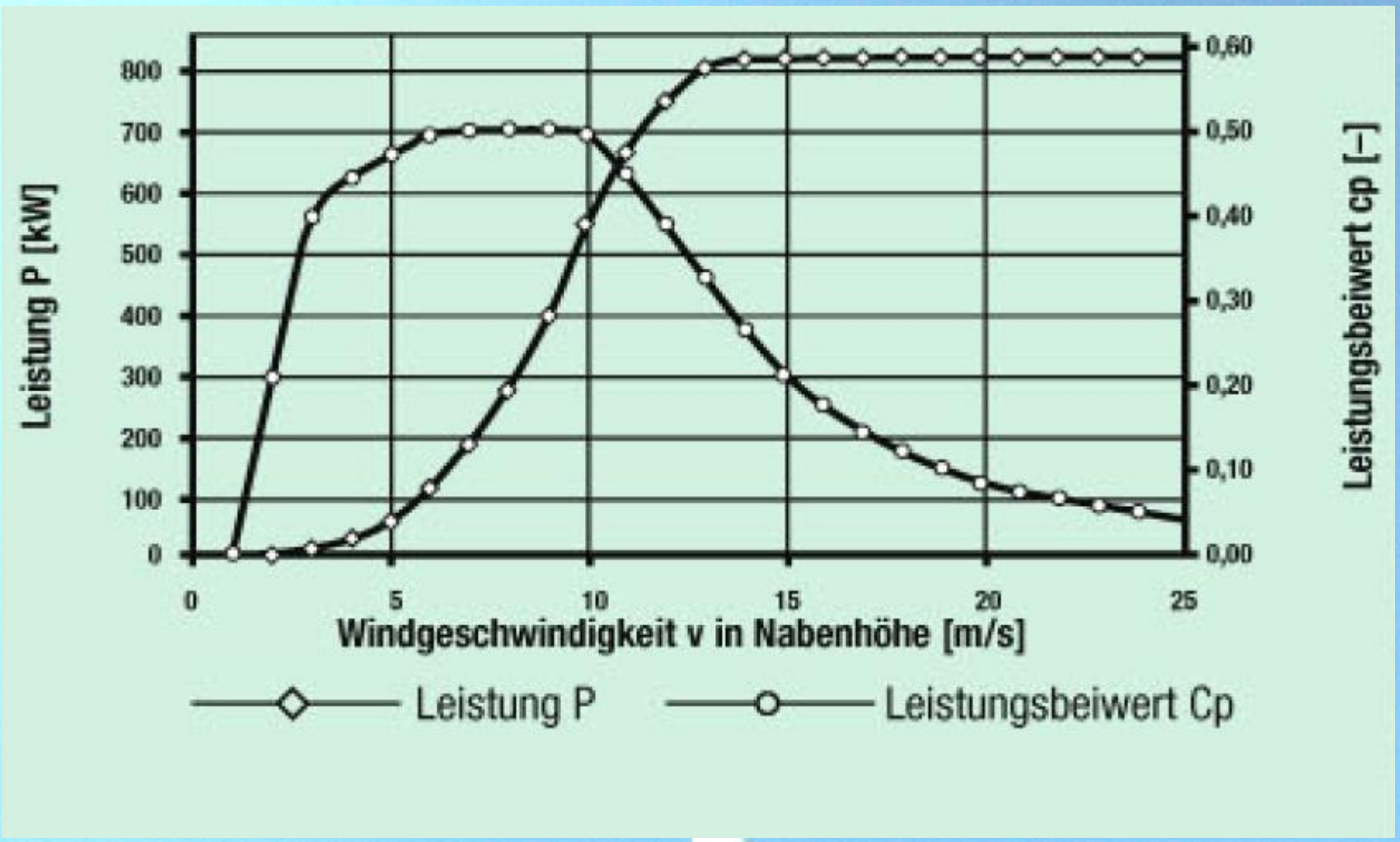
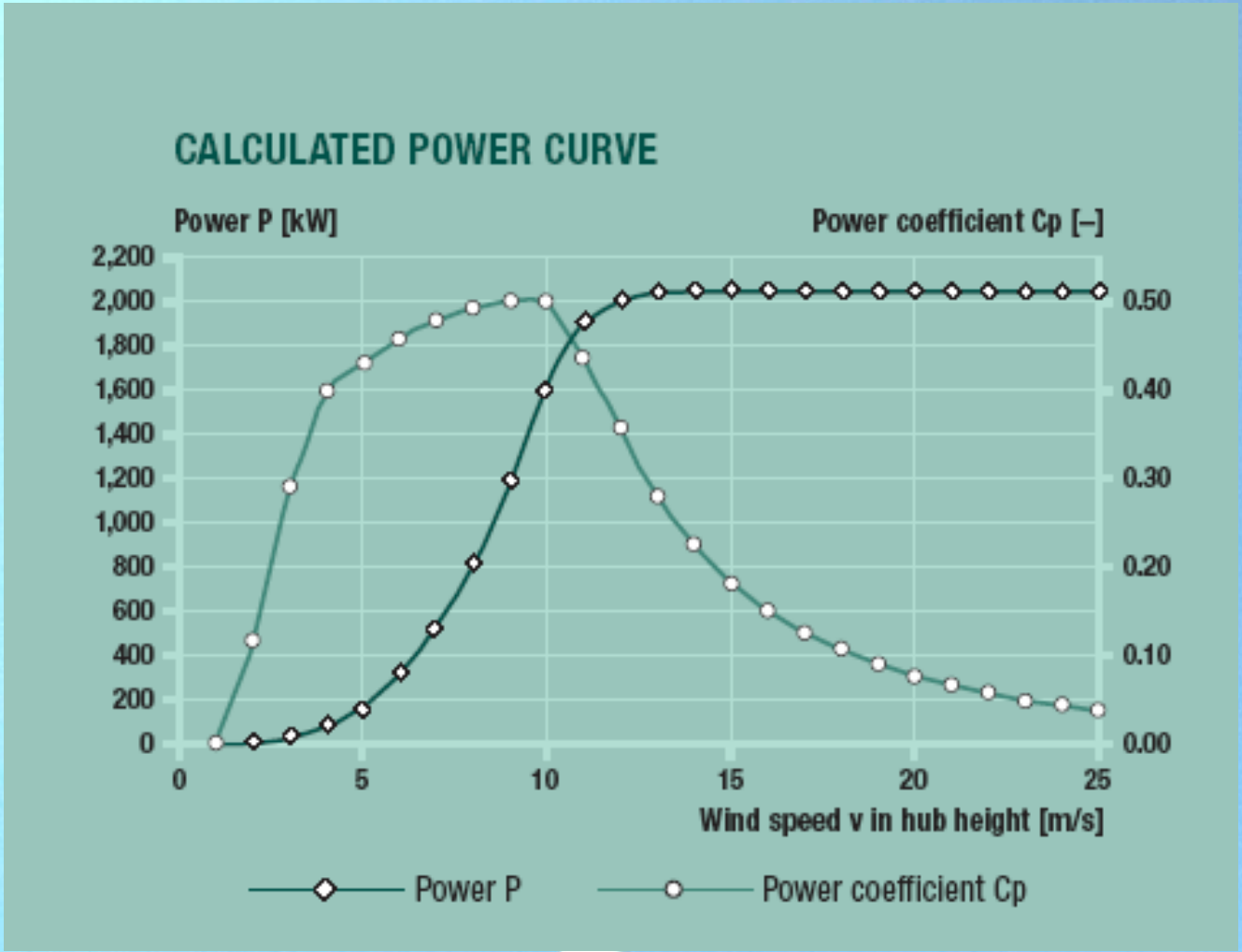


E 48


Leistung P [kW]
800
700
600
500
400
300
200
100
0
0,60
0,50
0,40
0,30
0,20
0,10
0,00
Leistungsbeiwert cp [–]
0
5
10
15
20
25
Windgeschwindigkeit v in Nabenhöhe [m/s]
Leistung P
Leistungsbeiwert Cp

E82

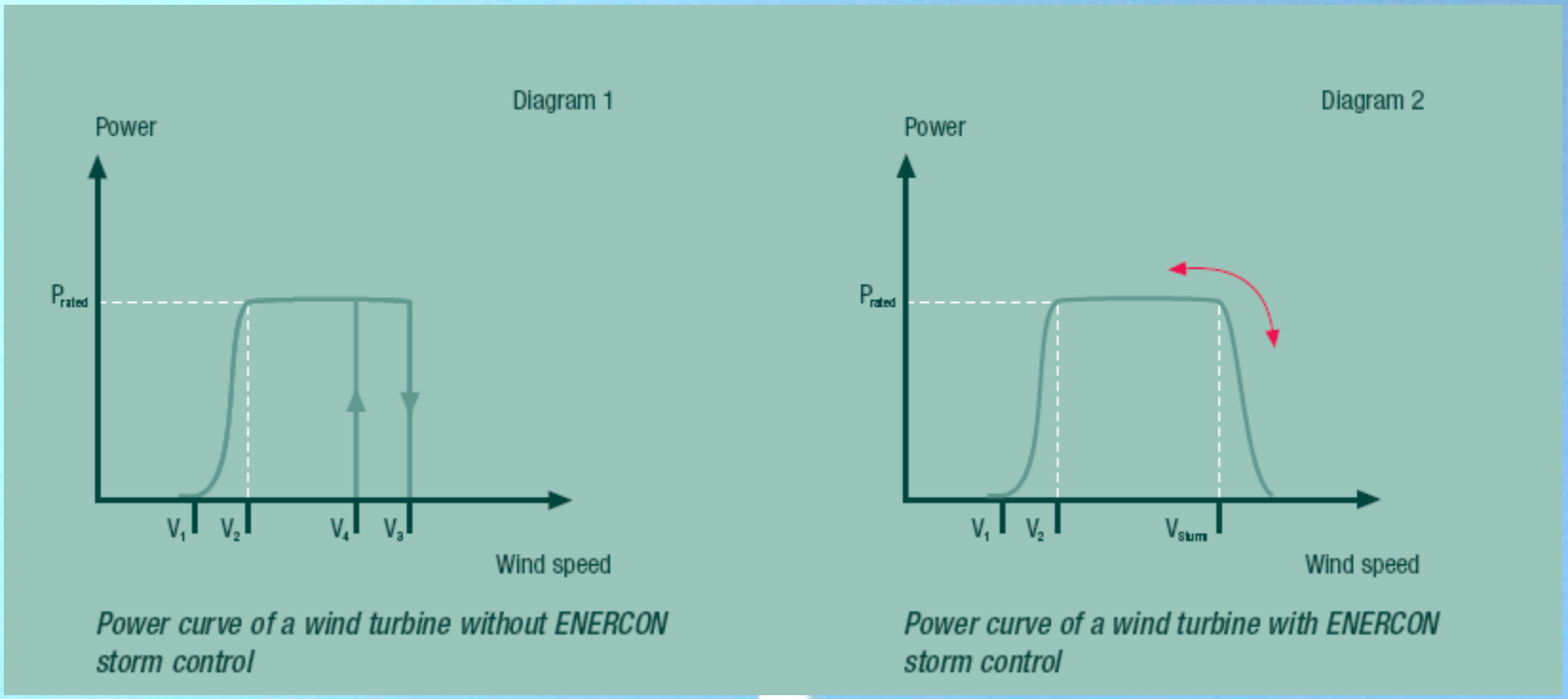

CALCULATED POWER CURVE
Power P [kW]
Power coefficient Cp [–]
2,200
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
0.50
0.40
0.30
0.20
0.10
0.00
0
5
10
15
20
25
Wind speed v in hub height [m/s]
Power P
Power coefficient Cp

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”



Power curve of a wind turbine without ENERCON storm control

Power curve of a wind turbine with ENERCON storm control

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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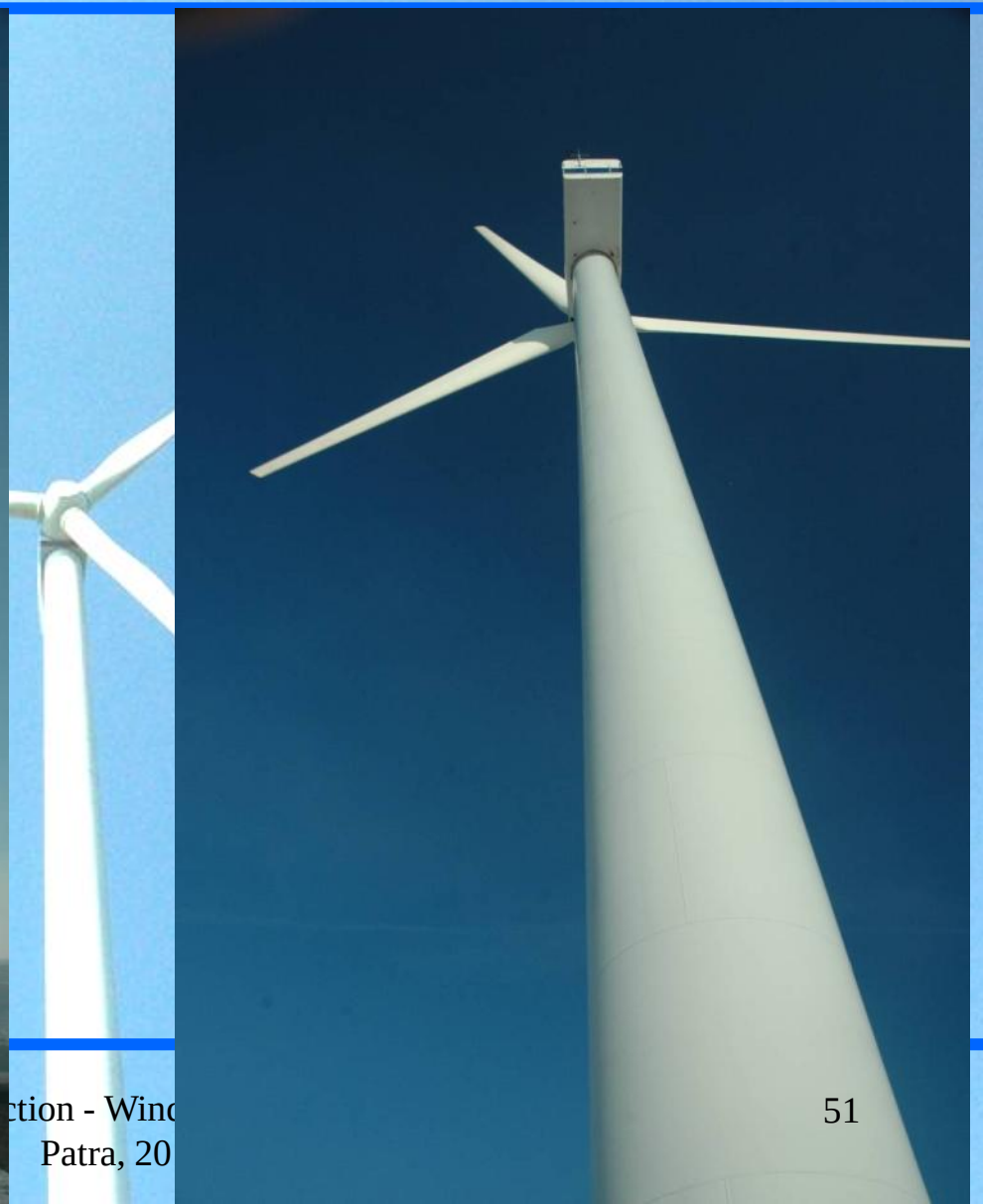

Erk

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Inota

Kulcs

Mezőtúr

Mosonmagyaróvár -Levél

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Mosonszolnok

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Szápár

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Törökszentmiklós

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System load <–> wind production

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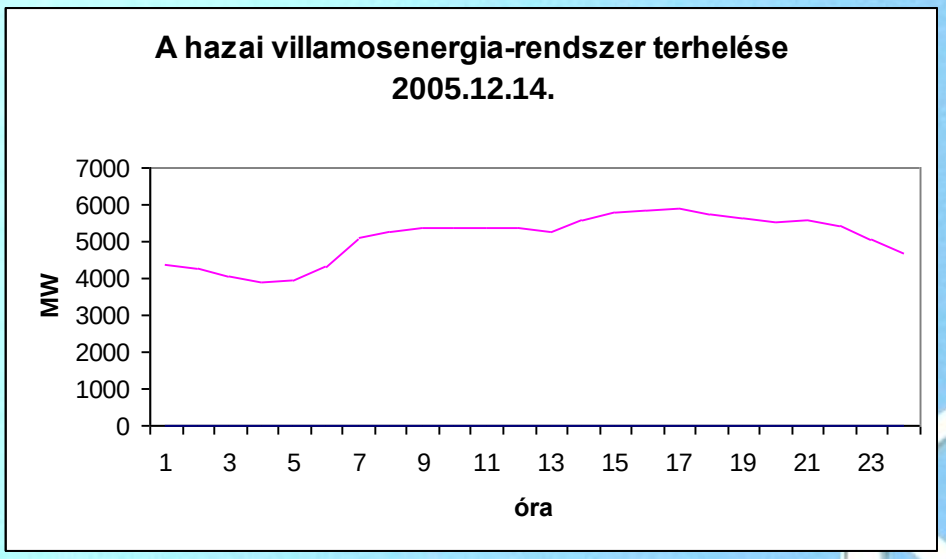

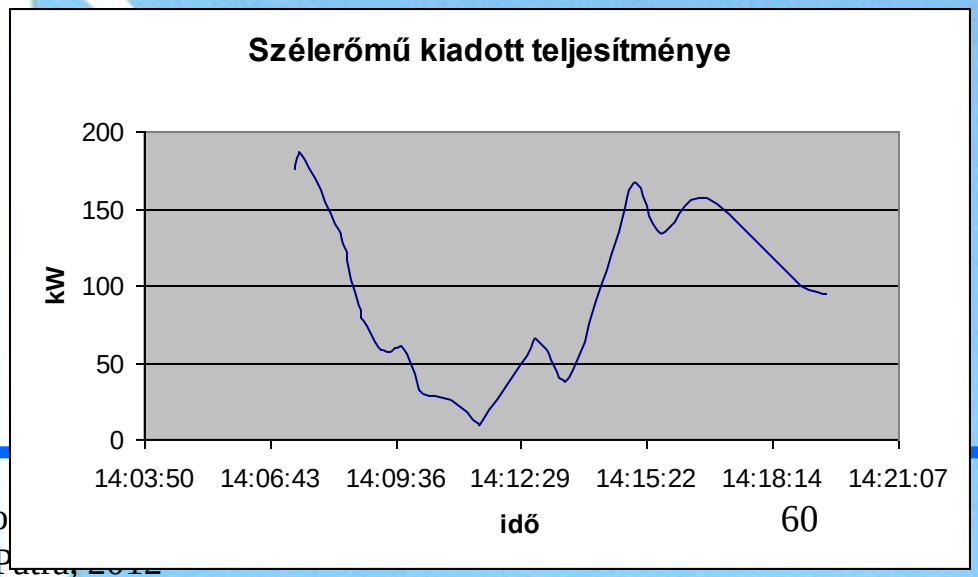

Balancing with CO_2

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Feel the measure!

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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

How many tower represents 1000 MW?

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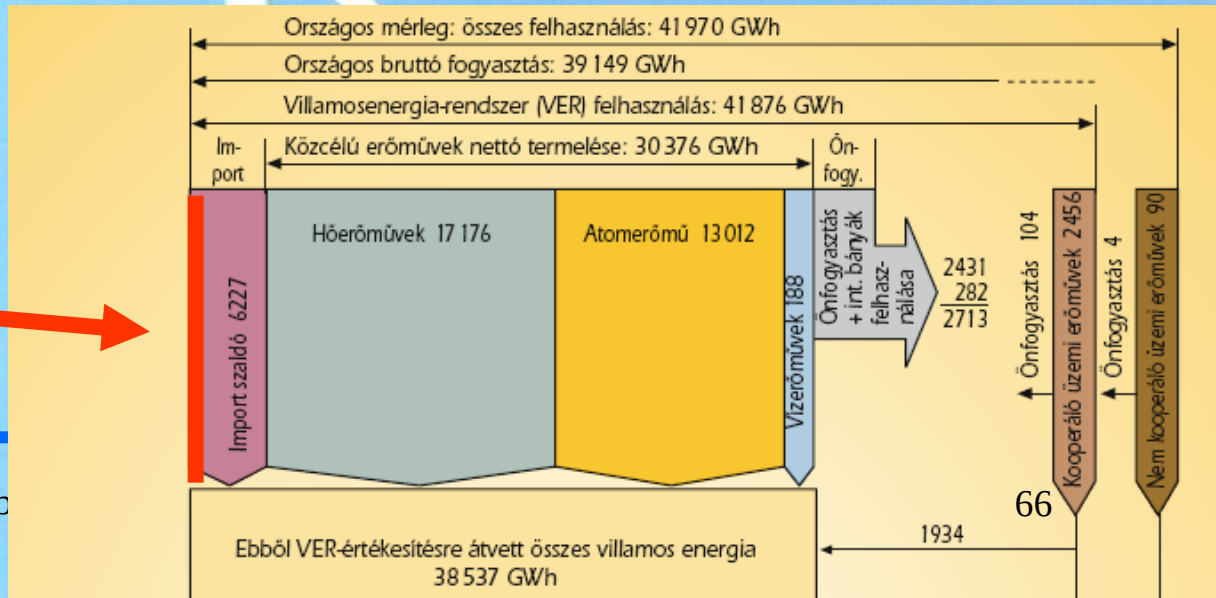
- If 1000 MW built in capacity operates in 1 year with 20 % usage ratio
- 365 days x 24 hours x 1000 MW x 0,2 % = 1.752.000 [MWh] = 1,752 TWh
- In Hungary it is only 4,47 % of the total consumption
- Not too much



Power ratio

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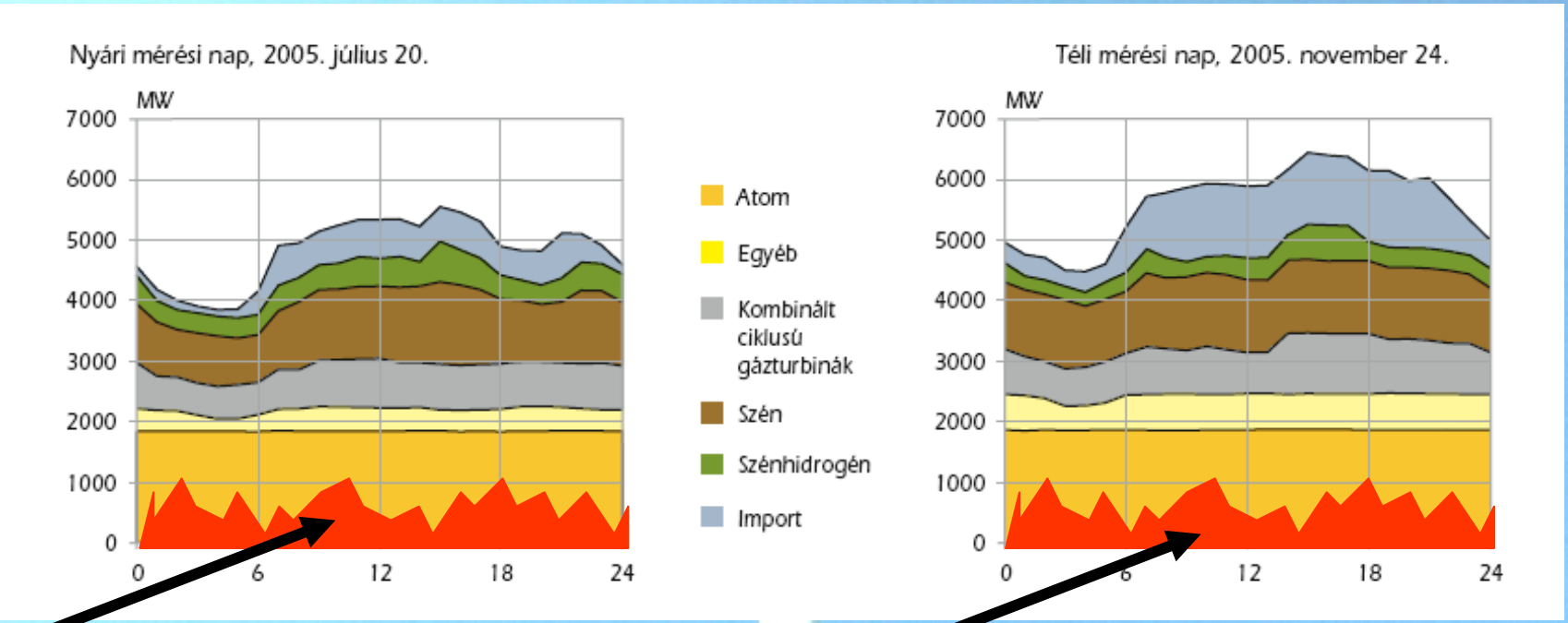

It is much!

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

How the wind blows

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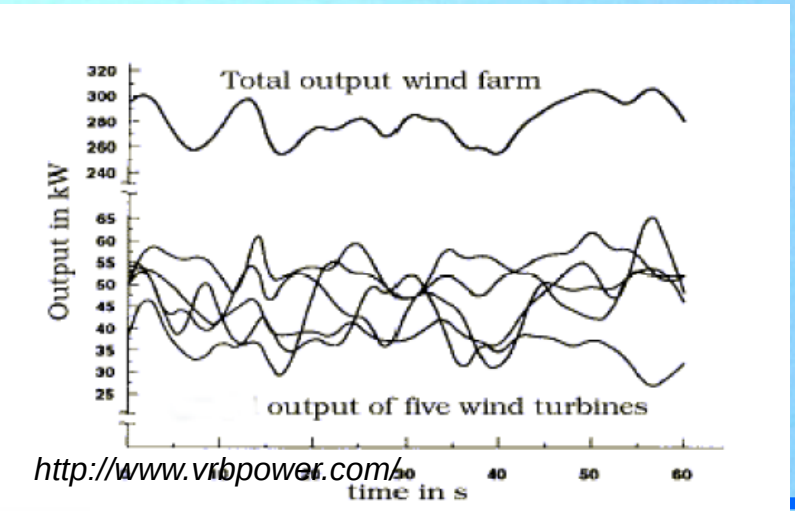
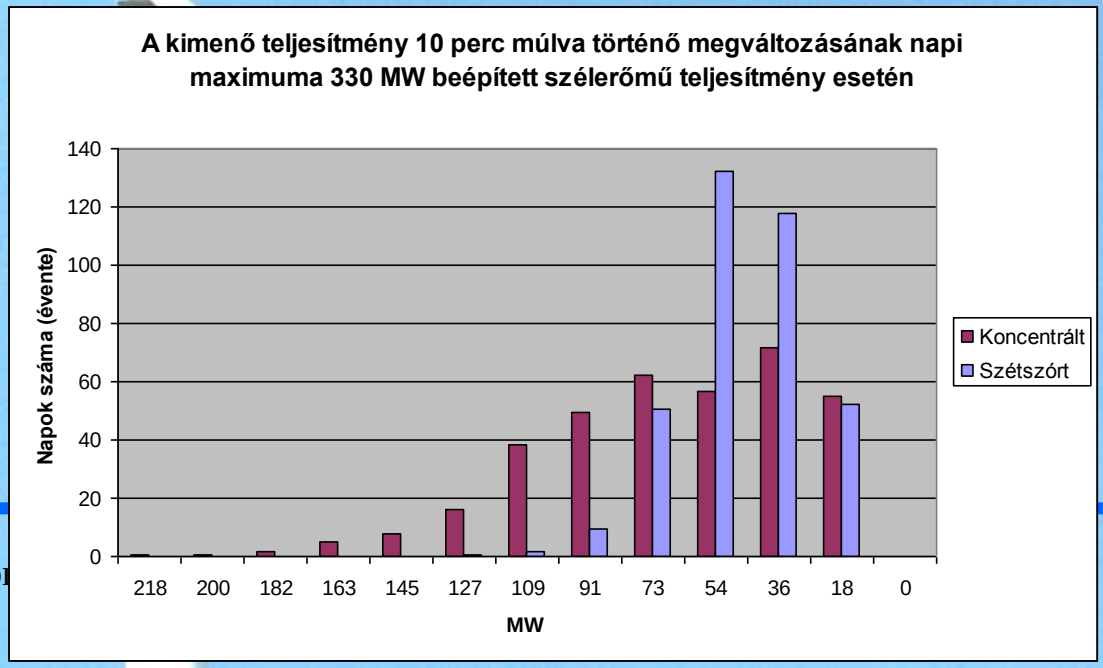
- BEWAG experiences: gradient 60 MW/h
- 3 areas - 3 different wind blows
- Local autobalancing in the windpark
- Balancing between different areas



http://www.vrbpower.com/



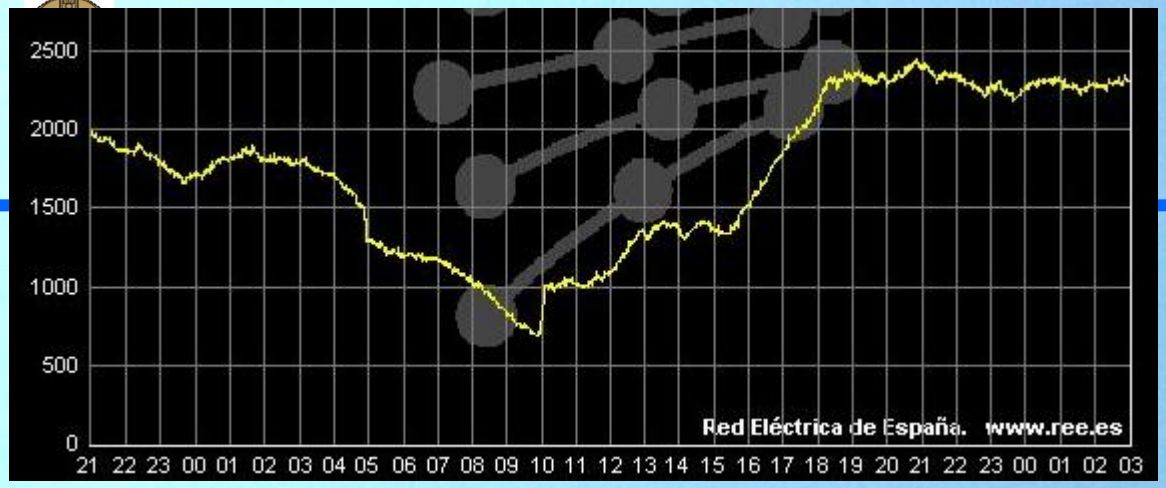
Sudden stop of wind power plants

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

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

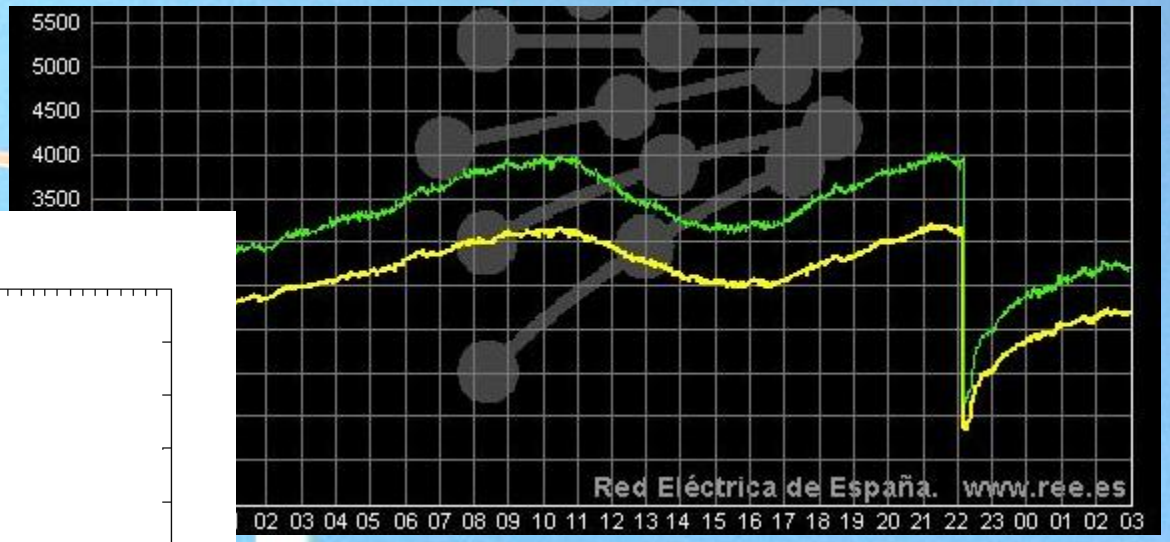
The network flexibility must be raised!

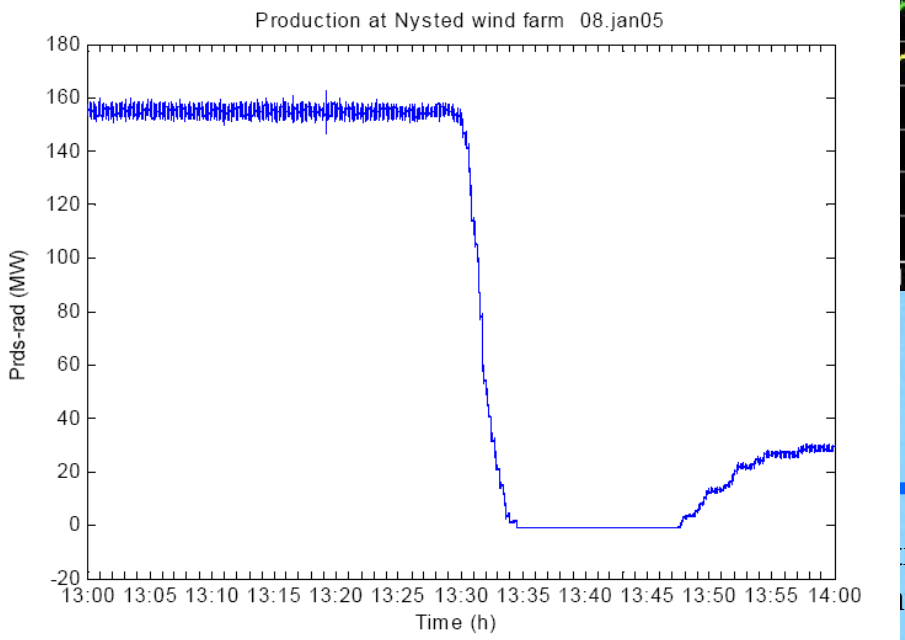
- Diversification
- Forecast



- Fault in Spain

- 2006.11.04.





- Storm in Denmark

2008. 04.01. operation - BEWAG

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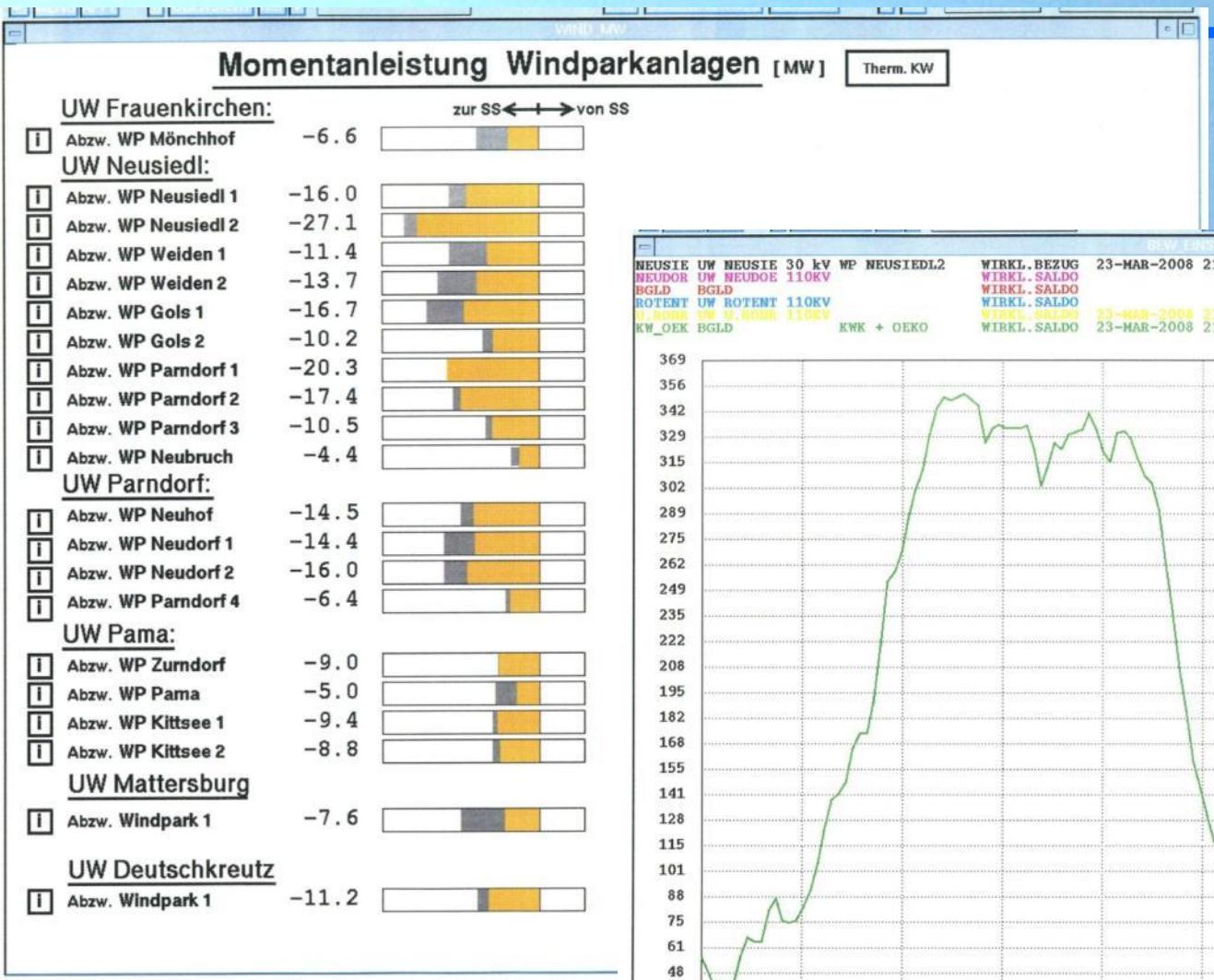

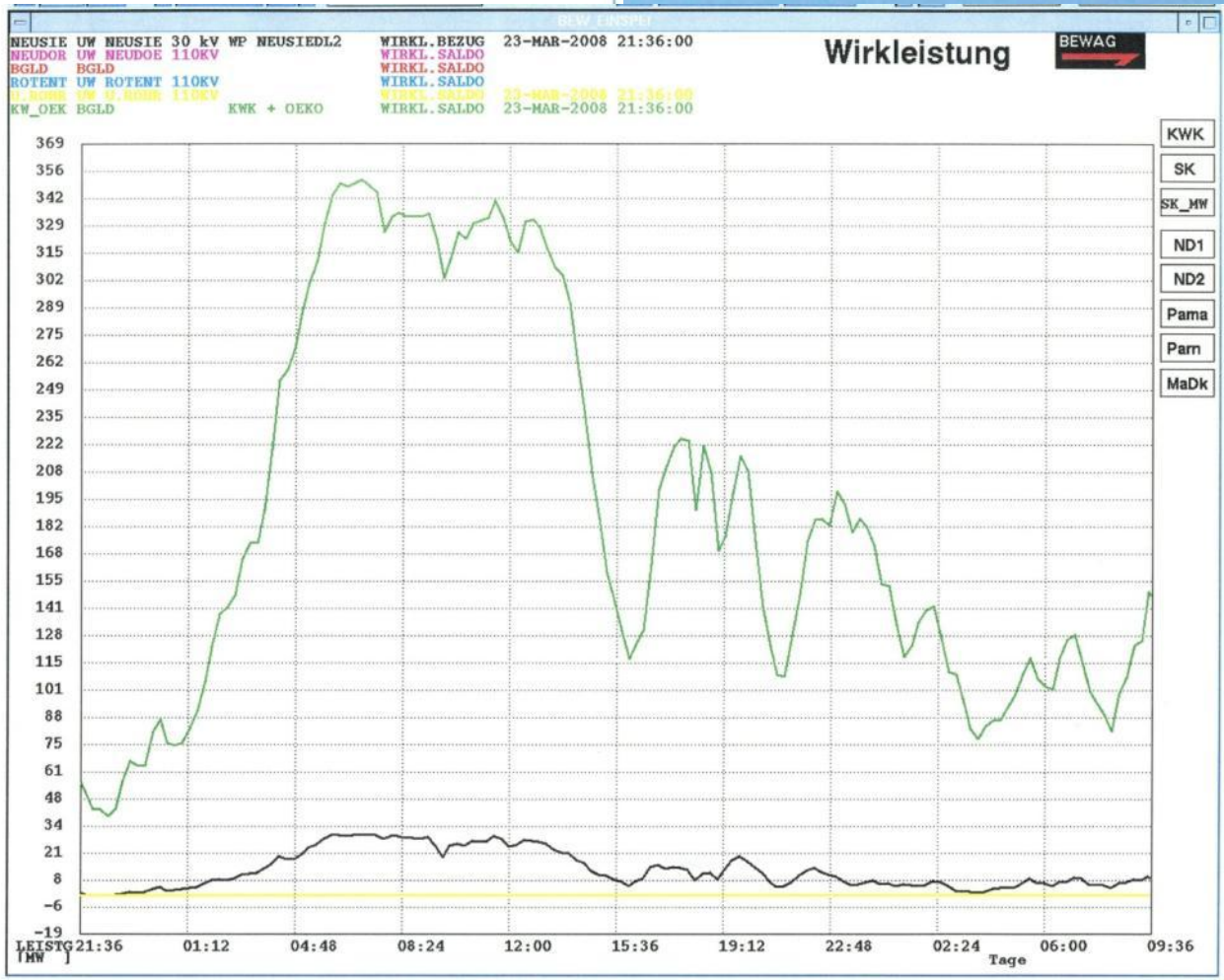

The UTSIRA project

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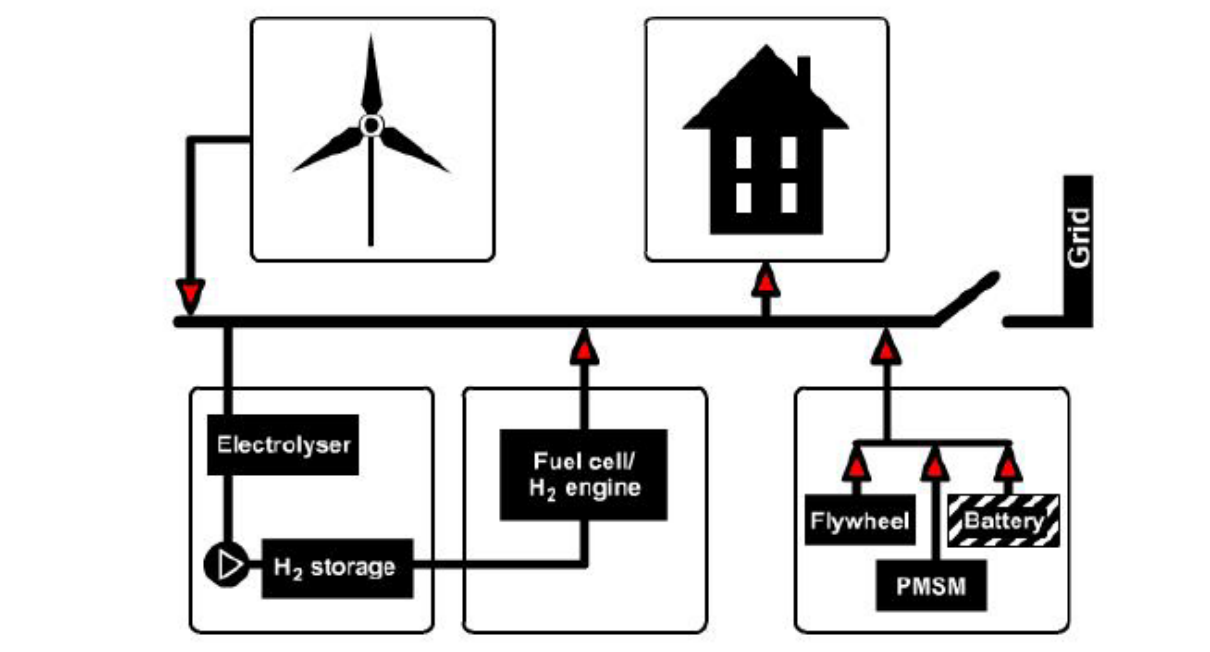

Wind Turbine C

Hydrogen generation

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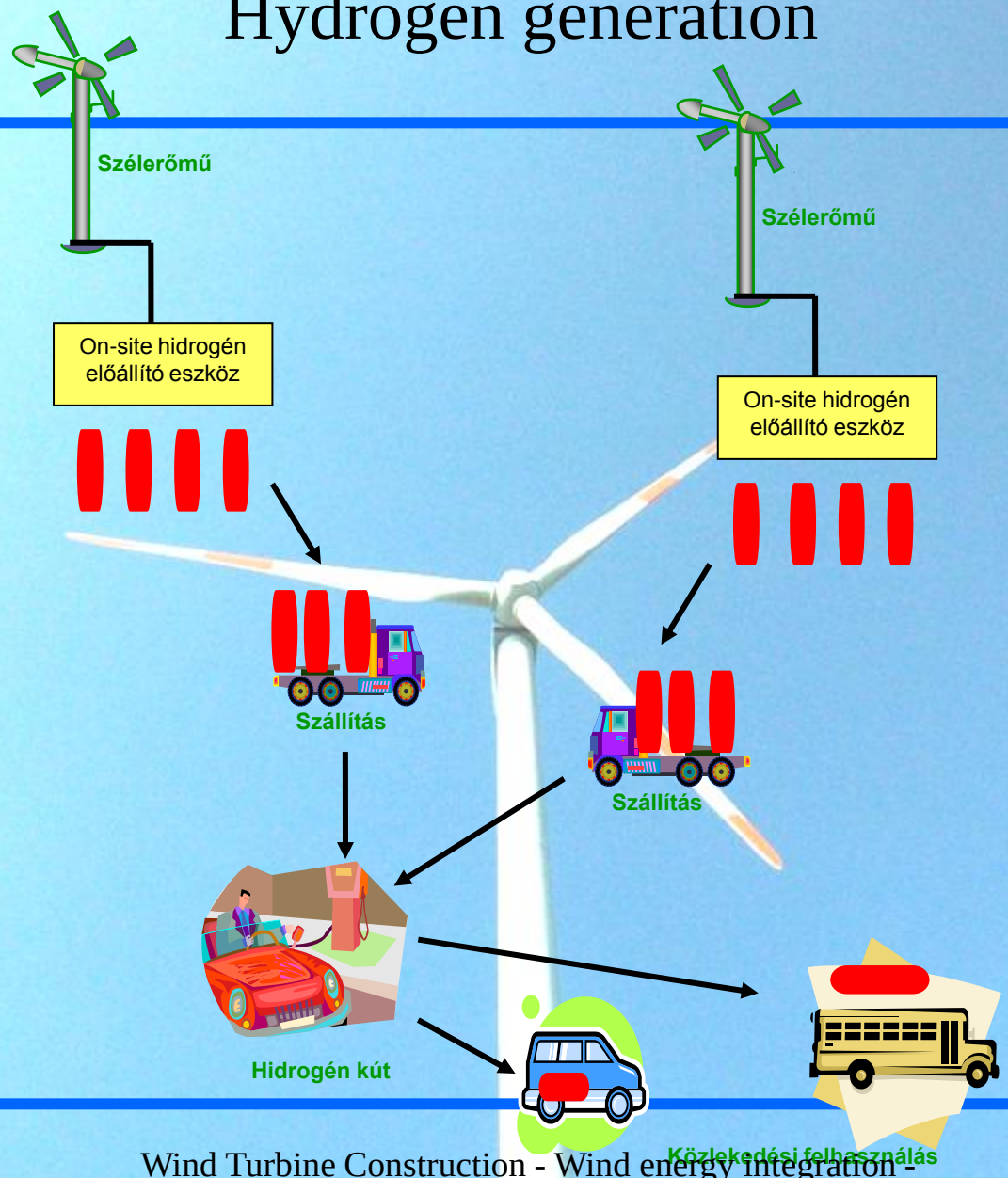

Central hydrogen generation – system operatior control

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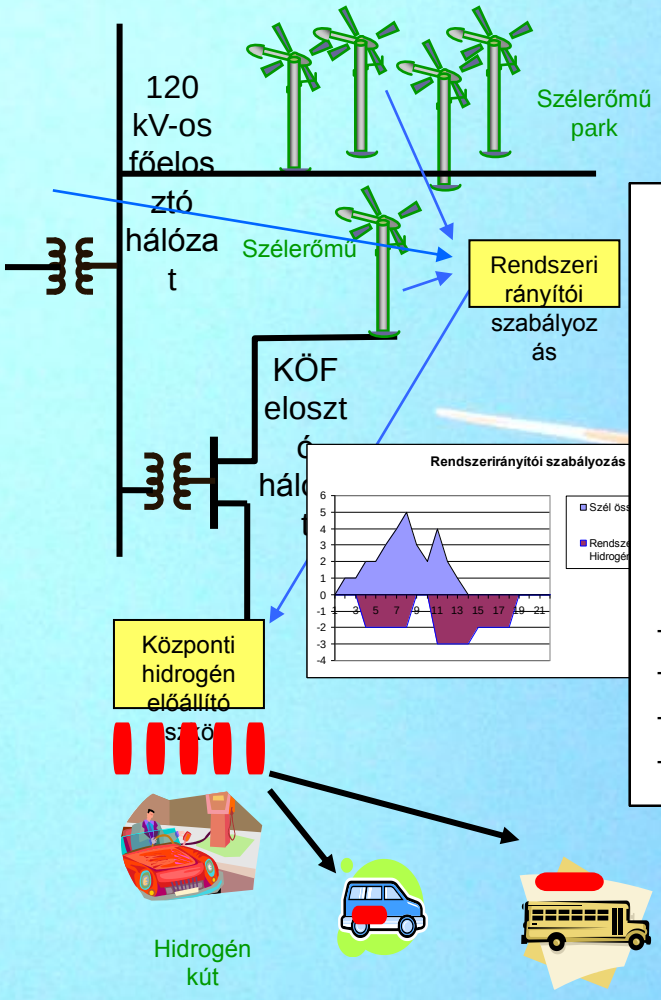

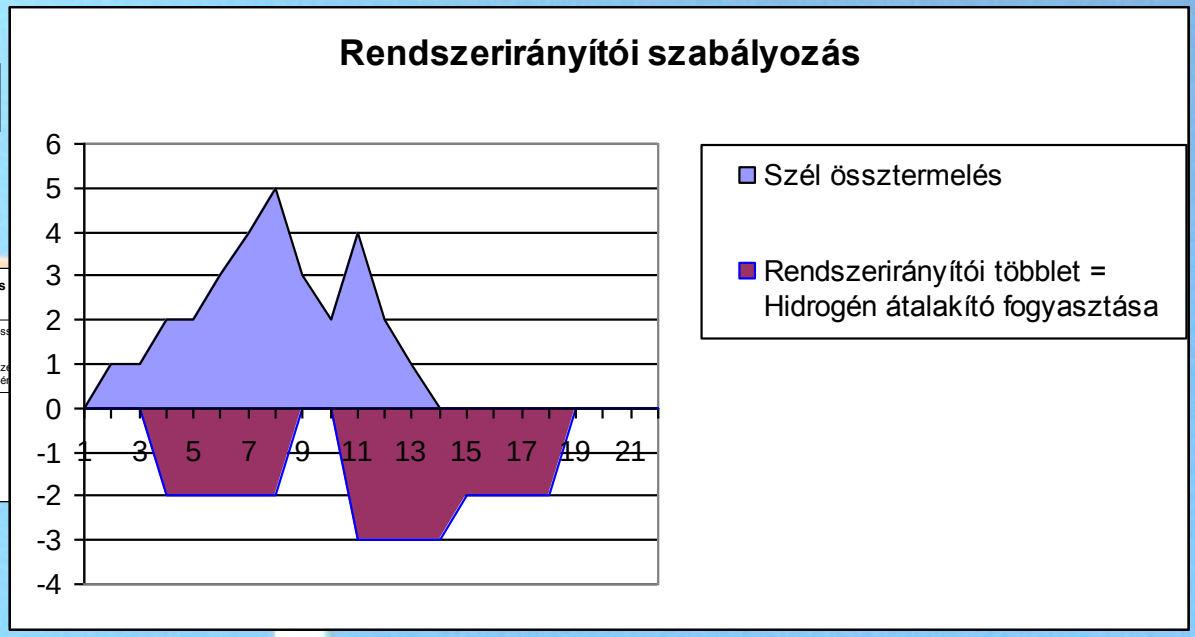

Where to find the control capacities?

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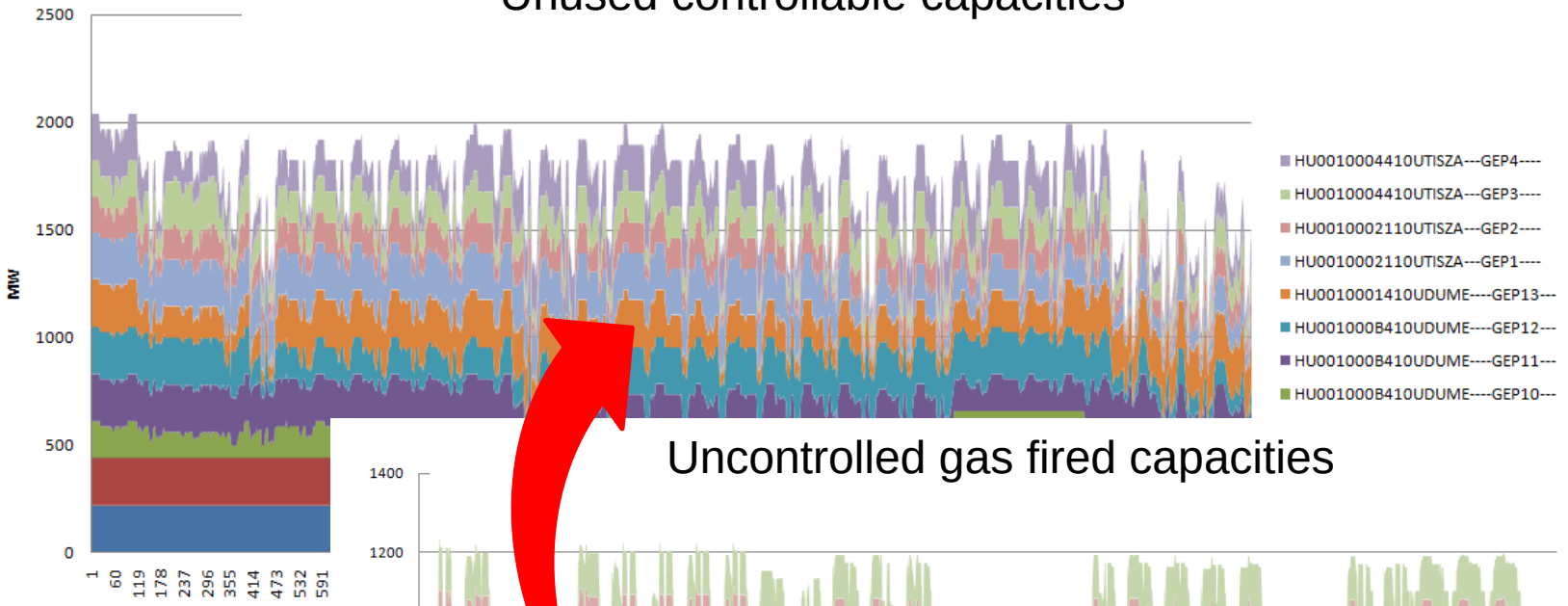
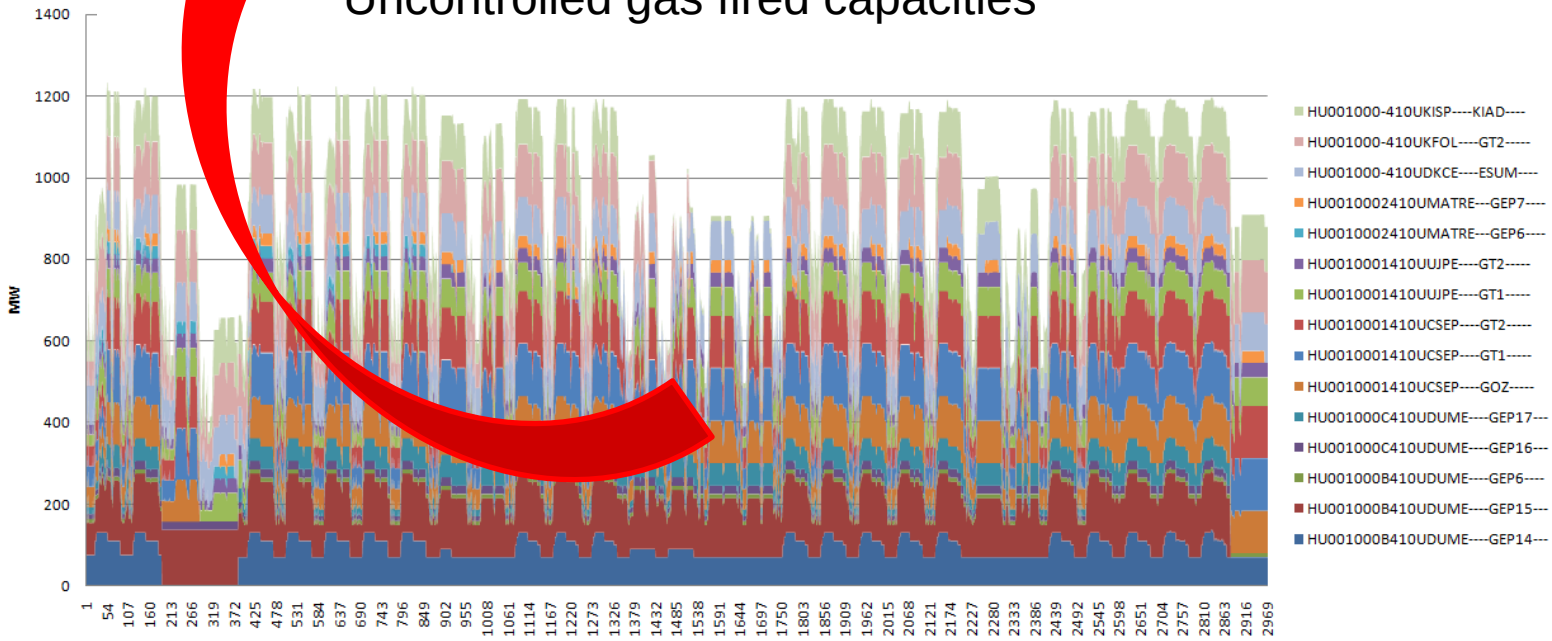
Unused controllable capacities



Uncontrolled gas fired capacities



Co-control of gas engines and wind turbines

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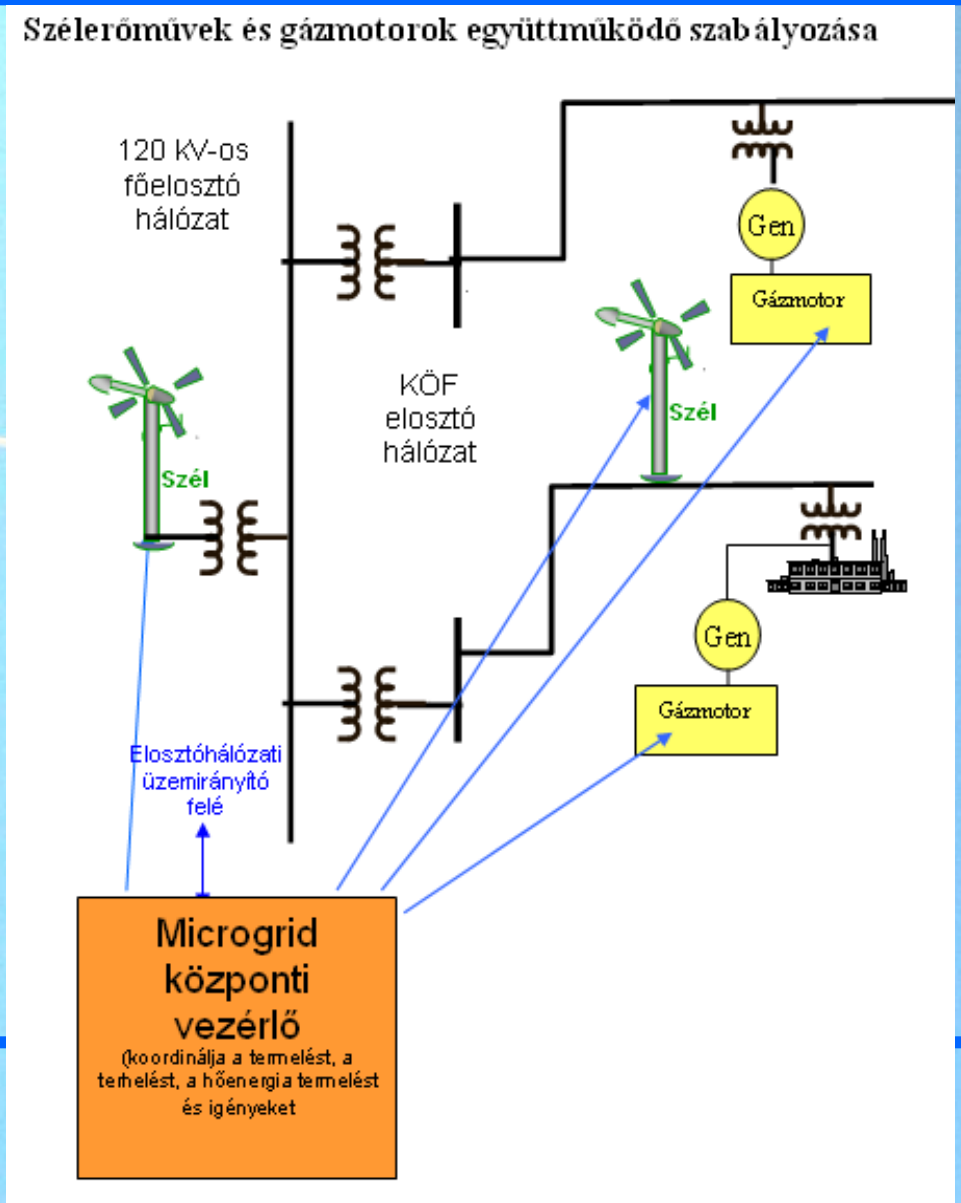
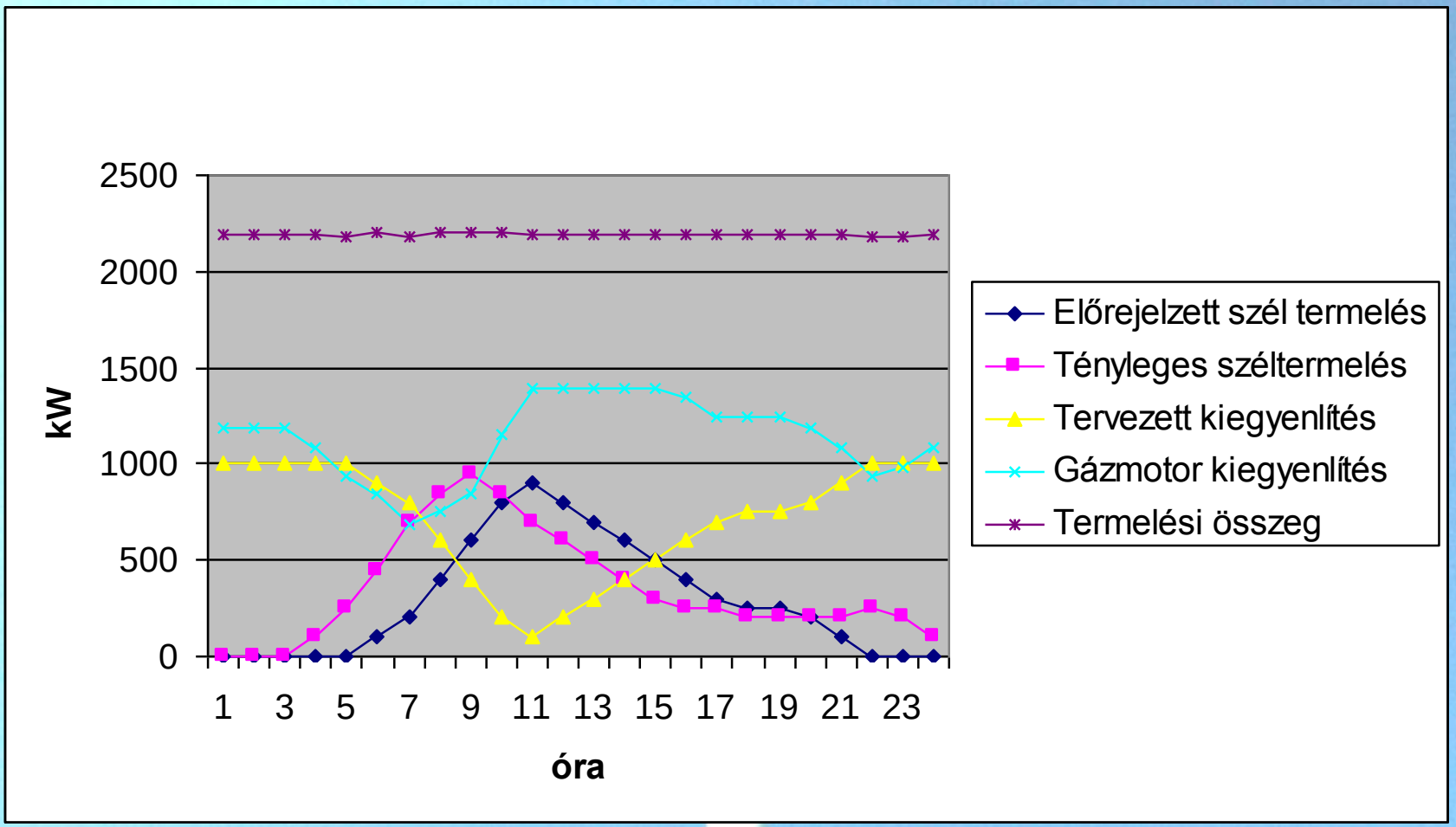


Wind generation + gas engine generation + balancing



Load of the gas engine

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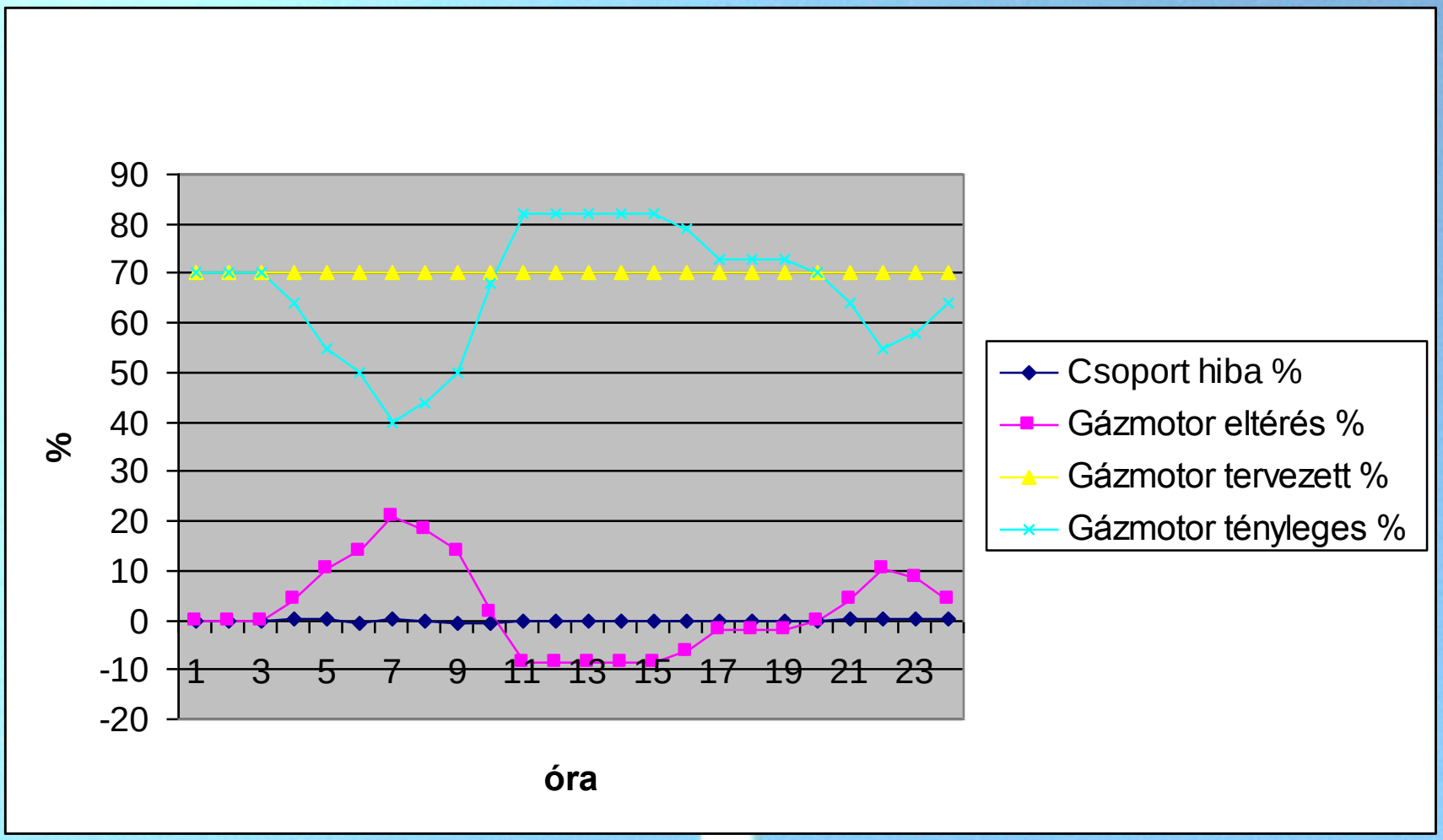

Control Center for Renewable Energy (CORE)

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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?

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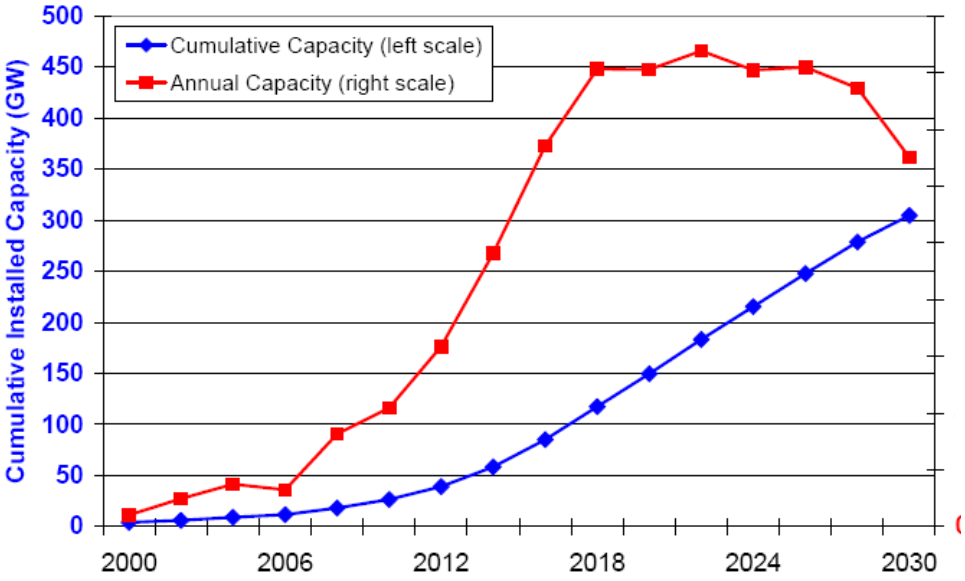
- Control of the windpark output
- Diversification
- Local control centers
- Intraday power exchange

American plans…

20% Wind Vision Summary

No fundamental barriers identified to achieving the 20% wind vision

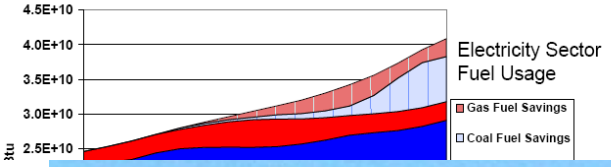
20% Wind Scenario - 305 GW by 2030



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

Fuel Savings From Wind



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!