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Suspicious work	Authentic work

OS	S.Ababei, Adaptive control algorithm in wind turbine speed regulation, In: Modelling and Optimization in the Machines Building Field (MOCM), vol.1, 2006, p.5-10.
OA	G. Barzyk, Construction of wind power plant – engineering strategy and technical aspects on the grounds of Nowogard's experience, In: ISTC UEES/99; St. Petersburg 1999. Disponibil la: http://barzyk.pl/teksty/construction_of_wind_plant.pdf

Incidenţa minimă a suspiciunii / Minimum incidence of suspicion	
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CONSTRUCTION OF WIND POWER PLANT - ENGINEERING STRATEGY AND TECHNICAL ASPECTS ON THE GROUNDS OF NOWOGARD'S EXPERIENCE

Key Words: wind power plant, engineering strategy, accomplishment

Abstract: The article contains a description of engineering strategy and certain technical aspects related to the construction of a wind power plant in Nowogard, the first plant that type in West Pomeranian Region. The article discusses the potential problems of the quality of electric energy produced by modern wind power plants in view of changes in Polish law of power engineering.

1. INTRODUCTION

Wind is undoubtfully a source of energy. Making use of that resource in covering local needs for energy brings, besides apparently evident economic effects, also several additional benefits including the changes in energy balance structure in conditions of activating areas characterized with low population or poor soils; it may also become an additional activity for expansive producers of in range of agriculture and processing activities. The ecological aspects of wind power plant erection comprise not only the lack of emissions but also the possibility to provide electric energy without necessity to construct transmission lines (electromagnetic field) mainly in those areas where the deficiency in electric energy supply from conventional electric power stations can be observed.

Since 1996, the official prices for electric energy in Poland supplied to particular users have been different, i.e. the farther the user is located from the resource mining region (e.g. coal mines) or from electric power plant or station, the higher the prices are. The latter examples allow to express an obvious conclusion of advantages resulting from wind power plant investments, particularly in areas significantly far from electric power plants and showing an essential wind potential.

2. BRIEF FOREDESIGN OF WIND POWER PLANT IN NOWOGARD

The city of Nowogard is a medium size town, situated in a Western Pomerania, on North-West of Poland. The climate, economical and law conditions in Nowogard are simmilar to the great number of cities in Poland, therefore the author presents a brief fordesign of wind plants just in Nowogard.

The Authorities of the Town and Commune of Nowogard (UMiG) became interested in a wind power plant construction when the subject of electric power supply to the local sewage treatment plant had appeared. As a result of certain study carried out by the Institute of Meteorology and Water Management, concerning the division of the territory of Poland into wind energy resource mesoscale regions, the region of Nowogard was classified into Zone I (at 6-grade scale, Zone I - indicates excellent wind conditions). The favorable classification as well as a later expertise by Dr Halina Lorenc (Institute of Meteorology and Water Management, Warszawa) based on Danish mathematical - physical model WAsP (Wind

Analysis and Application Programme), caused that the possibility of wind energy utilization was considered seriously as a method to reduce the electric energy uptake from the Power Grid when feeding the sewage treatment plant. Moreover, the present pro-ecological policy of financing institutions of European Union (PHARE Fund) has become an additional factor, and one of the most important ones, making a fundament of successful undertaking. The financial support obtained from PHARE Fund would reduce the costs of wind power plant construction and what follows, the energy produced by that wind power plant would essentially reduce the demand for electric energy purchased from the Power Grid so far.
Considering the problem in relation to the sewage treatment plant, the Authorities of the Town and Commune of Nowogard suggested the location of future wind power plant to be very close to the sewage treatment plant (about 250 m from the boundary of the sewage treatment plant), on the land owned by the Commune. The geologic expertise of a selected land has proved the wind power plant location was chosen reasonably. That made a basis to apply for successive permissions and consents to institutions that had influence on building and constructions of the plant.

III. CERTAIN ASPECTS OF DECISIONS ON WIND POWER PLANT CONSTRUCTION

In most cases the prevailing argument for any erection of a power plant is a volume of electric power output that might be produced there. In that case, the wind power plant output energy was calculated using the mathematical model WAsP, mentioned above. The model considered many factors, e.g. the roughness of the area surface, and transferred particular meteorological station wind parameters into local location tasks (in that case the local information of Nowogard were obtained on base of Szczecin station data).

Altitude over the ground surface [m]	Average wind speed [m/s]	Useful wind energy [W/m^2]
20	47,8	122,0
25	50,7	143,0
30	53,5	163,0
35	55,7	181,0
40	67,6	198,0
50	60,5	224,0

Table 1. Wind Parameters in Nowogard Region; Data obtained from WAsP model.

On base of information presented above and presuming the same altitude of rotor's suspension (h = 30 m), the comparison of electric energy generated by different types of wind power plants has been made and presented in Table 2.

Type of Wind Power Plant	Annual Production of Energy [MWh]
Nowomag EW-160-22-30	248,6
Bonus 150kW, Mk III	251,1
MICON M530-175/40kW	291,2
MICON M450-150kW	232,7

Nordex 150kW	322,6
Danwin 23 (180kW)_	216,1

Table 2. Comparison of Energy Production in Different type Wind Power Plants for Nowogard Conditions

Considering the performance experiences in Polish conditions (see: wind power plant in Lisewo) it might be expected that the actual effectiveness should be rather lower than those presented in the table above. E.g. in Lisewo, the plant using wind turbine Nordtank NTK 150 XLR, where the average wind speed is 5,7 m/s at the altitude of 30 m. over the ground surface - the annual production of energy amounts to 250 MWh (instead 320 MWh as should be expected on base of table information). The above result if the effect of several reasons, appearing repeatedly there, however, the reasons themselves are common enough to be considered and predicted to occur proportionally also in Nowogard conditions. The most often reasons under consideration are the following:

- too low wind speed (cut in) - up to 27% of inflow !
- power output operations,
- disengagements of 15 kV transmission lines (particularly at very high speed winds),
- not sufficient adaptation of Danish control computer program (current asymmetry and control panel overheating problems),
- icing of wind speed and wind direction sensors,
- thyristor control system failures,
- (disk) brake system failures,
- nacelle rotation system failures (yawing),
- poor lubrication (in winter conditions) of nacelle rotation system.

The above listed problems and failures caused that the effective operating time of wind power plant in 1992 - 1995 was equal to 5500 h/year at average, that means about 63% of annual nominal operating time.
However, even the energy gain at the level of 250 MWh per year constitutes a reasonable rationale to undertake the efforts to construct a wind power plant. Moreover, considering the wind power plant of slightly higher power output, e.g. the wind power plant of Vestas A/S Company allowing to reach V29 - 225 MWh, much better economic effects might be expected. At the average wind speed equal to v = 5 m/s, the annual production of energy should reach 320 MWh while when the speed is v = 6 m/s then it might reach as much as 502 MWh. Even if the imbalance to table effects is considered, particularly when it concerns the energy production for local own needs and perhaps certain external financial support, a construction of wind power plant seems highly reasonable.

3.2 FACTORS CONNECTED WITH A DECISION PROCESS

Considering the universal character of the above speculations in Polish conditions (an average wind speed at the level of 5-6 m/s) and the dynamics in wind power engineering development in our country - a beneficiary of European Union, a decision on undertaking the construction of a wind power plant should consider the following factors:

- Location establishment and recognition of wind conditions,
- Application for a Building Condition and Land Development Decision
- Verification whether the Main Development Plan had similar investment foreseen within a 10 km radius area (changes in surface roughness),

- Analysis of geological and meteorological conditions
- Assuming the legal status of an entity/business to provide the production and sale of electric energy (an obligation to possess appropriate license to produce electric energy at power output higher than 1 MW),
- Defining the manner of using the energy produced,
  Options: distribution of electric energy for own needs, for local users needs or for sale to Power Distribution Enterprise,
- Application to Power Distribution Enterprise for a consent or contract on sale/purchase of energy (determine e price for 1 KWh), agreement on conditions of connections to Power Grid,
- Agreements or consents with other institutions, including:
- Environment Protection and Building Supervision Department of University of Warsaw (establishing e.g. the level of allowed noise emissions by wind power plants),
- State Provincial Sanitary Inspectorate,
- State Inspectorate of Civil Air Force (depending on the tower height, appropriate signaling and marking on navigation maps),
- Main Headquarters of Civil Defence,
- Headquarters of State Air Force,
- The phase of business plan development

On having established the forms and statuses of using the electric energy produced, the investment effectiveness should be determined considering, among the others, the following costs:

- the costs of documentation, including the scope of investment, technical conditions, agreements and permits, tender bid preparation
- related charges and fees: rent (land) payments, insurance, taxes, service costs, building supervision, subcontractor's documentation, labour wages, training costs.

A positive analysis of the above factors in relation to prognosis of life time of a wind power plant considered (usually 25-30 years) an application for financial support from financing institutions, PHARE Fund or preferential credits, e.g. environment protection oriented banks (BOŚ), can be realized.

3. TECHNICAL PROBLEMS OF CONNECTIONS TO POWER GRID

The modern wind power plants, in most cases of connections to other Power Distribution systems, use the asynchronous devices as the electric energy generators. However, the use of those devices as generators causes several problems, e.g. the capacitive passive energy of magnetizing circuits is necessary (particularly when the inter-operation with autonomous receiver is concerned), fitting mechanical characteristics of a device to actual wind conditions. The case of inter-operation with so called “stiff network” usually solves the problem of delivery of passive power output to the generator or it synchronization with the system. It does not solve, however, the problem of optimum use of device capacity, its efficiency, power output matching or ensuring the electric energy quality. The above issues are considered in context of power engineering operating systems that aim mainly at generation of current and/or voltage at required shape, course and value regardless the short- or long-lasting enforcement signal that is the wind in that case.

The Authors of this article have already published several other papers considering the suggestions on power engineering systems of wind power plants. However, all the systems presented there, as well as other power engineering systems known from professional publications, do net ensure the quality as it would be required by that energy producer. According to new Polish regulations, including those published in Law Journal No. 135, item 881, dated 22.10.1998, it is required to obtain e.g. the voltage distortion coefficient at connection terminals should not exceed 1,5% while the content of individual harmonics should not exceed 1% of basic harmonic component. The typical, most often used electronic systems of wind power plants have conventional converters installed (e.g. inverters), that negatively affect the stiff networks, i.e. they generate higher level harmonics of current. Those solutions make the wind power plant independent from the effects of changes in wind speed, enable stabile operation in a wide band of: cut in – cut out (switch ON speed – most often about 4-5 m/s, switch OFF speed – most often about 25 m/s), due to the european accordance i.e: IEC 1400-1 (Draft), DS.472, "Germanischer Lloyd Rules and regulations IV-Nonemarine Technology Part I –Wind Energy", NEN 6096/2

Wind turbines require active or passive regulation as power is derived from the free air stream which is, of course not contollable. Active control includes varying the pitch of the whole blades or blades tips. Passive control results from blade profiles that produce aerodynamic stall at high wind speeds without a change of blade pitch.

Regulation, achieved by controlling the power extracted by the rotor, is necessary since there is little opportunity to store excess energy within the turbine (although there is very short term storage in large machines due to inertia of the rotor and drive train, and small variations in rotor speed). The philosophy of turbine control is based on three operational requirements:

1. The generation of maximum power up to rated power
2. Satisfactory electrical power quality
3. The minimisation of variable and transient loads (especially fatigue inducing changing loads), thereby maximising turbine life

To achieve above presented requirements, in wind turbines are used below showed the regulation's methods:

- Stall regulation
- Active pitch regulation
- Load Control
- Yaw Control
- Aileron Control

The modern wind power plants apply solutions based on it; some of such solutions are listed below:

1. Two generators – one of the working at lower speeds and the other one at higher speed levels, this solution reducing the noise emission significantly
2. Two generators – working as described in 1., however the bigger generator operates at option of alternating pole pair number (at lower rotary speed the winding forms a triangle, and at higher speed – it form double star). That solution allows to reach nearly the same power output for both rotary speed values, $\Omega=\omega/p$, even if the motor's capacity is not used in full.
3. The change in slide – adjustment of generator's parameters (change in resistance).
4. The change in slide – adjustment of optimum power output of generator through modification of rotor's plate angle of attack.

The discussion and analysis of the above issues, presented partly in the publication: The Structure of Modern Wind Plants – a View of Vestas A/S Products (also printed in preprints of 4UEES), allows to conclude that the most effective solution seems to be the one described in item 4. That solution, known as OptiSlip®, has been developed, applied and patented by Danish Company VESTAS Scandinavian Wind Syatems A/S.

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