CONFERENCE PUBLICATION

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SYMPOSIUM AND DEMONSTRATION OF THE USE OF WIND ENERGY IN ROMANIA

TIMIȘOARA
3-6 May 1992

SDuWE

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Calea Martirilor 1 Timişoara,phone:96.162865
fax: 96.162495

Assistant editor and cover:Sanda Lăzărescu,Timişoara
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The geographic space, the Earth vital environment, is the cover in which as said the great Romanian geographer Simion Mehedinţi-"there are interfered the highest forms of energy". We are therefore absorbed in an "ocean of energy" and however the mankind feels increasingly the effect of the lack of energy. We inherit a huge storage in which the nature has accumulated in thousand millions years important reserves of "energetical concentrates" and the energy thirst is still felt more and more.

Though we live, in the same time, in a world in which divine laws demonstrate us, at each step, the nature's perfection to obtain with a minimum of energy a maximum efficiency-the human being representing the most evident model-the energy dissipation dominated by "thermodynamical measures" received impressing dimensions. And the phenomenon has become the more dramatic as the residues of energy consumption are not only poisoning the environment but also degrade its structure and its "functionality".

That is why we can say, for this moment, that the most evident proof of the human mind skill, of its ecological common-sense(we can say also anything of the kind !)consists in directing its attention towards other energy generating " fields". And among these, that of the "air rivers" is not to be ignored. Certainly, the wind energy will not become the miracle solution, but, where it exists it will be able, locally but efficiently, to demonstrate the human competence to find the connection means to nature "functionality" sense. It isn't a fantasy but an imperative of the ecological consciousness.

MINISTER SECRETARY OF STATE
UNIVERSITY EDUCATION DEPARTMENT
Prof.Dr.Alexandru Roşu

In the primitive man's cave the wind probably seemed to be the most terrible force of nature. The ancient Greeks placed the god EOLUS over the earth and waters. In Arabia the Europeans met, especially by the crusaders, the taming of the god in the form of windmills and, when they came back home they had the ingenuity of using them in other climatic conditions. Although on the sea the wind energy lay at the basis of the great geographical discoveries whose 500th anniversary we celebrate this year-the discovery of America-, on the land the wind - mill represented for some only the illusion of a famous hidalgo. In fact, the wind is the movement of the air under the action of the sun, but, unlike the water movement, for example, the wind can come from anywhere, towards anything and in any direction.

The big wind constructions in California, Great Britain, Danemark, have opened new possibilities for the use of an inexhaustible energy. 49,000 towers with aerodynamic orientable helixes, tens and hundreds of installed megawatts, rural power stations have changed the image don Quijotte was looking at, seeing only a huge army.

The Ecological University has proposed the organization of this International Conference in order to find a new dimension of the alternative energies in the countries situated in the Carpathian-Danubian area.

We wish to thank R.E.C. who has appreciated and materially supported the project. We have found in Romania many passionate researchers in the field of wind energy, at HIDROTIM S.A. Timişoara, at ISPIF Bucharest, at the Universities of Braşov, Bucharest and Timişoara, as well as interesting results in the neighbouring countries.

We wish the Conference a great success in the development of new ideas for the use of wind energy-ecological and unendless at the same time.

RECTOR OF THE ECOLOGICAL UNIVERSITY
BUCHAREST, ROMANIA
Prof.Dr.eng.Dolphi Drimer

The energy resulted from the wind blowing on the Earth day by day and year by year is available for all the nations which have the wisdom and competence to catch and use it.

Different from the fossil fuel,especially oil,with finite reserves,the wind energy will be available as long as the sun shines,this source is inexhaustible,efficient as price,and can be used applying the existing technology.

Globally,the wind energy is constant from one year to another and although its distribution on the planet varies from one season to another and from one year to another,its total value is invariable,allowing long-standing programmes.

The wind energy is clean,generates electricity directly,does not pollute, does not require cooling water,does not produce heat,and offers an alternative to the high cost and transportation of the conventional fuel.

No country or region of the world can monopolize this energy source, there is no cartel which could control the wind distribution and it does not require hard currency for importation as it is indigenous.

Despite its simplicity and existence since the days of the ancient Greeks,the large-scale commercial exploitation of wind energy is quite recent.

Rather little is known about the wind regarding the parameters,economic aspects,choice of machines and their calculation,control of performances,some aspects connected to the environment.

The optimistic prospects for the wind energy use,resulted from the development of research and technologies in the E.E.C countries and USA have determined the drawing up of special research programmes at national level,in many countries,among which Romania,which should lead to a deeper knowledge in this field,both from the technical-scientific and economic point of view,aiming at the achievement of wind generators which should allow the exploitation of this national energy source at the highest parameters.

The organization of this Symposium in Timişoara is the result of the concern of the specialists from this part of Romania and of the successes obtained up to now in the research,designing and implementation of wind generators.

We appreciate the exchange of information between the specialists grouped in the Romanian Wind Energy Association(ROWEA),a professional, autonomous,non-governmental and apolitical association,whose aim is to support and encourage the promotion of wind energy in Romania,and other specialists in this field from Europe,to be extremely useful for the promotion at a greater extent of this non-polluting energy source in the Central and Eastern Europe too.

I wish to thank the organizers of this Symposium-the Ecological University of Bucharest,the collaborators who have supported it,especially REC (Regional Environmental Center for Central and Eastern Europe) for funds and technical assistance.

Dr.Eng.A.Anghel
Technical Manager-HIDROTIM S.A.

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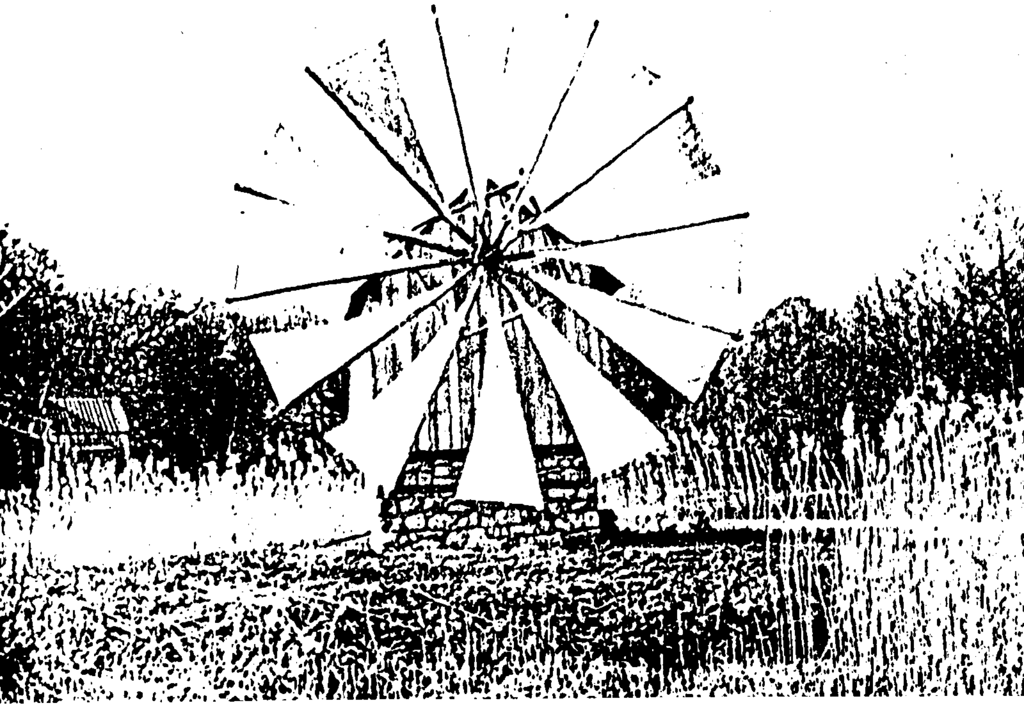


DEVELOPMENT OF THE CONCEPTION AND FABRICATION OF HORIZONTAL AXIS WIND GENERATORS IN ROMANIA

Dr.eng.A.Anghel-Technical Director HIDROTIM S.A. Timişoara,eng.C.Ghiţulescu-Senior Research Worker HIDROTIM S.A. Timişoara,Romania

1.INTRODUCTION

The use of wind energy has been also reconsidered in Romania with the come back,in the international technical society,of the interest in the activities in this field,after the seventies,following the first oil crisis.

Romania has an important wind energy potential,its weight being concentrated in the mountain area and the Black Sea coast.In these two areas with high wind energy potential,the working time of wind generators can achieve between 2000 and 3000 hours yearly.

If we refer to the whole area of Romania,the installed power of the wind power stations and small-sized autonomous wind generators,can attain 2500-3000 MW,representing 10-15% of the whole power of the present energetic system.

Romania has the technical,human and industrial potential to develop this energy source,which can be taken over profitably through a reasonable cooperation with the hydroelectric power stations,by the National Energetic System.In order to fulfill this very important energetic objective,two programmes have been conceived:a-research programme testing of solutions and component equipments of the wind machines b-programmes,for achievement of industrial pilots(demonstration programme)

2.RESEARCH PROGRAMME

In its first stage,the research programme comprises the achievement of experimental models for operation in isolated grid,in the power range of5-10 kW and of experimental models in the power range of30;5o;300 kW, connected to the National Energetic System.The programme is extended to 500 kW power.

In the carrying out of this programme there have been involved research,designing,execution and erection teams from HIDROTIM S.A. Timişoara,ICEMENERG Bucharest,the Technical University of Timişoara, EOL Tîrgu-Mureş,CMB S.A. Bocşa,Electromontaj Timişoara.

The tests on components and systems,including rotor blading and wind generators,have been performed in the laboratories of HIDROTIM S.A.,Timişoara,the Technical University of Timişoara and the sites in Timişoara,Moraviţa,Sibioara and Semenic.

The experimental model with 5 kW power presented in Fig.1,operates in an isolated grid.The machine has a three-blade rotor,5m in diameter, and a synchronous generator.

The blades being fixed,the power adjustment is made modifying the generator excitation and limiting the power captured by the rotor, through the blade aerodynamics.

The machine is controlled by the electric generator speed,which varies between 740 and 4300 rpm, speed resulting from the wind turbine rotor through the multiplier, having a transmission ratio of 13. Protection against overspeed is assured by a centrifugal brake.

Figure 1.
Experimental model 5 kW

The solutions adopted for the 30 kW experimental model,Figure 2.,conceived to deliver energy in the National Energetic System,consists of a 10 m diameter rotor,with two adjustable blades, 128 rpm speed, a planetary multiplier with transmission ratio of 16,asynchronous generator with 1500 rpm speed,operating in oversynchronous state,with or without oversynchronous cascade.The machine is provided with a centrifugal relay for brake actuating in case of overspeed.The adjustment of rotor input power is made changing the blade pitch angle with a hydraulic driving system.

The orientation on the wind direction is made with an el.mechanic system controlled by the wind direction transducer.The operation of the wind machine is controlled by a processing computer which receives information about the wind speed, rotor speed,generator speed,blade angle,and from centrifugal protection relay.The operating range of the wind turbine is at wind speeds of 4-28 m/s.

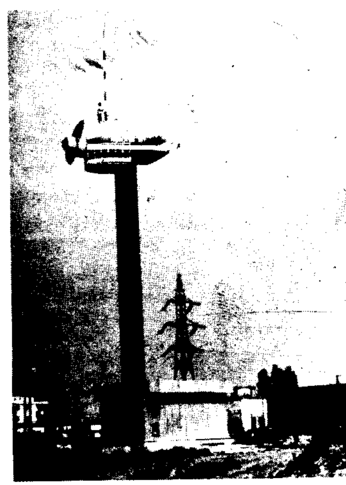
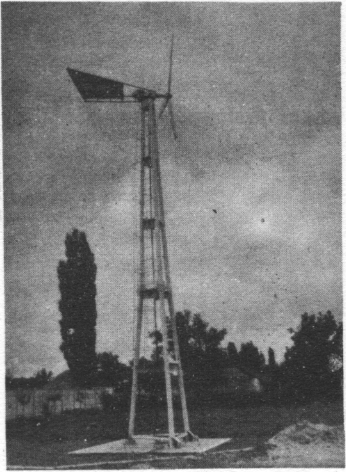
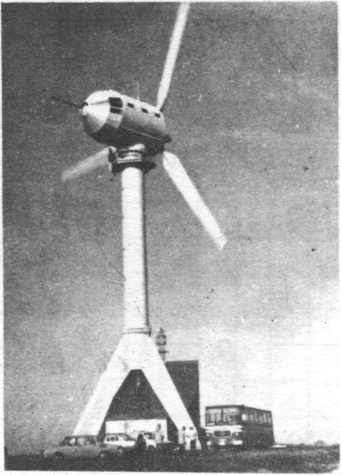


Figure 2.
Experimental model 30 kW

The two-blade rotor can operate for making tests,in up wind or down wind position to tower.The 300 kW experimental model,Fig.3,conceived





to operate connected to the grid (system) has two generators operating in oversynchronous state.

The main characteristics of the model are:rotor diameter 30m,speed 50 rpm, cylindrical multiplier with transmission ratio 31,two asynchronous generators of 55 kW and 275 kW power, control system,processing computer.

The rotor,down wind to the tower,is provided with three adjustable blades,driven,in this case,by an electromechanic mechanism.The diagram and componence of the mechanical assembly of the machine results from Figure 4.

The belt transmission assures the driving of the small size 55 kW generator,which delivers at the lower limit of the wind speed variation range.The machine operates in the range of wind speeds: 3.5-32 m/s.

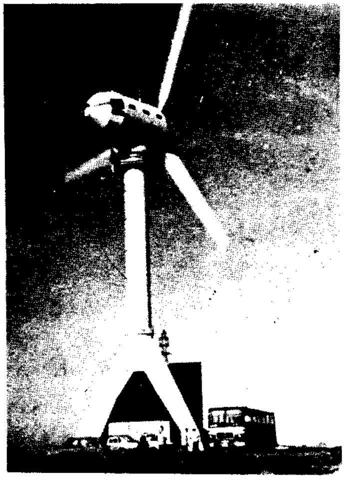


Figure 3.
Experimental model 300 kW

The unit is erected at Semenic site (mountain area in the western part of Romania)and it is in the stage of operation and testing,from the beginning of 1990.

The realization of these three experimental models of wind turbines: 5 kW,30 kW and 300 kW is considered as an experiment stage for the solution which will be adopted in the development of the industrial unit.

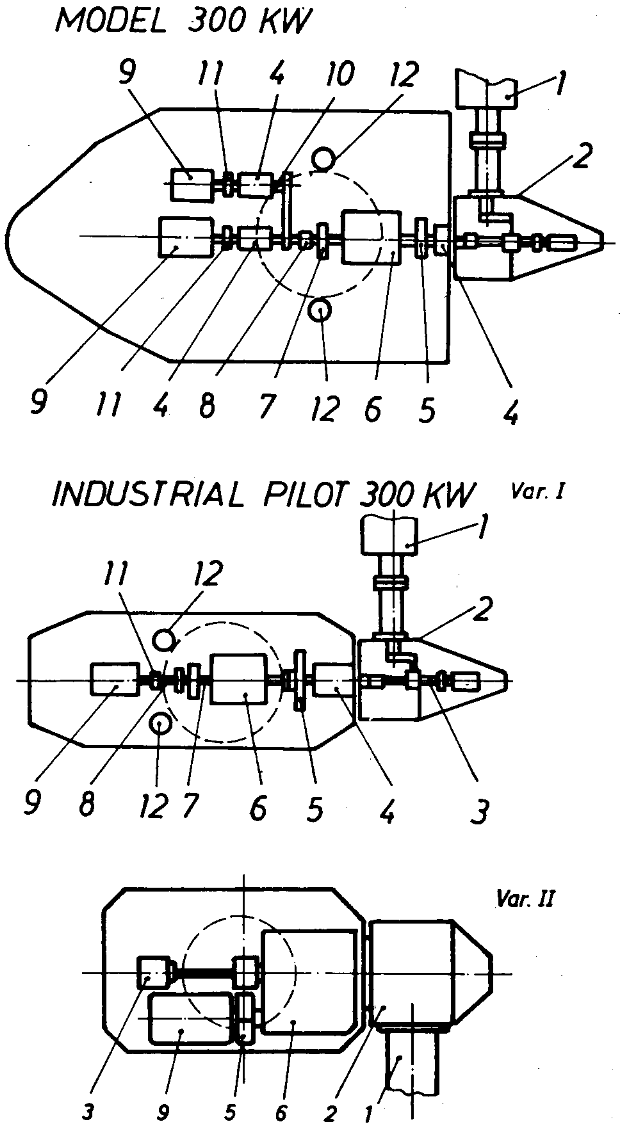
These models were conceived pursuing large testing possibilities for a great diversity range of solutions(rotor aerodynamics,mechanical, electric and control system solutions)their achievement being not limited by economic or cost criteria.

3. INDUSTRIAL PILOTS

Based on the experience acquired in the design,fabrication,shop testing, field testing and operation of these experimental three models,the solutions 5 kW,10 kW,3o kW,50 kW and 300 kW for industrial pilots,were conceived.

Of these,we present solutions adopted for the 300 kW wind machine,which is now in erection stage,on the Semenic site.This wind turbine is part of a series of ten units which will equip the future wind power station in Romania,with a power of 300 kW.

According to the wind speed variation range at the characteristic:power wind velocity,from Figure 5.



1.Blade;2.Hub;3.Blade control mechanism;4.Bearing;5.Emergency brake; 6.Multiplier;7.Operational brake;8.Torsiometric coupling;9.Generator; 10.Belt transmission;11.Electromagnetic coupling;12.Yawing mechanism.

Figure 4.-Aggregates components

The industrial pilot conceived to deliver energy in the National Energetic System is equipped with a single generator,which operates in oversynchronous regime.

The rotor up wind of tower is equipped with three adjustable blades,driven by an electromechanical mechanism.The aggregate's parameters and componence result from Table 1 and Fig.4 and 6.

On the basis of the experience accumulated by HIDROTIM S.A. regarding the assimilation of the conception of 300 kW wind generators from fig.4,we present the general evolution of this unit.In comparison with variant I EOLTIM 3/3 and variant II EOLTIM 3/5,the following improvements have been made:
The unit rotor is directly coupled to the multiplier which is dimensioned so as to fully take over the forces resulted from the rotor.By adopting the solution with multiplier hollow shaft,the operating system of the rotor blade adjusting mechanism could be located in the nacelle as compared to the solution with location in the ogive,as in variant I,with the resulting advantages regarding the access for interventions and repairs.

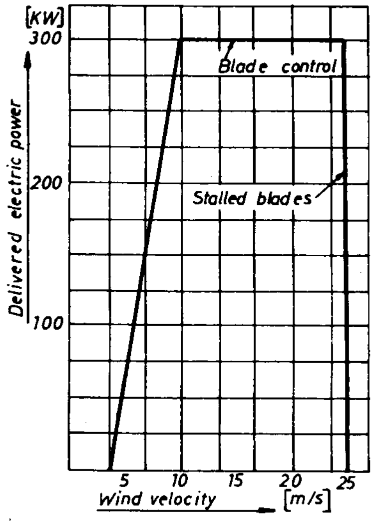


Fig.5
Power diagram

Inside the hollow shaft the threaded rod is mounted,which drives off the rotor adjusting mechanism.

When the rated speed is exceeded due to emergency situations(disconnection from the network, etc.)by automatic uncoupling of the driving motor, the turbine rotor automatically brings the blades in out of wind position,byits direction of rotation and locked threaded rod.

By introducing a specially conceived mechanical coupling inside the multiplier mounted on the outgoing shaft,the electric generator is automatically disconnected when the wind speed decreases below the operating value in generator conditions.In this situation,the generator being connected to the network,works as a motor.When the wind speed, and the rotor power respectively,increase ,the motor automatically shifts to generator condition.

The electric equipment fully differs from the solution adopted for the EOLTIM 3/3 unit(variant I)which is of logical type with relays by introducing the control and monitoring system with programmable logic controller(type Texas Instruments).In this case almost all the electric equipment is located at the tower base.

The new solutions have led to the achievement of a compact nacelle with effects on the general solution of the unit,resulted from fig.6.

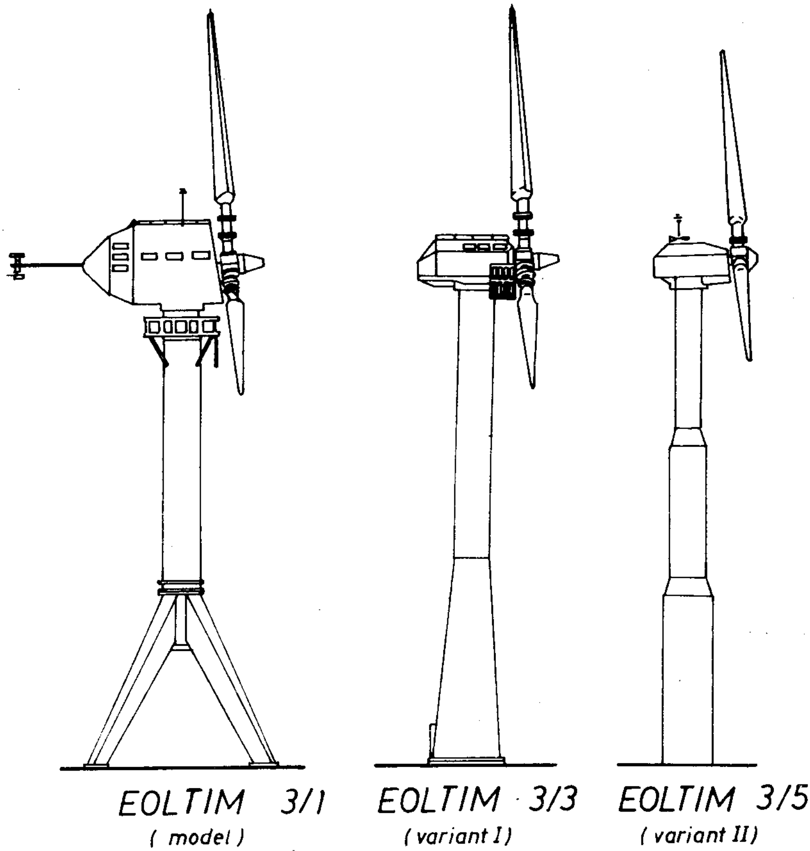


Figure 6.-General solutions

The better knowledge-as a result of the tests performed on model units-of the loads resulted from wind and blade and equipment weight,the value of vibrations and deflections,the adoption of modern calculation methods and the experience in the process of fabrication and erection have led to new solutions for the supporting tower.

Thus for EOLTIM 3/5 unit (variant II)there has been adopted the solution of the tower built of 3 cylindrical sections,joined by flanges and bolts.

All these improvements in the conception of wind generators have led to the possibility of building them at competitive economic parameters, with important effects on the cost of installed kW.The evolution in time of the weight index only,resulted from fig.7,brought about a weight reduction of approx.2.2 times.

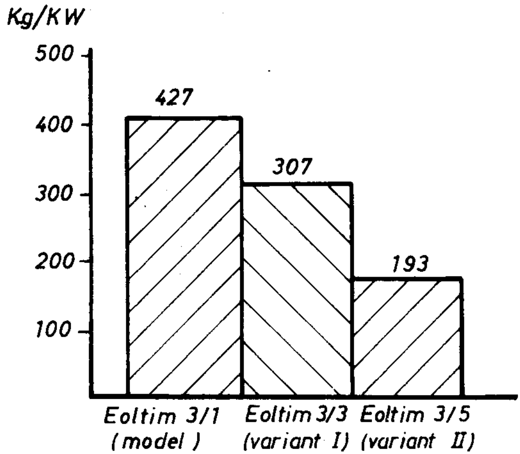


Figure 7.-Weight index

Table 1-300 kW Industrial pilot Parameters. Variant II

1.ROTOR	
Diameter (m)	30
Speed (rpm)	50
Number of blades	3
Rotor position to tower	upwind
Power control	blade angle control
2.BLADE	
Profile	NACA
Installation angle	controllable
Material	Reinforced resin
3.MECHANICAL TRANSMISSION	
Multiplier type	cylindrical
Transmission ratio	31
4.GENERATOR	
Type	asynchronous
Power (kW)	375
Speed (rpm)	1500
Operation regime	oversynchronous
Voltage (V)	delivery through stator 380/660
5.YAWING SYSTEM	
Type	active
Turning speed of nacelle	0.31

6.CONTROL SYSTEM	
Type	programmable logic
Controls	controller
7.PERFORMANCES	
Power (kW)	300
Min.cut-in wind velocity	3.5
Max.operation wind velocity	25
Sizing wind velocity	64

The functional block diagram is shown in Fig.8.

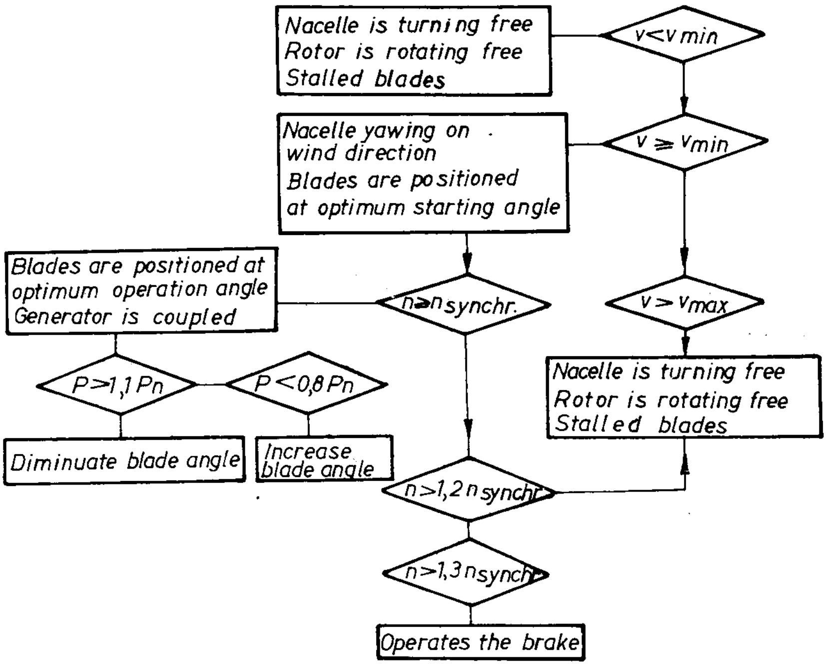


Figure 8.Control Block Diagram

The aggregate is provided with two operation regimes:automatic and overhauling regime.The automatic regime is the normal operating regime, when the aggregate is automatically driven through basic parameters: wind velocity,rotation speed and power.

The overhauling regime is needed for the commissioning or testing after the remedy of faults.In this regime all equipments of the aggregate can be individually controlled.The measuring system assures the information needed by the automation system.The information is about the state and position of equipment and also the control parameters of aggregate.

The measuring system consists of:transducer,measuring and data processing equipments.

The connection system to the electric network assures the connection and automatic disconnection respectively,or wanted disconnection of the aggregate from the National Energy System.

The power transducer is permanently measuring the power supplied to the network,and in case of exceeding by P>1.1 Pn,the power regulators command the decrease of the blade pitch angle,until the power becomes P<0.9 Pn.

If the delivered power decreases under the value P<0.8 Pn the power regulators command the increase of the pitch angle until P>Pn.Thus,if the wind velocity exceeds the nominal value V>Vn,the delivered power is maintained in a range between:0.8 Pn<1.1 Pn.

The aggregate is protected against runway,overload,short-circuit,excessive temperature in nacelle respectively bearings,and exceeding of maximum allowable vibration limit.

The positioning of nacelle on wind direction is made only if V min<V<V max.Outside these limits the positioning doesn't work.This machine is in erection stage on the Semenic site,commissioning being planned in the second half of 1992.

4.FABRICATION

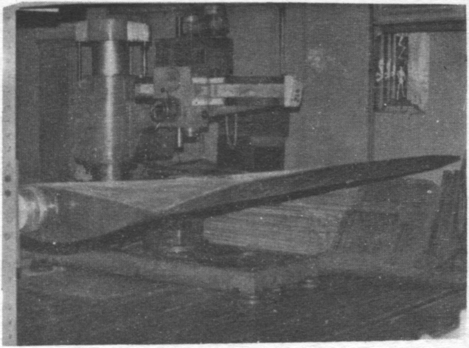
In order to ensure the fabrication of wind generators in Romania in view of their commercialization,several enterprises have been drawn into it,as they also deal,among others,with the fabrication of wind generators.For this at CMB S.A.Bocsa teams of technologists have been specialized and there have been built test stands for components general erection and shop tests platform for testing the operational unit (mechanical,electric and control equipments).

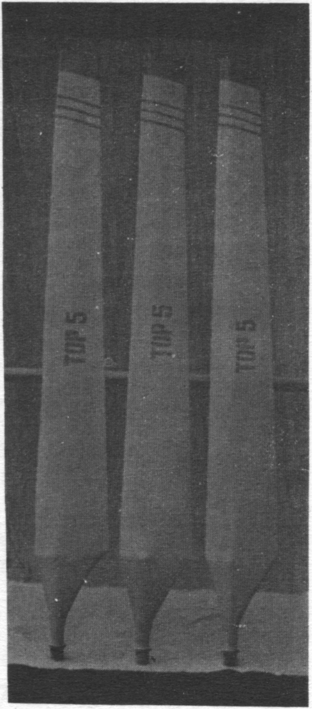
Based on the collaboration between HIDROTIM S.A. Timisoara and the Romanian-German firm Resita-Renk,there has been assimilated the fabrication of multipliers for 300 kW units,in HIDROTIM S.A.conception.Up to now two multipliers have been already delivered,and the third,of an improved conception,is being fabricated.

Regarding the rotor blades fabrication,by the agency of the specialized firm EOL Tg.Mures,we have gradually passed from metal fabricated blades at CMB S.A.Bocsa to mixed structure blades of metal and glass fibre reinforced resin.

The blades with this structure include the power range of 5-50 kW and 300 kW. (see the Figures 9,10 and 11).

The blades are fabricated according to the conception of HIDROTIM S.A. and the Technical University of Timişoara.For the overspeed test a test stand has been built at the Technical University of Timişoara,





Figures:9;10;11.Metal and glass fibre reinforced resin blades.

The transducers (wind direction and velocity,speed) the warning, communication and control systems are fabricated in the laboratories of HIDROTIM S.A. Timisoara.

For the erection of the horizontal axis wind generators the Electromontaj Enterprise of Timisoara has adequate technologies,in accordanc e with the units conception and location areas.

5.CONCLUSIONS

a.The two aggregates,the experimental model of 30 and 300 kW,being equipped as described above,will constitute the experiment base for assurance of conception in the field of aeroelectric aggregates with horizontal axis,connected to the National Energetic System in the power range 30-300 kW.

b.With its constructional and functional parameters,the industrial pilot of 300 kW for implementation in the National Energetic System is one of the greatest achievements in the world in this field.

c.The experience which will be gained by testing wind turbine models on the especially rigged up testing stands belonging to HIDROTIM S.A. Laboratories and to the Technical University of Timisoara,CMB Bocsa, EOL Tg-Mures,will enable us to conceive,in a future stage,solutions for wind machines with unit powers in the 300-500 kW range.

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EXPERIMENTAL RESULTS AND CONCLUSIONS REFERRING TO TESTS ON THE 300 kW MODEL UNIT-SEMENIC

Eng.Cornel Albu,eng.Sorin Lăzărescu-The Technical University of Timişoara;eng.Cezar Ghiţulescu,eng.Mircea Nicodin-HIDROTIM S.A. Timişoara-Romania

1.INTRODUCTION

The result of the designing efforts of the specialized staff of HIDROTIM S.A.-Timişoara and IPROTIM Timişoara and of the execution and erection efforts of ICM Bocşa,Electromontaj Timişoara and IACMM Reşiţa was the achievement,at the end of 1990,of a 300 kW model unit on the Semenic site,within a national programme co-ordinated by the Technical University of Timişoara and financed by the Department of Science of the Ministry of Education and Science.

The experiments at the end of 1990 and during 1991 have gathered the teams of specialists from the Technical University of Timişoara-the Research Centre for Wind Energetics and HIDROTIM S.A. Timişoara,who have carried out a complex test programme,part of the conclusions serving for the improvement of the technical solutions and of the performances of the existing wind generator,and,in general,the obtained experience has constituted a reference in the designing of the following wind generators.

2.CONSIDERATIONS REGARDING THE SITE AND WIND GENERATOR

Based on the processing of the primary data obtained from the National Institute of Meteorology,the Semenic site has proved to be one of the best from the point of view of annual wind provision (min.2000 hours/year,representing the equivalent time of using the installed power of 300 kW.)

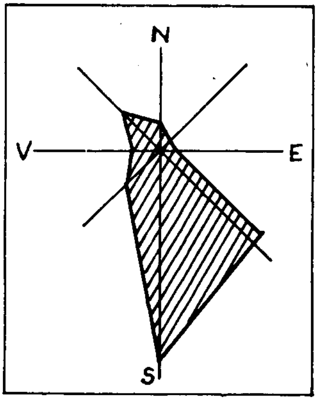


Figure 1.

Analysing the specific land conditions, the site offers conditions for the building of 330 wind generators with individual installed power of 300 kW,at a turbine diameter of 30 m,thus existing the possibility of achieving a site installed power of approx. 100 MW.This installed power is achievable due to the possibility of intensive use of the available physical space,the site having an extremely advantageous characteristic of wind orientation on the N-S direction for approx. 70% of the year. This is observed in the adjoining figure,(Fig.1)representing the energetic wind rose.

The wind generator is connected to the national energetic system by means of a 10 kV discharge line;for this aim it is equipped with a 0.4/10 kV transformer station.

The 300 kW wind generator mounted on the Semenic site is characterized by the following parameters:

-no.of blades	3
-rotor diameter	30m
-rotor max.speed in operation	50 rpm
-max.admissible rotor speed	75 rpm
-rotor position with respect to tower	downwind
-speed multiplication ratio	1:31/1:21
-no.of generators	2
-generator type	asynchronous with wound rotor
-generator synchronism speed	1000/500 rpm
-wind installation velocity	11.8 m/s
-tower weight	75 t
-tower height	29 m
-weight of equipped nacelle	45 t
-power control	by blade adjustment
-speed control	by oversynchronous cascade

3. PERFORMED TESTS

In a first stage the programme of the performed tests implied the check of the behaviour of the main operational groups.This stage had as a specific of the imposed limiting conditions the operation up to the synchronism speed and the manual unit control

After approx. 300 hours of operation in various meteorological conditions(wind velocity 0-35 m/s; temperature -21......+25^{0} C,relative humidity 60-97.6%) the following conclusions could be drawn:
-the electromechanical systems of the machine line composed of blade rotor-blade adjusting mechanism-shafts line-multiplier-electromagnetic couplings-brake generators have a good behaviour;
-the nacelle orientation system has a good behaviour,the downstream rotor location leading to a very good stability in operation and not producing disturbing vibrations;
-unit operation within normal noise and vibration limits;
-good operation of the direction and the wind velocity transducers, except the periods of rime deposits and the necessity of improving the shaft speed and moment transducers.

The rime phenomenon seriously affects the wind speed and orientation transducers and at the same time the rime deposits on the blades lead to considerable rotor unbalance.

It seems that the provision of rime deposit prevention systems is indispensable.

4. TURBINE CHARACTERISTICS TESTS

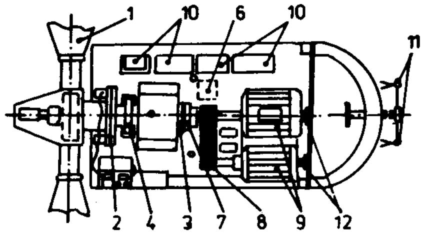


Figure 2.

1. rotor and blades
2. emergency brake
3. working brake
4. blades operating commutator
5. multiplier
6. centrifugal relay
7. electromagnetic couplings
8. belt transmission
9. generators
10. instrument cubicles
11. transducers
12. speed transducers

The tests had as objective limits, from safety reasons, the operation with manual control ensured by the technical staff in the nacelle, at wind velocities up to 17m/s (when operating as a generator) and till reaching the synchronism speed both at no-load and at on-load running.

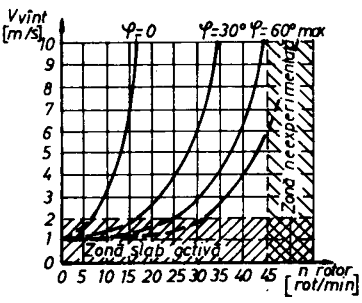
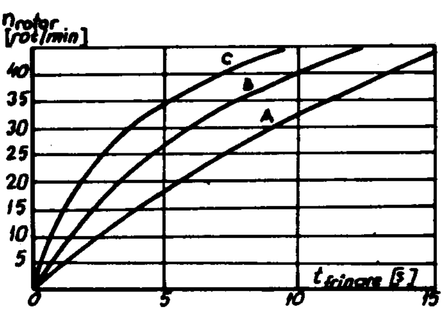


Figure 3.

The tests performed with the free turbine, i.e. with non-operated electromagnetic couplings (see Fig.2) have led to the determination of the curves in fig.3. These curves render evident the rotor speeds at various blade angles. A very good rotor starting is observed, the start from the rest position being achieved at wind velocity of approx. 3m/sec. At $\varphi=30^0$ and wind velocity of 4m/s the synchronism speed is already reached for generator G1 and at $\varphi=60^0$, for the same wind velocity, generator G2 is very close to the synchronism speed.

Having in view the other losses, both mechanical and electric ones, at wind velocity=5m/s and φ optimum=81.5^0, the operation of G1 is safe, the electric coupling of G2 being convenient at wind velocity over 8m/s.



A,B-working brake
C -emergency brake

Figure 4.

The curves in Fig.4 point out the braking times obtained with the two braking systems,(see Fig.2) starting from various rotor initial speeds. The efficiency of both systems is remarked,the hydraulic brake(pos.2) having the advantage of a much more uniform braking,free of shocks or vibrations.Curves A and B are related to the braking with the working brake at various lowering times of the hydraulic jack corresponding to the stroke ends of the adjusting element.

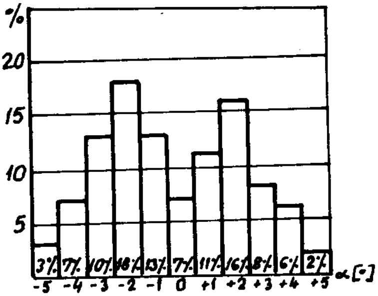


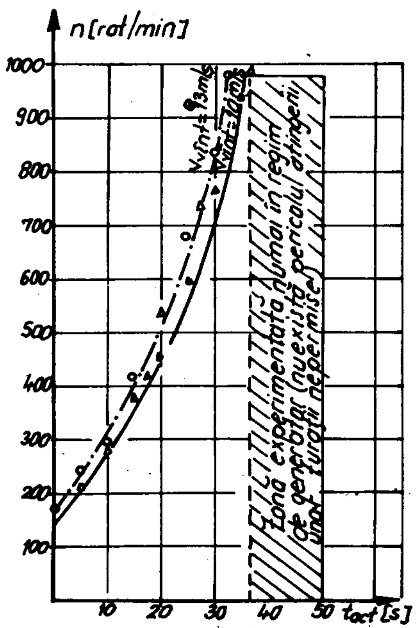
Figure 5.

The stability in operation of the nacelle is very good,the rotor downwind position with respect to the tower contributing to keep it on the wind direction without producing vibrations.

Fig.5 renders evident the deviations of the nacelle axis from the wind direction,by statistic evaluation,being possible to observe that 83% of the deviations are within an error limit of $\pm 4^{0}$.

The racing curves,with the generator coupled by means of the electromagnetic coupling,have been plotted at two of the most frequent wind velocities in the site under discussion of 10 and 13 m/s respectively,watching the generator G2 speed(direct drive multiplication factor 31:1) depending on the time elapsed from the moment of the beginning of operation(start from n=o).The blades are all the time in feed motion towards the optimum angle.(see Fig.6)

The reaching of the synchronism speed in a short time with respect to the system weight is observed, this speed being reached in approx.36 sec.These determined times have a great importance in the evaluation of the response time to an order which implies the rotor-blades system as well as on the strategy of the system automatic control.(see Fig.6)



t_{act}=blades operating time starting from "out of wind" pos. (total stroke=60 sec)
n=generator G2 shaft speed

Figure 6.

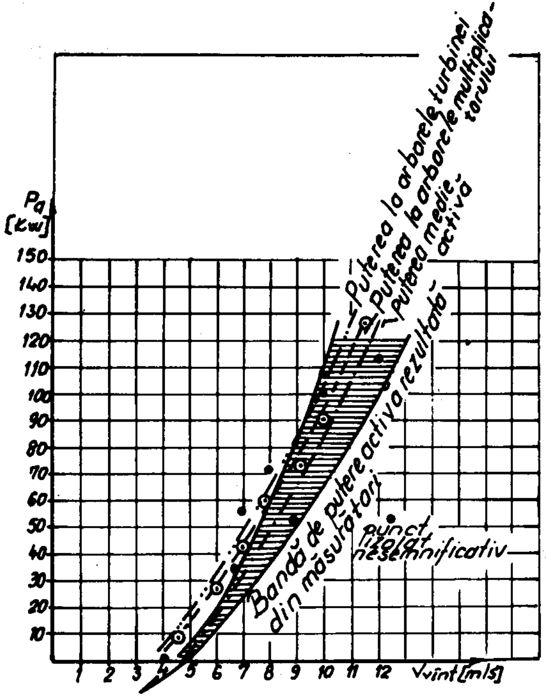


Figure 7.a

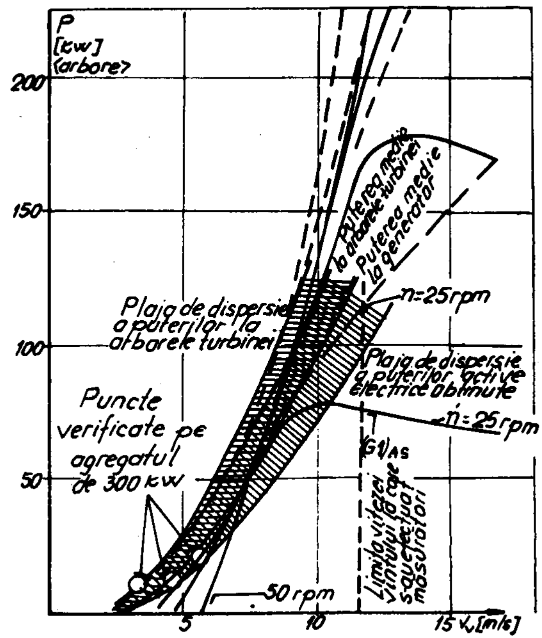


Figure 7.b

Fig.7.a presents the power curves obtained by experimental plotting of the energetic points depending on the wind velocity at a blade installation angle evaluated as being optimum.

In Fig.7 b these curves are superposed on the theoretically determined curves on a mathematical model.

A correct theoretical evaluation of the generator performances in the wind velocity range of 2.5-12 m/s is observed;the future experiments are to extend the comparison to higher wind velocities.

5.CONCLUSIONS

The experiments have demonstrated a good conception of the 300 kW wind generator,as it can be observed in Fig.7.b,the experiments confirming the theoretically determined values.

Of course,the acquired experience has determined the choice of new solutions for some elements or the partial modification of others, experience which has been rendered valuable both for the existing wind generator and especially for the designing of the ones to come.

CONCEPTS CONCERNING THE ELECTRICAL EQUIPMENT FOR AUTONOMOUS WIND GENERATORS WITH CAPACITIVE EXCITED ASYNCHRONOUS GENERATOR

Prof.dr.eng.N.Budisan.Technical University Timisoara, Hidrotim S.A.

The concepts presented below are the result of many years of researches (at the Scientific Research Centre of the Romanian Academy,Timisoara Technical University and Hidrotim S.A)concerning the promotion of some original electrical energy generation equipments for unconventional energetics (microhydro plants,wind generators,biogas energetical groups)based on capacitive excited self-contained asynchronous generators.

1.AUTONOMOUS,ASYNCHRONOUS GENERATOR

The autonomous,asynchronous generator with capacitive excitation has the advantages of a more simple and solid construction as well as reduced weight,size and price with respect to other electrical generators.

In case of wind generators,the reduction of generator weight and size and the simplification of its operation are advantageously reflected on the size and weight of the nacelle and of the whole construction of the wind generator.Table 1 presents the comparative price,size and weight of some asynchronous and synchronous generators made in Romania (which may constitute alternatives of equipment for some low power wind generators).

Table 1:Characteristic data of some asynchronous and synchronous low power wind generators.

Characteristic data		1		2	
		asynchr.	synchr.	asynchr.	synchr.
Power	kW/kVA	14(kW)	15(kVA)	28(kW)	30(kVA)
Speed	rpm	1500	1500	1500	1500
Weight	kg	130	275	235	300
Price	relative units	790	2250	1355	2650

In [1,2] the results of our first researches regarding the use of asynchronous generator with constant capacitive excitation are presented.The voltage stabilization in the above conditions was made by a suitable adjustment of the generator speed (see also [8]).The experimented 10 kW generator has been charged with active load up to the rated power,resulting-at constant voltage,after speed adjustment - a change in the generator frequency from 47.5 Hz to 52.4 Hz,which can be considered admissible in the conditions of self-contained generator groups (At RAL,England ,for the wind/diesel system with energy storage through flywheel,a frequency variation from 45 Hz to 50 Hz [4] is accepted).The experimented system was installed at the micro-hydropower station Negoiu in the Fagaras Mountains,Romania [2] .The system had the advantage of an extreme simplification of the hydro-generator group,having a single voltage and speed controller,acting on the (Pelton) turbine control element.

It can be mentioned that the variation range of the asynchronous generator frequency by voltage stabilization through speed control differs from one machine to another (smaller at machines with a greater degree of magnetic saturation).

By a suitable design of the asynchronous machine,an admissible variation range of the frequency (about ± 2.5%) at load change,can be assured.

2.ELECTRICAL EQUIPMENT SYSTEM FOR AUTONOMOUS UNCONTROLLED TURBINE AND ACTIVE LOAD WIND GENERATORS WITHOUT ELECTRICAL STORAGE

The basic ideas which led to the electric system structure were:
-asynchronous generator (for reasons given in paragraph 1)
-voltage stabilization by speed adjustment through generator charging/discharging made with a surplus/lack wind energy compensation system [1,2,11] .
-single-phase generator for simplification,price reduction and higher reliability of the wind energy surplus/lack compensation system (only for single-phase load)
-achievement of the compensation system with magnetic amplifier [6,11]

The single phase achievement of the compensation system leads to the reduction of size and price (see Table 2).

Table 2:Weight,size and price of magnetic amplifiers of surplus/lack compensation system.
Single-phase and three-phase alternatives

		Alternative					
	Units	Three-phase			Single-phase		
		I	II	III	I	II	III
Max.dump load	kW	6	12.9	21.6	7.2	16	30
Weight	kg	54	126	210	70	150	230
		225	340	340	340	520	520
Size	mm	390	675	675	225	350	350
		630	795	900	300	425	530
Price	relative units	5025	8760	11925	3975	7803	10500

The proposed structure of the electrical equipment system for autonomous, uncontrolled turbine and active load wind generators without electrical storage is given in Figure 1,in which the notations are:GA-asynchronous generator,EXCIT-excitation system,1C-excitation system capacitors,GPRM-a.c. microgenerator for generator pre-magnetization,1AM-magnetic amplifier,DSP-dump load resistor or accumulator system (pump,etc.),RV-voltage controller,v_0,v_1......v_n-load circuit connection wind speeds.

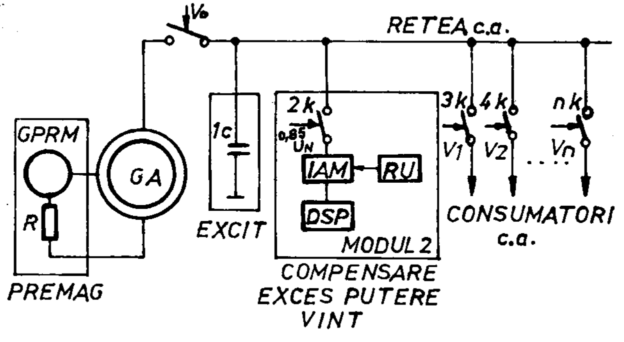


Fig.1:Electrical equipment system for autonomous uncontrolled turbine and active load wind generator without electrical storage.

3.ELECTRICAL EQUIPMENT SYSTEM FOR AUTONOMOUS,CONTROLLED TURBINE AND ACTIVE LOAD WIND GENERATORS

When using controlled wind turbines,voltage stabilization through speed can be achieved through a slow pitch control and a fast control of the compensation (dump load) system,having the structure discussed in paragraph 2,but a reduced power corresponding to fast disturbance variations (gusts and consumers connections/disconnections).In this case,the compensation system has such a waiting load state,that it can take over the maximum disturbance variation.The power (current) change of the compensation system with respect to the waiting load state is the error for the pitch controller.The structure of the double controlled system is presented in Figure 2.

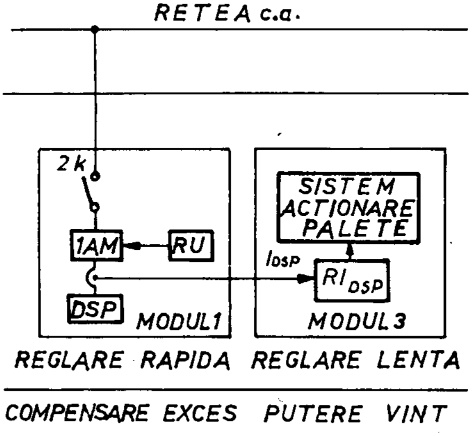


Fig.2:Electrical equipment system for autonomous controlled turbine and active load wind generators.

The above system was also proposed for the autonomous groups using biogas. The [5,6,7] system was experimented on a 7KW laboratory model. The bio gas engine and its slow speed control were simulated with an electric motor. The proposed automatic voltage control was tested in fast generator load variation conditions, observing a high dynamic control quality.

4. ELECTRICAL EQUIPMENT SYSTEM FOR AUTONOMOUS WIND GENERATORS WITH ELECTRICAL STORAGE

In this case, the following two problems must be solved:
- -adjustment of accumulator charging current intensity according to the preset charging value or a smaller value according to the wind energy.
- -accumulator voltage limitation to the maximum admitted value.

For the proposed system both problems are solved adjusting the generator voltage through speed, the latter being adjusted by charging/discharging with a dump load system as described in the previous paragraphs (MODULE 2). The system structure is presented in Figure 3.

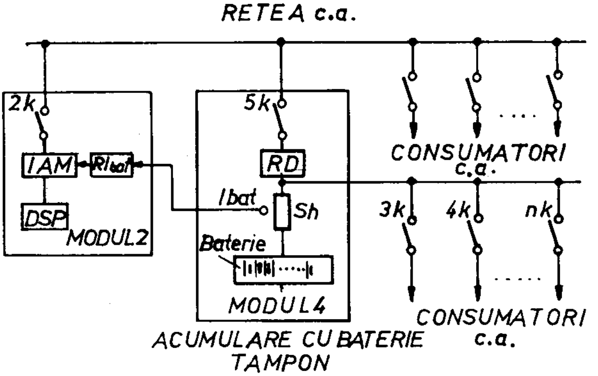


Fig.3: Accumulators current control and dump load control system

In this case, the consumers circuits connection is made in accordance with the accumulators capacity, their charging degree and wind conditions of the site. (Figure 4)

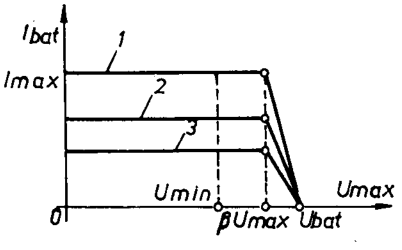


Fig.4: Accumulator current control characteristics. Curves 2 and 3 represent the situations when the wind power is insufficient to assure max. current (I_{max})

5.ELECTRICAL EQUIPMENT SYSTEM FOR AUTONOMOUS RESISTIVE-INDUCTIVE LOAD WIND GENERATORS WITH VOLTAGE STABILIZATION THROUGH ADJUSTMENT OF THE SYSTEM REACTIVE CAPACITIVE POWER AND FREQUENCY STABILIZATION THROUGH POWER CONTROL OF DUMP LOAD SYSTEM

In case of important variable inductive component consumers,in order to compensate the variable inductive component,a source of controlled capacitive-reactive energy is necessary.

For powers up to 100 KW,we consider that the best solution is our proposed system [3,4,5,10] with the structure presented in Figure 5,for wind generators without accumulators

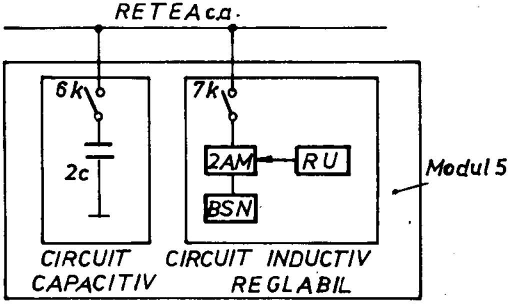


Fig.5: Adjustable capacitive-reactive energy source for wind generators without electrical storage.

respectively in Figure 6 for wind generators with accumulators.

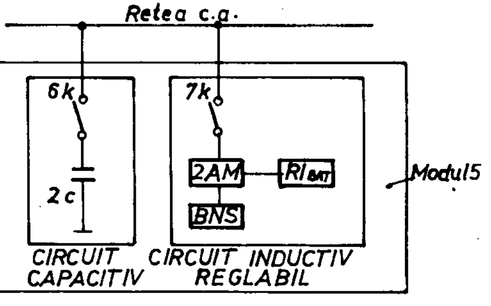


Fig.6.:Adjustable capacitive-reactive energy source for wind generators with electrical storage.

The reactive-capacitive energy source,developed at TUT,consists of a capacitive circuit 2C with fixed capacity and an adjustable inductive parallel circuit achieved with a magnetic amplifier 2M in series with an unsaturated coil BNS.The adjustment of the inductive circuit current is made by the voltage controller RU,respectively by the accumulator charging current controller RI_{BAT},acting on the magnetic amplifier 2AM.In case of voltage control with RI_{BAT},the voltage varies depending on the accumulator charging degree,within the minimum and maxim um admissible values,for the given accumulators.

The fixed blades wind generator frequency control is made with a dump load system(Figure 7),

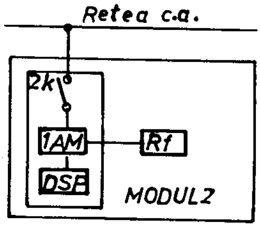


Fig.7:Dump load system for frequency control

like the one presented in the previous paragraphs(MODULE 2),differing from the above-mentioned by the fact that the charging/discharging is made depending on the system frequency(with R_f controller,Figure 7).

In Figure 8, the whole proposed electrical system for autonomous

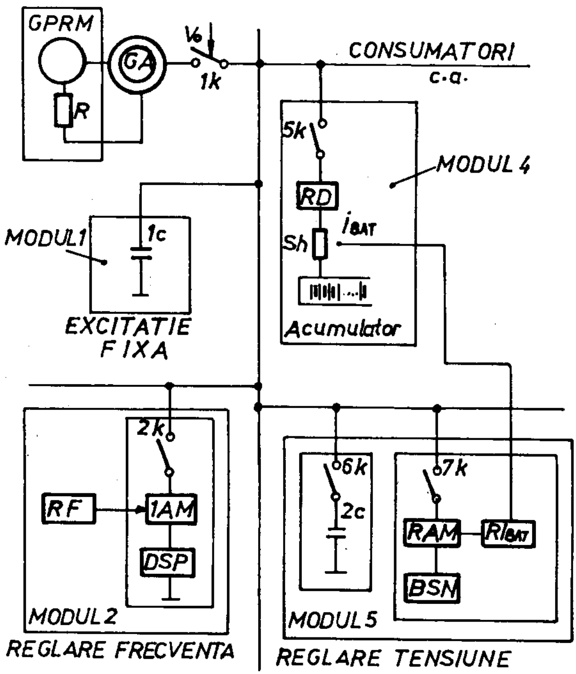


Figure 8.

wind generators with important variable reactive energy is presented.

The modular structure of the system MODULE 1,MODULE2,MODULE3,MODULE4, MODULE5 can be noticed;the system modules are also used in the systems presented in the previous paragraphs,except MODULE5,which is characteristic for a system with important variable reactive energy.

One must pay attention to the fact that the controllers of the different modules are identical differing only by the controlled parameter.

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A NEW CONCEPT ABOUT ELECTROENERGETICAL EQUIPMENT, ORGANIZATION AND AUTOMATIC CONTROL STRATEGY OF WIND-DIESEL SYSTEMS

Prof.dr.eng.Nicolae Budisan,Technical University Timisoara/Hidrotim S.A.Timisoara,Romania
Assistant profesor eng.Sorina Stern Agrarian Sciences University of Banat,Timisoara,Romania

1.INTRODUCTION

The most common solution regarding the electric power elements of microhydro-wind-Diesel systems seems to be the one with synchronous generator for the Diesel group or microhydroplant and asynchronous generator for the wind unit (in case the units are operating in parallel).

When the wind energy is in excess the synchronous machine can operate as a synchronous compensator supplying the asynchronous generator of the wind unit with reactive energy.We have already reported such a possibility of exciting the asynchronous generators in1957 [1].

The great advantage of such a system is the extreme simplification of the wind generator and the possibility to concentrate the whole system excitation in one place of the network even when the system has more than two groups.One of the system disadvantages is that the used synchronous generator has greater constructive power than the consumers, a more complex structure,size,weight and price exceeding those of an asynchronous generator.

2.ASYNCHRONOUS GENERATORS,STATIC EXCITATION,DUMP LOAD FREQUENCY CONTROL

Acknowledging the obtained performances of the above discussed systems, we consider however that the improvement of their quality is possible using only asynchronous generators at all groups and a centralized excitation system,which can be placed in any point.

Thus,the rated power can be reduced,the structure simplified and the size,weight and price of the Diesel group generator diminished.In figures 1 and 2 the structural schemes of Diesel-wind microhydro systems in the TUT/HIDROTIM conception are presented.

The system in Figure 1 is conceived for resistive consumers.The system comprises a wind group with an uncontrollable wind turbine TV and asynchronous generator 1 GA and a group with Diesel engine MD and asynchronous generator 2GA,the excitation systems 1EXTFX and 2EXTFX with capacitor batteries 1C and 2C of constant capacity,the consumers CNSM,voltage controller 1RU acting on the Diesel engine MD speed and, accordingly,on the system frequency,resulting the modification of the wind group speed too and,as a general consequence,voltage regulation; when the Diesel group reaches and operates in no-load condition,or is

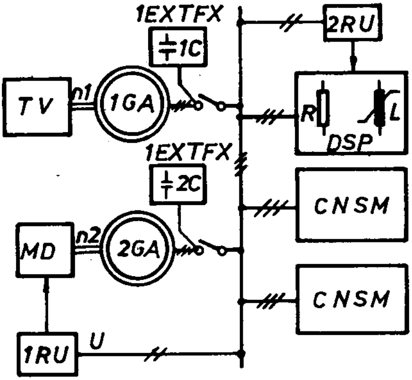

Fig.1:Structure of UTT/ HIDROTIM wind-Diesel system for resistive consumers.

disconnected,the voltage regulation is made by increasing/decreasing the speed of the wind group,by decreasing/increasing the dump load DSP,achieved with resistors R and a magnetic amplifier voltage variator 1AM.The DSP system is controlled depending on the system voltage U, through the voltage controller 2RU.

When the turbine control is possible,the dump load fast control system operates complementary to the slower pitch control system,only in the transitory regimes (in case of consumers load variation) its action being taken over in the steady-state regimes,by the pitch control system.In this case the rated power of the dump load system is considerably reduced,to a value equal to about two times the power of the biggest possible consumer;in steady-state regimes the dump load system is in expectation regime at a power equal to the biggest possible consumer.

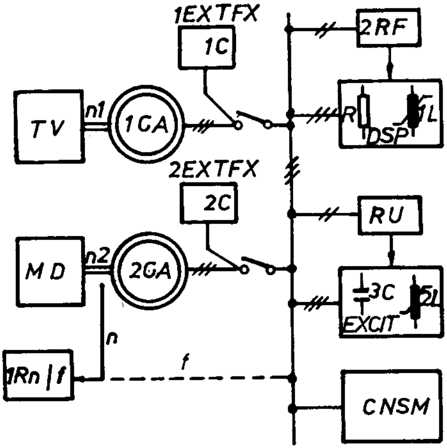

Fig.2:Structure of UTT/ HIDROTIM,wind-Diesel system for resistive inductive consumers.

The system in Figure 2,is meant for resistive-inductive consumers (lighting,electric apparatuses for domestic use,asynchronous motors). The system comprises a wind group with uncontrollable wind turbine TV and asynchronous generator 2GA,uncontrollable excitation systems for no-load run 1EXTFX,2EXTFX,achieved with capacitor batteries 1C and 2C common excitation system for both groups EXCIT,consisting of constant capacity condensers 3C and controllable inductive circuit 2L, achieved with a controllable magnetic amplifier in series with unsaturated coil,the excitation system being controlled depending on the system voltage U,by the voltage regulator RU.

The speed/frequency control,when both groups are operating,is made only by the Rn/f controller,acting on the Diesel engine MD,and if only the wind group is operating (the Diesel group being disconnected or in no-load conditions) the frequency control is made by the2Rf controller acting on the dump load system,built as in Figure 1,with resistors R and a magnetic amplifier voltage regulator 1L ,system which achieves the speed/frequency control by charging discharging the network.

The suggested excitation system is presented in Figure 3,with the following notations:
C-constant capacity condenser
L-controllable inductive circuit (achieved with a magnetic amplifier in series with an unsaturated coil)
RU-voltage controller

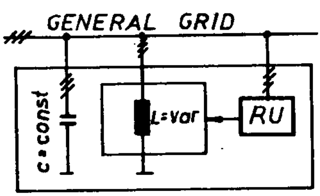

Fig.3:The suggested excitation system.

A design methodology of the electrical excitation system was elaborated.The estimated results obtained for an adopted exemple,are presented below:
-consumers power..............................75 kW
-Diesel group power...........................75 kW
-windgenerator power.....✓....................75 kW
-unit power of the biggest induction motor
 with direct set in motion....................5.5 kW
-needed reactive constant excitation power.....50 kVAR
-needed reactive variable excitation power.....70 kVAR
-needed total reactive excitation power........120 kVAR
-condensers capacitive power...................120 kVAR
-continuous controlled inductive circuits
 power...70 kVAR
-conventional version needed reactive
 synchronous generator power...................120 kVAR
-conventional version needed synchronous
 generator construction power..................200 kVAR

-condensers price.........................24000 u.(money units)
-continuous controlled inductive
circuits price...........................97500 u.
-Diesel-group asynchronous generator
price(75 kW,1000 RPM)....................25000 u.
-Diesel-group asynchronous generator and
excitation system price..................146500 u.
-conventional asynchronous version (200
kVAR,1000 RPM) estimated price...........180000 u.

The comparable price of the proposed system and of the conventional system can be observed.However the proposed system has the advantage of simplicity and more reduced dimensions and weight of the Diesel-group generator.

The estimated prices of the UTT/Hidrotim dump load system in the case of a 75 kW windmill,are presented below:
-asynchronous generator (75 kW,1000 RPM)
price.....................................25000 u.
-transducers price.............................52500 u.

We have investigated the excitation and dump load systems on a laboratory model [5].The tests demonstrated the high performances of the proposed systems.

3.OPTION FOR CONTINUOUS OPERATION OF DIESEL ENGINE

It is known that in wind-Diesel systems,in conditions in which the available power from the wind unit is close to that required by the consumers,the variation in one direction or other of the available wind energy,respectively the variation of energy consumption,causes repeated stops and starts and accordingly,the intermittent operation of the Diesel group.To reduce the number of stops and starts of the Diesel engine,storage systems of the excess energy arising from wind are used,followed by its subsequent delivery to the consumers (in periods of wind energy shortage).The use of the above-mentioned storage systems however complicates very much the wind-Diesel systems and also their automatic control.To remove these shortcomings,we consider justified the elimination of the intermittent operating conditions of the Diesel engine (see also [4]);it will operate continuously also in the periods of electrical energy excess resulted from the wind unit.We suggest that the heat from combustion in these conditions,as well as the one resulted from losses in the other conditions of the Diesel engine should be recuperated with heat exchangers.

Today such groups [6] with integral recuperation of the losses in the heat engine group,in the form of heat,do exist.These groups use as fuel biogas,pit gas or liquid fuel and operate in autonomous conditions or in self-contained electric and thermal power stations or in parallel with the general electric power system,supplying electric and thermal energy.

The existent experience in using such thermoelectric groups under-lines the possibility to obtain important economies of fuel and rapid recuperation of investments (about 1.5-2 years).If such groups are used in parallel with uncontrollable wind units with dump load,the concentration of systems for recuperation of the heat engine group losses,respectivelly of those from the dump load systems,as it is shown in the principle scheme from Figure 4,is reasonable.

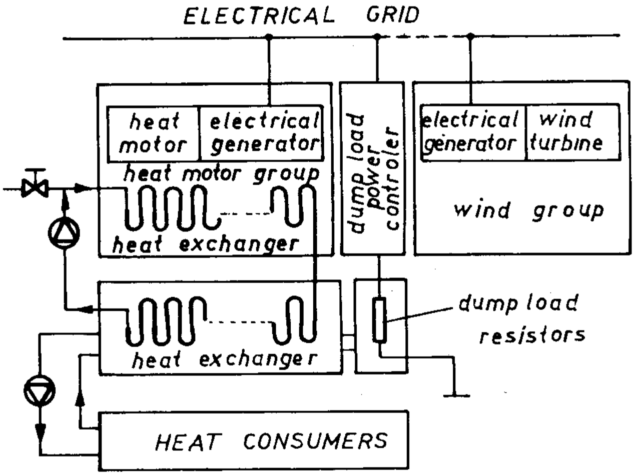

Fig.4:The suggested wind-Diesel system with integral recuperation of heat losses.

Important structural,operational and control simplifications result for the whole system.

Considering the results we have obtained in the experimentation of the component subsystems of the suggested wind-Diesel system (asynchronous generators,concentrated static excitation system,dump load system and their control systems),at Hidrotim S.A. Timisoara,the achievement of a 15 kW wind/Diesel system and its testing in a mountainous area with touristic interest is planned.

We are looking forward to cooperating with other companies,national and international organizations (cooperation offers are awaited at: HIDROTIM S.A.Timisoara,Calea Martirilor Nr.1,1900 Timisoara,Romania).

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ENVIRONMENT PROTECTION BY BUILDING WIND TURBINE ACHIEVEMENTS ON SEMENIC MOUNTAIN

Anton Gârbacea Dr.eng.-Mechanical chief engineer
ELECTROMONTAJ S.A.-Seiler Street no.7 1900 Timişoara
ROMANIA
Member of Romanian Wind Energy Association and
European Wind Energy Association

Environment protection today has important implications in contemporary life.The proof reading which is imposed and necessary to be taken at present,will have a great importance in the future,tomorrow,in a year's time and in the next decades.

Regarding the environment protection,the activities connected with wind power production have a fundamental importance.In this context,I think that it is not necessary to bring arguments to prove the multiple advantages which the energy wind confers in the world,and consequently in Romania too.

In order to present the great achievements of the wind energy,I further present some clarifying data of USA and Denmark.

The American Wind Energy Association reports that the total statewide wind generated electrical power reached nearly 2.5 billion kWh in 1990 and in 1991 ,2.7 billion kWh. were estimated.This balance is for California Wind Power generation [1]. according to Figure 1.

The total capacity has reached 1500 MW from 15,200 wind turbine units in service in 1990.Figure 2 shows the diagram of "California Wind Power plants installed capacity."

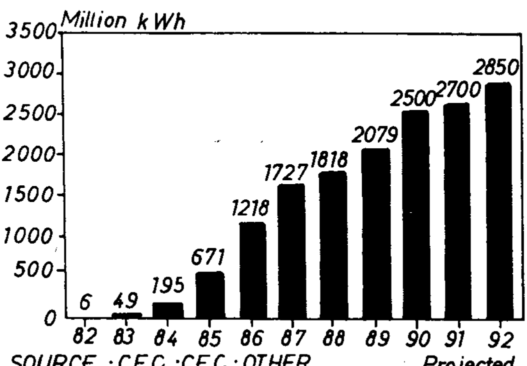

Figure 1.
California Wind Power Generation

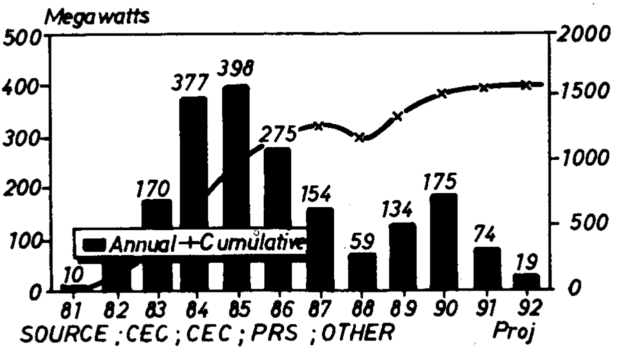

Figure 2. California Wind Power Plants Capacity Installed

From the American report result the important quantities of electrical energy produced by the wind: 1500 MW installed capacity in 1990,estimated to 1600 MW in 1991.The operational capacity is equivalent to that of one nuclear plant,but with certain advantages for environment protection.

The oil equivalent of this installed capacity is more than 3 million barrels per year.

The activity of wind energy in Denmark is répresentative.To prove it I give data provided by the Association of Danish Windmill Manufacturers [2]. in 1990.

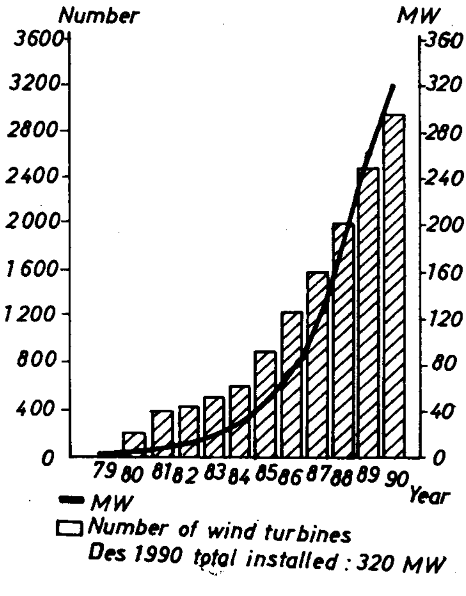

Figure 3.
Growth in Danish Wind
Turbine Capacity

Figure 3. shows the installed wind power in Denmark at the end of 1990.

From these results a representative dynamics of the increasing number of wind turbines mounted in 11 years.Beginning from 1979 there have been mounted 3,000 wind power units.

The installed capacity at the end of 1990 was 320 MW.Up to 2000 MW/year are estimated to be obtained from wind energy,i.e. 10% of the electric power necessary for Denmark.

It is a representative balance for Romania too,which is confronted year by year with great problems in energy assurance.

However,the wind power in Romania is insufficiently represented at the present moment.

Regarding the concern of the wind energy development in Romania,I wish to underline the importance of the theses included in"The Blue Book" elaborated by the Romanian Wind Energy Association in 1990 [3].

From these I remark chapter 7 dealing with the requirements from the governmental structures.I quote:
"The concern for the wind energy development has existed in Romania for 10 years,but the concrete finality has been delayed.The principal causes of this situation are the bureaucracy of the proceedings in the relation between research,designing,fabrication and erection organizations as well as the absence of some active beneficiary in favour of the promotion of new technology, interested in this in some way.

In the field of attested prototypes as well as in that of the achievement of some demonstrative farm;such farms must be built in places with wind turbine potential,like the following wind turbine farms:

FARM SEMENIC	10 horizontal axis 300 kW wind generators
FARM TULCEA HILL	3-5 vertical axis 100 kW wind generators
FARM SIBIOARA CONSTANTA	5 horizontal axis 55 kW wind generators

I wish to present in the following some aspects of the erection activity in the field of wind turbines in the Banat mountains,i.e. the Semenic.

The ELECTROMONTAJ Erection Organization S.A.Timişoara is the company which has built the 300 kW horizontal axis wind turbine in the Semenic area.At the end of 1991,the situation of works was the following:
EOLTIM-1 built by the Timişoara Technical University.The works began in 1988 and were finished in October 1990.
This wind turbine is an experimental model.
EOLTIM 2 -built by RENEL Bucureşti-National Administration of Electricity by the agency of F.R.E. Reşiţa-Local transmission network Reşiţa. This wind turbine is the prototype of the Department of Electrical Energy of Romania.

The works began in 1989.Presently the following are finished:tower erection up to 28 meters height,house for control and supervision,50%; 20 kV electrical cables 80%.
EOLTIM 3-built by the Timişoara Technical University.This turbine is the first unit of the ten turbines,contained in the first wind turbine

farm situated in the Semenic area.The works began in 1991.Presently only the concrete foundation is finished 50%
EOLTIM 4-built by HIDROTIM Institute of Timişoara.This wind turbine is the second unit from the Semenic farm.The works began in 1991.Presently part of the concrete foundation has been built.

The research,designing and fabrication of the 300 kW wind turbine families erected in the Semenic area have been carried out at the Technical-Scientific Centre of Timişoara.This is composed of the following:the Technical University of Timişoara,HIDROTIM S.A.Timişoara,Designing Institute-IPROTIM,Electromontaj S.A. with the wind turbine factory named the Metallic Structures Works-Bocşa.

The technical results obtained till now are very important.We are at the third generation of 300 kW horizontal axis wind power units.These generations are following:
-the first generation -EOLTIM 1
-the second generation-EOLTIM 2
-the third generation-EOLTIM 3 and EOLTIM 4

Normally,each generation suffered important transformations which were made by the staffs described above.

One of the most important transformations is the problem of foundations. This is very important from the point of view of environment protection.

The concrete foundation for the wind turbine EOLTIM 2 has been designed by ISPH Bucureşti-Hydropower Design Institute.This concrete foundation was built in 1989, including excavation of a circular area with diameter of 20 and depth 4.5 m,the total excavation being 1590 m^3.

The concrete volume is 790 m^3 and reinforced weight 35 tons of steel.

For building this foundation according to ISPH technical prescriptions 14 concrete mixers of 16 tons were necessary for transportation of concrete from Reşiţa to Semenic,40 km road length [4].

The wind velocity for which the foundation was calculated was 80 m/s.

The dimensions designed by ISPH Bucharest and the quantities needed for this foundation cannot be accepted because of the following causes:
1.The wind turbine farm from Semenic is provided to finally have a number of 300 wind units of 300 kW,i.e. an installed capacity of 90 MW. Their foundations have an estimated volume of excavation of approx. 477,000 m^3 for EOLTIM 2.
2.EOLTIM 2 built by RENEL Bucharest was the prototype of the 300 kW wind turbine for the erection of 300 units in the future in the Semenic area.Electromontaj S.A.Timişoara cannot accept this technical solution for foundation and use it for the series erection of wind turbines.
3.Environment protection was seriously affected.The quantities of 1590 m^3 excavation seriously affected the alpine plateau at the height of 1446 meters in one unit only;if for the first farm were necessary 10 units,15,900 m^3 of excavation resulted.An auxiliary place for depositing the soil resulted from excavations was necessary.
4.The economic situation resulted from the foundation EOLTIM 2 on the Semenic plateau was unacceptable.Also taking into account the environment protection and high price of the foundation,Electromontaj S.A.

Timişoara makes technical studies for other new technical solutions for a new foundation.

The new constructive solution,elaborated by Electromontaj S.A.,was not assimilated by ISPH Bucharest,because EOLTIM 2 is an industrial prototype,which must be continued in series.

Electromontaj S.A.has cooperated with the research staff for wind turbines from the Technical University of Timişoara-Hydraulic Machines section and ordered a new foundation to be designed by IPROTIM.

The new foundation materialized in EOLTIM 3 and EOLTIM 4 wind turbines as well as in the series execution,has a volume of excavation of 137 m^3 and 108 m^3 of concrete.

The wind velocity for which this foundation was calculated is 65 m/s. This foundation ensures the protection of alpine pasture of the touristic area of Semenic.

Finally, I'm sure that in Romania too,there will be found solutions for the development of wind turbines and,like other progressive countries, Romania will be able to obtain every year greater percentages of electrical energy produced by wind units which contribute to the environment protection.

The absence of financial resources was the principal difficulty in the past and also in the present.This influenced the high price of wind turbine erection up to now in the Semenic area.For example,because of these problems,RENEL Bucharest,National Electricity Administration of Romania,has achieved only approx. 50% of the erection works of EOLTIM2 in 3 years.

Looking at the experience of other countries,especially those of the EUROPEAN COMMUNITY, I'm sure that our country will much progress in the field of wind turbines in the future.

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ECOLOGICAL ARGUMENTS FOR THE WIND FARM SEMENIC ROMANIA

Prof.Dr.eng.Fr.Gyulai-Technical University Timişoara
Research Center for Wind Energy-1900 Timişoara,
Bv.Mihai Viteazul no.1 ROMANIA

1.INTRODUCTION

In this paper is presented the opportunity of the wind energy development in ROMANIA [1]. Some realizations in the westward of the country (Timişoara,Bocşa,Reşiţa)are described,also the industrial intentions: the Semenic Wind Farm and other farms in the mountain range of the Banat region.Near the economic arguments are presented the ecological supportings for the wind energy.

2,THE RECEPTION IN ROMANIA OF THE WORLD MESSAGE CONCERNING THE WIND ENERGY DEVELOPMENT

Between the characteristics of the middle of our country is as well a new revelation of an old-fashioned energy source:the kinetic energy of the atmosphere maintained through solar radiation.THe wind receives rough 5 W/m^2.

A theoretical approximation of the mean value of the utilizable power gives 0.25 W/m^2, represented about 10% of losses through frictions along the ground.For the whole globe result 130 TW power.This potentiality is very great comparative the other generable energy sources.With this premise for the Romanian territory results as mean value 60 GW, respectively about 500.000 GWh for year.At present the installed power in Romania in thermo-electric and hydro-electric power station is about 22 GW and the mean consumption about 10 GW.This values indicate the perspective of the wind energetics.For all that,the technical and economical restrictions limit the provisions for 2000-2010 years at 5-10% of the whole world energy production.For Romania in this way results an installed power in wind-farms of about 2000 MW.This estimation of the research workers is realistic.

The wind energy has a millenial history(water pumping,sea navigation, etc.), present also in Romania(grain mills).The modern development has very little technical connections with the background.This is founded on the scientific knowledge in the aerodynamics and on the experience of the engineering in hydraulic machinery and aeronautics.Some first modern wind energy assemblies are a result of the scientific pressure and less of an economical demand.Some example of these wind-electric equipments:USSR-100 kW in 1931;SUA,-1250 kW in 1941;Denmark-200 kW in 1957;Scotland-100 kW in 1950;France-132,800 and 1000 kW in 1943-1963.

The petroleum crisis in '70,on the ground of the information accumulation along 30 years,dynamize a new generation of the wind-electric units. This is a pressing of the energy market:units of 2 and 2.5 MW in USA

1980,3 MW in Germany(1981),2 MW in Sweden(1981),two units of 650 kW in Denmark(1981).These technical masterpieces indicate a design maturity.The next ten years between 1980-1990 are a period of the economical and industrial maturity.This maturation begins in USA and Denmark and takes place at this time in all countries of C.E.E. [2], [3], [4] .

In California after 1980 there have been demonstrated the possibility of the industrial electricity production from wind,as well as the competitivity of the wind energy with the classical sources.In 1989 about 1% from the electricity produced in California came from wind. About 16,000 wind-mills in 1988 have furnished an equivalent to the production of a middle power nuclear reactor.The equivalent in oil is over 3 millions barrels per year.

In Denmark in 1983 were in function 500 wind installations,in 1988 these are greater than 2000,producing in this year an electrical energy of about 300,000 MWh.

The report of the E.C.'s Directorate General for Energy DG XVIII [4] informs usabout the respective installed power in wind stations in C.E.E. countries:185 MW in 1989,4000MW in 2000 year and 12,000 MW in 2010.

This message from the developed countries has been intercepted in Romania.In 1976 the research institute for modernisation in the energy field ICEMENERG has prepared the first investigation.After 1980 some programmes are in development in Bucharest,Braşov,Timişoara.The Romanian Wind Energy Association-ROWEA have been founded in 1990.In 1991,ROWEA has published a "Blue book" concerning the development of the wind energy in Romania in 1991-2010.ROWEA is member in the European Wind Energy Association(EWEA).

3.RESEARCH IN THE WEST REGION OF ROMANIA ,NEXT AND FUTURE DESIGN

At the wind energy programme started in 1982 in Timiş and Caraş-Severin districts, collaborate specialists in research and design from the Technical University of Timişoara(aerodynamics,mechanics,vibration, steel construction,foundations,electric machines,computers,automation, chemistry,technology),HIDROTIM S.A. Timişoara,ICEMENERG and IPROTIM,in fabrication and installing from C.M.Bocşa S.A.,ELECTROMONTAJ,IACMMR, EOL etc.

A synthesis of the programme is showing in Fig.1.

The results of this multilateral cooperation,besides scientific papers become visible through two experimental wind-electric units(30 kW and 10 m diameter),Fig.2,two units on the Semenic mountain region(300 kW and 30 n diameter),Fig.7,the first in testing,the second in installing. It is materialized also in three research stations for blade testing:
-the station for vibration tests
-tha station for static tests
-the station for overspeed tests.

These test stations offer not only a research basis but also a hard check of the wind-turbine blade before it's assembling on the site. This is very important for the security of the environment round the power stations.To impose these tests is also an ecological objective.

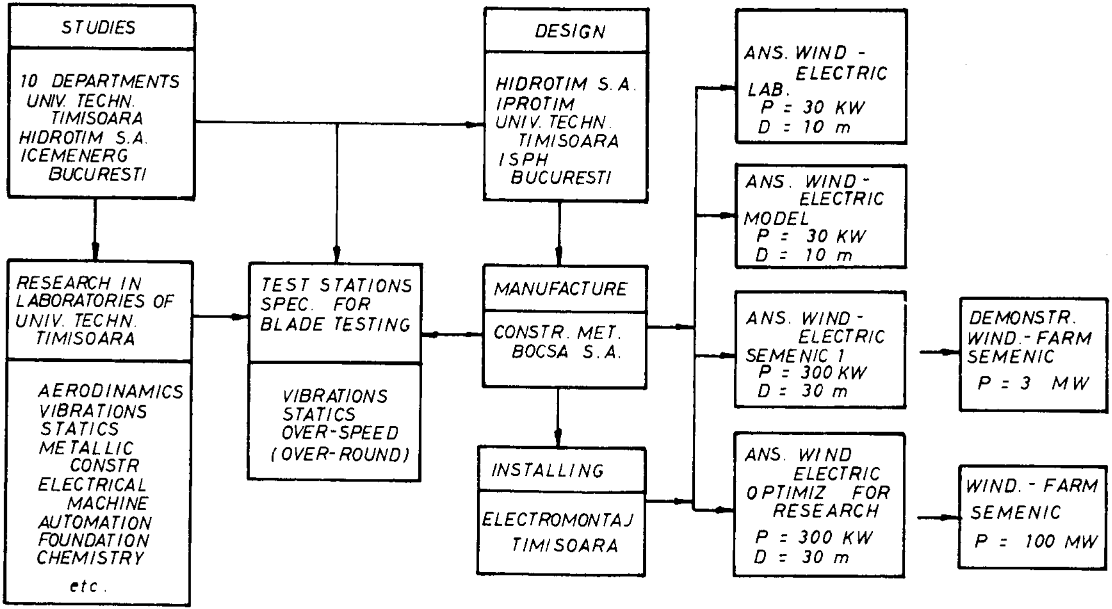

Figure 1.
WIND-ELECTRIC ASSEMBLY WITH HORIZONTAL TURBINE (General diagram of the programme)

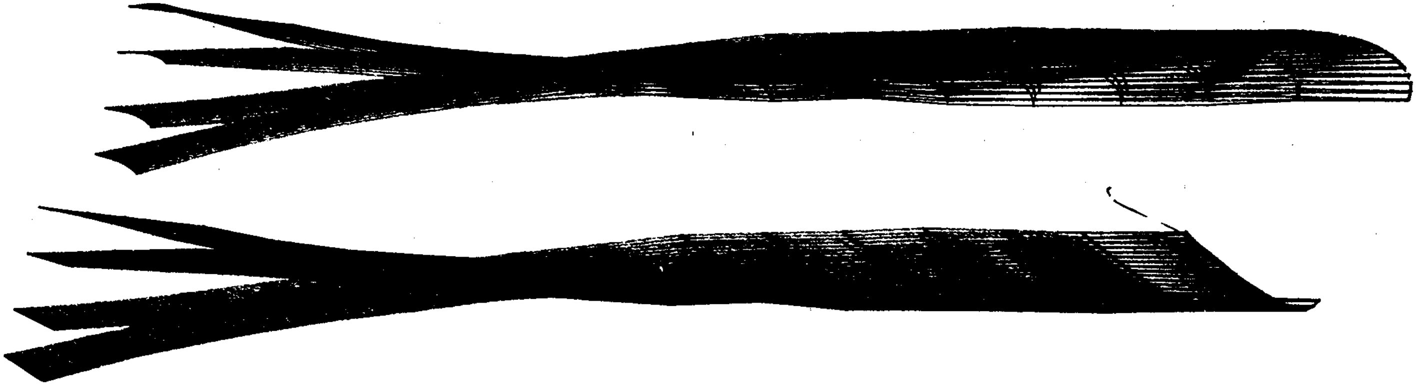

Figure 4.Vibration tests of the blades


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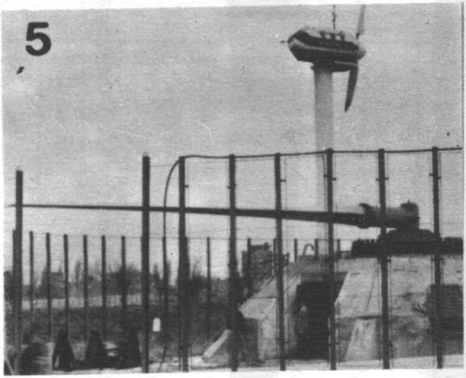
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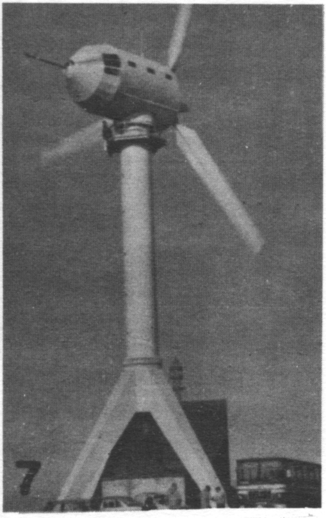
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Figure 2.Laboratory wind installation with 30 kW

Figure 3.Statical tests of the blades

Figure 5.Overspeed tests of the blades

Figure 7.The research wind installation no.1
with 300 kW (Semenic)

The next objectives of the research are to develop a complex test programme in mountain climate circumstances, to determine the most favourable solution for these conditions. Our project is to test also some wind-mills manufactured in other countries. Further, our project is to build a demonstrative wind farm with a power of about 3 MW, consisting of 10-12 wind-mills, probably not only from Romania.

The future design concerns in a first period to build an industrial wind-farm on the Semenic with a power of about 100 MW(330 wind-mills with 300 kW power). Our researches have identified several emplacements in the Banat Mountains, situated between the Danube and Cerna-Timiş valley in the south-west of Romania. The largest altitudes are in the Semenic area with three peaks(Semenic-1445 m, Gozna-1447 m and Nedeia-1436m). Some emplacements are shown in the next synopsis by the research of Prof. I.Preda.:

Empl. pos.	Location	Surface km^2	Installed power MW	Energy GWh/year
10/1	Semenic 1	3.6	100	240
10/2	Semenic 2(extens.)	6.8	160	256
1	Anina	4.4	88	208
11	Gărîna	8	160	381
2	Caraşova	2.8	50	116
12	Brebu	1.2	21	50
3	Poneasca	1.2	19	43
13	Bibanul	6.8	95	202
14	Tîlva lui Vasile	8.8	123	262
15	Pietrele de moară	20.8	291	620
4	Eşalniţa	2.8	28	66
9	Sfînta Elena	7.2	72	171
6	Moldoviţa(east)	2.0	20	41
7	Gîrnic	7.2	72	150

4.ECONOMICAL AND ECOLOGICAL ARGUMENTS FOR PROMOTION OF THE WIND FARM SEMENIC IN THE WEST REGION OF ROMANIA

The wind farm Semenic 1 has been examined in detail. It is a favourable place with the value of the mean wind speed of about 8 m/s(at 30m height). Details concerning the wind farm and the wind speeds are shown in Fig.6.

The Figure 7 represents the first experimental wind-mill.

The ecological arguments are not separable from the economical ones, these are complementaries.

4.1.Economical Elements for the "Semenic Wind Farm"

In the Semenic wind conditions ensure the work of the wind mill 6250 hours/year to 8760 hours/year. During 2160 hours/year the wind speed is small, the engine cannot deliver energy towards the electrical system. During 350 hours/year the speed rise above 25 m/s. In these conditions the engine is stopped for protection: survival conditions. From these 6250 h/year during 4900 h/year the wind mill has a partial loading between 9 and 300 kW, while during 1350 hours/year it works in full power : 300 kW.
The first experimental wind mill no.1 run at two rotation speed: the

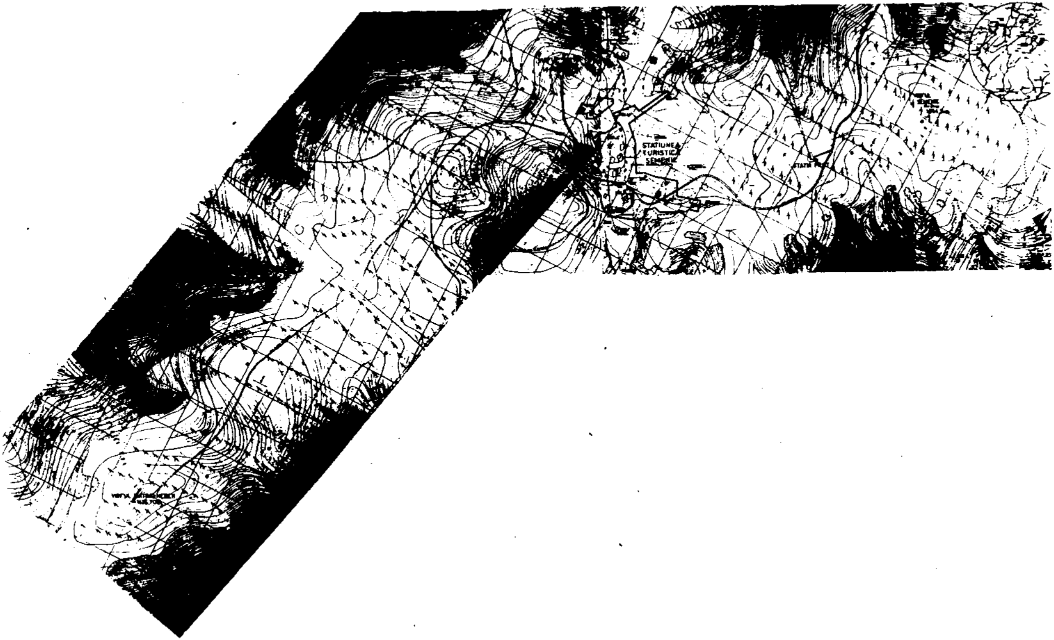

Figure 6.Wind farm Semenic (studies)

first ,a little speed for wind speed of 4 to 7 m/s and a greater for v>) M/s. By wind speed over 12.5 m/s the turbine is regulated to keep the electrical power at 300 kW.There are in investigation also other methods to limit the power.

The productivity of the wind -mill results in this conditions around 2790 kWh/kW year by an availability of 100% and 2510 kWh/kW year by 90 %.

In this way the "Semenic Wind Farm" with 100 MW in m a mean year sends in electrical system 240.000 MWh/year.By a price of the electrical energy about 40-50 $/MWh results a cashing about 9.6-12 million $/year.

By an investment of about 1000 $/kW a liquidation time about 20 years, the expenditures resulted are of 7 million $/year.The profit will be 2.6-5 million $/year. Therefore the balance is advantageous.

The production of the electrical energy :

Operation	Wind speed m/s	Time for wind speed h/y	Power kW	Energy MWh/year	Ratio %
1.Little power	4-7	1900	9-29	35.4	4.23
2.Great power	7-12.5	3000	29-300	396	47.35
3.Max.power	12.5-25	1350	300	405	48.42
TOTAL:		6250	9-300	836.4	100%

4.2. Ecological Arguments(Environmental)
Two aspects are analysed:
-Climatological influences
-Influences on the tourism

In 1985 the Biological Research Centre from Cluj-Napoca have prepared an investigation-report on the ecological implications of the"Semenic Wind-Farm"(Author:Dr.Alexandru Filipescu).The conclusions of the report are synthesize in the following manner:
"It is most evident the fact that the wind farm do not disturb never the landscape,but it enrich that in significances adding a human gesture to preceeding activities,which had evacuated its substances. The action is timely and correspond to this region.."

As effects of the wind-speed diminution,produced by the power extraction,will be:
-a growth of the hygricity in the area
-a reduction of the negative effects of the wind:the natural drying of the vegetation.
-a growth of the insects with pollination role,with favourable effects as for instance on the bilberry bush.

This research in any case is a beginning,it have been achieved using field survey,an"ecological witness background" for Semenic.This will be very useful in the future research concerning the evolution in the future of the ecological changes as effect of the"wind-farm".

Looking at the effects on the tourism I noted several advantages.A forest wind-mills creates a favourable environment,their noise do not disturb.The alarm concerning the disturbation of the telecomunications announced in few papers haven't been proved as a general conclusion. The administration of the TV system authorized the wind-farm.

The protection of the tourists ,animals and objects against the damaging of the wind blades is a very important question.This hazard is necessary to be excluded.For this reason,shall be prescribed a certain very severly control technics.The such importance have the dangers of the atmospheric electricity.

With reference to the energetical assambly of the Semenic system,subordonated to the economical interest of the industrial centre Reşiţa,I have remarked an ecological aspect,as a result of the clean energetical policy in this region,promoted during near a century.A maturity in solving both the water and the energy necessity has generated very spectacular hydrotechnical workings.At present the water is collected off all flanks of the Semenic massif.Water is shifted out of two basins(Timiş and Nera) into the third(Bârzava),which flows towards Reşiţa.This system have sewers,canals,conduits,barrages,lakes for accumulation,hydroelectric power stations,pumping stations,etc.

The wind farm can compensate in winter the deficit of the hydraulic system.It is a favourable association.

4.3.Ecological Arguments(Pollution)

An important argument in favour of the wind energy is its purity.A comparison between wind farm and a thermo-electric power station using inferior coal(lignite) and bituminous shale is significant.

The "Blue book of the ROWEA" [8] gives the following information concerning the pollution ratio of the thermo-electric power stations:

-SO_2	5-8 t/GWh
-N-oxides	3-6 t/GWh
-CO_2	750-1250 t/GWh
-Dust (in smoke)	0.4-o.7 t/GWh
-Slag,ash	310-545 t/GWh

I have analysed the real conditions in Romania. The composition of the lignite(Rovinari) and of the bituminous shale(Anina) are:

	C%	H%	S%	(O+N)%	Minerals %	H_2O %
Lignite	20	1.8	0.7	10	24.5	43
Shale	10	1.6	0.7	9.7	71.5-73.5	6.5-8.0

The caloric power	for lignit:	2000 kcal/kg
	for shale	100-1380 kcal/kg
The density	-for lignite	1.2 t/m³
	-for shale	2.32 t/m³

The calculations performed by Prof.C.Ungureanu give us values near of those over for lignite:

SO_2 7.8 t/GWh

CO_2 1176 t/GWh

Dust 16.6 t/GWh(for eff.of the electrofilter) about 0.96)
2 t/ GWh(about 0.995)
Slag,ash 390 t/GWh

Composition of the ashes:

	SO_2	Al_2O_3	Fe_2O_3	CaO	SO_3	Na_2O	K_2O	MgO
Lignite (Rogojelu)	41.6	23.26	8.83	8.06	5.63	-	-	2.1
Shale (Anina)	57	27	10	1.28	0.4	0.6	1.6	0.79

The two combustibles have the following differences:the calorical power relative to volume is near the same values about 2.4 Gcal/m³,in contrast the afferent mass is different because of the densities(2.32/ /1.2.)In consequence the mass of the dust, slag and ash will be in proportion about 6,disadvantageous for shale

$$\left(\frac{2.\quad 0.725}{1.\quad 0.245} = 6\right)$$

The quality of the electro-filters determines how mach can evacuate through the smoke stack and how through ash.The first gives an atmospheric pollution and the second a soil pollution.

Based on this information it has it has been examined the pollutions for a station using lignite and one using bituminous shale by an equivalent power with the wind-farm Semenic (100 MW).

The energies produced are 240 GWh/year.

Polluants	Lignite	Bituminous shale
SO_2 t/year	1870	1870
N-Ox t/year	960	960
CO_2 t/year	300,000	300,000
Dust,slag,ash t/year	96,000	576,000

The efficient protection technologies costs about 1/3 of the electricity costs.

In conclusion the "Semenic Wind Farm" will protect the environment through avoidance of 310,000 t/year atmospherical polluants and 570,000 t/year-soil polluants.

Through these arguments I will not manifest a general opposition against the classic sources.Options for the rate of the wind energy in Romania over 10% in 2010 would be exaggerated because of the big investments.

I may but underline the economical and ecological advantages of the wind energy.The world wide tendency is the development of the wind farms,this new technology being in a stage of industrial maturation.

In these conditions,to ignore this new,non polluant source is a serious mistake.

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ASPECTS OF PRESENT-DAY ROMANIAN LEGISLATION REGARDING THE USE OF WIND ENERGY

Dr.Doru Silviu Luminosu,The Ecological University of Timişoara-ROMANIA

The knowledge of the legal background is the premise of the carrying out of any socially correct activity.So the concern of the economic agents to set the contents and parameters of their action within the space determined by the recent normative acts is only normal,the more so as the old laws and decrees of the old totalitarian regime are still not entirely abrogated or they have been issued on the grounds of a juridic thinking distorted by the political-ideological and economic structures set up by the government party in the communist period.The pre-eminence of the "directions",social voluntarism,truth veiling and rejection of the internationally acknowledged real values are some of the characteristics of the old juridic acts.

The short period defining the effort towards transition,chronologically placed between mid-December 1989 and the present moment.is also marked by the legislator's attempt to rethink and propose new draft bills which might settle each major compartment of society on the anticipated new direction of evolution.Undeniably,this attempt is difficult,sometimes even a failure,leaving the task of solving it to the future.Other times the proposed solutions only succeed in stating the situation de facto and de jure of the moment,wrongly considering it to be the sure prospect of the future development.

The examples could constitute the substance of a more extended paper.

From among the laws and decisions adopted by the Romanian Parliament and Government taken in the lot selected for the object of the "Symposium and Demonstration of the Use of Wind Energy in Romania"(SDuWE)held on 3-6 May 1992 I have retained those which allow a clear orientation regarding to:

A. The new social-economic background generated by the overthrowing of the totalitarian regime in Romania and the transition to a free economy; here I had in view especially the problem of the ownership of the soil and atmospheric space,as well as the naming of the bodies defined as responsible for the creation of the new legislative background referring to the natural and social patrimony and energy administration.

B. International conventions regarding to the protection of the natural energy patrimony,paying special attention to the Convention for the World Cultural and Natural Patrimony Protection,adopted by the U.N.O. General Conference for Education,Science and Culture in Nov.1972.

C. Essential aspects reffering to the legal persons empowered with the right of administering the natural and economic patrimony under the evolutive aspect, as well as the main adopted and issued laws and governmental decisions.

This presentation is also the consequence of the interaction of the two fundamental dimensions,the temporal and the spatial one.The former obliges us to treat any juridical event and act evolutively(historically)and causatively,the latter makes an express reference to the nature of property and the legislation respectively which substantiates and regulates it.

If we start from the fact that any energy producing equipment is located in the space,then we must determine the nature of that place in the space.In the given case,these wind generators are placed at a certain altitude,well determined by the designer,on towers built of metal reinforcements and concrete,anchored in the soil(and obviously subsoil). The problem can be stated in the following way:

1.Who is the owner of the soil and subsoil where the wind generator tower is intended to be placed or is already placed?

2.Who is the owner of the atmospheric space where the respective tower is or is to be erected ?

3.Can the constructor(designer) of this wind machine benefit at his will by the energy thus obtained ?

The first aspect of the problem sends us to the situation de jure of the national economy.We still have a state and centralized economy,inherited from the previous regime,whose first beneficiary and owner is the state.The legislation referring to the state ownership on the national territory and circumscribed atmospheric space called"aerial space",within the national borders,is maintained.According to these legal provisions,also included in the recently adopted Constitution,the owner of the land(soil and subsoil) and of the aerial(atmospheric) space is the Romanian State,in principle.

The Law of Landed Property,adopted by the Parliament in 1991 and promulgated in the same year,raises the citizens of this country to the rank of persons entitled to private ownership on the land-in the plain, hills and mountains.Must we understand by this that the law refers to ownership on the land only ?The respective law specifies this.

The ownership of the Romanian or/and foreign citizens on the land of any kind is presently under the provisions of Law no.9/1990 referring to the temporary interdiction of land transfer by documents drawn between living persons,adopted by the Deputies' Assembly and the Senate on July 30th 1990.Art.no.1 of this law also mentions an exception,i.e. the lands belonging to the transferred buildings,of max.1000 m^2(MOR 100/1990).The motivation of this interdiction is to be found in the absence of new legal regulations referring to the landed property situation.

Consequently the acquirement or temporary obtainment of a land necessary for the erection of a wind generator is governed by the law of landed property and by law no.9/1990,so that the perimeter which can be legally obtained(except land nationalization)cannot exceed 1000 m^2.

The acquirement or temporary renting of the land does not mean the coming into possession of the subsoil and/or the aerial space over it. That's why the constructor must take into account the approvals of the District Council and the Town Council where the obtained perimeter is situated,of the Ministry of Economy,Ministry of Public Works and Land Reclamation and Ministry of Transport(for the altitude range, having in view that the exceeding of a 6 m altitude from the ground may affect the aerial navigation;this imposes adequate warning systems according to the aerial code,visible for the pilots).

Having in view that the advantageous obtainment of electric energy with low,mean and high power wind generators by their intensive erection in territories with constant local winds,the following problem arises: doesn't the erection of these generators at a certain density/ha take the respective agricultural or forest surface out of a well-determined economic circuit in which the product unit has ensured an income estimated by the owner ?

And so we come to the question formulated by the present paper:3.Can the constructor(designer) of this wind machine benefit at his will by the energy thus obtained ?

At the present moment we must make the following distinction:the constructor(designer) is in fact the owner of the machine,but not of the land.In the future,alongside the producing and commercialization of these machines,the purchasers can be both the trading companies(state or private ones)and the land owner who will erect these wind generators for their own interests.

Coming back to the present,the answer could be the following:the constructor(designer)of this wind generator cannot benefit at his will by the obtained energy.He can commercialize it only if,as trading company, observes the electric energy rules(which presently is a state monopoly)and the laws referring to goods circulation.Thus he will come,due to the tax on goods circul ation,to obtain energy whose kWh will be more expensive than the one obtained by the state,and this not due to the technological aspect of the process of converting the wind energy into electric energy,but especially to the existing regulations regarding the activity of the economic agents.

The following conclusions result from this problem:
1.The wind generator designer must have in view the legal possibilities of the beneficiary of the space location.
2.The designer will also retain,from the multitude of juridical aspects, that any elevation exceeding 6 m height(from the ground level)may be a virtual obstacle for aerial traffic.Consequently,for the final erection on tower or in other enclosures,the approval of the Ministry of Transport and the adequate warnings are necessary.
3.The designer will keep in mind that the erection of these generators in the vicinity of roadways ,railways or navigation ways may endanger the public traffic in case of catastrophy.But if they should be located in such areas,besides the erection authorization in the areas mentioned in this paragraph,the owner must place a traffic sign indicating"Other dangers","speed limitation" and "no parking".
4.Having in view the prices(both of the generator and of the electric energy thus obtained)one would come at due to the present legislation

referring to economic agents and goods circulation,one must study carefully the materials and subassemblies estimates to make the obtained product competitive under the commercial aspect of merchandise.
5.The beginning of fabrication would call for the consultation of a jurist who would advise the possible beneficiaries on the multiple existing normative aspects and with present validity,from which this paper has mentioned only the essential ones.

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ELECTRICAL EQUIPMENTS FOR ENERGY GENERATION,DRIVE, AUTOMATION AND CONTROL OF THE HORIZONTAL AXIS WIND GENERATORS

Eng.M.Nicodin,eng.C.Vergiliu,eng.L.Nincov,HIDROTIM SA Timişoara,Dr.eng.N.Budişan Timişoara Technical University Romania /HIDROTIM S.A. Timişoara,ROMANIA

The programs of wind energy utilization have been promoting very different constructive and equipping solutions for wind generators,which justifies,also from this point of view,the wind energetics characterization as "unconventional". In the following,we present with some justifying considerations,the concept of electrical equipments for energy generation,drive,automation and control,elaborated in cooperation,by the specialists of the Timişoara Technical University and HIDROTIM S.A for horizontal axis ,network connected wind generators.Some of them have been already achieved and others are being manufactured or assembled or in design stage.

1.ELECTRICAL GENERATORS

Having in view the experimental,respectively the prototype character of the wind generators under consideration,different solutions have been adopted,but all of them are provided with asynchronous machine.The peculiarities of the discussed generators are presented in Table 1.

Electrical Generators of Horizontal Axis Wind Generators Already Built Respectively in Manufacture,Assembly or Design Stage.

Table 1.

Wind generator	Electric generator	Justifying considerations
1. AEROTIM 30 kW	Two asynchronous generators with phase-wound rotor and static Scherbins cascade in the rotor circuit 1.Generator no.1 PN=6kW no=650 rpm n=650-1300 rpm 2.Generator no.2 PN=15 kW no=1500 rpm n=1500-2250 rpm	Allows operation at variable speed and the study of oversynchronous cascade solution.
2. AAETO M1 30 kW	Asynchronous generator with static Scherbius cascade	Ditto

Wind generator	Electric generator	Justifying considerations
	PN=18 kW no=1500 rpm n=1500-2550 rpm	
3.EOLTIM 300 kW/1	Two generators with Scherbins cascade 1.Generator nr.1 PN=55 kW no=500 rpm n= 500-1000 rpm 2.Generator no.2 PN=250 kW no=1000 rpm n =1000-1400 rpm	Ditto
4.EOLTIM 300kW/2	Asynchronous generator with phase-wound rotor and resistances in the rotor circuit PN=315 kW no=1500 rpm	Allows the operation at a higher speed than the natural one and consequently optimmum conditions for turbine.
5.	Asynchronous two-speed generator with short-circuited rotor, PN=5/7 kW no=750/1500 rpm	Provides the expansion of the operating range also at smaller wind speeds.
6.	Asynchronous two-speed generator PN=22/30 kW n =750/1500 rpm	Ditto
7.	Asynchronous two-speed generator PN=35/50 kW no=750/1500 rpm	Ditto
8.	Asynchronous generator with short-circuited rotor,star connection of stator windings at smaller wind speeds and delta connection at higher wind speeds.	Ditto

2.DRIVING AND CONTROL SYSTEMS FOR THE NACELLE AND BLADES POSITION

For the nacelle position control system,the"three-position" system with two asynchronous motors with short-circuited rotor was adopted,except for the 5/7 kW wind generator.

For the blade driving and control systems,different driving systems have been provided for the various wind generators,in order to draw the proper conclusions on the opportunity of using one or another of them(see Table 2),as a result of the accumulated experience.

Table 2.

Wind generator	Driving system and blade control system	Critical considerations
1. AEROTIM 30 kW	with d.c.rotor,controlled motor, with static voltage convertor;the motor is placed in the ogive being fed through a ring-brush system; control is P type(proportional)	the system eliminates the contactors and allows a continous linear control.The presence of commutator motor,of the ring-brush system and voltage convertor affects the reliability,respectively increases the complexity and price
2.EOLTIM 300/1 EOLTIM 300/2 5/7kW 22/30 kW 35/50 kW 50 kW	with short-circuited rotor, asynchronous motor placed in the ogive,fed through a ring-brush system; "three-positional"control	commutation with contactors and feeding through rings and brushes affects the reliability. Lower control quality.
3.EOLTIM 300/3	with short-circuited rotor, asynchronous motor placed in the nacelle,controlled through static frequency converter,the motor is rotating continuously in one direction only;control direction and speed depending on the motor speed value.	the system eliminates the feeding through ring-brush system and the contactors. Provides a higher control quality.

3.AUTOMATIC GOVERNING AND CONTROL SYSTEMS
The blade position, oversynchronous cascade and nacelle position control systems are achieved with conventional controllers except AAETO M1 30kW,EOLTIM 300/1 and EOLTIM 300/3 wind generators,for which the control is achieved by program,by programmable logic controllers(PLC) respectively by an electronic computer(EOLTIM 300/1).

The general automatic governing strategies of the wind generators are provided by hard logic systems,respectively programmable logic,presented in Table 3.

Table 3.

Wind generator	Governing system
1. AEROTIM 30	Hard logic controller and conventional controllers
2.AAETO M1 30	Programmable logic controller which has also the function of the three-position blade controller(the other controllers are conventional)

3.EOLTIM 300/1	Computer (PC) with the above-mentioned functions
4.EOLTIM 300/2 5/7 kW 22/30kW 35/50kW 50kW	Logic systems with relays and conventional controllers
5.EOLTIM 300/3	programmable logic controller (PLC).

Of the following elaborated systems,the control system with PLC,proposed for EOLTIM 300/3 is presented.

Based on the design experience obtained by HIDROTIM S.A.,and the experimental data determined during the operation of EOLTIM 3/1 wind unit on the Semenic,the following configuration of the automation equipment was adopted for EOLTIM 300/3:
-in the nacelle there are located a data acquisition system and the data serial transmission to the tower base through an optocoupler.
-in the tower there is located a power commutator which provides the continuity of power circuits to the nacelle.
-at the tower base,the power and control equipments are located;the latter is connected through a serial channel to the data acquisition system in the nacelle.

The data acquisition system and serial transmission in the nacelle is a microsystem organized around a microcontroller which takes over the following categories of signals:
-impulse sequences from the incremental transducers:wind speed,generator speed,turbine speed,blade driving axle speed.
-analogue signals:nacelle temperature,generator stator temperature,generator bearing temperature,multiplier oil temperature,nacelle humidity vibrations in the nacelle(accelerometer),blade angle position.
-binary signals of the type "All/Nothing" from the following elements: "out of wind" and"optimal" blade positions,nacelle rotation CLOCKWISE /ANTICLOCKWISE,nacelle on wind direction,rotor brake raised,smoke detector.

This data acquisition system comprises two serial channels according to RS 232 C standard for:
-data transmission to the programmable logic controller in the tower base,which constitutes the wind generator automation basis.
-monitoring of the above-mentioned parameters on a liquid crystal display(LCD);this is necessary only at the comissioning or after injuries when local(manual) control of the wind generator and the display of its parameters are imposed.

The serial connection nacelle-tower base is made in one direction only:nacelle(transmitter)-tower base(receiver).

The transmission from the rotating part-the nacelle-to the stationary part-the tower -is made optoelectronically,locating a LED in infrared on the rotating part and,at a short distance on the stationary part,a phototransistor in infrared.Thus the sliding contacts which cause great troubles,are eliminated from the transmission of signals.

As the execution elements(contactors) on the electric power side are located at the tower base and the controlled elements(motors,couplings) are in the nacelle,the connection is made by a suitable power commutator located in the tower.

The wind generator also comprises a commutator located on the turbine rotor,by means of which the following signals are transmitted to the data acquisition system in the nacelle:blade angle transducer,blade position limiters in"out of wind" and at "maximum" angle.

The main electrical equipment is located at the tower base,namely:
-power,protection,driving and control electrical equipment
-wind generator control equipment
-power factor compensating equipment.

The wind generator control system is constituted around a TEXAS INSTRUMENTS programmable logic controller of TI 435 type.Besides the parameters which the programmable logic controller receives serially from the data acquisition system there are local collected data,namely: generator active electric power,generator reactive electric power, network frequency and data about the state of some equipments.

The recommended control system withTI 435 programmable logic controller allows the carrying out of the following functions:
-AUTOMATIC control of wind generator
-local light signalling of the state of various equipments
-by means of the specialized testing and monitoring equipment MIU 405[1] the system with TI 435 can be quickly repaired and/or various parameters can be monitored on its LCD display.
-in experimental tests TI 435 is connected to a PC computer,LAPTOP type[1],monitoring and storing the wind generator parameters.

1) product of TEXAS INSTRUMENTS

4.POWER FACTOR COMPENSATING SYSTEM FOR WIND GENERATORS

The power factor compensating systems through step connection of capacitors are well-known.These systems have the disadvantage of not providing the total compensation when the reactive power to be compensated has a value between the power steps of the compensating system and have a reduced reliability when the capacitor steps switching is made with electromagnetic contactors.

The recommended compensating system(for EOLTIM 300/3) eliminates the above-mentioned disadvantages,representing a continuously adjustable reactance,made up of a group of constant capacity capacitors in series with adjustable magnetic amplifiers.The system is applied to wind generators up to a few hundreds of kW and also when the number of generators belonging to a plant is small.At plants with great number of wind generators the use of the synchronous compensator is justified.

5.CONCLUSIONS

The above-presented material reflects the development at the Timişoara Technical University and HIDROTIM S.A.,of the concepts regarding the electric generating driving and automatic control equipments of horizontal axis wind generators connected to the National Electric System materialized in the already achieved wind generators and also in the ones which are being erected or manufacured or are in design stage..

Advanced solutions have been promoted(operation at variable speed, control with μ P systems,etc)and also original solutions(blade driving and control systems,and power factor compensating systemsEOL-TIM 300/3 etc) which led to a wind generator EOLTIM 300/3,representing the synthesis of the experience accumulated until now by our research, design,fabrication,erection and commissioning.

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RENEL-ISPH's*) STRATEGY CONCERNING THE DEVELOPMENT OF WIND ENERGY FARMS IN ROMANIA

M.Sc.mech.eng.Cristian Niţescu
RENEL -ISPEH Bucureşti-ROMANIA

1.INTRODUCTION

The ISPH-Romanian acronym of INSTITUIUL DE STUDII SI PROIECTARI HIDRO-ENERGETICE-is a consulting-engineering organization specialized in dam and hydro power engineering,as well as of wind farms.ISPH is a distinct branch of the NAtional Authority of Energy-RENEL.Thus the firm RENEL's main consultant in hydro power field.

Founded and existing since 1949,ISPH was set up as a distinct unit by separation of the Hydraulic Department from the Institute of Power Studies and Design.Its rich activity in designing the hydro power stations in Romania is certified by 10,000 MW installed capacity,i.e. the half of the hydraulic potential of our country.

Except the designing of hydropower development schemes,dams,hydro power stations and wind farms,there is a whole range of services starting from preliminary studies and specific surveys and ending with start-up operations and structure monitoring put to the client disposal.

The firm has highly skilled and competent consultants with a rich experience,among the about 1800 permanent staff employed with at the beginning of 1991,some 800 are graduates of higher educational schools and the ability and competence to offer complex services in Romania and abroad.

For your information we enclose the RENEL-ISPEH background.

2.WIND ENERGY DEVELOPMENT PROGRAMME

2.1.Wind Energy Use

Between the renewable energy sources,the wind energy is the most appropriate to be used on large scale.The use of wind energy as alternative to other energy sources has a large support in the developed countries.

The wind energetic potential economically harnessed as it results from the ISPH's studies,to be converted into electric energy is over 20TWh/year,i.e.equal to the Romania's hydraulic potential estimated to be economically developed and it saves 50 billions barils of oil/year.

Firstly,the use of wind energy is a problem concerning the high technology possession and secondly of favourable financial laws.

*) RENEL-ISPH=National Authority of Energy-
Institute of Hydroelectric Studies and Design

computer side assistance etc.) and less about the equipment cost or the investment cost.

It is to be mentioned our opinion that how excellent would be a wind turbine if its cost is not between competitive limits of the whole investment,the machine risks to be never promoted.

All over the world the energy investments are financed by governmental programmes or by founds of a group of countries(see the European Economic Community).Other developed countries as USA have advantageous laws for wind farms permitting to the investors to obtain interestingprofits.

The Romanian laws are much more severe and restrictive providing that the investments for energy production should be supported from governmental founds.The investments for wind farms are considered economically between the limits of 40-60,000 lei/kWi for the investment and of 1.1-1.7 lei/kWh for the generated energy.Even in these conditions and taking into consideration the Romanian currency(1 US$ = 60 lei) the costs in US$ are not high.

We must improve of course the financial laws so that through their effects we pass to the encouragement and systematic promotion of new energy resources-especially wind energy.

3.2.Investments Connected to the Wind Farms

Setting forth the investments connected to the wind farms as appurtenant investments without which the main object cannot operate,we must here enclose the transmission lines of 20 or 110 kV to evacuate the generated power and the access road to transport the equipment and assure the intervention and service teams in accident or failure situation in wind machines.There are also other appurtenant investments as: buildings , water supply,dwellings etc.

In our country the cost of the appurtenant investments must be assured together with the investment of wind turbines.

It is sure that one prefers zones with less favourable wind potential if there are access roads and electric transmission lines in the aim to not increase the investment costs of wind farms.

4.CONCLUSIONS

The studies performed on the use of the wind energy offer us the certitude we have a rich energetic potentialcompared with the hydraulic one which must be developed.The experience of other countries demonstrated that the wind farms are promoted intensively as an alternative of other energy sources,especially oil and natural gas.

Our technology allows us to develop wind farms accomplishing wind turbines with unit power of 100-1600 kW and the cooperation in this field should be a mutual advantage.

Our experience gained along 40 years of hydropower designing allows us to carry out projects and built wind farms everywhere,offshore included.

The commissioning after 2000 of the hydraulic potential of Romania would with the statistic parameters of the wind: average speed,average frequency on directions,average number of hours with various speeds, ice and hoar frost deposits-shows that the wind energetic potential is better within the offshore than in mountaneous zones.The ecologists call the attention on the specific noise disturbing people and birds and the architecture of these structures disturbing the natural landscape.Some pessimists name them "scarecrow".

So these conditions as well as the land intensive utilization lead to consider the offshore areas(with lower water) which seems to be economically more advantageous to develop large wind farms.

The Romanian shore between Sulina(Northwards)and Năvodari(Southwards) has water lower than 15-20m on offshore surfaces reaching about 2o km distance from the shore.Supposing only 10 km distance from the shore should be used,this means about 2000 km^2-excepted the Danube Delta, Razelm lake and other large water surfaces with depths lower than 2-5m amounting other about 1000km^2,we could consider them as areas with an important wind energetic potential.

These areas meet the following important criteria for the first off - shore stage:location outer the restricted zones,a reasonable esthetics, short distance to the national transmission lines,water depth of max. 20m,no brakers and good conditions of the sea bottom(flat surfaces).

According to the international standards the navigation is allowed up to 500m around any maritime structure.In order to allow the navigation around these structures we could suppose that only half of these areas would be used to the wind farm development.

They computed that about 4000 machines could be installed up to 10 km from the Romanian shore and other 2000 machines in the lakes and zones of lower sweet rivers of the country.

Supposing the utilization of the wind machine of 1500-1600 kW unit power,about 8000 MW could be installed producing normally over 10,000 GWh/year.

RENEL-ISPH wishes to install up to 2000 at least one wind machine on the Romanian offshore,so that in 2o10 we may promote intensively the investments within these areas, improving during this period the special offshore technologies both by our own efforts as by cooperation with any person or firm possessing high technologies and experience in this field, so that up to 2020-2025 we finalize to implement 10,000 MW on the Romanian offshore.

3.ECONOMIC ASPECTS

3.1.Investment Cost and Technic-Economic Parameters

Any investment can't be realized even the experimental one without speaking about the investment cost and main technic-economic parameters, without the overall investment value and finally without an investor decided to spend his money based on the previous computations and without a profit.

It is interesting to note that we had met in the technical literature only the references on the solution of technical problems(determination of the wind energetic potential,rotor blade aerodynamic,automation, 300 kW machine.The researchers are of course more optimistic and ISPH considers as very satisfactory a production of 300,000 kWh/year having in view the real operation conditions,interruptions due to different false signals given by the automated protections,remedials and other failures.

Once the 300 kW and 1000 kW horizontal axis machines completed up to the end of 1995,may be one or several wind farms too,we shall use these machines at industrial scale,programming to have up to the end of the year 2000 about 300 MW installed in wind farms connected to the national energetic network.

We'll develop parallelly from the 300kW machine a whole serie of wind machines with powers between 100 and 500 kW.We'll also develop from 1000 kW machine an other serie of machines with power between 600 and 1600kW.

Concerning the location of these machines we take into consideration now to implement within the hill and mountain zones,machines with power between 100kW and 500-600 kW and within the seashore zones between 600-1000 kW.

We have less information on the vertical axis or Darieux machine,the most of them are from USA,and recently we were amazed by the Canadian 4MW YAWT machine waiting news on its behaviour under operation.

We have experience in this field too:a research and design institute from Braşov has manufactured and installed within an experimental stand, vertical axis turbines with power of 6 kW,10 kW,20 kW,50 kW and during 1988 they installed a very elegant turbine of 100 kW.

We have tried to promote this machine designing the projects for a wind farm with a small number of machines,3 to 5 wind turbines located on Redi Hill(near Tulcea town) and we have agreed with the institute from Braşov to realize a 300 kW vertical axis machine,and the machine of 100 kW will be manufactured in small serie up to the moment when it will be manufactured in industrial regime.

Any way RENEL-ISPH intends to promote also these machines of 100 and 300 kW with vertical axis carrying out projects for small wind farms(about 1-3 machines)connected to the national energetic network so in 1995 we shall have exact knowledge on their behaviour.

We wish even install machines of same power as 100 and 300 kW but of different types,i.e.three-bladed horizontal axis wind turbine and vertical axis wind turbine in the same site in order to compare the electric energy output under the same operation conditions.

We have programmes-in draft stage-for the period after the year 2000 to implement wind turbines amounting 500-1000 MW,for periods of 5 consecutive years,after that rhythm will be accelerated.The location areas will be the hill and mountain zones with altitudes generally greater than 500-1000m and theBlack Sea's shore Southwards of Sulina and Northwards of Năvodari towns(the touristic area excepted).

2.3.Wind Turbine Implementation on the Romanian Black Sea Shore
The present increasing of unit power of the wind machines correlated

production of the country.

We direct our attention on the use of two types of equipment in view to produce electric energy: two bladed wind turbines with horizontal axis, two -bladed vertical axis wind turbines and Darieux turbines.

The studies carried out in our country,some years ago,had as model the MOD American system performed by NASA within the US Department of Energy.We have a lot of references on the MOD 2 unit of 2500 kW so that we had defined very well its operation regime.The Danish 29.3/3/d-340/70-60 Hz has been considered as reference for three-bladed model. Comparing the optimum aerodynamic parameters of MOD 2-107 and 29.3/3/D-340/70-60 units the results had been at that time,as follows:
-three-bladed rotor is more slowly than the two bladed one,the optimum speeds being of 7.80;9.32 ratio(0.832).

The last characteristic shows the reason in adopting the two bladed solution for power greater than 2000kW.Over this limit,the resulting rotations for the three bladed rotor in the usual rated speeds(12-13 m/s)are placed under 10m/s.This reduced rotation involves on one side, the adoption of a very large transmission ratio and on the other side, as decisive argument,it leads to the increasing of the mechanic torque.M=973 P/n(kg.f.n.) so that the dimensions of rotor pieces and primary axis in rotation increase over the allowed limits from economic and technic view point.As much as the rated power is decreasing under 2000kW so the possibilities to use the three bladed turbine are greater.

The technic economic studies had shown the maximum operation power of an wind machine for Romania is of about 1500-1600 kW/unit,taking into consideration the possibilities to realize wholy in Romania this machine.So we had practically adopt only the three bladed machine with horozontal axis.

RENEL's conception(the unique energy suppliyer within the national energetic network) is to implement a wind machine connected to the national energy system ,characterized by a frequence of 50 Hz and 220V tension to the consumer,the transmission lines being of 3kV,6kV,20kV, 110kV and 220kV function of the transmitted power and the respective network length.The minimum power of the wind machine-promoted by ISPH-is of 100kW and the maximum one is of 1500 -1600 kW as we have mentioned above.

We proposed to perform up to 1995,two types of wind machines:300 kW three-bladed horizontal axis machine and 1000 kW three-bladed machine.

Using the 300 kW machine we proposed to realize some wind farms amounting about 50-60 machines.This means the maximum power evacuated on a transformer will be of about 15-20 MW and if the machine is of 380 V,the transformer will be of 0.4/20 kV.

We design now an wind farm amounting 10 machines of 300 kW each,located in Semenic Mountains(1400 m above the Mediteranian Sea Level,max.altitude),this area possesses a remarquable wind potential. Research insti tutes from our country had established on the bases of wind parameter measurements an energetic potential of about 800,000kWh/year for the

Some countries possessing high technology had contributed to impulse the manufacturing,at industrial scale,the equipment better improved and the financial laws adopted had contributed to have profit both the internal and external suppliers(as USA and Danmark)of the use of wind energy.

We have not sensational evolution in this field.On August 1981,RENEL-ISPH had installed to Petrimanu(near Lotru hydro power station) an experimental wind turbine of 20kW connected to the national energetic network,in service today,after the general repair(replacement of rotor). On December 1985,in Bucegi Mountains,had been put in operation(Cocora peak) an other wind turbine of 30 kW,generating energy since now.

Based on these results and looking especially to the American wind turbines from California,RENEL-ISPEH passed to a new orientation establishing a new long term strategy,on 30 years,in order to use the wind turbines and farms,as alternative to other energy important sources(oil and coal).

Between 1988-1989 two Romanian institutes(Timişoara Polytechnic Institute and ISPH)have designed three-bladed horizontal wind turbines of 300 kW.Both turbines had been installed in Semenic Mountains,where about 1000 wind turbines are provided to be installed till 2010.The first turbine is operating early 1991 and the second one will be in operation at the end of 1991.

The nwe modifications appeared after December 1989,the passage to the market economy and price liberalization had contributed to the delay, of about two years,in developing the wind turbine programme,but the situation became better now.

Due to the fact we have a high technology in manufacturing wind turbines except the rotor blades which we intend to import or to cooperate with other foreign firms,the 300 KW Romanian wind turbines are chipper than the American or the European Community's ones,so we foreseen a rapid resume of the wind turbine programme in order to produce electric energy in Romania(estimation in US$; 1 US$=60 lei).

We can say that at the end of the eighties,between 1979-1980,there is an industrial scale development of the wind energy use,after that only the USA and Danemark know an explosive development.We suppose the arabian countries ,although they are rich in oil,will be interested in using wind energy,one of the most advantageous and non-polluting resources.

2.2.Strategy of Wind Farms Develcpment in Romania
RENEL-ISPH has carried out,based on successive studies a long term programme up dated periodically in view to develop the wind potential as source producing energy.

This is also the national programme to develop the wind farms in Romania. RENEL-ISPH is the unique performer of the energetic policy,wind energy programme enclosed.

Romania intends to finalize in about 30 years the implementation of wind farms using practically the whole Romanian wind potential.In other words, we hope to be able at the end of the year 2020 to obtain about 20.000

GWh/year,in wind farms,representing 10% from the whole electrical energy keep free the implementation of the intensive wind farms within zones with high wind potential.

As soon as we develop this energetic potential which is a renewable resource so we avoid to burn in boilers the liquid,gaseous or solid combustibles required by other brances of the national economy.

The prospect to achive in the future a better life conditions on the Earth from ecological point of view opens large ways to the use of wind power due its characteristic of "clean energy".

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WIND-FARMS IN THE SOUTH-WESTERN MOUNTAINS OF ROMANIA

Preda I.-Dr.eng.,Consulting professor;Gyulai F.-Prof. Dr.eng.-Technical University Timişoara;Research Center for Wind Energy,1900 Timişoara,Bv.Mihai Viteazul no.1 ROMANIA

The absence,regarding the covering from the conventional sources of the continuing increasing needs of energy has determined the necessity of a systematic exploration of the repalaceing energetic sources and between them the Windsources.

Studies covering this field were achieved at the aero-energetical research Center in Timişoara,regarding specially the area of the south-western mountains,where the wind energetic resources could be capitalized depending on the economical and technical conditions.

1.In these studies ,there was achieved and applied an estimation methodology of the raw Windpotential,respectively,its areal distribution,in its virtual shape associated to a wind-farm referring to each m^2 of surface covered by the turbine rotor(kWh/m^2 per year)in normed conditions(wind velocity considered at 10 m up from the ground).

As primary data were used maps with the distribution of the hourcovering in the studied area(absolute h/year,respectively relative) of the several steps of wind velocity(2,4,6,8 and 10 m/s) achieved by INMH Bucureşti.

The assemblage of those maps,aligned in territorial way,specifies(in the limits of the maps precision)regarding to each geographical point, the distribution function(empirical,local)of the wind velocity.

Choosing in a right way in one area a lot of points(from which points of known values) put on different alignments,one could build a map with the repartition of wind energetic potential(raw,local)calculable through the described distribution functions.

Appealing to the theoretical Weibull distribution with suitable chosen three parameters were obtained,through a program,the discrete values in the analysed points of the energetic potential;then through necessary interpolation,the needing data for building a map with its distribution referring to the studied area.

2.Realising that usually the wind farms are settled and exploited in groups of a precisely determined areal,there was studied and applied the way of determination of raw energetic disposal(kWh/km^2 per year) distributed on one km^2,thus localized in the mentioned area.

It can be demonstrated that, in those conditions, the searched values of the potential are independent from the size and thickness of the wind farms, but there is necessary to impose corrections determined by choosing the installed elevation other than the standard one(10m from the ground at which there was taken into account the wind data).

Thus analysing the exploited parameters of the wind-farms through the main values of the wind velocity, for the manufacturing process, the usual working with partial disipations(for keeping the power at the installing limit) it was estimated a global efficiency parameter, wall balanced, through which it was possible to estimate the probably output of energy in some placements chosen in the given areal.

Practically, for avoiding the mutual influences in working, the wind farms are placed on the top of an equalsided triangle, with the side multiple K(=4) of the rotor diameter; it was found that the ratio between the local potential, at the considered point(representative one for the placement)and the specific potential (on km^2) of its surface is constant($=56,68.10^3$).It was considered that the wind velocity increases exponentially with the installed elevation, in average, in the territory, with the exponent α (=0.25).

At the same time, it was adopted a performenced specific feature of the wind turbine $C_p(\lambda)$ (after Growian) at which were associated the relative values of C_p to the relative values λ at the characteristical exploiting points(at launch out λ_l/λ_{opt}), which applied to an virtual pattern Semenic determined to asses the well balanced middle value C_p(=0.27), assimilable to the whole territory.

Also, admitting a medium value ofmechanical efficiency, including the transmission, η_m=0.95 and that of the generator η_G=0.9 , it will be obtained the probably energy production associated to the extension of the different placements.

It were chose in the area 17 placements on the following criteria: exposion of the dominant winds, an uniform structure of the area(low slopes, low level variations) disafforest area with out involvement in other economical activities(agriculture, extraction industry)accessibility in the territory, from those 4 were eliminated on the basis of the reduced potential.

Position of placement	Potential kWh/m^2.year	Placement	area km^2	Altitude m	Inst. power MW	Estim. product. value GWh/year
1	1600	Semenic 1 (extension)	3.6	1200	100	240
2	1600	Semenic 2	6.8	1200	160	256
3	1600	Anina	4.4	800	88	208
4	1600	Gărîna	8	1000	160	381
5	1400	Caraşova	2.8	800	50	116
6	1400	Brebu	1.2	1000	21	50
7	1200	Poneasca	1.2	600	19	43
8	1000	Bibanul	6.8	800	95	202
9	1000	Tîlva lui Vasile	8.8	800	123	262

10	1000	Pietrele de moară	20.8	800	291	620
11	800	Esalniţa	2.8	800	28	66
12	800	Sfînta Elena	7.2	400	72	171
13	700	Moldoviţa(East)	2.0	600	20	41
14	700	Gîrnic	7.2	600	72	150
			83.6		1299	2806

In the above table there are data about specific feature of the staying 14 placements,with their localization and arranged in decreasing order to the available raw wind potential (>700 kWh/m^2.year).The estimation was done after the described methodology with the immediate corrections made in the presented manner.If there are considered the constructive types of the wind turbine(therefore of the group) associated with approximation to the local potential in the placement, it can be appreciated that the number of those can be reduced to four. The placement altitude varies from 400 m to 1300 m of a total area of 84 km^2(evaluated on a map at the scale 1:200,000 through planimetration) The total installed power is estimated at 1.3 GW and the probable energy output at 2.8 TWh/year.

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A SMALL BUT DECISIVE STEP IN THE FIELD OF REGENERABLE ENERGY-LOW AND MEAN POWER WIND GENERATORS

Eng.N.Raicov Popa;eng.O.Bebeşelea Sterp;prof.dr.eng.N. Budişan;eng.M.Buga;eng.M.Nicodim;eng.L.Nincov
HIDROTIM S.A.Timişoara ROMANIA

The oportuneness of promoting the use of wind energy on industrial scale is indisputable at the present moment,from the energetic,ecological and,in the near future,economic point of view.

The highly industrialized countries with energy surplus have begun the serial production of mean power wind generators,but have started the promotion of this form of energy with low power units.

HIDROTIM S.A.has in view the conception of units in the power range of a few hundreds of watts up to 50 kW because,due to their low price and easy erection,they appeal to the electric energy consumers as well as to the National Electricity Administration(RENEL),

The studies aimed at the conception of units with independent operation as well as units operating connected to the National Energetic System. At the units of the first category the continuity of energy availability is ensured by accumulator batteries.

For the units connected to the national energy system a double registration(of the energy supplied to the network and the energy absorbed from the network) is made,the owner of the wind generator being at the same time consumer and producer.

In the following we shall describe the constructive solutions and the operational parameters of the low power wind generators conceived at HIDROTIM S.A.

Schematically these generators are shown in Fig.1

0.5 kW SELF-CONTAINED WIND GENERATOR

This unit is in erection stage,and the first experiments on site will be performed in a few months.

The horizontal axis rotor equipped with 6 fixed blades is located upwind to the tower.

The driving torque is transmitted by means of a conical step multiplier to the generator placed in the tower centre.The multiplier incoming shaft is also the turbine shaft and the directional ball bearing is mounted on the generator.The orientation in the wind direction is ensured by a gearing.The D.C.generator supplies energy at

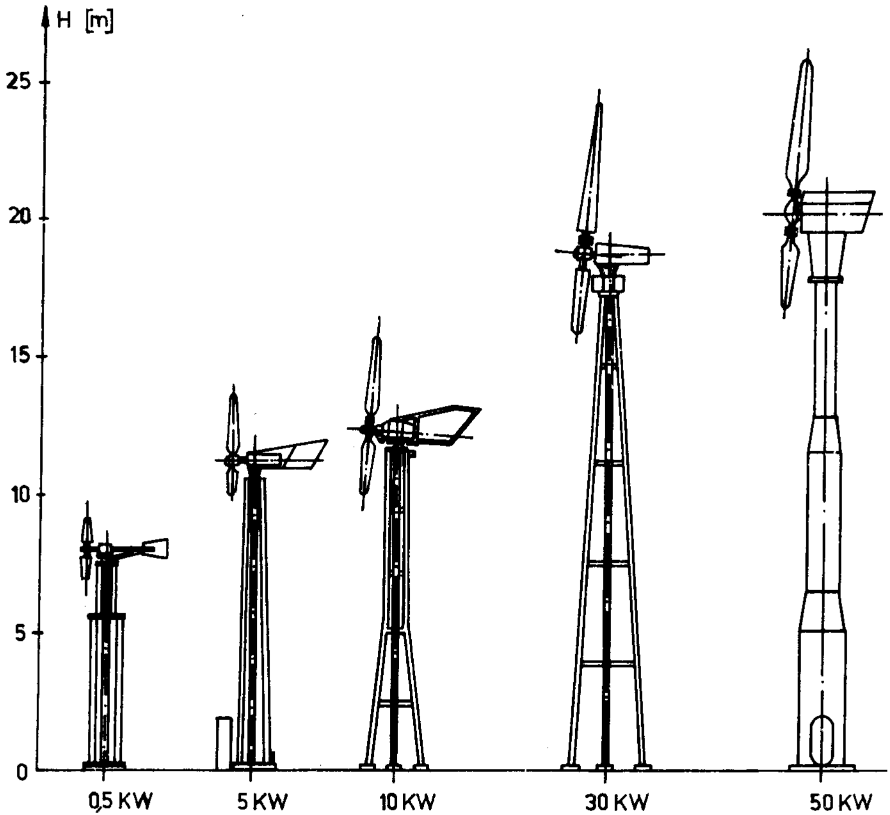

Figure 1.

24 V D.C.Depending on the voltage obtained at terminals,the generator is charged by connecting new consumers in order to keep the speed within the admissible limits.

Constructive and Operational Parameters
The 6-blade rotor with fixed installation angle mounted on the multiplier incoming shaft has the following characteristics:

-diameter	2 m
-max.speed	90 rot/min

The characteristic of multi-blade slow wind turbine rotor is established taking into account that the power supplied by the rotor should be obtained for optimum speed values of approx.45-9o rot/min.The acceptance of exploiting the unit at variable speed depending on the wind velocity leads to a power curve for which the design tip velocity ratio λopt.=1.5 is achieved,in the admitted wind velocity range from start up to a max.imposed velocity called protection velocity.Starting from this velocity step the dynamics of the system leads to a tip velocity ratio different from λopt. which,from the aerodynamic point of view, means the gradual decrease of the power up to complete stopping.The blade shape and installation angles are the characteristic for constant chord along the blade and variable performance coefficient along the radius.The blade chord is 300 mm and the installation angle varies from 37^{0}at root to 20^{0}at tip,which means a 17^{0} twist angle.

The blades are made of ribbed plate,fixed on a central axle,only the back of the blade being materialized.

The conical step multiplier has the transmission ratio=12.5

The steel tower of Viereendel beam type is 8 m high and of tilting type.

The D.C. generator has power=0.1 kW and max.speed=1500 rot/min.

Unit performances:

-power	kW	0.5
-voltage	V	24 V D.C.
-wind velocity		
-starting	m/s	4
-rated	m/s	8

On the basis of experiments made on site,which will also give data on the rotor performance,electric installations in several variants(lighting,battery chargers,mixed)will be conceived.

SELF-CONTAINED 5 kW WIND GENERATOR
This generator is mounted in Moraviţa,south-west of Timişoara.The horizontal axis rotor equipped with 3 fixed blades is located upwind of the tower.The power caught by the rotor is transmitted by means of a planetary multiplier to the generator.The connection with the tower is made by a guide and thrust bearing and the orientation by a gearing. The Vierendel beam type tower is tilting,thus facilitating the erection. The unit runs automatically without needing supervisory staff.

The unit is permanently oriented in the wind direction and the rotor is always unlocked(it will be braked in emergency case only).

As generator theG.I.F.V synchronous generator is used,with voltage rectification by means of rotating semi-conductor diodes,which eliminates the commutator and collector rings of the synchronous generator inductor.The choice has been determined by the positive experience(robustness ,easy maintenance) regarding the exploitation of these generators in railways in heavy duty(under the carriage,in open,humid,dusty atmosphere).The generator works in floating condition with an accumulator battery .The unit has 2 adjusting systems.
-accumulator battery charging current adjusting system, depending on voltage
-speed frequency adjusting system by surplus energy dissipation with a system consisting of magnetic amplifiers and constant resistance resistors. [1]. The principle sketch of the speed/frequency and of the accumulator battery current adjusting system is shown in Fig.2

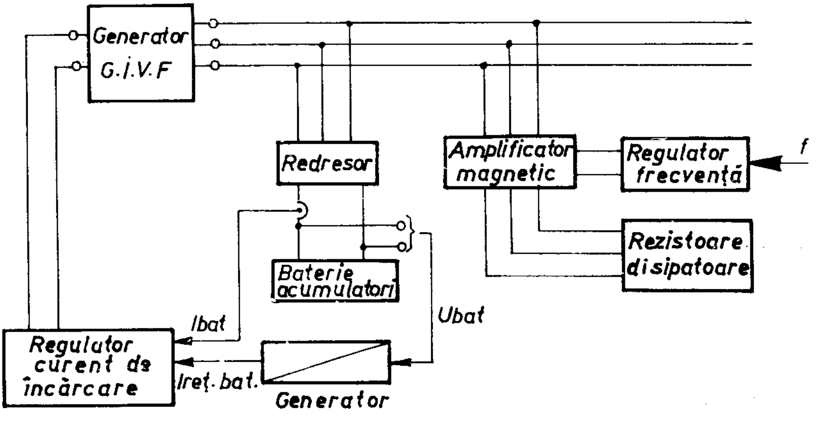

Figure 2.

The unit overspeed protection is ensured by a spring-operated and centrifugally released band brake.In order to reactivate the unit it is necessary to manually switch in the brake.

The unit charges the batteries which are dimensioned so as to be able to absorb as much as possible the energy supplied during wind periods in order to ensure the energy during the calm periods.If the Owner requires 220 V 50 Hz voltage,it is possible to include an inverter too in the installation.

Constructive and Operational Parameters:
The monoblock rotor,with the possibility of installing the blades at various angles depending on the site characteristics,is mounted on the main shaft and has the following characteristics:
-diameter 5 m

-max.speed 254 rot/min.
-power 5.51 kW
-no.of blades 3

The 5 kW rotor characteristic is specific for fast units with tip velocity ratioλ=7.The rotor is equipped with 3 fixed blades,2 m long.The blades have been conceived for the hypothesis of the rotor operating at variable speed.The speed value up to which the aerodynamic flow conditions correspond to λ opt. is 254 rot/min.,which in its turn corresponds to a wind velocity of 10 m/s.The used profiles are of NACA 4418 family,so the relative thickness is constant along radius.The chord installation angle and implicitly the performance coefficients are variable along the blade.

The chord at root is 300 mm,and at tip 160 mm.The blade twist angle is $8^{0}26'$.The unit operation over the max.speed corresponds to the rotor operation at higher speeds with direct implications on the incidence angle.The aerodynamic conditions substantially modify the upward force value on the full blade length,finally leading to a power limitation around the value of 11-13 kW.

The blades,with an effective length of 2.3 m,are made of glass fibre reinforced polyester,the connecting spindle to the rotor being made of steel.

The planetary multiplier has the multiplication ratio=13 and can transmit a power of 13.5 kW.

The steel tower is 12.5 m high.

Unit performances:
-power kW 5
-voltage V 24 D.C.
-wind velocity
 -starting m/s 3.5
 -rated m/s 10
-max.for dimensioning m/s60

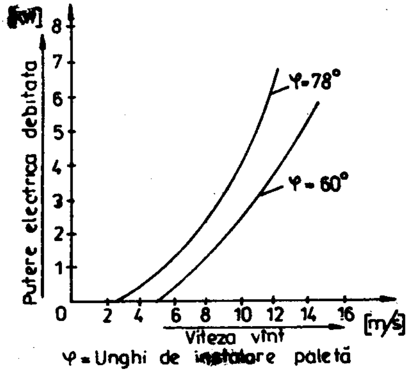

Figure 3.

On the basis of experiments made on site,improvements have been made and the unit was designed again.Also in conception phase is an equipping variant with a-synchronous generator.The experimental characteristic of electric power depending on the wind velocity are shown in Fig.3

10 kW WIND GENERATOR CONNECTED TO THE NETWORK

The unit is conceived to work connected to the national energy system.

The horizontal axis rotor equipped with 3 fixed blades is located upwind to the tower.The power caught by the rotor is transmitted by means of the multiplier to the generator.Between the multiplier and generator a one-way coupling is mounted,which allows the driving torque transmission from the rotor to the generator only.This is compulsory due to the fact that the aenerator works in two-speed steps.The mechanical transmission is attached by means of a guide-and-thrust bearing to the tower.The orientation in the wind direction is permanent and ensured by a gearing.The unit runs automatically without needing supervisory staff.

The rotor is located with the brake in the calm periods;the brake will be raised only when the wind velocity reaches the value at which the unit is able to supply energy,and the running at the generator first speed step(max.7 kW) will be ordered.The unlocking and unit start signals come from the wind velocity transducer.The unit control is ensured by relays.

When the wind velocity ensures the catching of a higher power,the running at the generator second speed step(max.11 kW)will be ordered.If the max. power limit or the max.admissible speed are exceeded the unit will be braked with a shoe brake.

Constructive and Operational Parameters:
The monoblock rotor,with the possibility of installing the blades at various angles,is mounted on the main shaft and has the following characteristics:

-diameter	7 m
-max.speed	115 rot/min
-no.of blades	3

The rotor equipping the 10 kW unit is of fast type,with tip velocity ratio λ=6.The blades are fixed,3.15m long.The used profiles areNACA 4418.The chord at root is 540 mm and at tip 260 mm.The blade twist angle=23.51^{o}.As this unit works at constant speed,the initial hypotheses of the blade aerodynamic calculation are in accordance with the working conditions of a two-step 750/1500 rot/min.asynchronous generator.For the rotor,taking into account the multiplier with i=13, result the speeds of 57.7 rot/min and 115,4 rot./min respectively. For these working speeds we obtain the tip velocity ratio λ= 6, corresponding to the optimum aerodynamic parameters for energy transfer. The modification of the aerodynamic flow conditions and the energy calculation for other ratios $\lambda \neq \lambda$ opt. have been made in the hypothesis of the tip ratio variation with the wind velocity on the basis of the linear proportionality principle.Due to the chosen diagram of performance coefficient variation along the blade,the modification of incidence in the flow conditions leads to the performance decrease in the first and last thirds of the span with direct implications on the energy transfer (Cp).The energy limitation is obtained at approx.1.8-2 of the rated power.

The blades,with effective length of 3.15 m,are made of glass fibre reinforced polyester and have a central steel spindle.

The planetary multiplier of series production has the transmission ratio=13 and can transmit a power of 18 kW.

The synchronous generator has two speed steps:750/1500 rot/min.,power of 7/11 kW and supplies energy at 380 V A.C.

The steel tower is 12.5 m high.

Unit performances:

-power	kW	10
-voltage	V	380
-wind velocity		
-starting	m/s	3
-rated	m/s	8
-max.for dimensioning	m/s	60

INDUSTRIAL 30 kW WIND GENERATOR CONNECTED TO THE NETWORK

On the basis of the experiments made on a laboratory model unit conceived and fabricated at HIDROTIM S.A.,a much simplified unit has been conceived,with estimated higher performances.

The rotor is equipped with 3 fixed blades,the turbine shaft being in line with the multiplier and generator.The planetary multiplier is connected by means of a one-way coupling to a two-speed asynchronous generator.

This unit is not provided with a nacelle to accomodate the mechanical transmission,it has only a cover,the interventions being made from a platform which rotates together with the equipment.The rotor is locked with the brake in the calm periods and when the wind velocity exceeds the max.working velocity.

The necessary signals for the unit control come from the wind velocity, the power and the speed transducers.The orientation in the wind direction is electromechanical and is active only when the unit is in operation.

In general all the unit groups are simplified in order to increase reliability and implicitly the unit availability.Also there have been chosen equipments from the serial production only,with good behaviour in operation.

Constructive and Operational Parameters:

The monoblock rotor is mounted on the main shaft and supports the blades with fixed installation angle.But it is also possible to mount them at various installation angles.

Main characteristics:

-rotor diameter	11.2 m
-max.speed	129 rot/min.
-no.of blades	3

The 30 kW rotor is equipped with fixed blades with the following characteristics:

-length	4.7 m
-chord at root	1200 mm
chord at tip	650 mm
-twist angle	8.8^{0}
-tip velocity ratio	$\lambda=7$

-NACA profiles from the 44 family(4427-4412).

The profiles relief angle in air flow are determined so that the optimum incidences corresponding to the max. energy transfer should be obtained at a wind design velocity of 10 m/s.The deviation from the optimum design parameters has a direct effect on the variation of the energy-transfer coefficient.The modification of the incidence angle along the blade depending on the wind balancing velocity is materialized in the shifting of the optimum design point whose consequence is the rotor power variation within the stated limits.

The blades with effective length of 4.7 m are made of glass fibre reinforced polyester,having a central steel spindle.

The planetary multiplier with the transmission ratio=13 can transmit a power of 38.5 kW.The asynchronous generator works at two speeds 780/ /1530 rot/min. and supplies 22/30 kW energy in oversynchronous conditions.

Main considerations regarding the unit control strategy:
a)Starting at a certain wind velocity
b)Shifting from low speed to high speed and viceversa is made at certain values of the power supplied to the network.
c)Generator connection to network(on the first and second step)takes place at speeds close to the synchronism ones;the generator is brought to these speeds by means of the turbine and the shifting from high speed to low speed is made with the mechanical brake.

We remark the advantage of using the one-way coupling which ensures the uncoupling of the kinematic chain turbine-generator in the periods when the wind velocity is lower than the necessary one for energy supply to the network,thus avoiding the operation in fan condition.

The 18.5 m high tower is of Viereendel beam type.At its basis there is a cubicle accomodating the electric installation.

Unit performances:

-power	kW	30
-wind velocity		
-starting	m/s	3
-rated	m/s	8
-max.for dimensioning	m/s	60

50 kW WIND GENERATOR CONNECTED TO THE NETWORK

On the basis of the blades designed for the industrial 30 kW unit provided to work in areas with low mean wind velocity,there has been developed a 50 kW unit meant for the mountainous site Semenic.This unit is substantially different from the 30 kW unit but is adapted to mountainous conditions.The tower is cylindrical and allows the staff access in a nacelle accomodating the mechanical transmission.The electric installation is distributed on two levels at the tower base.

Constructive and operational parameters:
The rotor diameter is 11.46 m,it is equipped with 3 blades,max.speed= 140 rot/min.The blades are the same as for the 30 kW unit.The multiplier with i=13 transmits a max.power of 144 kW.The three-phase

asynchronous generator has short-circuited rotor and supplies energy at 1464 rot/min.

The cylindrical tower with 3 diameters is 19.3 m high.

The unit control is ensured by relays

Unit performances:

-power	kW	30
-wind velocity		
-starting	m/s	4
-rated	m/s	12
-max. for dimensioning	m/s	60

CONCLUSIONS

Having in view the relatively short time(the first project has begun in 1984)elapsed from the first approach to the topic of small wind units, our firm,HIDROTIM S.A.,considers to have gone over the difficult stages of the beginning and found final solutions for a series of components,equipping variants and specific technologies.

In the first place we must mention that we have conceived the first re-inforced resin blades in our country and at the present moment we can conceive any type of blade up to rotor with diameter D= 14 m.These blades have been assimilated as fabrication technology by the firm EOL-Tg.Mureş.

HIDROTIM S.A. can also conceive and fabricate slow rotors with light plate blades up to a diameter of 4 m.

In the field of wind direction and wind velocity transducers we have gone through several stages and we have developed strong transducers which can work also in mountain climatic conditions.

In order to determine the energetic characteristics of the various sites there has been conceived a self- contained wind velocity and direction continuous recording installation.The reading of the data stocked in the internal memory of the installation is made with a P.C. computer coupled by means of a serial interface.

Regarding the towers,the HIDROTIM specialists conceive such structures in several variants depending on the unit power and location.

The equipping solutions of the orientation systems in the wind direct-ion are clarified and checked in practice.

The use of planetary multipliers for the units mechanical transmissions has proved to be correct,but the designing of specialized multipliers is necessary at the moment of passing to serial fabrication of the units.We are prepared to draw up design topics for these multipliers.

As to generators,it has been proved that the asynchronous electric machine meets the requirements imposed by the unit operation.

The ideal would be the construction of multi-polar low speed electric machines,in order to be able to eliminate the multiplier from the kinematic chain.This would reduce the starting torque very much as well as a part of the losses.

The experiments made with the units mounted in sites go on and we keep accumulating experience which should allow us to conceive new units with as high reliability as possible.

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SDuWE

EXPERIMENTAL RESEARCHES ON THE DYNAMIC CHARACTERISTICS OF THE BLADES OF WIND TURBINES WITH HORIZONTAL SPINDLE

Conf.dr.eng.Ioan Santău,Prof.dr.eng.Francisk Gyulai
Technical University Timişoara-Research Center for Wind Energy 1900 Timişoara,Blv.M.Viteazu 1 ROMANIA

To validate the hypotheses admitted in the design of wind turbine blades,as well as the guarantees of their performances in exploitation complex experimental studies of these components are needed.The research program worked out in this scope at the Technical University of Timişoara [1] includes experiments concerning the determination of the centre of mass and mechanical resistance,as well as vibration and aerodynamic measurments.The mechanical resistance is tested both in static [2] and dynamic [3] regimes.

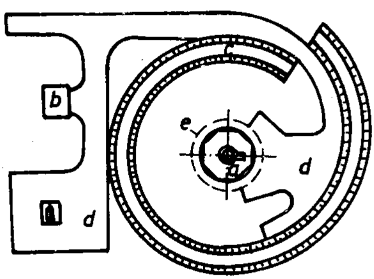

Figure 1.

The mechanical resistance tests in dynamic regime determine at the fairing of the blade for rotation speed values $n=(0-1.5)n_n$ where n_n is the nominal rotation speed of the wind turbine,whose component is the blade we tested.At the same time these tests verify also the resistance overload of the fairing of the blade.These tests were performed using the installation for overspeed at the Technical University of Timişoara(Fig.1), having the following components: observation platform(a),energy supply unit(b),wind turbine with horizontal axis(c), access ways and assembling platform(d), protective systems(e).The functioning and characteristics of these components were presented in [3,4].

The tests for overspeed of the blades are performed on the observation platform (a).(Fig.2) which have a blade driving system with vertical axis.In this situation the blade is rotated in a horizontal plane.

The testing of each blade is performed by driving it successively at the following rotation speed values: 30,40,50,60,70 and 75 rot/min.At each rotation speed the blade is rotated constant by 10 minutes.The rotation speed is controlled using a photoelectric transducer,placed

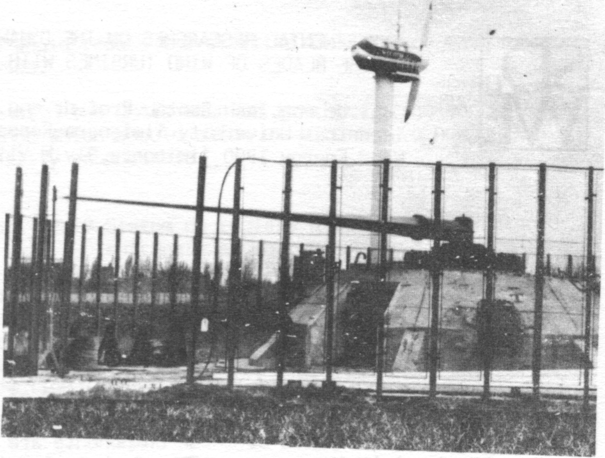

Figure 2.

on the shaft of the speed reduction unit of the first stage and connected to a frequency meter.The deflection at the end of the blade is determined using a fixed measuring staff whose divisions of 1 cm length are successively breaked when passing through the increasing rotation speed values.

The characteristics of the OPSM-7 type blades,which belong to the wind turbine model situated in the Semenic mountains,are as follows:length 12m,mass 1360 kg,nominal rotation speed 50 rot/min. $\pm$ 15 %,maximal rotation speed at which the last protective device is activated,75 rot /min.,characteristic number 7.

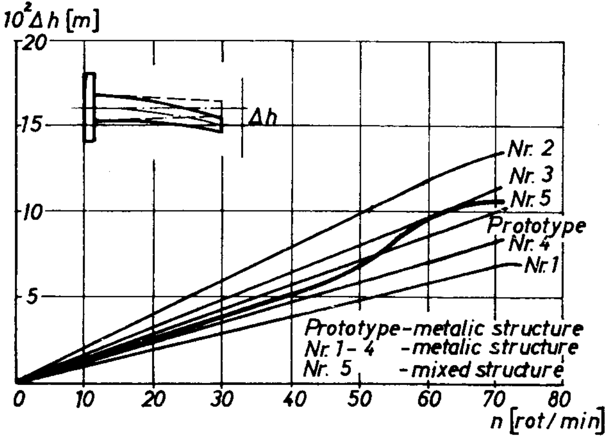

Figure 3.

The results of the tests performed on 5 blades with metallic structure and one blade of mixed structure are given in Fig.3.The curves of deflection Δ h as function of the rotation speed evidence the follow-

ings:
a)the values of the deflection Δh of the matallic blades are varying between the prescribed limits and are always below the adissible limit initially imposed by the designer;
b)comparing the deflection values of the mixed structure blade to those of the metallic ones,it follows that these are middle values but inside the prescribed limits.

CONCLUSIONS

The performed overspeed tests on 6 blades of type OPSM-7 show that all these blades correspond to the imposed conditions concerning dynamical loading,therefore they may be mounted on wind turbines of 300 kW.

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VIBRATION TESTING FOR WIND TURBINE BLADES

Gheorghe Silaş,Professor emeritus,Technical University of Timişoara,fellow member of Romanian Academy;Titus Cioară,Dr.eng.senior scientist,Technical University of Timişoara;Liviu Marina,Main eng. Technical University of Timişoara Romania

INTRODUCTION

One of the most important part of a wind turbine is the blade which is a complex elastic twisted thin enveloped beam structure of which dynamics is very difficult to be mathematically modeled.Also,the manufacturing of the blade rise a lot of problems as technological faults which can be dangerous for the integrity to the blade or even to the turbine,in working condition.

The about mentioned problems impose for reliability safety of the blade some ground testing,the vibration testing being an essential one. The blade diagnostic can be obtained by a short time vibration resonant testing at natural frequencies of the blade.

The vibration testing is performed using a special stand made in the Vibration Testing and Research Laboratory (VTRL)of Technical University of Timişoara dedicated to the 300 kW horizontal axis wind turbine blades testing.

VIBRATION TESTING STAND

The vibration testing stand is consisting of one massive rigid body 1 (Fig.1) to which the blade 2 is connected in the same mode like to the turbine rotor:clamped by fixed flange.

The whole,emsemble rigid body 1-blade 2 is borne by four pneumatic cushions 3 so that the vibration system of the ensemble has its rigid body natural frequencies under 1.5 Hz.In this condition for the frequency range of the vibration testing,3-50 Hz,which include the first six elastic natural frequencies of the blade 2 the ensemble is completely energetically isolated.The exciting force to the vibration ensemble system is acting in a point of rigid body 1 by the shaker 4 and a force transducer 8.This isolated mode of vibration ensemble allows to transfer whole energy to the elastic blade structure so that the large amplitude of vibration can be obtained using a small power amplifier 15 controlled by a signal generator 5(made in VTRL), of high stability of frequency, programmable by a PC computer B.

For vibration measurment on the elastic structure of the blade is used a three axle mounting transducers 7 connected to the charge amplifiers 11 and measuring instruments 12. For a harmonics vibration motion the phase between the vibration motion and exciting force if measured by a

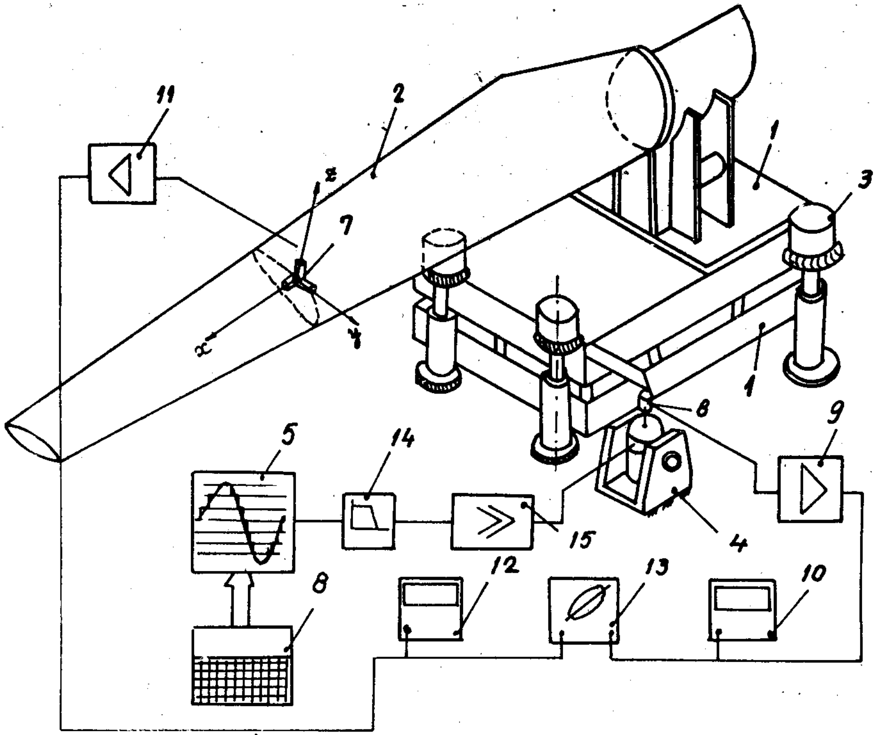

Figure 1. Set up of vibration the testing stand

phase meter 13.

The amplitude and phase of vibration motion are used,for modal parameter estimation,by a very accurate algorithm [1] ,and for modal shape representation.

EXPERIMENTAL RESULTS AND CONCLUSIONS

In the Table No.1 there are presented synthetically the vibration testing results,including the values of natural frequencies and modal damping ratio,for three different structure of the blades:

1.mettalic frame and metallic skin;
2.metallic naked frame;
3.metallic frame and PFAS skin.

For the points 2 and 3 there are used the same sample frame.

In the Table No.2 are presented the values of natural frequencies and modal damping ratios for a set of three blades mounted on a 300 kW wind turbine.

Table No.1 Comparative values of natural frequencies and mode damping ratios for three type blade structures

Mode no.	metallic frame metallic skin	metallic frame naked	metallic frame PFAS skin
	natural frequency [Hz] / modal damping ratio [%]		
1.	5.4993/.260	4.0834/.321	3.9360/.387
2.	11.4400/.294	9.6948/.194	8.7929/.326
3.	20.8440/.228	17.8095/.262	16.0074/.403
4.	28.6820/.201	29.1138/.294	27.2670/.399
5.	35.9727/.272	40.8467/.184	41.7022/.301
6.	46.5353/.142	51.4942/.084	55.4486/.313

Table No.2 The values of natural frequencies and damping ratios for one set of three metallic blades destined to 300 kW wind turbine

Mode no.	blade 1/1	blade 2/1	blade 3/1
	natural frequency [Hz] / modal damping ratio [%]		
1.	5.5271/.219	5.5003/.218	5.4706/.183
2.	11.4260/.303	11.4850/.314	11.4090/.267
3.	20.8840/.239	20.9290/.246	20.7190/.200
4.	28.6520/.201	28.7610/.213	28.6900/.191
5.	36.1580/.303	36.1240/.341	35.6360/.172
6.	46 .7260/.145	46.6140/.125	46.2660/.156

Analyzing the two tables following conclusion occur:

1.In the frequency range of the vibration test there are six natural modes of blade elastic structure grouped in the narrow distinct frequency bands: [3.8->5.5.], [8.7->11.5] , [16->20] , [27.2-28.9], [35.41->41.7] , [46.2->55.5 Hz] , their values depending on the mass and stiffeness distribution along the blade axis.Thus,for matching the best set of the blades to be mounted on a turbine machine by the criterion of the minimum differences between natural frequencies of the modes,is a certain criterion to match the more appropriate manufactured strucures of the blades.The maximum admissible relative value between the frequencies of the modes was imposed at 1%.In Table 2 there are given comparatively the natural frequencies values for a set of three blades which was mounted on 300 kW wind turbine at Semenic mountain.

2.Comparing the values of the natural frequencies between the three different structures(Table 1) occurs for the metallic frame and metallic skin of the blade maximum values compared to correspondent values the other two,minimum values belongs to the PFAS skin blade.Results that the matallic skin has a major contribution at stiffness of the blade.

3.By comparing of the modal damping ratios results the maximum values are for the blade with PFAS skin,which is an advantage to diminish of the vibration levels on the blade structure in running time of turbine.

Displaying on an oscilloscope the history of vibration motion signals of one point on the blade,by a natural frequency harmonically excited if there are hidden manufacturing faults,as wrong parts weldings,these give the nonlinearity in the area of the fault,the signals of vibration motions occuring on oscilloscope display in a nonharmonic form.Thus, this method is very easy to diagnosis the faults of blade structure manufacturing.The best results can be obtained using acceleration signals of which high harmonics have significant levels.

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WIND ENERGY IN ROMANIA-MEETS FAVOURABLE EXPECTATIONS

eng.Gheorghe Voicu-ICEMENERG Bucureşti ROMANIA
eng.Cristina Andreev RENEL Bucureşti ROMANIA

The first wind mills(for grains grinding) appeared in Romania before the 13th century.More than 1000 mills were in operation in the Dobro - gea and Moldova districts(Fig.1)at the end of the 19th century,but during the modern age,utilization of wind energy was gradually given up.

The forced industrialization which was started after the second World War,in a relatively small territory,led to setting up a powerful system of electrical networks and implicitly to abandoning all wind turbines.At present,some handicraft wind mills can only be found at open-air folk technical museums.

A programme of renewable sources implementation,wind energy field in-cluded,has been launched in Romania once the first oil crisis started in 1973.

The first actions aimed at estimating the potential using standard meteorological data.Today it is unanimously acknowledged that the

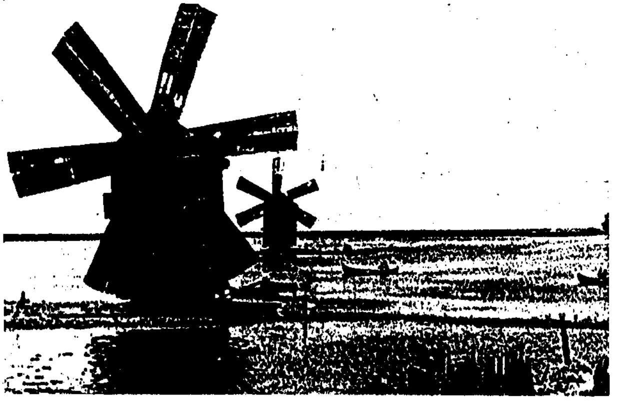

Fig.1 Wind mills in the Danube Delta before 1950

Romanian wind potential is of the same size as the hydroelectrical one, which means several billion kWh/year.

The territorial distribution of the main interest zones according to ICEMENERG studies is given in Table 1.

Table 1.

ZONES	% of the country surface*	Average wind speed (m/s)	Potential (10^3 kW/km^2)	Generable energy % of Romanian total	Generable energy (10^6 kWh/km^2 . year)
Mountain ridges of over 1500 m	0.1	6-10	5.63	1.3	11.41
Mountain masses of over 1000m, ridges excluded	1.1	4-6	1.10	24.5	2.13
The Black Sea shore and the Danube Delta	3.6	4-7	1.27	9.1	2.45
The Black Sea continental olatform with water depth up to 20 m	2.3	5.7	2.98	13.0	5.57
The rest of the territory	92.9	below 4	0.30	52.1	0.61
Average per country			0.41		0.82

*)Romania's land area is of 237,500 km^2, to which some other 5,500 km^2 have been added of the Black Sea offshore area presumed as harnessable.

There are two zones of interest for industrial applications, each of them concentrating about 25% of the whole potential:
-the high area of the Carpatians mountains where the power density is about 300 W/m^2, operating up to 3000 h/year;
-the Black Sea cost, Danube Delta and continental platform included, having a lower power density of about 150 W/m^2, as well as a smaller operating time.

The winds distribution during the year is in accordance with the energy demand due to the country's continental climate, more than 65% of the yearly wind energy being available during the cold season of autumn-winter.

The wind potential once estimated, and the first good locations found-out, inter-disciplinary groups have been created in different centres with main purpose to develop wind turbines for various applications.

Starting with 1979, the Ministry of Electrical Energy emphasized the problem of centralized utilization of wind turbines in view of generating electrical energy supplied to the public networks. It was then that a research group was created in ICEMENERG, aiming mainly at drawing up macro-power studies on wind energy utilization in Romania.

Certain universities and machine building institutes from Timişoara, Braşov and Bucharest have had consistent concerns in the field of equipments.

Certain 10-20 kW experimental turbines have been tested at first,and then some 100 kW-vertical shaft,Darrieus type,and 300 kW-horizontal shaft-prototype turbines(Fig,2-5) have been manufactured.The prototype of a 1000 kW wind generator is also under advanced designing stage,following the years when special studies have been carried out in this field.

The emphasis on renewable sources utilization-hence of wind energy also has significantly lowered under the new political-economical context in Eastern European countries,because of the economical crisis which is intrinsic to the transition period.

But the economical and social life democratization has increasingly emphasized the ecological effects of non- pollutant energies utilization,and the governmental bodies interest seems again directed towards the wind turbines and moreover,to the erection of wind farms.

The feasability studies which have been previously carried out located sites(Table 2),where several hundreds of MW can be installed under favourable economical conditions.

Table 2.

WIND FARMS	Geographical position, altitude	Average wind speed at standard height (m/s)	Potential (MW)	Energy which can be generated in an average year. (mill.kWh)
Semenic	Semenic Mountains plateau,1450 m	6.3	93	206.7
Sulina	Black Sea coast; Baia de Sud-Sulina	7.1	72	197.0
Constanţa	Constanţa sea harbour break-water	6.0	16	28.7
Tulcea	Tulcea hills-South of Danube Delta, 220 m	5.3	88	155.0
Micaia-Negovanu	Căpăţînii Mountains 1950-2150 m	7.8	20	35.5
Carpathian Arch	Baiu Mare,Neamţu Bobu,Stoleru, Penteleu Mountains,1400-1900 m	6.4-7.2	89.7	156.3

The Semenic wind farm site(providing the installment of 310 turbines of 300 kW each)has been chosen for erection of a first demonstrative

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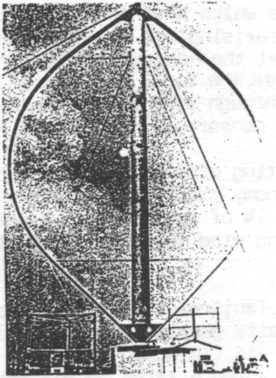

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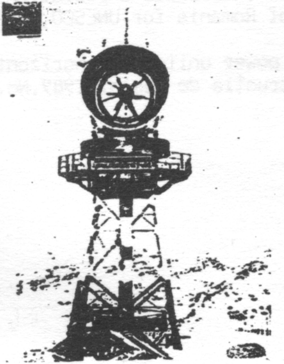

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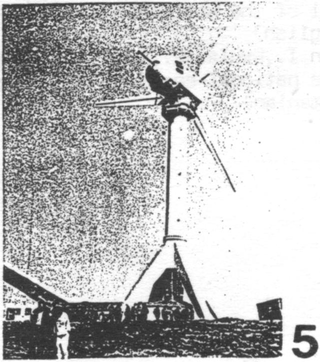

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Fig.2 The first experimental wind turbine installed in high mountaineous area(1950 m height)-grid connected
D= 11.2 m; H= 22 m; P= 20 kW
V= 4/11.6/25/50 m/s

Fig.3 A topical experiment: shrouded wind turbine,located at 2350 m height.
D=3;P= 15.5 kW; V=6/18/28/80 m/s

Fig.4 Darrieus type 100 kW wind turbine(prototype conceived and manufactured by ICSITMUA-Braşov destined to the sea coast zone
H/D=34.5/27m; P= 132 kW;V=5.5/10/15/54 m/s

Fig.5 300 kW three blades horizontal shaft turbine(prototype conceived by Technical University of Timişoara,designed by HIDROTIM,manufactured by C.M.Bocşa S.A.) destined for high mountainous areas
D= 30m; H= 30m;P= 300 kW;V= 6/13.5/32/80 m/s

wind farm in Romania with 8-12 turbines of such power.

The studies which have been carried out for this wind farm pointed out certain surprising,but favourable ecological aspects.Thus,biologists declare that the hundreds of turbines location in the Semenic plateau foreseen for the final stage will result in increasing the zone humidity through wind speed reduction,which will improve the vegetal and animal conservation safety of the existing ecological micro-systems.

The restarting of wind energy field in 1992 under the conditions of the market economy might help to carry out the specialists' forecast of generating 1% of the Romanian electricity demand by years 2005-2010 by implementing wind turbines of about 500 MW total power.

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