CAPACITY AND STRUCTURE OF THE INSTALLED WIND POWER PLANTS ON HUNGARY

Wind Energy Capacity and Structure in Hungary

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Summary:

Nowadays there are significant development projects and ideas about increasing wind power plant efficiency. In Hungary, wind energy capacity increased in the years between 2006 and 2010. At the end of this period the quota was fulfilled, and since then there are no new investments, although there is a big demand for new projects.
The current wind energy capacity is 330MW, built of modern units, which are designed for the Hungarian wind circumstances. Because of this energy production is very good (740 GWh/year) and the capacity factor (24.1%) is good as well (the 4th best in Europe in 2012). With this we save approx. 220 million m^3 /year natural gas whilst we avoid ~400 000 tons of CO_2 emission.
It is a fact that wind power plants (after the return of investment -9-10 years-) produce cheap energy. From financial side wind power plant utilization is one of the most perspective investments. Our analysis points out that the ambitious plan of Hungary for 2020 (the increasing of renewable energy utilization) is unlikely to be met without wind energy utilization.

Key words: *Wind Power Plant, Wind Energy Capacity in Hungary, Cost of Wind Energy*

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1. FOREWORD

Overview of Hungarian development on the fields of wind energy

In the period of 1980-90 energetic wind measurements proved (made on measurement towers) that at bigger heights (100-120 m) at certain areas of Hungary there are right circumstances for wind energy utilization. The first wind measurement made for energetic purposes (1998-'99) was done by the experts of Szent István University at area of Kisalföld. The installation of the first wind power plant was in 2002 at Kulcs, in Middle Hungary, the wind power plant is an Enercon plant with kW performance. The height of the tower is 65 m. The location of it was chosen according of

the measures of Szent István University (or as short SZIE). According to the wind measurement results it can be stated that Hungary is a proper place for wind energy utilization.
In 2005 the new law on electricity stated the government subsides in the frames of the KÁT subsidy. This subsidy helped the investments to return in 9-11 years. After this a 'so called' wind tender was announced for Hungarian companies. Approx. 330 MW was installed in Hungary.

2. FEATURES OF TECHNOGICAL DEVELOPMENT AND CAPACITY GROWTH

In Hungary the big energy content winds are on 80-200 m, so the tower height is very important. Capacity depends on rotor diameter as well, nowadays D>100m is typical.
Expected biggest capacity (can be W_p as well):

$$P_{max} = \frac{16}{27} \cdot \frac{1}{2} \cdot \rho \cdot A \cdot v_{\infty}^3 \quad \text{(kW)}$$

where:

ρ - air density [kg/m^3],
A -examined surface ($D^2\pi/4$) [m^2],
v_∞ - wind speed until control [m/s].

Wind speed is important, see v^3. Before wind power plant installation is made these parameters must be defined. (Fig.1) The change of v can be seen on Fig. 2.

Capacity of given wind power plants (P_x):

$$P_x = c_{px} \cdot \frac{1}{2} \cdot \rho \cdot A \cdot v_x^3 \quad \text{(kW)}$$

c_{px} is the capacity factor of given areas, defined with v_{nx} (mean wind speed) values. (c_{px} can be defined with experiments. Wind power plant producers give the P-v, cp-v diagrams.)

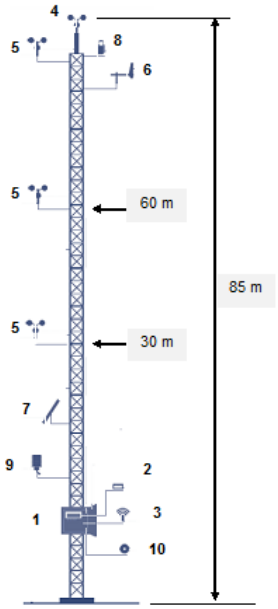

Fig.1

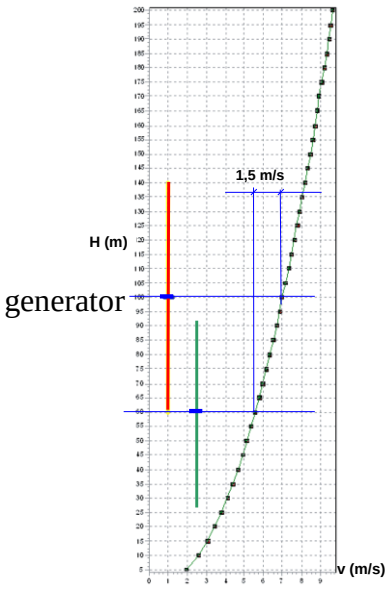

Fig 2

Hungarian development, 85 m tower height
1- gauge box, 2- data logger, 3- data transmitter, 4- anemometer (control),5- anemometer at 30, 60 and 80 m height, 6- wind vane, 7 – energy source (solar cell, PV), 8- light signal, 9- moisture measurement gauge, 10- air pressure measuring gauge.

Data from the measurement system on Fig.1. (wind speed difference 1,5 m/s, 60 and 100 m tower height)

On the c_p-v diagram at the biggest c_p value the P_n = nominal performance can be found. On the basis of the measured yearly energy production (kWh/year) and nominal performance the utilization number can be calculated (K_F):

$$K_F = \cdot \frac{E}{8760 \cdot P_n}$$

A K_F *8760 (hours in a year) gives the nominal utilization hours, which is h_n/year (pl. 8760 x 0,23 = 201.8 h/year on P_n performance). According to Hungarian calculations the operation of a wind power plant is economically efficient on 2000h_n/year nominal performance (P_n), the investment returns in 9-10 years with KÁT subsidy.

Wind power plants utilizations in the world

Wind power plant production is the most dynamically developing branch of industry. Yearly installed capacity can be seen on Fig.3 with the focus on the biggest investors. Until 2007 Europe was the first, in 2008 the USA and in 2009 China. Now China installs the capacity of Europe and Eurpoe altogether. The estimation of WWEA shows that in the year 2020 the built capacity will be as much as in the past 10 years. This is an investment of 240 million dollars/year. Until the end of 2020 100-1200 billion dollars are needed for this investment. This requires huge producer and developer basis. Hungary can only be a leader in wind energy industry if we use our corporate advantage.

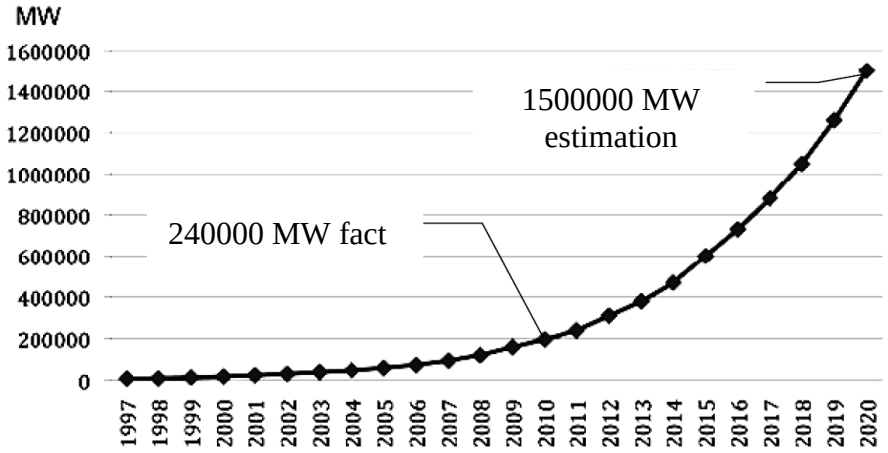

Fig.3
The development of wind energy capacity until 2020
(Source: WWEA-2011. Remark: until now all WWEA estimations were underestimated At the beginning of 2013 the estimations were modified to 800000-1200000 MW)

In the world approximately 700.000 small capacity household wind turbines were in operation in 2012 (Fig.4). Their capacity is in average 0.2-0.6kW. The 50 % of these devices is in China, and the 25% in the US. In Hungary currently 150-200 units are in operation, they solve local energy problems.

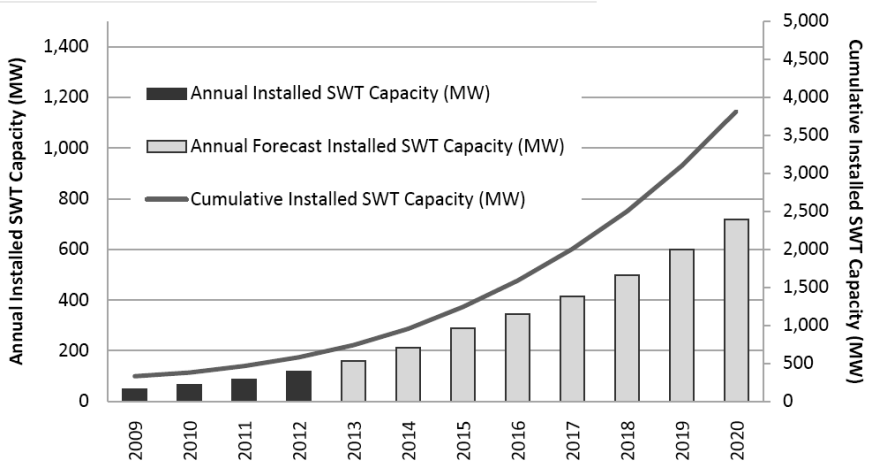

Fig.4

The capacity of small wind turbines (SWT = Small Wind Turbines)

(source: WWEA 2012, 11th World Wind Energy Conference)

In the last years China made the biggest development (Fig.5). Until 2006 Europe had the leading role in Europe. In 2008 the USA, and in 2009 China took over Europe. In 2011 China invested more in development than Europe and the US altogether.

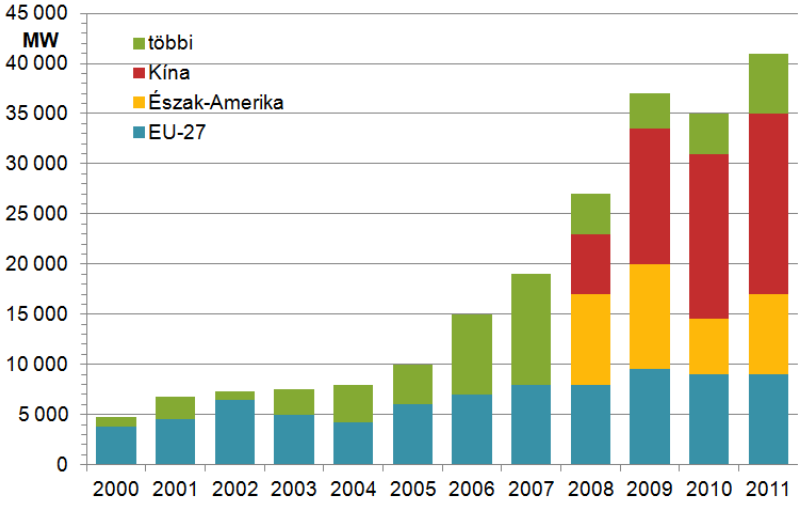

Fig. 5

Development of the world's wind energy capacity

Source: Mind Power Barometer – EUROBSERV'ER – February, 2013.

**green: other, red: China, yellow: North America, blue:EU-27*

The plan of Europe 27 countries is to triple the capacity until 2020. The trend shows that the plan can work. (Fig.6)

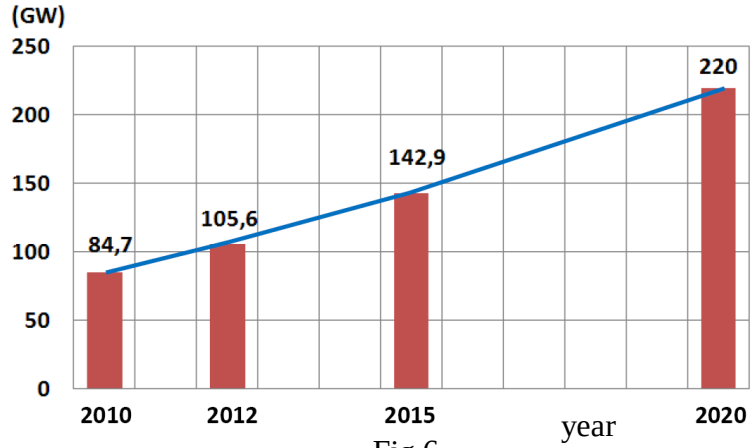

Fig.6
The plan of the Europe 27 countries
Source: Wind Power Barometer – EUROBSERV'ER – February, 2013.

3. COSTS

The utilization of the wind power plants

The production costs of the wind power plants have to be given with their utilization level since 2000. The Hungarian wind power plants are modern and they are chosen for the wind conditions of Hungary. Unfortunately we are not in leading position in wind energy; we are at the 24th place (produced energy per capita).

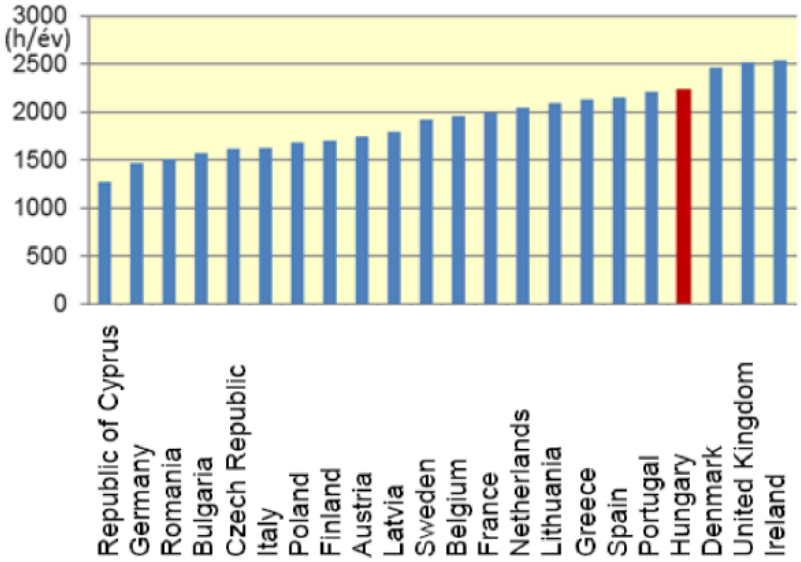

Fig.7
Utilization wind power plants (h_n/year) in EU 27 countries
Source: Wind Power Barometer – EUROBSERV'ER – February, 2013.

Energy production costs and costs of investments

On Fig.8 the curve represents the production cost per utilization level. The upper curve shows the data of maritime plants, and the lower the terrestrial plants. The maritime and the terrestrial plants differ in their material and in their construction. The terrestrial types have higher towers and big diameter rotors, but the blade angle change (pitch control) is happening faster.

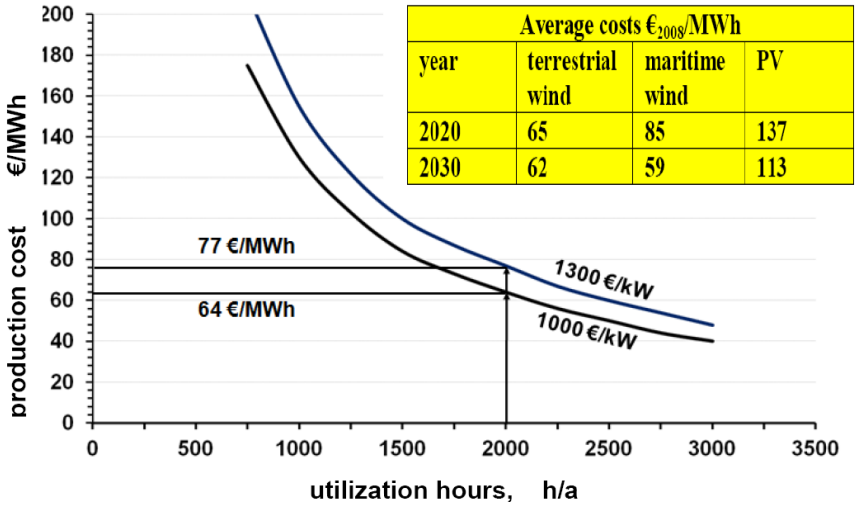

Fig.8. Energy production costs and the utilization time (hour)
source:
Wind Power Barometer – EUROBSERV'ER – February, 2013.

As Fig.9 shows the maritime wind energy is more expensive. But the development of them is ongoing and because of this their cists will decrease. (Fig.9)
At maritime wind power plants a huge decrease of costs is estimated until 2020.

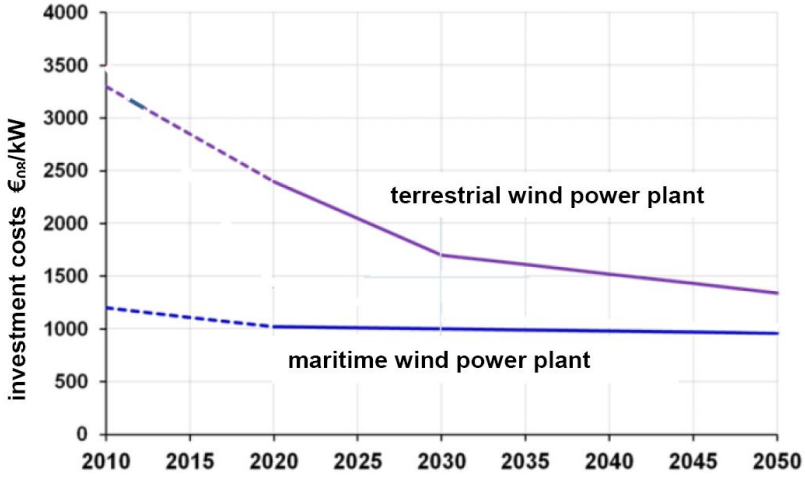

Fig. 9
Investment cost change of wind power plants
source:
Wind Power Barometer – EUROBSERV'ER – February, 2013.

The price of electricity is changing because of cheap surplus energy, and this may cause differences in stock prices. At those power plants where the investments returned there are only low external costs.

Costs

For an example let's check the costs in long-term. Such example can be seen on Fig 10. After installation of the plant the costs are typical (KÁT interval). The maintenance, repair another costs does not reach the 25-30 % of overall costs, but they are 15-20% bigger the market price of electricity (PA). At the interval of return the wind power plan gains subsidy (min. 8-10 years). The energy production costs are 25-30% smaller at ŐK1 and at ŐK2. (It rises because of higher maintenance costs, etc.) At T the difference between average wind energy price and costs is bigger than the subsidies. At governmental investments the profit is as well governmental. In Germany the price of wind energy will be lower than market electricity price in 2015-2016. The power plants which were built before 2006 returned.

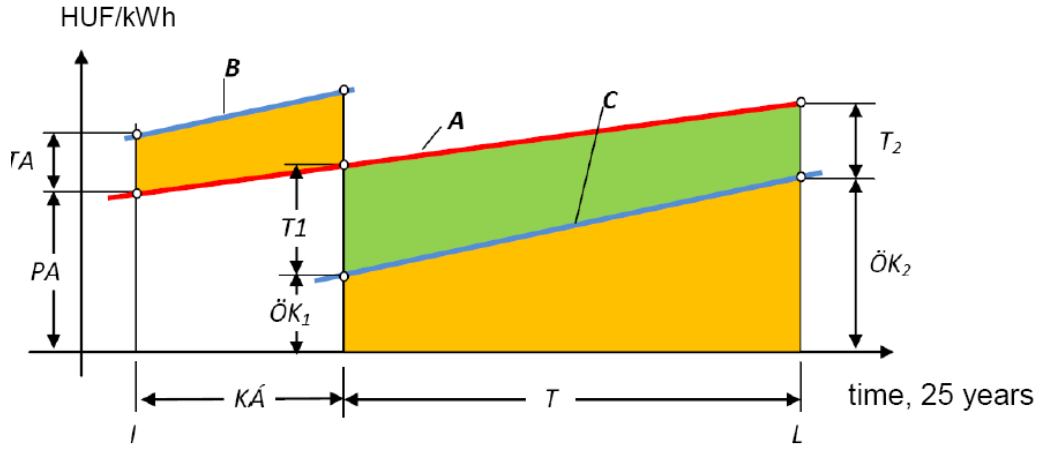

Fig.10
Costs of electricity during wind power plant lifetime
Abbreviations:

- *PA = market price of electricity*
- *TA = governmental subsidy (KÁT, or METÁR)*
- *A = trend of electricity price*
- *B = trend of subsidies*
- *I-L = lifetime of equipments = KÁ + T*
- *KÁ = subsided interval*
- *T =interval after the payback of loan and subsidy*
- *$ÖK_1$ =costs of wind energy production(utilization, repair, control costs) after KÁT*
- *T_1 = the difference of electricity price and wind energy production costs after KÁT*
- *C = trend of electricity production (increasing utilization, repair and maintenance cost)*
- *$ÖK_2$ = costs of wind energy production (at de-installation of the plant).*
- *T_2 = costs of wind energy production(utilization, repair, control costs) a at de-installation of the plant*
- *T_1 , T_2 , A and C area= gaining of the society(min.3-4KÁT investment)*

4. CURRENT HUNGARIAN SITUATION

Capacity

At 90 % of the Hungarian wind power plants the tower height is 90-120 m and the performance is 2 MW. The installation trend is shown on Fig.11. The energy production is 610-700 GWh/year. The utilization factor is ~21-24 %. At some parks 23-25 % value can be measured. With these data it can be proved the estimations were correct.
The current wind energy capacity is equal to the energy of ~200 million m^3 natural gas, whilst ~400 000 tons of CO_2 emission can be avoided.

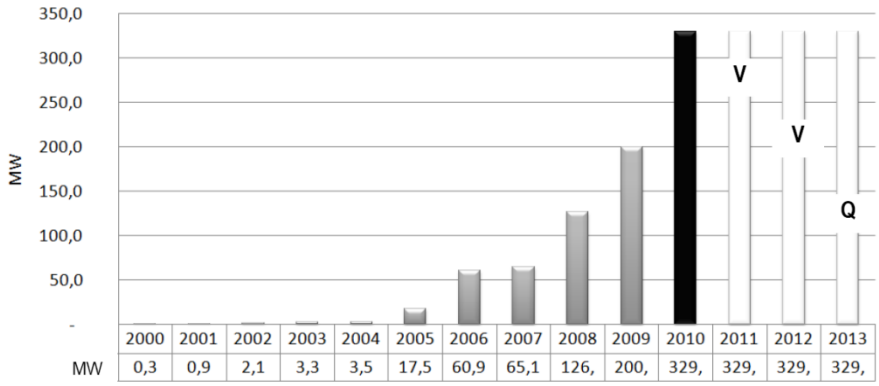

Fig. 11
Trend of Hungarian wind energy capacity
(V = remains the same, Q = new installation is not likely)

Base numbers of Nemzeti Cselekvési Terv (National Plan)

According to NCST until 2020 750 MW wind energy capacity should be reached. This means that additional 410 MW must be built. (See Fig.1)
In 2009 a tender was announced, and companies competed for 1100 MW. The tender was not announced properly so the quotas were not distributed. New capacities can be built earliest in 2015. To reach the 750 MW can only succeed if new plants are built in an increasing tendency.

The wind power investments did not get subsidies. The mood for investment is good; three years ago 1000-1200 MW additional capacity could have been built. If we would like to reach the capacity defined in the NCST, than we need to build additional 900-1000 MW. With this at the end of 2020 1300 MW would operate. Of course, the investors the only invest if they see their investment to return.

In Hungary the government does not invest direct stock in the wind energy installation only KÁT subsidy. The KÁT subsidy returns in short term. With the usage of wind energy the fossil fuel addiction of the country is decreasing and income rises from selling CO_2.
The lifetime of the modern wind power plants is 20 years, but with care it can be 25 years. In the future the energy produced by wind power plants will be cheaper than the energy produced by carbon plants or gas plants.
The technological increase and the increasing value of fuel prices cannot be neglected.
To be concrete if the investment returns then (approx. 10 years with subsidies) the price of electricity decreases to 8-10 HUF/kWh. There is no cheaper energy source, and the plants produce it for additional 10 years (it can be 20 years as well).
Wind energy as other alternative energy sources need network equalization.

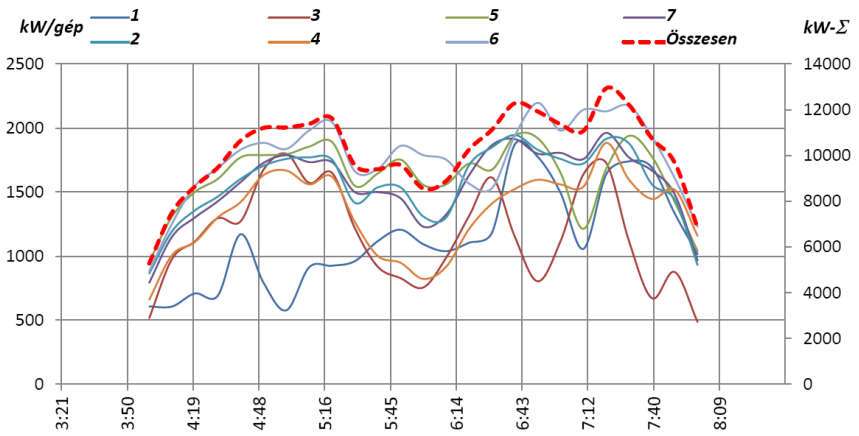

Fig.13
Wind power plant capacity (7 plants, 2 MW)

On Fig. 12 it can be seen that there can be 300-400 % differences in a 5h interval, and the total outcome changed 30-35%.
The wind parks have big network equalization effect. In Hungary the control price in 2011-2012 was 0.8-1.5 HUF/kWh. These costs do not influence the production costs.
It is important to state that the control of the electricity network can be done with bigger capacities as the current as well. The utilization level of the plant in Gönyű was only once 60 % since it is in operation. The plant capacity of Hungary is approx. 9000 MW, the max. consumption is approx. 6000-6500 MW. Yearly we use 1000-1500 MW import energy. It is not true that the existing 330 MW wind energy capacity or 3-4 times bigger would cause unsolvable problems in control.

Literature

[1.]Tóth G. – Schrempf N. – Tóth L. (2005): A szélenergia prognosztizálása, üzemi tapasztalatok, MTA AMB, K + F Tanácskozása Nr. 29 Gödöllő.
[2.]Tóth L.- Schrempf N. : (2012) Szélenergia helye, várható szerepe Magyarország Megújuló Energia Hasznosítási Cselekvési Tervében (MCST) ENERGIAGAZDÁLKODÁS 53. évf. 5. szám
[3.]Tóth L. – Horváth G. (2003): Alternatív energia, Szélmotorok, szélgenerátorok, Szaktudás Kiadó Ház, Budapest, 93-124. p., 281-321. pp.
[4.]Wilkes J. Moccia J. Dragan M.: (2012) Wind in power, European statistics (EWEA) http://www.ewea.org/fileadmin/ewea_documents/documents/publications/statistics/Stats_2011.pdf
[5.]Stróbl A.: (2012) Tájékoztató adatok a magyarországi villamosenergia-rendszerről, A piacnyitás (2003) óta eltelt időszak fontosabb adataiból, MAVIR, 2012. április 15. kézirat, ábragyűjtemény
[6.]Stróbl A.: (2013) Energetikai tájékoztatások szakirodalomból (ábragyűjtemény)
[7.]www.eurobserv-er.org. Wind Power Barometer – EUROBSERV'ER – 2013. febr.
[8.]Tóth, G. – Tóth, L. – Horváth, G. – Berencsi B. (2007): A hazai energia célú széltérkép elkészítésének feltételei. = MTA AMB Kutatási és Fejlesztési Tanácskozás. Gödöllő, Gödöllői Agrártudományi Egyetem – FVM Műszaki Intézet, 2. kötet 148-153. p. HU ISSN 1419-2357, HU ISSN 1419-2365
[9.]Small Wind World Report 2012 Summary, BONN, 3 – 5 JULY 2012 Germany