Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 52 (2014) 38 – 47

Energy Procedia

2013 International Conference on Alternative Energy in Developing Countries and Emerging Economies

Time for change! Decentralized wind energy system on the Hungarian market

Katalin Hartung[a*], Tibor Kiss[b]

[a] *Institute of Economic and Regional Studies, Faculty of Economics, University of Pécs, Pécs, Hungary*
[b] *Institute of Economic Studies, Faculty of Economics, University of Pécs, Pécs, Hungary*

Abstract

The purpose of the study is to focus on finding new ways at the Hungarian wind energy market by concentrating on Small and Medium Wind Turbines (SMWTs) and to nominate barriers what Hungarian wind energy innovators find. The current technology regime, working systems and Blue Economy solutions will be investigated. This topic constitutes an important area, because a necessary technology transformation let new markets to emerge. Based on Deutsch [1] technology regime researches and Painuly [2] framework of renewable energy technology barriers, due to the Hungarian technology regime will be identified. The solution seems to emerge as part of a different technology regime, other than the energy industry, which considers SMWT technologies as a complementary source for core businesses. The study provides a holistic view on the Hungarian market and equip with probable solutions.

Selection and peer-review under responsibility of the Organizing Committee of 2013 AEDCEE

Keywords: Barriers; Hungary; SMWT; Technology regime; Wind energy

1. Introduction

Climate change became an influential factor to foster the replacement of the current fossil energy sources. As an answer to the EU 2020 Millennium goals, Hungary has worked out an energy efficiency plan for 2020 which is based on 4 pillars: energy saving; increase the renewable and low carbon emission energy production; redesign the central heating and individual heat production; and green industry/agriculture. In our study the second and fourth pillar is important. Hungary is going to increase the renewable share in the primer energy consumption up to 14.65% by 2020 [3]. This proportional number is due to Hungary size. Today the preferred renewable energy sources to produce electricity are biogas, hydro, waste burning and wind energy in our country [4]. Utilizing wind energy is favored by the

* Corresponding author. Tel.: 0036 30 3294858
E-mail address: hartungk@ktk.pte.hu.

Selection and peer-review under responsibility of the Organizing Committee of 2013 AEDCEE
doi:10.1016/j.egypro.2014.07.052

Hungarian government; however practical experience shows lack of support and public acceptance. The reason may hinder in the centralized and decentralized energy systems.

Lovins [5] emphasized in his work that centralized energy systems has been dominating historically from the 19th century due to the resulting cost savings and improved reliability. One of the main features of a centralized system is that it is very expensive to construct, but potential individual problems are less in magnitude (more economical to maintain). It is easier to reach an agreement on locating the power plant as there is only few in a country. Decentralized systems' costs are not lower, the individual problems may be multiplied and they should be close to the residential or consumer areas. Both systems are similarly exposed to climate events and any kind of disruption. But a very strong argument for the centralized system is that in case of a blackout, it is expected that problems are going to be restored by the major utility service. However a decentralized community would be left alone. Same might happen when support is needed. On the contrary, the centralized systems' blackout could be big in magnitude, affecting large areas for a long time, while decentralized systems are much less in magnitude. Traditionally, government stands behind a centralized energy system, therefore making it more reliable. [5] [6] [7].

Lovins [5] forecasted that by 2050 the major monopolist business model to provide electricity is going to be diversified. It will shift slowly from a centralized to a decentralized system. It will involve more renewable combined with flexible fueled generators and demand response. The vision is while wind peaks during night, solar at daytime, it can provide constant electricity while geothermal-biogas can balance out the system. Drivers for change are observable, like the growing need for renewable energies, innovation of smart grid technologies, grid flexibility, which set new directions for electricity market. Large-scale installation of renewable energy creates benefit for centralized system, and their small-scale applications are regarded as decentralized. Hence horizontal axis wind turbines (HAWTs), like large wind parks belong to the centralized energy systems. The growing need for HAWTs will drive the cost down for the technologies and accordingly SMWTs will be cheaper for local generation. Smart grid system will be more open for centralized renewable energies; consequently will connect in the future locally sited generations more easily. As a result consumers will have a chance to join the electricity production, and save energy and money at the same time [6] [8].

The old monopolistic business model is obsolete and the market is looking for a customer centric, diverse system with a more competitive market. For example the small and medium wind turbines have already success in rural electrification projects. In China the first SMWT was recorded in 1980 and until 2010 there were 400 000 turbines counted. According to the Alliance for Rural Electrification the price of SMWT is cheaper than small-scaled PV or mini-hydro and any other system [5]. The wind turbines have multiple benefits; however there are barriers which set back the soundness of the system. This fact is detailed later.

Blue Economy concept founded by Gunter Pauli [9] is based on an extensive research which looks for a new business model for the world ever increasing problems. It thinks in auto-poetic systems which can constantly change itself. The key is to force the system around us, then the system will adapt. The old, regulated schemes are not tolerable in the aging European society. It is time for change. An open system should trust local communities. Energy generation should be produced at local levels in order to eliminate the dependence on centralized systems as coal and nuclear. Commons like wind, water, sun should be free for a community and communities should rely on multiple cash flows to generate income. For example wind energy is available for all, it could be utilized without expensive large towers and without ruining the landscape as well [9]. For instance, the prayer flags which are traditionally being located on hilltops in case of Bhutan are now generating electricity by wind fluttering. This is a so called holy energy for Bhutanese who pray by setting flags in the wind. It could be an alternative for rural communities. Estimated if one million flag poles would generate electricity, it would result 360 MWs output [10].

There are industries where wind or other source of energy serve as a complementary business activity and operate in harmony with the centralized energy systems. For example when agricultural biogas plants use the organic waste from land work or other biomass source and turn it into renewable heat. From agricultural waste fuel or power can be produced with Combined Heat & Power system (CHP). Biogas became a by-product of anaerobic digestion of organic waste. It is clean and reliable [11]. Similarly small and medium wind turbines have been utilized historically to pump up water and to ground grain in agriculture. Today wind can be used for electricity production in agriculture [12]. For the energy portfolio of this particular industry decentralized systems such as wind or biomass are being applied without any barrier. These do not conflict with their main technology regime rather complement it. Wind energy is not just environmentally friendly, but provides a cost-competitive solution for off-grid applications. While the prices of conventional energy sources are escalating, for small and medium wind turbines it is the other way around. Another example is the paper and pulp industry, where waste provides an opportunity for energy generation. As Pauli [13] describes fibers for paper only represent a minor fraction of the total biomass. Integration of technologies results in the nearly 100 percent use of the wood as raw material, creating synthetic fuels (among other useful raw materials) avoiding the creating of diosin, which is otherwise an accumulating toxin. A new, Blue Economy business model emerges, generating multiple cash flows.

2. Methodology

Primary data was specifically gathered for this research project. Interviews were conducted. The nature of the interviews was unstructured with pre-researched guideline questions [14] [15]. All three interviewees were wind energy innovators with different innovations: Béla Szabó from Tatabánya (PV system, solar parabola and Vertical axis wind turbine (VAWT)); Raymond Davis from Oswego, NY (Vertical Axis Wind Turbine, commercial name powAIR Sail); and Dénes Kókai from Érd (Energy sail).

During the analysis secondary data was used to define and prove the validity of the information. External sources constitute library books, periodicals from database systems, such as EbscoHost, Scholar. Government sources from ministries directly or from governmental institutions/ UN websites were used as well. These data was helpful to forecast trends, read background information.

This study is going to focus mainly on the Hungarian market and especially on small and medium sized wind turbines which is a niche market at the moment.

3. Wind market in Hungary

Hungary is a landlocked country in Central Europe, situated in the Carpathian Basin with 93,030 km^2 area.

The country considered to be moderately windy. The duration of 1-3 m/s wind is the most frequent, in total 1500-3000 h/year; while the 10 m/s wind speed is rare, fewer than 100 h/year. The finding of Radics et al. study shows that there is a great regional difference within the country [16] [17]. Figure 1 is illustrating the direction and speed of wind. Wind blows from multiple directions, hence horizontal axis wind turbines (HAWT) should be carefully planned or other technologies than that should be considered.

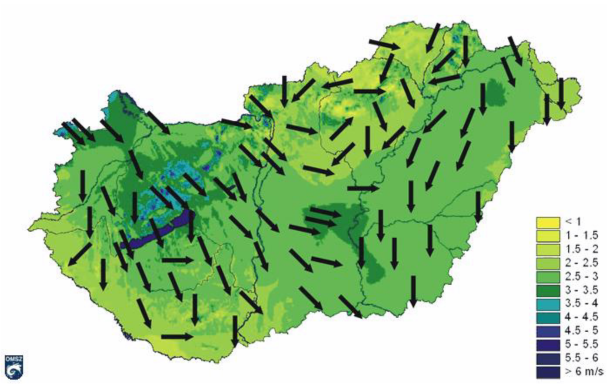

Fig 1. Wind map of Hungary [6]

Looking at Hungary wind characteristic, it has more potential for small and medium sized wind turbines, as they are better accommodate for the local standards.

By modifying Hunyár [18] findings to our research, Hungary is able to utilize 41.8% of its land to build up small and medium sized wind mills. Hunyár excluded those fields from the total area where the installations of wind mills are not possible. He concentrated on industrialized HAWTs; therefore the "Cities inner territories" were also removed from his table to come up with the utilization ratio of small wind turbines. There are overlaps between data like forests and preserved lands, but it is balanced out with those objects which were not considered (airports, military lands, inhabited buildings…). Table 1 summarizes the detailed calculation.

Table 1. Excluded lands to install small-sized wind turbines

Name	**Forbidden land (km^2)**
Waters	1753
Preserved lands (National Parks)	8573
Gardens, vineyards, fruits	2880
Forests	17468
Railway systems	3949
Public roads	2205
Transmission lines	15419
Territories above 400m and steep slopes	1860
TOTAL	**54 108**
Compared to the total area of the country	**58.2%**

It suggests that Hungary has potentials to consider and to increase the level of awareness on the field of wind energy.

4. Technology feasibility and working systems

In Hungary there is 329.325 MW installed wind power capacity in 2011. Mostly it constitutes horizontal axis wind turbines (HAWTs). Since the first two wind power stations were established in 2001 at Várpalota with an output of 250 kW and at Kulcs with 650 kW the construction of HAWT was growing rapidly [16]. Both of the constructions are located at the central-western Hungarian region. The rate of expansion of HAWT was 46.8% from 2009 to 2010 [19]. There is a typical example for a wind-energy park built in 2006 at Mosonszolnok, close to the Austrian border. The project costs 36 million Euros. Hungarian entrepreneurs worked for 8 million Euros. In the project, the rest of the work was managed by foreigners. The park has 12 wind turbines with 48 MW capacities, however only 24 MW capacities have been licensed by the Hungarian Energy Office. Investors hope that in the future they can validate the rest of the capacity. The height of one tower is 78 meters and rotor diameter is 90m. In total, the 12 HAWTs produce 52 thousands MWh. Payback time is 10-13 years. The energy is fed into the sub system of Mosonmagyaróvár‘s energy system and then into the national grid system. Per agreement the electricity should be accepted for 13 years by the electricity trading company in Hungary. The park was built merely by private investors from Spain and Hungary [20]. This short case already illustrates problems such as capacity licensing, non-Hungarian construction workers, and foreign ownership.

According to the Hungarian Energy Office Handout for licensing wind power projects in 2012, no more than 330 MW built in capacity is accepted to feed into the Hungarian grid system. It is due to the system’s physical condition that is unable to handle the volatile electricity with great magnitude provided by wind. The office states that it is not going to change in the next 3-5 years as the overall structure of the electricity system would remain unchanged. Therefore there is a limit on licensing the incoming requests for wind energy capacity. It is expected that by 2020 it will be extended to 740MWs. It is disappointing that from the demand side, investors would plan 2000MWs wind power [21] [22]. Many times built systems are not working in a potentially windy condition, because it is banned to feed in more electricity than accepted.

To avoid predicament with the centralized energy system, the solution would be to increase the share of small and medium sized technologies, which are mainly for covering local energy need and are not planned for grid. This leads to a decentralized system with multiple benefits. Technological improvements in SMWT make it possible to utilize the low and moderately windy regions and to exploit free wind energy. Medium sized wind turbines are generally between 15-30 rotor diameters with a 50-250 kW capacity. Small wind turbines are the one with less than 15 diameters and an output below 50 kW. There can be even smaller installations with 2 diameters and 1kW output or less [23]. SMWT can be horizontal or vertical axis, and other electricity producing systems are also possible. Nowadays it is a growing market and being economically viable.

A few technological developments are taken as examples which were witnessed on a field trip. The hereby mentioned cases are capturing low wind speed, and producing energy. The energy is either charging batteries directly or being fed into the grid system. These have been developed for households, private use than actually for industrial energy production. One Hungarian innovator is Mr. Kókai with Energy-Sail. He made the first prototype at Érd. The invention is wind-power utilization with surface waves. It has a front side (could be made from recycled materials like plastic); it has a whole at the middle which captures wind and creates energy through side pressure. This is a basic concept of one panel. Multiple panels can be built together to increase the level of efficiency. Generally a household needs 8 panels to substitute their yearly electricity consumption (with help of batteries). Energy-sail costs around $650 without inverter or generator. It is environment friendly and could be used alternatively in the agriculture industry at the side of the fields as a wind breaker and also as a place for advertisements. It has multiple benefits: protect growing crops from windy weather, generates additional cash flow from advertisement, and generate saving on electricity needed.

A vertical axis wind turbine was developed by Viktor Györgyi in Felcsút. The innovation was patented for its hydrodynamics solution and its stable and strong spatial frame. It has a cost saving and practical aspect that the gear box and the generator stand at the bottom of the tower lowering the price of maintenance. The material is made of light aluminum alloy, easy to place together. The tower is 5.5 diameters and 29 meters height. The system energy production starts at a very low wind speed, but due to the resistant structure it also works in heavy wind [24].

Another local innovation is a Vertical Axis Wind Turbine by Mr. Szabó. It was built in June 2010. The height is 3 m, the material is aluminum. The area of capturing wind is 6.3 m^2. It can be utilized in urban area, because it is silent and the construction is within 6 m, so it does not require building permit. The system was first operated with 3 blades, and 3 blades were added a year ago. The efficiency has improved from 3% to 18%. The yearly electricity production is 300-400 kW. It reduces the costs by 20,000-25,000 HUF yearly. It has been created with six blades on top of Tatabánya University where students can also cooperate in the project and make real analysis.

A foreign example is in America where a similar VAWT is installed on the rooftop of a faculty. The project was alike to the Hungarian one mentioned above. It captures a wind speed between 3-6 mph. The goal was to develop a wind turbine with light weight and vertical axis which perfectly works in any wind environment. It guaranties 20 years life time expectancy with proper maintenance. There is an axial flux generator built in the system.

These are tailor made technologies; therefore they cannot be compared to anything else. They are unique and they perform differently at different locations depending on height and wind speed. It was great to see how similar brains work at different point of the world.

The Blue Economy concept mentioned earlier in the study brings two perfect examples for decentralized systems how to exploit wind [9].

The first example is the case when wind turbines are working without building new pylons [25]. It is known that building up a HAWT is expensive, because it relies on rare earth metals (with the current growth and technology, metals may run out), cabling cost to feed into grid, batteries. Three architectures - Nicola Delon, Raphael Ménard and Julien Chopin – found a new solution, called Wind-it. The idea was to utilize millions of already existing infrastructures like transmission towers, pylons, phone transmissions. Wind turbines are designed into the already existing pylons instead of constructing an independent structure. Vertical axis small wind turbines should fit into the transmission tower by reinforcing and slightly modifying the structure. It would decrease investment cost ($3000 to $5300); use the current infrastructure; reduce wiring need from generator to grid system. If in France all pylons would be equipped with Wind-it technology (assuming proper wind for each), then it would substitute 15% of the country energy demand (equivalent to build six nuclear power stations) [25]. This is a break-through innovation in the energy system.

Another blue economy case is "wind energy without turbines". The innovation is found by Shawn Frayne. He designed a system how to capture the power of fluttering. The new technology does not require rotational movement and rare earth metal. The first commercial product name is mini-sized wind belt. A very small wind blow is enough to turn the system on. It is estimated, that over the lifetime of a wind belt, it can replace 100 batteries and the labor requirement for changing the batteries. It is anticipated that the sensor market will grow in the future and the battery power sensors could be replaced by wind belts. Another type of application for the same idea is when flag poles are functioning as wind belts, while wind flutters, flags generate energy. This concept was employed in Bhutan mentioned before. In this country the remote communities at the mountains can be powered by this concept. "One million flag poles represent 360 MW energy" [10]. It could supplement for grid energy or be an only source of energy.

The Blue Economy innovations are turning wind energy to Unique Selling Proposition (USP) beside their financial benefits. When the investment cost of wind energy is calculated based on return from feed-in-tariff, it might not generate good returns. However it is incorporated into the production process as a source of energy, then our product can be appealing for the market [26]. A survey was conducted in 2011 which shows that more than 60% of consumers globally want to buy from environmentally responsible companies. In developed countries such as US and UK 20% of interviewed would be willing to pay 10% more on green products. People tend to pay extra for bio or clean products [27]. These examples prove the success of renewable energy.

The above mentioned alternatives may have potentials on the Hungarian market in the near future. However at the moment developing countries such as Hungary is not yet environmentally conscious to make a proper decision what to purchase and invest in. In the country the capitalistic approach rules the process of decision making where price and cost dominate among all other objectives.

5. Analysis

Deutsch [1] and Painuly [2] studies have been further investigated and they helped to identify the main barriers of small and medium sized wind turbines in Hungary. The aim was to find the answer why these systems are not available on the market.

Painuly work tried to summarize barriers for renewable energy technologies in developing countries in a structured matrix. His study listed six barrier categories, namely, 1 Market failure/imperfections, 2 Market distortion, 3 Economic and financial, 4 Institutional, 5 Technical and 6 Social, cultural and behavioral barriers. On the other hand Deutsch study was written on the innovation of technology systems focusing on electricity producing technologies. Part of her research was to determine the characteristic of the current centralized system and compare it to an ideal decentralized system in Hungary. She has categorized five dimensions, namely, 1 Physical, 2 Legal, 3 Market, 4 Corporate and 5 Political dimensions. After analyzing the two, current wind energy barriers were determined. The matrix facilitates to structure thoughts around these barrier categories and put remarks for better understanding. Table 2 summarizes the findings [1] [2].

In Hungary the centralized energy production is dominating. This system has worked well for several years, but the aging power plants and technology systems are looking for a new way of electricity distribution/production. As the renewable energy producers enter the market, a new business model will be required. Experience evidenced on the European Union market, that major technical problems to integrate renewable energy are how to feed in electricity into the grid system and the production structure of electricity [1].

The strongest barrier against small-scale renewable is the resistance of current producers. The conventional energy sector historically receives large amount of subsidies which creates boundary for emerging technologies to compete [8]. The energy sector is highly controlled and the main actors are centrally being pointed out. It set back the willingness to invest in wind energy and also increases the level of uncertainty. SMWTs are still not available, because Hungary lacks the knowledge, know-how and experience of the use of wind energy. Utilization of SMWTs is still rare.

Institutional and policy barriers on the market restrain progress in the renewable energy sector. The only possible way would be to take away subsidies and internalize external costs to conventional energies, and then it would establish a fair market [8]. The procedure of certification is lengthy and bureaucratic.

Unfortunately there is a lack of quality standards and certifications for both the technologies and the installation process, which would guarantee the reliability and the safety of the system [5].

One of the most important technical barriers is that the conventional transmission lines have not been modernized yet and their volumetric capacity therefore is limited. The aim would be to lessen the possible transmission loss and solve the volatility problems.

Among corporate barriers the most serious is the presence of large corporations and their strong influence on the market. Due to the corporate form and size, energy industry has developed its risk management and planning strategy which is not able to conform to the decentralized systems. There is a need for change. However studies shows that the Hungarian society is not ready yet for a paradigm shift. The conclusion of Bíró and Udvardi questionnaire was that there is a conflict between the acts and the thoughts of people. When the society has to spend money, time and effort to save energy and environment, less people are willing to act or to be responsible for its action [28].

Table 2. Barriers for the decentralized energy production cross sectional analysis of the current situation in Hungary

BARRIER category*	BARRIERs	Remarks
Market Failure	1. Highly controlled energy sector 2. Lack of information 3. High transaction costs	1. Lead to lack of investment 2. Increase uncertainty 3. Viability of the project affected
Market Distortion	1. Favor to conventional energy 2. Non-consideration of externalities 3. Monopole market	1. Affect competitiveness 2. Conventional energy cost less 3. Small-network models local market
Economic and Financial	1. Economically not viable 2. High discount rate 3. High payback period 4. Market size small 5. Lack of access to capital	1. Cost reduction 2. Incentives 3. Risk for un-viability 4. Economy of scale is not possible 5. No. of producers are less
Institutional	1. Lack of institutions to disseminate information 2. Problems in realizing financial incentives 3. Unstable macro-economic environment 4. Lack of R&D culture	1. Non-available information 2. Red tape 3. Increase risk, uncertainty 4. Difficult to adapt
Technical	1. Lack of certification 2. Lack of skilled personal 3. Conventional transmission line 4. Products are not available 5. Energy storage	1. Purchase risk – negative perception 2. Constrain for producer 3. Transmission loss, less reliable 4. Market size is affected 5. Not solved yet, high cost
Corporation	1. Large corporations dominance 2. Importance of corporate strategy, price competition 3. Risk management, planning 4. Corporate size and form	1. Does not support diversity 2. New business models, strategies, role of R&D and marketing 3. New way of risk management 4. Need for new corporate sizes
Social, Cultural and Behavioral	1. Lack of consumer acceptance for the product 2. Lack of social acceptance	1. Market size gets small 2. Negative perception, Environmental consciousness

After looking at barriers at the Hungarian market and its wind energy potentials, it has to be emphasized that technology developments will drive the market to a new direction where low and medium wind turbines will be widespread and let self-sustaining business models to emerge, but this vision is not going to be carried out in the next decade. There should be technical, institutional, economic and social alterations worked out to lead for a complete success. The new model has to be carefully planned not to conflict with the current central technology regime.

6. Conclusion

SMWT is a good choice for Hungary, because it aims for sustainable energy system, reduces emissions and generates more cash flow. The technology is cost competitive and has an early break-even point in comparison to large HAWTs. It is reasonable to assume that SMWT is a good opportunity to substitute own energy consumption for a growing industry on a cheap and clean way [28]. For a sound decentralized system the first would be to spread reliable, transparent, relevant, tailored information about SMWT and provide examples/solutions for the relevant shareholders.

There are some suggestions how to increase the accessibility of SMWTs in Hungary. The first step should be to organize trainings and spread reliable information for communities through universities or non-profit organizations. Industries, businesses and households should be encouraged to use wind energy. Studies should be available about current wind parameters in each region of Hungary to help objective decision making of industries and businesses. Certification procedure should be eased and standardized in the long run. It would be necessary to encourage the development of joint ventures and partnership agreements with expert companies to develop a local solution for Hungary and this would ensure the rights establishment of small and medium wind turbines [29].

Acknowledgement

We would like to express my gratitude those whom I were interviewed Mr. Dénes Kókai, Mr. Béla Szabó and Mr. Raymond Davis for dedicating their time, sharing their knowledge with me, and presenting real life example.

References

[1] Deutsch N. *A technológigi rendszerek innovációja*. Dissertation at the University of Pécs, 2011
[2] Painuly J.P. Barriers to renewable energy penetration; a framework for analysis. *Renewable Energy*, Vol. 24, 2001, p73-89
[3] NFM (Nemzeti Fejlesztési Minisztérium) *Magyarország II. Nemzeti Energiahatékonysági Cselekvési Terve 2016-ig, kitekintéssel 2020-ra*. NFM Az Európai Parlament és Tanács 2006/32/EK irányelve 14. cikk (2) bekezdésében előírt beszámolási kötelezettség, 2011
[4] Gergely Á. Renewable energies: The green side of Hungary. *ITD Hungary Zrt. paper*. Retreived from www.itdh.com, 2012
[5] Lovins A. *Small is profitable: the hidden economic benefits of making electrical resources the right size*. Rocky Mountain Institute, US, 2002
[6] Lovins A and Rocky Mountain Institute. *Reinventing fire: bold business solutions for the new energy era*. Chelsea Green Publishing Co., USA, 2011
[7] Robertson JAL. The plain man's guide to Amory Lovins. *Electric Perspectives*, Issue 3, 1977, pp21-24.
[8] O'Keefe P, O'Brien G, Pearsall N. *The future of energy use*. Pearsall, 2nd ed., London, 2010
[9] Pauli G. *A Kék Gazdaság*. PTE Kiadó, Pécs, 2010
[10] Pauli G. *Wind Energy without Turbines*. Case 12 Retrieved from zeri.org at 15.05.2011, 2011
[11] Arthur R, Baidoo MF, Antwi E. Biogas as a potential renewable energy source: A Ghanaian case study. *Renewable Energy*, volume 36, Issue 5, 2011, p1510-1516
[12] World Wind Energy Association. *Wind Turbine technology*. Retrieved from www.wwindea.org at 11/05/2011
[13] Pauli G. *Innovations in Paper* Case 36 Retrieved from zeri.org at 15/05/2012, 2011
[14] Gill J., Johnson P. *Research Methods for Managers*. London, Paul Chapman Publishing Ltd., 1997, pp. 18, 37, 60, 63, 155, 157
[15] Zikmund WG. *Business Research Methods*. Mason, Thomson/South-Western, 7th edition, 2003
[16] Radics K. Bartholy J. Bohoczky F. Present state of wind energy utilization in Hungary: policy, wind climate, and modeling studies. *Renewable and Sustainable Energy Reviews*, Issue 7, 2003, p175-186
[17] Radics K, Bartholy J. Estimating and modeling the wind resource of Hungary. *Renewable and Sustainable Energy Reviews*, Issue 12, 2008, p874-882
[18] Hunyár L. A szélenergia potenciál hasznosítását korlátozó tényezők Magyaroroszágon. *Magyar Energetika,* 2004, 4
[19] Országos Meterológiai Szolgálat. *Magyarország szél viszonyai*. Retreived from http://www.met.hu/eghajlat/magyarorszag_eghajlata/altalanos_eghajlati_jellemzes/szel/ at 1/3/2013
[20] Vadócz A. *Mosonszolnok-levél szélerőmű-park zajszintjének vizsgálata*. Pannon Egyetem Mérnöki Kar, Környezetmérnöki Intézet, Szakdolgozat, 2009
[21] Magyar Energia Hivatal (Hungarian Energy Office). *Tájékoztató a szélerőmű-projektek engedélyeztetésének helyzetéről*. Retreived from www.mekh.hu at 20/12/2012
[22] Alternativ Energia.hu. *A MAVIR szerint nem a kapacitáskorlát a gátolja a szélenergia terjedését*. Retreived from www.alternativenergia.hu at 4/3/2013
[23] Rolland S. Promoting small wind in developing markets. *Renewable Energy World*, Issue 4, 2013
[23] World Wind Energy Association. *Wind Turbine technology*. Retrieved from www.wwindea.org at 11/05/2011
[24] Cseri P. Különös áramfejlesztő torony a felcsúti mezőn. *Népszabadság*, 2011. Retrieved from http://nol.hu at 6/3/2013
[25] Pauli G. *Wind Energy without (new) Pylons*. Case 11 Retrieved from zeri.org at 15/05/2012, 2011.
[26] Pauli G. *Exporting Wind*. Case 29 Retrieved from zeri.org at 01/06/2011, 2011

[27] Cohn&wolfe. *Consumer interest in green products expands across categories*. Top 2011 US ImagePower®Global Green Brands Study. Retrieved from cohnwolfe.com at 2012
[28] Bíró P, Udvardi A. *Fenntartható Fejlődés Évkönyv 2010*. GKI Gazdaságkutató Zrt, Budapest, 2010
[29] Alliance for Rural Electrification. *The potential of small and medium wind energy in developing countries*. A guide for energy sector decision-makers. Position paper 2012