Hydrostatic Transmissions Used to Drive Electric Generators in Wind Power Plants

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Abstract: *The article presents the new trend of massive use of wind energy by its conversion into electrical energy, this being clean and sustainable energy; it also presents the wind power potential in Romania, as well as the evolution of this industry in our country and abroad. It presents some aspects of wind energy conversion into electricity and highlights the role and advantages of hydrostatic transmissions. In the end, it presents some achievements at global level, and also some research concerns in Romania regarding the promotion of hydrostatic transmissions in wind power plants.*

Keywords*: wind power, hydrostatic transmission, adaptive hydraulic transmission, fluid power transmission, renewable energy, power hydraulics, wind industry*

1. Introduction

Wind energy is a form of solar energy and that's because at the basis of its generation is the sun.
Wind energy is the energy of wind, a form of renewable energy [1]. In the current context, characterized by the alarming rise in pollution because of energy production by burning fossil fuels, is becoming increasingly important to reduce dependence on these fuels. Wind energy has already proven to be a very good solution to the global energy problem. Using renewable resources addresses not only energy production, but also, by particular way of production, it restates the development model, by decentralizing the electrical energy sources.
Yearly wind power potential amounts to about 260.000 TWh worldwide. Theoretically this potential exceeds by far the yearly global consumption of electricity [2]. This potential is **15 times higher than the world's current energy consumption** and 40 times higher than the world's current electricity consumption. Exploiting this potential of energy is limited by certain constraints or disadvantages.
Disadvantages of wind power are: relatively small energy concentration; energy concentration in a very limited timeframe; unpredictability.
The unpredictability of wind can make 20-25% of the total installed capacity to appear or disappear suddenly, which raises serious problems of management.
Advantages of wind power are: Does not generate greenhouse gases; Does not results in concentrated toxic and radioactive wastes; Does not consume fossil fuel; The cost comes down to return on investment and the maintenance; It is widespread geographically; Land immobilized by wind turbine is insignificant; Wind farms can vitalize rural economies by renting land and royalty fees.
In the last decade, a significant development had the onshore wind farms, Figure 1, and also the offshore ones, Figure 2.
Total installed wind capacity has increased by 2010, according to the diagram in Figure 3, and will increase until 2020 as in the diagram in Figure 4.
Demand for renewable energy sources has led to major technological breakthroughs in wind energy development. Therefore, a large number of new wind turbines installed worldwide in the past 20 years now offer new ways of generating electricity.
According to a report of **Wind Energy Association** cited by Reuters Agency, on June 11, 2011, China surpassed the USA, and, at global level, the largest producers of wind energy are: China (44.733 MW), USA (40.180 MW), Germany (27.215 MW), Spain (20.776 MW), India (13.065 MW), Italy (5.797 MW), France (5.560 MW), UK (5.203 MW), Canada (4.008 MW), Danmark (3.734 MW).

Fig. 1. Onshore wind farms

Fig. 2. Offshore wind farms

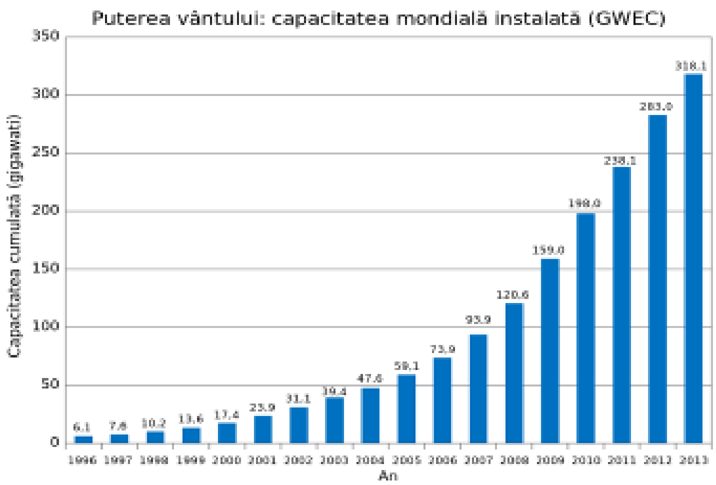

Fig. 3. Total installed wind capacity by 2010

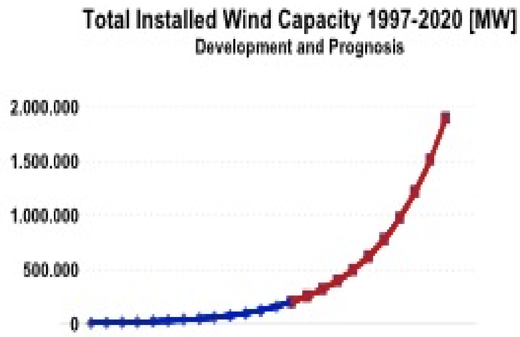

Fig. 4. Total installed wind capacity by 2020 - Prognosis

In Romania, wind turbines in the area of Constanta and Tulcea, Figure 5, have surpassed the capacity of **the Nuclear Power Pant** in Cernavoda, peaking at number 10 in the world, depending on the capacity of the wind farms commissioned, as shown by statistics published by the European Wind Energy Association. Currently Romania has installed wind farms of about 2100 MW, following investments of over 3 billion euro. [2]. In total, at this moment in Romania there are 25 large wind farms with a total capacity of nearly 1.900 MW. In addition to these large projects, there are a number of small size farms, which do not fall under the control of the national power dispatcher, their capacity being more than 200 MW, according to the data released by Transelectrica on 01.04.2013. The map of wind potential in Romania, with winds at 50 m height, is shown in Figure 5, while the map of usable wind speeds is shown in Figure 6.

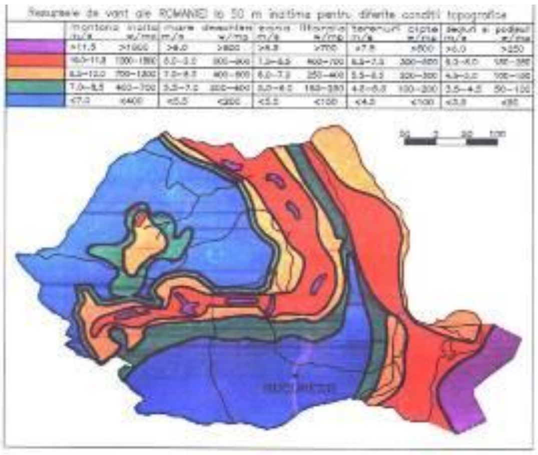

Fig. 5. The map of wind potential in Romania

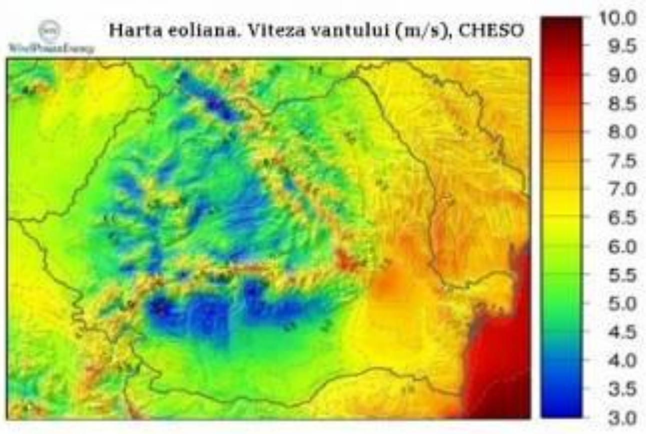

Fig. 6. The map of usable wind speeds

To produce enough electricity for a lot of people, power companies build "wind farms" with dozens of huge wind turbines. The wind farms are built in open plain areas, where the wind blows at minimum 14 miles per hour, Figure 7, but also in mountain areas, Figure 8.

Fig. 7. Wind farms in plain areas

Fig. 8. Wind farms in mountain areas

Wind potential is generally operated in areas with intense and constant wind, as the coastal areas of northwest Europe. Thus, large-scale wind turbines (500-1000 kW) have made remarkable progress in the last decade. A complementary orientation, with great expectations, is returning to small power wind turbines (<100 kW) integrated in decentralized/distributed applications, especially for rural areas with moderate winds. Compared with large wind turbines, small power wind turbines (SPWT) are more versatile and have a considerably higher technological development potential. In addition, SPWT, through its direct placement in areas of consumption, reduce energy losses due to energy transport from place of production to the user. [3]
Taking into consideration the wind power potential in Romania, the perspective for further development of great investments, and also of small-size wind power plants, special attention should be paid to rendering efficient the operation of these wind power plants.
To this goal research themes have been initaited, both in our country and abroad, which deepen and optimize various aspects of converting wind energy into electricity.

2. Aspects of converting wind energy into electrical energy

The kinetic energy of the wind is used to rotate some wind turbines which, through special mechanical transmission, actuate the electric generators, which are capable of converting the mechanical energy of the wind into electrical energy.
Conversion chain elements are of several types. However, some elements are always found in the conversion chain, such as a wind turbine, Figure 9, an electric generator, an interlocking device which achieves connecting the generator to the distribution network or to a remote load, Figure 10.

A major problem with these models is that variable rotational speed of the turbine requires a frequency converter to connect each turbine to the grid. Other issues include reliability problems with mechanical gearbox and with the weight of electric generator, due to increasing turbine size.

Fig. 9. A wind turbine

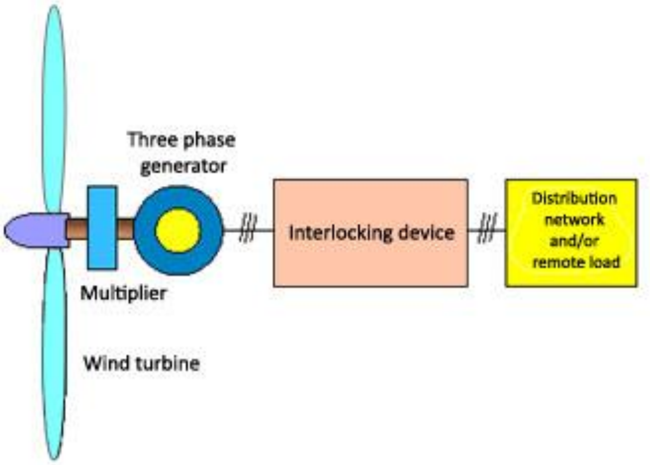

Fig. 10. Schematic wind power plant

Generally, for wind energy conversion into electrical energy there is used a mechanical transmission between the wind turbine and the electric generator; the common solutions consist in using one mechanical speed multiplier, with a high multiplying ratio, because these transmissions are difficult to manufacture, contain expensive components and generate high maintenance costs.
Essentially, for small power wind plants, to become profitable it is necessary to increase the rate of extraction of basic energy and conversion of it into electrical energy, even to the low speed of the wind, which is frequently in a large period of the year.
An important role in increasing the energy efficiency of the wind power plants is played by the type and performance of the transmissions used to allow mechanical energy from the wind turbine to reach, with appropriate parameters, at the electric generator, which, in turn, generates electricity with the desired frequency constant, regardless of the wind velocity in the range accepted to be good.

3. Hydrostatic transmissions used in wind power plants

One of the ways to increase the energy efficiency and also flexibility and elasticity in functioning, in the sense of increasing possibilities to adapt to variation in wind speed, or variation of rotation speed of the wind turbine, is the use of **hydrostatic transmissions**, which offers a number of advantages, as it will be seen below.
In principle, a hydrostatic transmission consists of a pump, which is driven by wind turbine, and a hydrostatic motor, which drives the generator, Figure 11. In reality, aiming at a maximum efficiency of energy capture is more complex because the wind speed is variable in a very wide range, Figure 12 .

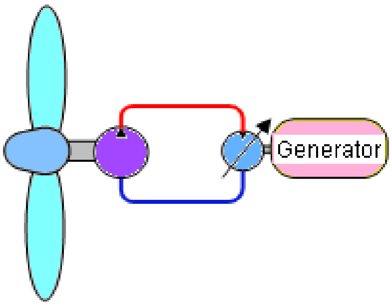

Fig 11. Principle hydrostatic transmission

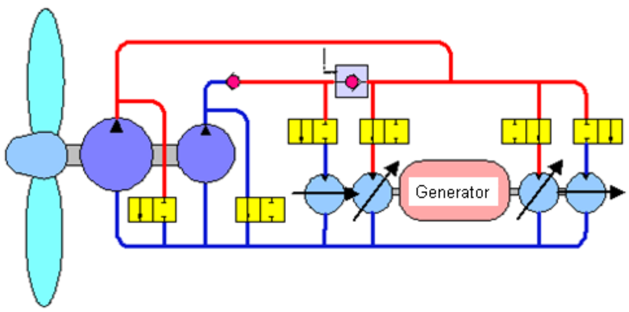

Fig. 12. Real hydrostatic transmission

Hydraulic transmission of wind energy to the ground is a research direction that we found in R-D programs related to renewable energy. Hydraulic transmission and driving included in the wind plant has all the advantages of hydraulic driving. Small power horizontal-axis wind turbines equipped with adaptive hydraulic transmissions can operate at variable speed. The adaptive hydraulic transmission allows adjustment of the outlet to the consumer demands (power or constant speed), without affecting the performance of the turbine. Adaptive hydraulic transmission requires a constant speed of the electric motor shaft during variations in pump speed at the hydraulic motor shaft. For the cases analyzed, it was found that the adaptive hydraulic transmission behaves like a stable system of damped oscillatory type with good dynamic performance [3].
Generally, for energy conversion and transmission, solutions with mechanical speed multiplier or the direct coupling between the turbine and the slow electric generator are adopted. These transmissions contain difficult to manufacture or expensive components: slow electric generator, gear transmissions, frequency converters etc.
Replacing the mechanical speed multiplier with a hydraulic transmission can lead to a more robust behaviour and competitive cost prices. If hydraulic transmission takes over also the speed multiplier function, the system can use series AC motors as electric generator.
In case of hydraulic transmission, the speed control can be achieved by adjusting the displacement of pump from hydrostatic transmission. The wide range of variation of power and speed impose the use of positive displacement hydraulic machines, respectively adjustable volume pumps. Hydraulic transmissions have a reduced gauge, a high power density, they allow a continuous and widely adjustment of the output mechanical parameters (are flexible) and offer the possibility to attach rotation speed and/or torque adaptive control systems into conversion subsystem [3].
At the designing of the hydraulic transmision, it is necessary to obtain a good dynamic behaviour, with a good safety and stability of the system in functioning.

4. Hydrostatic transmissions intended for wind power plants investigated worldwide

In the last period, a new concept, transferring the power via a hydrostatic drive train is supposed to combine good efficiency and grid stability with high reliability and low costs.
Institute for Fluid Power Drives and Controls (IFAS) of RWTH Aachen University, has developed a prototype of a hydrostatic transmission for wind energy plants of the 1-MW power class which is intended to replace the commonly used gearbox and the frequency converter. The idea is to use a slow turning pump that is directly connected to the turbine shaft to transfer the power into a high pressure oil flow and to use a hydrostatic motor that can convert this oil flow back into mechanical power to drive the generator. The high transmission ratio that is needed in a turbine can easily be achieved by the displacement ratio of pump and motor. By using a variable displacement motor the transmission ratio can be varied so that the generator can run at constant speed directly connected to the grid. [4]
The authors tell that one of the main requirements when dimensioning a transmission is a good efficiency at rated power as well as in partial load, where the turbine is operating most of the time. At the same time the rotor also influences the total power output, since the energy captured from the wind can be optimised by adjusting the rotation speed of the turbine to the actual wind situation.
Figure 13 shows a power and a torque plot of a three bladed rotor over wind speed and over rotation speed. It can be seen that to each wind speed a specific rotation speed maximises the captured power. At the same time these points of operation are not at maximum torque.

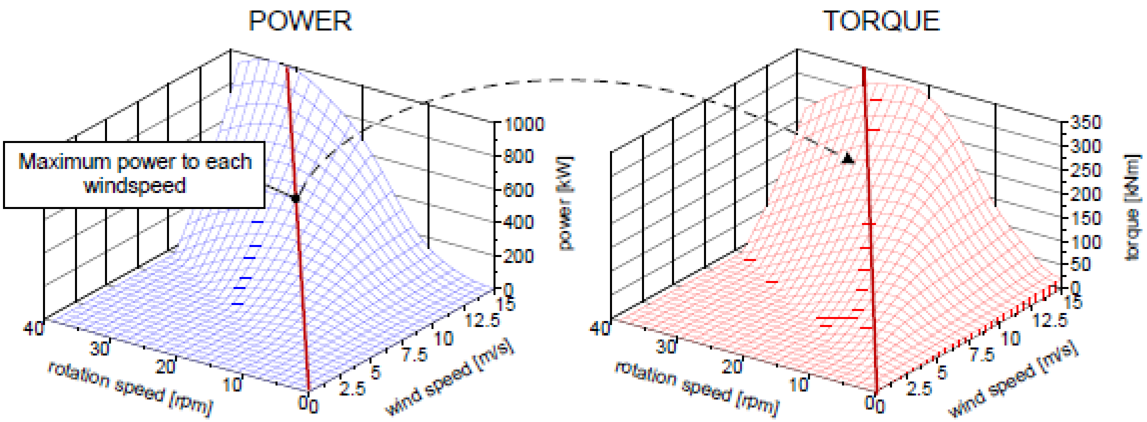

Fig. 13. Power and torque of a three bladed wind turbine

Optimal power production of a wind turbine is achieved by optimizing the drive train to the important points of operation and simultaneously using a control strategy leading to an operation in these points.

In order to optimize the efficiency, the authors have developed a great theoretical and experimental research. [5]

The authors have analyzed and evaluated different drive train concepts. Figure 4 summarizes the four main categories. The first concept consists of one pump directly driven by the turbine and one variable displacement motor mounted on the generator. Due to the wide power range such a transmission has to operate within, concept 2 uses two pumps and motors and thus can switch off single components in partial load. On the pump side this is done by connecting the high and low pressure side of one pump via a switching valve and thus setting this unit into idle mode. On the motor side, a single unit can be swiveled to zero displacement and cut off from high pressure to prevent leakage. In addition the affected generator can be switched off to prevent turning losses. Concept three also uses switchable pumps and motors but in a different way. To reduce the required pump displacement a spur gear is installed between the turbine shaft and the pump. Thus it is also simpler to connect multiple pumps to one single shaft. In contrast to concept two this configuration uses only one generator for both motors. Consequently all motors are rotating all the time even when a single motor is switched off. The fourth configuration is a power split transmission with one mechanical and one hydraulic path [5].

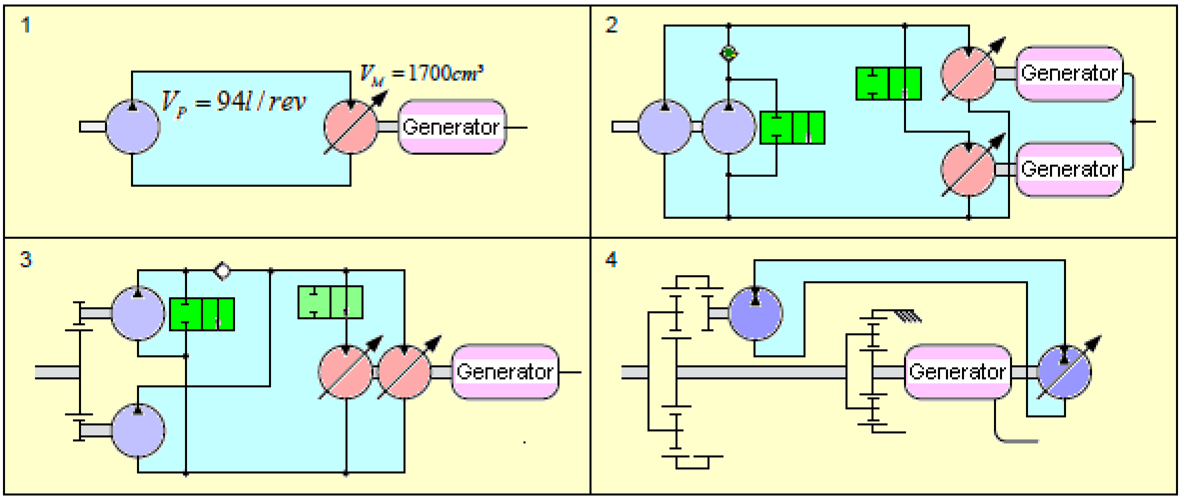

Fig. 14. Layout of four different concepts

In the Figure 15 is presented and compared the simulated overall efficiency of the four concepts. These values have been generated in simulations. At rated power (12 m/s wind speed) the full hydraulic concepts have nearly the same overall efficiency, since in this point of operation all components are activated and the total displacement of pumps and motors is the same. The power split concept 4 has a higher efficiency at full power because only about 45% of the rated power is transferred through the hydraulic path at this point. But, at the partial load the concepts differ substantially. [5]

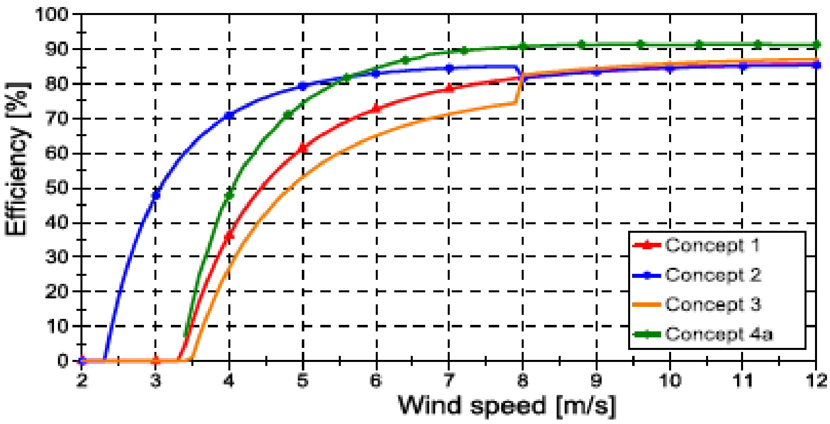

Fig.15. Overall efficiency of concept 1-4

In the following, the authors have studied different variants for the concept 4: Simple power split transmission (4a); Power split transmission with switchable hydraulic path (4b); Power split with two generators (4c) and Power split with reduced share of hydraulic power (4d). Finally, there are presented the results and is made a comparison of presented concepts.
There have been compared the various new concepts using split path technology with previous results of fully hydrostatic transmissions from which it can be seen that the overall efficiency could be improved especially at partial load. Compared to a fully hydrostatic drive train the split path concepts are beneficial but at the same time have a much higher complexity. In addition, the drive train is not completely decoupled as in a fully hydrostatic system. Before selecting a drive train for a wind turbine at a specific site two additional aspects have to be considered. First of all, each concept needs to be evaluated not only for the optimal point of the turbine but in all possible points of operation. Secondly dynamic loads have to be included since the transition between different points of operation is also relevant for the total power output.

5. Hydrostatic transmissions investigated in Netherlands

A very interesting solution for a hydrostatic transmission used in wind plant has been developed in Netherlands, in Delft University of Technology, Offshore Engineering Section, for the drive train of offshore wind turbines. The Delft Offshore Turbine (DOT) concept for the drive train of offshore wind turbines is to have the rotor shaft directly coupled to an oil-hydraulic pump in the nacelle. The hydraulic motor is located at the base of the turbine tower, where it is coupled to a seawater-hydraulic pump. The pressurized flow of seawater from each turbine converges to a hydro-power-like generator station where it is converted to electricity using Pelton turbines. All related studies and experiments until now have confirmed the technical feasibility and economic potential of this technology. [6]
The approach is to re-evaluate the way in which wind energy offshore is converted to electricity onshore. The project's defining research line is the re-assessment of the power conversion and wind energy power conversion & transmission technology is complex, heavy, and expensive and requires frequent maintenance. In any industry where robust machinery is required to handle large torques, the hydraulic drive systems are a common choice. It is therefore almost the obvious

solution for wind turbines. The design of the DOT power transmission system consists of two hydraulic circuits: a closed oil circuit and an open seawater circuit. The first runs from the shaft of the aerodynamic rotor to the base of the turbine. From here, the second circuit runs to the generator station.
The goal of the DOT demonstrator is to show-case this hydraulic power transmission system in a real turbine offshore using off-the-shelf components.
The focus of the project so far is on the power transmission system. An overview of the DOT transmission concept is given in Figure 16.

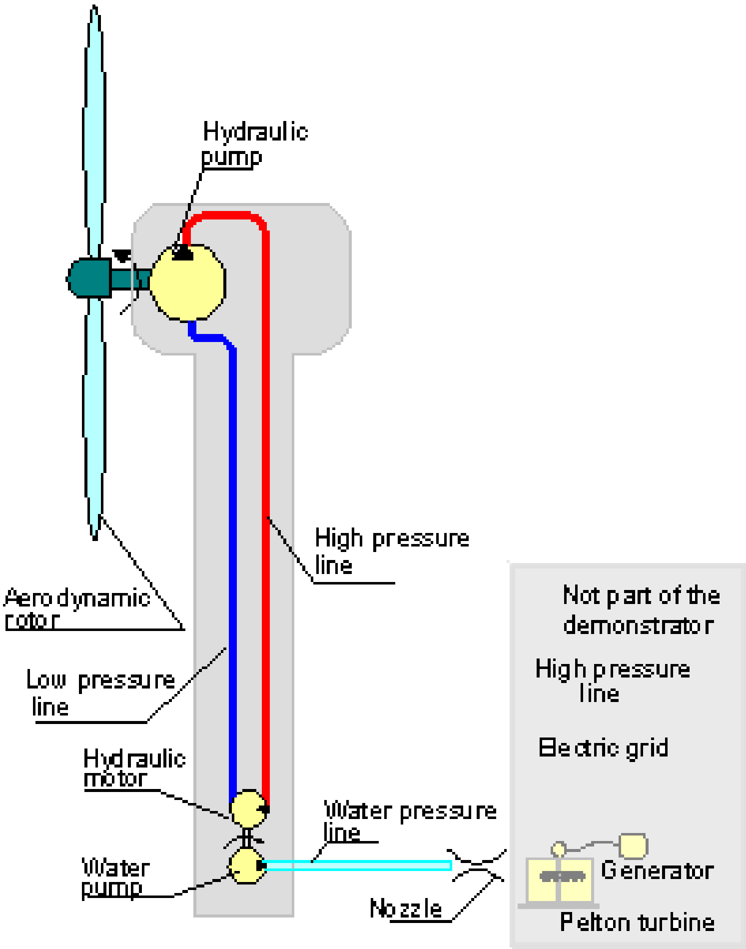

Fig. 16. DOT transmission concept

The energy conversion process from wind to electricity is radically different from conventional techniques. Recognizing the potential of fluid power transmission for wind turbines, the DOT pushes this idea one step further to fluid power transmission for offshore wind farms, with centralized electricity production and seawater as hydraulic fluid.
The energy in the seawater from multiple turbines is thus relayed to one station where it is converted to electricity, see Figure 17, where is presented the Artist impression of the DOT transmission concept.
This idea was invented and patented by Jan van der Tempel. (Van der Tempel, J. Energy extraction system, has water pump attached to rotor, windmill for pumping water from sea, water system connected to water pump, for passing water pumped from sea, and generator connected to water system, December 2009.), [6].

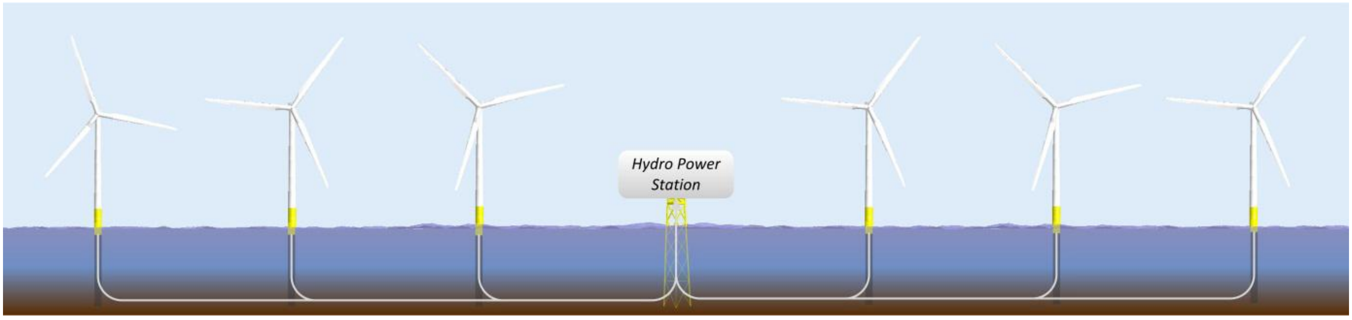

Fig.17. Farm of seawater turbines

The simplified hydraulic diagram of the DOT demonstrator is presented in Figure 18.

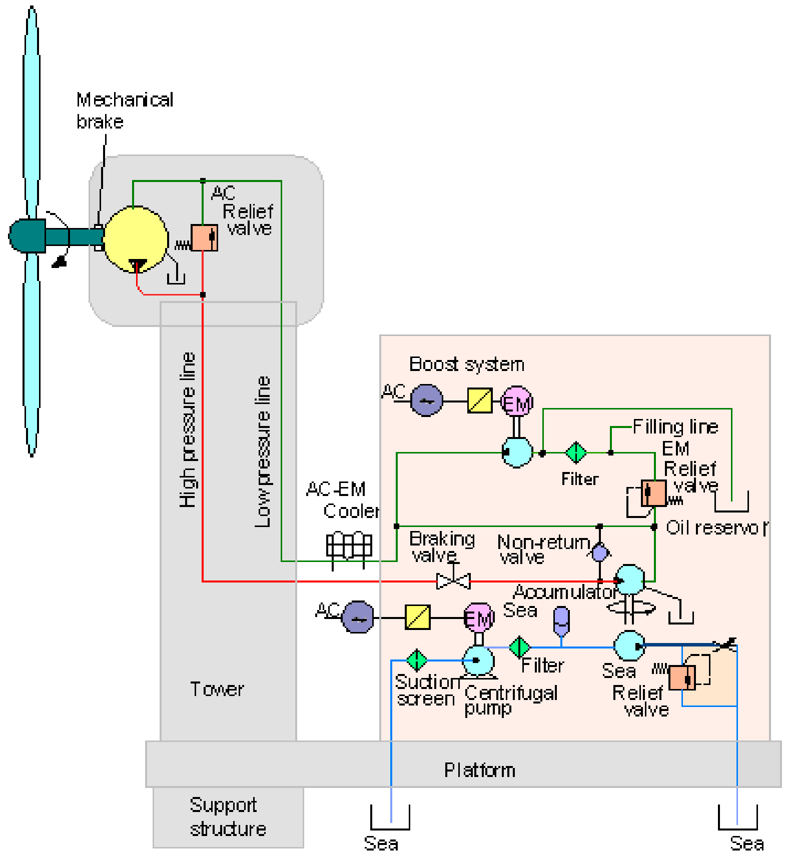

Fig. 18. Simplified hydraulic diagram of the DOT demonstrator

The only drive train component located in the nacelle is a directly driven positive displacement pump. A single pipe will transport seawater from each turbine to the generator platform. This gives the wind farm an open-circuit seawater-based power transmission system.
The goal is to use as few components and as little software as possible in order to simplify assembly and functionality, and reduce installation and maintenance requirements. In recent years mathematical models of fluid power transmission systems in wind turbines were developed and validated at the TU Delft.

Laboratory experiments were successfully carried out at scales of 600W (validation of control method with water hydraulics & rotor in wind tunnel) and 10kW (coupled oil and water circuits). Another set of experiments was carried out using the 1MW test rig (oil) at the Institute for Fluid Power Drives and Controls (IFAS) at RWTH Aachen University. **The main idea** of a variable speed wind turbine is that in order to operate at maximum aerodynamic performance, the rotor should be able to operate with a constant tip speed ratio where the maximum power coefficient is achieved for the required range of wind speeds. [6]
The main functional requirements of the Power Transmission System of a Single DOT were defined for the rotor & transmission:
• The aerodynamic rotor should operate at or close to max aero efficiency below rated wind speed.
• The fluid power transmission system should operate with energy efficiency of > 70% between the rotor shaft and the jet. • Peaks detected in the aerodynamic torque due to tower shadow or turbulence should not be visible from readings at the nozzle. • Safety: redundancy in shutting down capabilities.
Long lines of pipes allow the heat to dissipate via convection and radiation. By using the intake of the open seawater circuit as a source of cooling, the required capacity is decreased.
The seawater hydraulic pump is not self-priming. Thus the pressure needs to be boosted to secure the flow to the pump. The foreseen method to be applied for this is to have an integrated boost and filter system. An electrically driven German centrifugal pump sucks in seawater through an initial filter known as a suction screen. The flow then enters a filter system, after which it reaches the pump.
In Figure 18 can be seen: the Container TowerNacelle; AC Relief valve platform; Oil reservoir; Filling line; Sea Relief valve; Boost system; EM Relief valve; Non-return valve; Suction screen; Sea accumulator; Mechanical brake; Spear valve; Centrifugal pump; Braking valve high pressure line; low pressure line filter; AC EM cooler filter; Support structure.

The design constraints are based on properties of state-of-the-art off-the-shelf components. The properties that define the design values are 1. the maximum allowable tip speed of the blades (70 m/s), which sets the limit for the rotation speed of the aerodynamic rotor (25 rev/min), (2) the nominal pressure in the oil (350 bar) and water hydraulic circuits (415 bar), (3) the nominal rotation speed of the hydraulic motor (1800 rpm).
The relevant dimensions of the main components of the power transmission system, for the 500kW demonstrator, are given in Table 1.

TABLE 1: Design parameters for the 500kW demonstrator

Parameter	Value	Unit	Note
Radial pump volumetric displacement	52.8	L/rev	based on Hägglunds CBP 840
Hydraulic motor volumetric displacement	0.625	L/rev	based on Bosch-Rexroth hydraulic motors (500cc+125cc)
Seawater high-pressure pump volumetric displacement	0.489	L/rev	based on Hydrowatt pump R250/250
Nozzle diameter	7.7	mm	Adjustable nozzle through the spear valve

All properties of the radial piston pump are taken from the Hägglunds CBP840 hydraulic motor. A charge pressure of 15 bar is used for both oil pump and motor.
The operational envelope of the hydraulic transmission from rotor to nozzle is obtained as a function of the pump rotational speed, see Figure 19 and Figure 20. The possible operational area is shown as a shaded area based on the minimum and maximum nozzle diameter which allows staying within the design limits of power, pressure and speed. In terms of **power transmission efficiency** it is observed in Figure 20 that a significant part of the operational envelope has efficiencies above 60% and around 82% at rated conditions. For lower rotational speeds the efficiency is relatively low, however the selection of a rotor should be done in a way in which the lower rotational speeds correspond to the wind speeds with lower energy content and probability of occurrence.

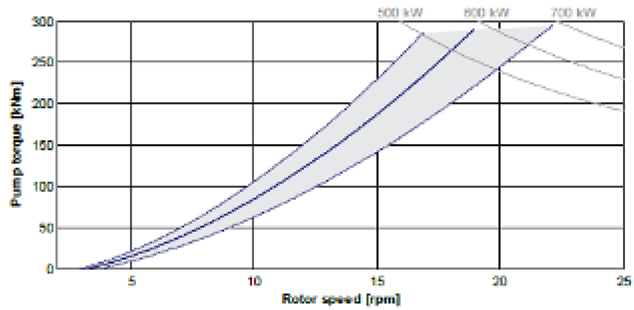

Fig. 19. Torque-speed envelope of the fluid power transmission

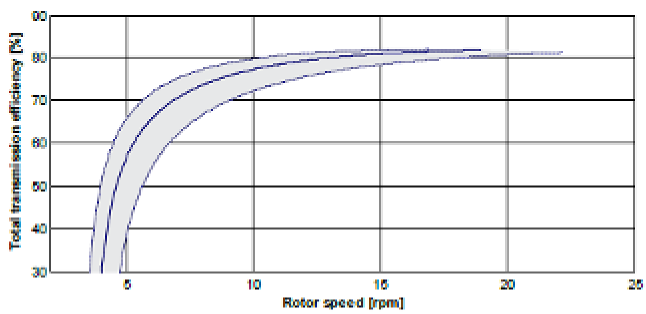

Fig. 20. Operational efficiency of the power transmission

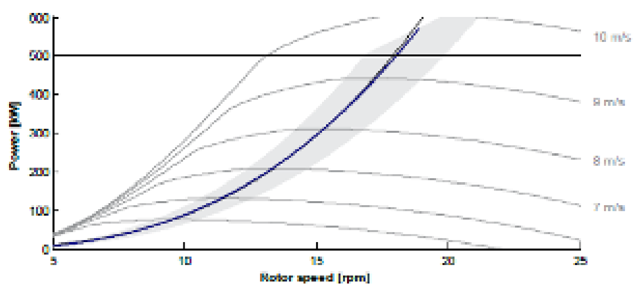

Fig. 21. Power speed curve for a rotor of 30m radius

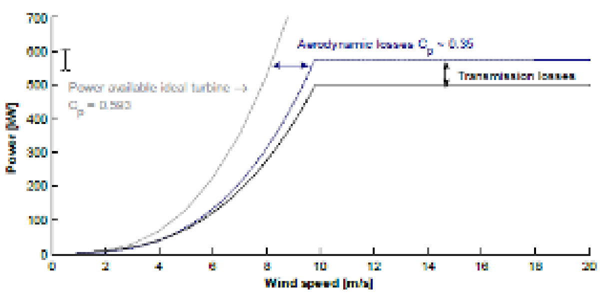

Fig. 22. Power curve example for the 500kW DOT demonstrator

In order to illustrate the overall performance of the DOT demonstrator, it is assumed that a three bladed rotor with a radius of 30m is available and coupled to the transmission. The rotor is assumed to have an optimal tip speed ratio of 6 with a resulting power coefficient of 0.35. The result of matching the rotor and power transmission envelope is seen in Figure 21. The power curve shows the effective power transmitted via the nozzle for different operational wind speeds, see Figure 22.
The power transmission efficiency is dependent on the properties of the main transmission components which are derived from current state-of-the art components.
Based on simulation results, it is shown that a hydraulic transmission provides a damped response of torque and transmitted power while keeping operational parameters within design limits.
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5. Hydrostatic transmissions investigated in ROMANIA

In our country, have been developed several technical solutions for wind turbines, under various national research programmes. [3]
Some of these wind concepts, were investigated both theoretically, through mathematical modeling and numerical simulation on the computer, and experimentally, through conducting laboratory tests, where have been performed phisical measurements done by acquiring data, subsequently stored and processed by computer.
Such research activities has been conducted in technical universities of Bucharest, Iasi, Cluj-Napoca, Timisoara, Craiova and Constanta.

5.1. Adaptive hydraulic transmission for small wind power plant

The Department of Fluid Mechanics of „Gheorghe Asachi" Technical University in Iasi together with Hydraulics and Pneumatics Research Institute INOE2000-IHP in Bucharest have developed a concept for an adaptive hydraulic transmission for small wind power turbine, and also a test stand [3].
The adaptive hydraulic transmission is based on specific operation elements of a wind turbine under variable wind speed and variable load at user. The realized experimental stand allows the testing of hydraulic transmission behaviour at turbine shaft speed variation (due to changes in wind speed) and at hydraulic motor shaft load variation.

5.1.1. The concept of adaptive hydraulic transmission for small wind power plant

The block diagram for the adaptive hydraulic transmission designed for low power horizontal-axis wind turbines is shown in Figure 23.
Wind turbine ***WT*** transforms aeraulic power (wind speed *v*) in mechanical power with parameters *ω1* (angular velocity) and *M1* (moment). The pump with adjustable unit volume ***PAV*** transforms mechanical power into hydraulic power with parameters *Q* (flow) and *p* (pressure). The hydraulic motor ***HM*** transforms hydraulic power into mechanical power transmitted to load ***L***. The feedback loop includes speed transducer ***ST*** which gives signal *Uω*. This is compared with reference value *Ur*. At the outlet of the regulator ***R*** results the command value *c*. The servomechanism ***SVM*** transforms the command value into an execution value *m,* which acts on the pump flow control elements ***PAV***. In the absence of the feedback loop, changes in wind speed *v* will increase pump speed, pump flow and therefore the drive speed of load *S* as well. Similarly, load variation leads to a decrease in motor speed.
The feedback loop, which depends on the value of the engine speed *MHR*, allows maintaining a constant speed imposed by the reference value *Ur* on the hydraulic motor shaft, under variations of

both the wind speed and the load *S*. The adaptive system allows adjustment of two disruptive values: wind speed *v* and load *S* variation on the engine.

5.1.2. The test stand

In order to simulate the working conditions of an adaptive hydraulic transmission designed for small wind power, we have developed a test stand with the configuration shown in Figure 23. A general view of test stand can be seen in Figure 24, where are presented the load module, the closed circuit module, the control panel and the frequency converter.

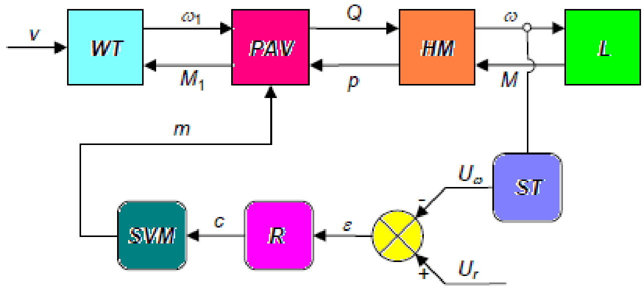

Figure 23. Block diagram of the adaptive hydraulic transmission system

Fig. 24. General view of test stand

The transmission module includes the pump with adjustable unit volume /flow ***PAV*** and the hydraulic motor ***HM***, connected in closed circuit. ***PAV*** is a double pump unit and is composed of a main unit with adjustable volume (flow) and a unit with constant flow that allows the compensation of hydraulic losses and the command of actuator in order to change the geometric volume. The pump ***PAV*** feeds the non-adjustable rotary hydraulic motor ***HM*** which, in real system, either drives an electric generator or a load of mechanical nature ***L***, through its shaft. In the test stand, the simulation of hydraulic rotary motor shaft load is achieved by the loading module, which consists of another hydraulic pump.
An important component of experimental stand is the automatic control loop, shown as block diagram in Figure 25.

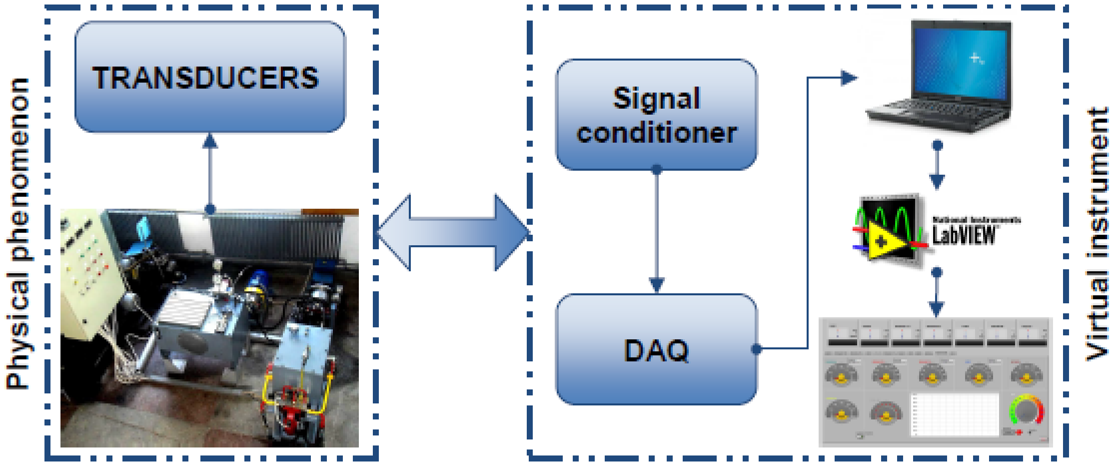

Fig. 25. Block diagram of automatic control loop

The transducers receive the physical phenomenon and convert physical parameters (pressure, flow etc.) in a unified type parameter, mainly voltage, the resulting signal being proportional to the variation of monitored parameters.

Conditioning modules transform electrical signals generated by transducers in a form that the DAQ (data acquisition) board can accept.
Acquisition board converts the electrical signals through its basic component: the analog-digital signal converter. A numerical value is attached to each voltage supplied by transducers, thus allowing interpretation of physical values by computing systems.
A lot of experimental tests have been made and there have been obtained a series of graphical variations for the main parameters of the system, presented in [3].
Experimental research has been conducted for a constant torque at the shaft of the rotary hydraulic motor, simultaneously with imposing the condition of constant rotation speed.

6. Conclusions

In the article were presented, first, some general data on the new technology of wind energy use in order to produce electricity, advantages and disadvantages of wind energy, wind potential in Romania, and the development of this technology worldwide.
We then presented a number of specific issues concerning the conversion of wind energy into electricity, emphasizing the important role of intermediate transmissions between wind turbine itself and the electric generator itself, showing that one of the ways to increase energy efficiency is the use of hydrostatic transmissions.
There were presented the principles underlying the hydrostatic transmissions for wind turbines and were presented a series of concrete achievements both globally as well as in Romania, which have shown their advantages in adapting variable speed rates of wind turbine and control of constant speed to the electric generator.
Research on hydrostatic transmissions in wind power plants will continue in order to optimize the schematic diagrams and the ways for controlling the speed of the generator.

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