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Utilization of Renewable Resources in Rehabilitation of Existent Micro-Hydropower Plants

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***Abstract*—The document presents a prototype Pilot station, realized near a Small hydro power plant, decommissioned in 1998, one between others 400 in Romania. In its structure, there are inter-connected a wind power plant equipped with a rotor of own production (a Romanian brevet under license), a photovoltaic power plant and the micro hydro power plant, needed to be rehabilitated. The wind turbine has a rotor able to start at low values of the wind speed, around 1,4 m/s. There are analyzed the environmental and geographic parameters, the economic necessity as to establish the optimum position for the pilot station. The theoretical modeling, the physical realization, the main steps in the project, the conditions needed to be satisfied for coupling these resources are mentioned. Consequently, are presented some obtained results during the first 6 months after implementation, some observations, and recommendation for further development as to improve its functioning for other conditions.**

I. Introduction

In the actual context, the European Union decides to reduce during the period 2010-2020, the pollutant emission with 8% compared with the year 2010. Accordingly, some specific documents concerning the principal solutions are mentioned in the Green Cart, White Cart, the Directive concerning the increase of the utilization of the renewable resources from 14% to 22% until 2020 into EU countries.

In Romania [1], during 1980-1990 were built over 600 Micro-Hydro power plants, having as principal purpose the electrical power supply for the isolated areas or the soil irrigation. After 25 years, less than half of them are still functional, because there are no investments concerning their maintenance and rehabilitation. Moreover, 150 of them are technically old, with parameters far outdone from their initial values. Consequently, in the present context concerning utilization of renewable resources in Romania, starting with 2005 there was held a constant campaign for monitoring the environmental data, in order to locate the economically favorable zones as to implement a wind power plant or a photovoltaic, connected to an existent small hydro power plant, needed to be rehabilitated. Nowadays, in the RES structure, in Romania, the hydro resource still has the largest share. The energy provided by SHP-s has the installed capacity ≤ 10 MW. The potential possible to be produced is equivalent to almost 80% of the energy produced by the Iron Gates I power plant, except that they are distributed in the entire country, so their construction would lead to an economic growth in all the regions. Notwithstanding, the EU Directive 2009/28/EC, says that hydro, wind, solar, geothermal, aero-thermal, hydro-thermal, considered as renewable energy would avoid large emissions of carbon dioxide, as it happens in the case of burning the fossil fuels. SHP-s (small hydro power plants) can also solve some local problems, such as new jobs, the water alimentation, the irrigation, the electricity in various isolated villages, the decrease in imports of the primary energy resources, the elimination of the voltage drop in the far electrical networks, reduction of energy losses in transmission lines.

Accordingly, to the new attempts as to improve the efficiency of the SHP-s they must begin with some initial steps as mandatory works and technological operations:

- The cleaning of the vegetation from the dam and the adjacent channels,
- Repair works to eliminate all the cracks from the concrete structures, the surfaces with eroded areas and lack of the material,
- Consolidation works upstream/downstream of the dam with the construction of reinforced concrete piers,
- Construction of a fish ladder, required by the actual EU standards,
- Rehabilitation, adaptation, and modernization of all metal constructions of the dam,
- Sandblasting, cleaning, and restoration by welding and polishing of the metal damaged surfaces,
- Changing of all the fasteners and fastening,
- Realization of the corrosion protection

In Fig. 1 is presented the share of the energy based on primary resources, source ANRE, the Romanian Energy

Regulatory Authority, [1], the report made in 2016 compared with the year 2012.

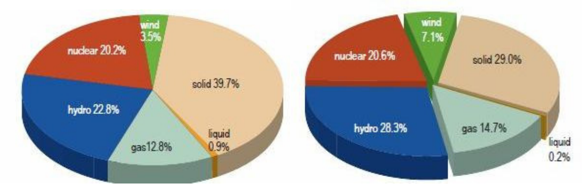

Fig 1. Components of the energetic balance 2012 and 2016

In present in Romania, the energy produced from renewable resources represents around 35%, but more than 28% due to the hydro resources. In Table I are presented the new capacities, and the total investments estimated to be spent in 2010-2020. There are mentioned the realized investments during 2011-2015. The abbreviations refer at S-T solar- thermal; S-E solar electric; W-wind; H-hydro, B-T biomass-thermal; B-E biomass-electric; G-geothermal; NI-New investment; TI-Total Investment and NC- New Capacities.

TABLE I.
ESTIMATION OF RR UTILIZATION IN ROMANIA

RR	**2010 - 2020**		**2011 - 2015**	
	NI	**TI 10^6Euro**	**NC**	**TI 10^6Euro**
S-T [10^3 tep]	37,3	175,0	16,0	93,0
S–E [MW]	11,5	87,5	9,5	48,0
W [MW]	520	420,0	280	280,0
H ≤10MW	320	350,0	120	120,0
B-T [MW]	5250	240,0	3488	200,0
B-E [MW]	590	480,0	380	400,0
G [10^3 tep]	27,5	15,0	23,9	12,0
Total	932	1887,5	789	1153,0

To estimate the opportunity of implementation of the pilot station into the selected area, there were monitored in the beginning the environmental data, for a period of two years. There were used independent weather stations, with electric supply from the solar panels, equipped with a system of on-line registration, data storage and the transmission via the internet of the collected data.

II. ENVIRONMENTAL DATA ACQUISITION

It was selected the Station Weather Hawk Series Signature 500, able to measure, store, and transmit by GSM: the direction and intensity of the wind, air temperature, relative humidity of the air, barometric pressure, solar radiation, the quantity of rainfall and dew point. The system stores and calculates a value for the ET (vapor transpiration). In November 2014, the weather station was installed consequently the first data acquisitions were made. The measurements were set and stored at each hour. As a supplementary option, was set the registration of the minimum and the maximum of certain parameters, considered essentials for further applications, as in Table II (as an example, part of 03.04.2015).

TABLE II.
MEASUREMENTS REGISTERED DATA

Parameter	**Max**	**Max T**	**Min**	**Min T**	**Av.**
Wind Direction	304	5:27am	267	1:00pm	292
Wind Speed	11	9:16am	0	8:00am	6
Wind Gust	11	10:00am	0	8:00am	8
In Humidity	0	5:24am	0	5:24pm	0
Humidity	86	8:00pm	44	8:00am	71
In Temp	17.8	5:24am	-18	5:24am	14.2
Out Temp	20.5	8:00am	7.7	6:48pm	20
Raw Bar	748	10:00am	732	8:00am	602
Total Rain	0.00	5:24am	0.0	5:24am	0.0
Ch 1 Temp	0.0	5:24am	0.0	5:24am	0.0
Ch 1 Hum	0	5:24am	0	5:24am	0
Ch 2 Temp	0.0	5:24am	0.0	5:24am	0.0
Ch2 Hum	0	5:24am	0	5:24am	0
Ch 3 Temp	0.0	5:24am	0.0	5:24am	0.0
Ch 3 Hum	0	5:24am	0	5:24am	0
Ev.transp	0.99	11:00pm	0.0	5:24am	0.5
Battery V	14	11:00pm	12	5:00pm	13
Solar Rad.	94	10:00pm	0	2:00pm	21
Wind Chill	20.5	5:24am	-17	8:00am	11

Consequently, after the data stored for an entire month, the average values are calculated. Ordinarily are stored, in special files, the direction, and intensity of the wind, the solar radiation, and the humidity, important for future developments. Separately is measured the flow rate and the quantity of rain. The internal storage of recorded data, since they are measured more than twenty parameters at every minute and the minimum and the maximum daily values were a challenge. Moreover, a dynamic database was created, structured monthly and annually.

III. THE SOLAR PHOTO-VOLTAIC PART OF THE PILOT STATION

A. *Analysis of the zone opportunities*

Ordinarily, were analyzed the local conditions where the pilot station must be implemented. The produced energy [2] is directly dependent on the solar radiation, the geographic position, season, time of the day, etc. Consequently, after some months of monitoring of all the mentioned parameters and supplementary of the solar radiation and temperature, it was selected a specific area from the south of Moldavia, Romania. By using the Homer software [3], for numerical modeling was estimated the efficiency and established to be realized ten modules of 1.4 KW each, meaning a pilot station of 14 KW.

For Romania, the solar radiation is between 1200-1400 h/year at maximum installed power. Making a comparison with other areas we may estimate that the solar potential is at a medium level, and the average produced energy is somewhere between 2.75-4.8 kWh/m^2. As medium estimated, the value for the selected area is 3.4 kWh/m^2, with variation of 12%.

Consequently, from the principal offers from the photovoltaic market were selected the first 12 producers (they assure in 2014 more than 90% of the whole production). It must be mentioned that today, from the market more than 25% of the total production is represented by the Japanese market, Europe 23%, China 37% and the rest by small firms, around 15%.

B. Numerical modeling of the PV system

Moreover, some tests are realized at different angles from the horizontal:

1. Firstly, panels realized at different angles: between 30^o-35^o, between 35^o- 40^o and from 40^o -45^o. The measurements and the estimation assume the pilot station realized at constant angle, for one of these values.
2. Secondly, measurements and numerical modeling take into account the realization of a pilot station having rows realized at different angles.
3. The third estimation considers the modules able to be oriented after the sun position.

Accordingly, to the measurements and the numerical modeling using specific software RET and Homer, some steps from the design are presented in Table III.

TABLE III.
RESULTS BY NUMERICAL MODELLING

System in Grid Connected Operation			
Location:	Racaciuni	PV Output:	101.3 kW
Climate Data Record:	Racaciuni	Gross/Active Solar PV Surface Area:	731.1 m² / 725.5 m²
Output:	33.76 kW	Ground Reflection:	20.0 %
Gross/Active Solar Area	243.7 m² / 241.8 m²	Output Losses	-
PV Module	152 x	Deviation AM 1.5:	2.0 %
Manufacturer:	Polycrystalline	Deviation	3.0 %
Type:	PV-210AE-A	Diodes:	0.5 %
Power Rating:	210 W	Due to Pollution:	0.0 %
P. Deviation:	0 %	Inverter	6 x
Irradiation Horizontal:	979,414 kWh	Own Use:	161.9 kWh
PV Array Irradiation:	980,171 kWh	Energy Produced by PV Array:	112,551 kWh
Irradiation - Reflection:	931,141 kWh	System Efficiency:	10.8 %
Energy from Inverter (AC):	105,716 kWh	Performance Ratio:	94.1 %
Consumption Requirement:	0 kWh	Final Yield:	2.9 h/d
Energy Grid:	161 kWh	Spec. Annual Yield:	1,042 kWh

Some general remarks must be mentioned after 6 months since the implementation:

- The intensity of global solar radiation, daily value is between 3.8-4.2 KWh/m^2
- The territorial dispersion of values for the average global solar intensity, measured on horizontal is 14-20% from the maximum value
- For the energetic purposes, the average value is 1390 KWh/m^2

The selected solution, adopted is with solar modules oriented towards the south with variable angles between summer and winter; in Fig 2. are presented some results.

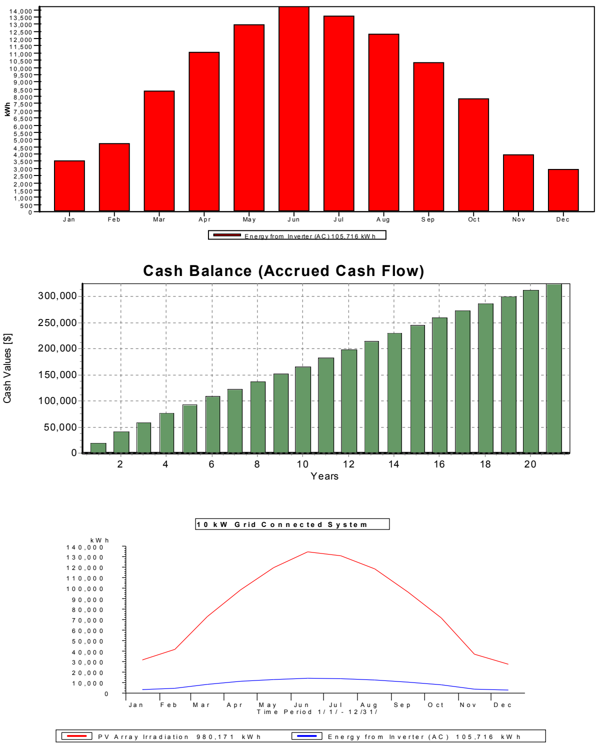

Fig 2. Components of the energetic balance 2012 and 2016

C. Implementation of the PV

Ordinarily, from offers of Sharp, Q-Cells, Kyocera, Sanyo, Mitsubishi, Schott Solar, BP Solar, Suntech, Motech, Shell Solar, Isofotón and Deutsche Cell was selected the variant Kyocera. The system is formed by panels Off Grid 1.4 kW PV with energy storage in batteries, recommended in areas where electricity is lacking. Each package contains two panels 700 W, 1 inverter 24V/UPS system 1400 with 1 Controller 60A 12-24V EP Solar, etc. Reliable modules are PV panels with great efficiency and high yield. Even with a reduced incidence of light, the module achieves a good performance due to excellent low light behavior. Before and after lamination, each module undergoes an electroluminescence test. Performance guarantee: up to 10 years: 90% of nominal output; Efficiency to 25 years: 80% of nominal power; the product warranty is 11 years for the Photovoltaic panel Polycrystalline 700W. Technical data: Maximum Power Pmax (W)=700 W, Voltage at Pmax (V) = 30,75V, Current at Pmax (A) = 8.34A, tensions empty (V) = 38,32V, short circuit current (a) = 8.83 = 1000V maximum voltage Nr. = 60 pieces of photovoltaic cells. The size of 156mm x 156mm size cell panel = 1.640x991, X=38 mm Weight = 18.0 Kg, 1000W inverter 24V.

The transformation of alternating current to direct one is provided through a robust integrated into the inverter of the transformer. For inverter is assured a management and a control with a microcontroller with amplification, in combination with the "MOS-FET" technology.

IV. The Wind component of the Pilot Station

A. *Wind resources of the area*

In Romania are five zones of wind potential, considering the geographic and environmental conditions. The measurements are made at an altitude of 80 m, estimated as the height of the wind turbine. From the European reports, Romania has important wind resources, especially in coastal areas and in some other three favorable zones: south and north in Moldavia and in the high mountains.

Some preliminary investigation proved that in the area of the Black Sea coast the intensity of the wind allows obtaining more than 4000 GWh/year. Some other Bulgarian institutes confirmed the results. Consequently, after the implementation of the weather station, measurement, and registration of the intensity and of the wind direction, the initial estimation is confirmed. The environmental data are still stored in a database.

B. *Numerical modeling of the wind system*

For numerical modeling there were tested more than twenty possibilities considering the power station equipment, referring to the power and number of the wind turbines. As numerical modeling was considered and tested six variants:

1. A turbine model DEWIND power 1.25 MW, 60 m high, Variant 1-one turbine, Variant 2-two turbines,
2. Model Nordex, power 1.3 MW, 70 m high, Variant 3-1 turbine, Variant 4-two turbines,
3. Model Siemens 1 MW, 60 m high, Variant 5- 3 turbines and finally Variant 6 with 4 turbines.

In Table IV, are mentioned some calculations taking into account, the Net average GHG reduction (t_{CO2}/yr): 3.161, the Renewable energy delivered (MWh/yr): 6.430 and the Year-to-positive cash flow: more than 25 years.

The estimation of the wind system in the Pilot Station is for turbines with a capacity of 3 MW. In Fig.3 are presented the economic efficiency of the wind power component of the pilot station.

TABLE IV.
ESTIMATED RESULTS

Wind plant capacity	kW	2.300
Unadjusted energy production	MWh	7.412
Pressure adjustment coefficient	-	1,00
Temp. adjustment coefficient	-	0,96
Gross energy production	MWh	7.116
Losses coefficient	-	0,90
Specific yield	kWh/m²	1.011
Wind plant capacity factor	%	32%
Renewable energy delivered	MWh	6.430

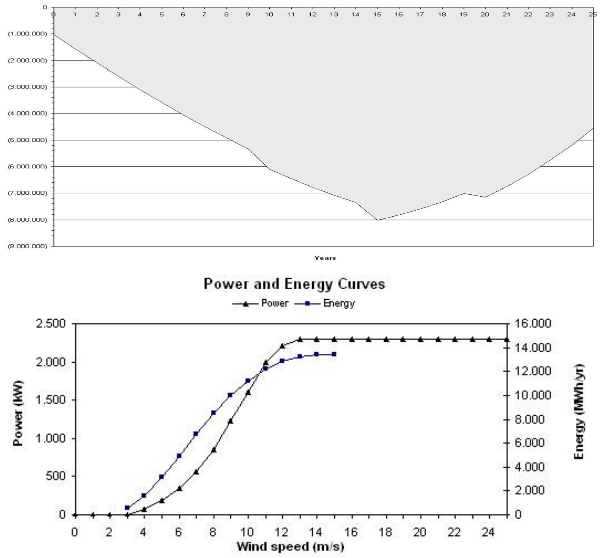

Fig 3. Cumulative Cash Flows and Dependence between the produced energy and wind speed

Nowadays there is implemented a wind turbine, equipped with an original rotor, REVIR able to start at low intensity of the wind velocity, around 0.4 m/s. It represents a Romanian brevet, under licence. A mixed collective of engineers from the ICPE Institute and University Politehnica of Bucharest creates it. Accordingly, to the numerical modeling and of the theoretical calculation a wind rotor with two blades with variable thickness was realized; such a wind profile is presented in Fig.4.

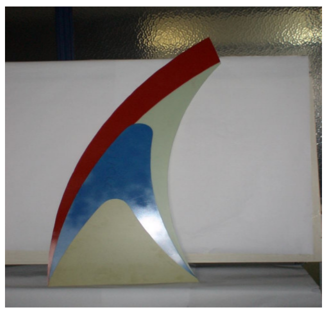

Fig 4. The REVIR wind blade

C. Experimental data for the new type of rotor, the REVIR

There are presented some experimental data obtained with the original rotor, variant with two rotor blades, at a low wind velocity, between 0,5-4,5 m/s, medium between 4,6-10 m/s and high values of wind velocities between 10,1-24 m/s, Fig.5. The rotor, nowadays tested, into the pilot station has three REVIR blades.

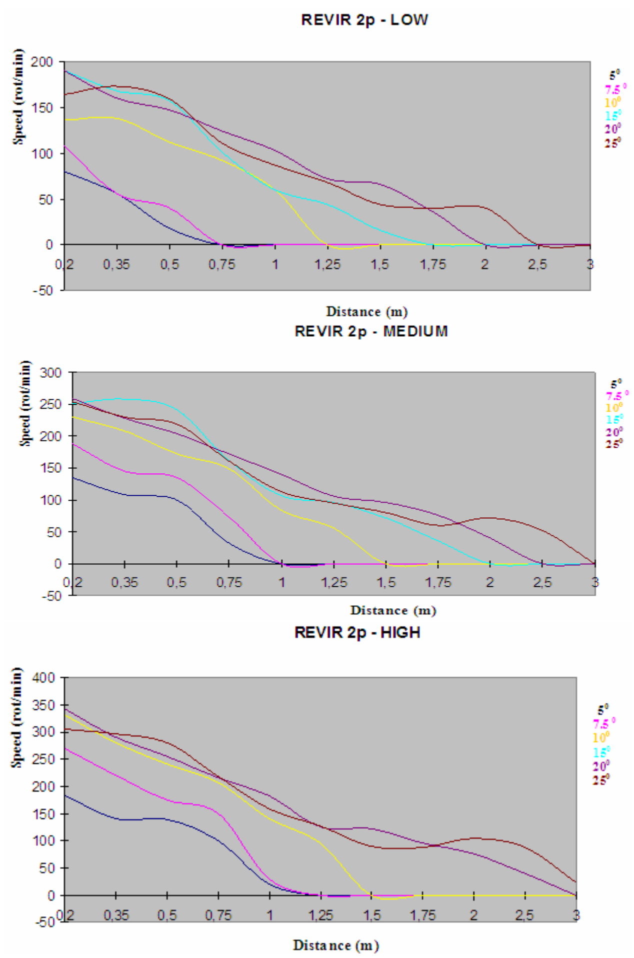

Fig 5. Experimental results with REVIR wind rotor

The fundamental advantage of this type of rotor is the fact that it starts to rotate at low intensity of the wind, at values between 1.3-1.5 m/s, compared with the classical type of rotors who start in the best case at 3.5-4m/s. The rotor represents a Romanian Patent. Supplementary, the REVIR rotor has received the Gold Medal at International Salon of Inventions from Geneva, 2007.

This type of turbine may be implemented in areas with a medium intensity of the wind due to the small velocity necessary to start rotates. In the solution with the mobile rotor blades at a high value of wind velocity, the rotor stays out of the load [9].

As a further development, we intend extending the mechanical part, as to obtain a constant rotation at different values of the wind intensity, meaning an extension of zones with a rapid variation of the wind intensity.

Consequently, taking into account the number of the rotor rotations may be evaluated the produced energy [11]. New models of rotors with three and four blades are realized in University laboratory.

Moreover, must be mentioned some observations between the classic wind rotor and the REVIR wind rotor:

- the classic rotor, at values of the wind intensity under 3 m/s does not start; at a velocity over 3.3 m/s the velocity at the rotor axis is around 550 rot/min, but only for the high value of the incidence angle, between 10^{o}-15^{o}. Ordinarily, it is recommended for such applications somewhere between 5^{o} -9^{o}. The rotation decreases quickly with decreasing of the wind intensity.
- the REVIR rotor starts to rotate at low values of wind velocity, in some conditions even under 1 m/s, but at incidence angles of 20^{0}-30^{0}. For a velocity of the wind between 3,5 – 4,2 m/s the rotor rotation at axis remains almost constant, due to the blades configuration, even when the wind velocity decreases. The decreasing of the rotation is smaller, compared with the classic rotors.

V. THE SMALL HYDRO-POWER SYSTEM

The energy produced by the hydropower systems represents the principal utilization of the renewable resources. In Romania in present are more than 600 small hydro-power plants (SHP); more than 300 belong to SC Hidroelectrica SA, 200 to the National Authority Romanian Waters and the rest of the local administration [4].

Accordingly, the geographical advantages of the selected area for the solar and wind developments, the implementation of the pilot station was selected near an existent SHP Racaciuni, in the south part of Moldavia.

A. Energetic efficient management

Firstly, it is necessary to assure a management of the local energy demand DSM-Demand - Side Management. DMS assumes to identify and implement initiatives that improve utilization of the production capacity of the provider by altering with the characteristics of the energy demand. Modern tracking in real time of the behavior of the electricity network, with automatic SHP may be realized with software, providing an energy management. They allow the optimal leadership of the local/regional energy systems with higher energetic efficiency by ensuring the demands of the power quality electricity, supplied to consumers [5].

Intelligent monitoring systems ensures

- Remote reading of energy meters
- Centralized load control consumer by changing the load curve of the system
- Control of the disturbances introduced by the consumer network
- Centralized control for changing tariffs / prices
- Automated billing

TABLE V.
ADVANTAGES OF THE ENERGETIC MANAGEMENT

Producing	Consuming
Ensuring adequate energy production	Quantities accepted Control required
Flexibility of the offer in planning/production in the medium and long term	Knowledge / estimation of the consumption trends
Optimizing the production planning and supply	- demand forecast - daily load curves, week timetables -flattening, filling gaps, transfer the load from peak hours in the hours of low demand
Compliance with quality indicators correlated with consumer input frequency disturbances, temporary and transient surges, supply disruptions	Secondary indicators - rapid fluctuations of voltage unbalance, non-sinusoidal regimes
Dispatching and common commercial offer	monitoring of the tender request

To determine the annual average flow Q in the natural conditions, are used for correlating, at least three methods

B. Energetic efficient management

B1. Utilization of the graph curves

The method assures a connection between the multi-layer average flow (mm) and the average altitude. It is determined from the statistic data, from the catchments area F (Km^2) connected with the average elevation of the basin H_m (m). From the local map, it is determined the watercourses. Then, the multi-annual average of flow, calculated, where T is the time reference(s), is:

$$Q_m\left(m^3/s\right)=\frac{F\left(km^2\right)\times H_m(mm)\times 10^{-3}}{T(s)} \quad (1)$$

B2. The method of the water balance

Notations: Y_0 - the Annual average of river leakage, S_0 - the surface Leakage, U_0 - the Groundwater flow, W_0 - the Wetting annual average of soil, K_{u0} - the Feed rate underground river.

$$K_{u0}=\frac{U_0(1)}{W_0}\Rightarrow Y_0=S_0+K_{u0}\times W_0 \quad (2)$$

$$Y_0=S_0+U_0$$

By using of the map of the territorial distribution of the component of the hydraulic balance, are obtained the corresponding values of the geographical position of the surface stream. As it follows:

- From the full surface runoff layer, it was extracted the value S_0 (mm).

- From the map of the geographical spread of the total soil, the moisture, it is extracted the value W_0 (mm).

- From the map of the power, the underground distribution coefficient is extracted the K_{u0} value.

By substituting, the values extracted in the above point Y_0 may be estimated the average annual average flow.

B2. The method of hydrologic balance

Notations: X_0 - average annual rainfall, Y_0 - average annual flow, Z_0 - the annual average evaporation from land, surface evaporate-transpiration

$$X_0=Y_0+Z_0(1)\Rightarrow Y_0=X_0-Z_0 \quad (3)$$

From the precipitations map is extracted the value X_0. From the map distribution, of the total average of evaporation-transpiration, it is extracted the value Z_0. By introducing the extracted values in (3) is obtained the average annual runoff value Y_0 (mm) and determined the annual average flow rate.

C. Numerical modeling

For the numerical modeling, was selected a part of the Siret river basin. Here it was applied the software Vapidro-ASTE, which generates a hydro-graphic network of the area of interest. The model uses the local terrain, implemented as input data, based on the existent geographic and hydrologic maps of the field.

The software can locate the best position of the water supply, for the realization of the hydropower plant, optimized technically and economic. The selected area is the Siret basin, in the energetic sector Bistrita and Trotus, between cities Bacau and Adjud.

Consequently, the necessary data are introduced for the financial analysis: the equipment costs, the maintenance costs, the costs of execution, as to obtain the cost-benefit analysis. The water volume flowing along the riverbed is determined by numerical modeling, taking into account the soil roughness, the soil incidence, rainfall intensity, temperature, etc. Moreover, it is analyzed the existing situation for the local, realized SHP.

By numerical modeling, it is also estimated the installed capacity for further possible SHP, the total annual energy able to be produced, the total costs for realization, the benefits, the cost-benefit analysis and finally the amortization period. All the economical optimizations are performed and the results are transposed into a graphic form. Technical and economic optimization results consist of the most favorable locations for positioning of the hydroelectric power plant and of the water intakes for the new SHP, as mentioned in Fig.6.

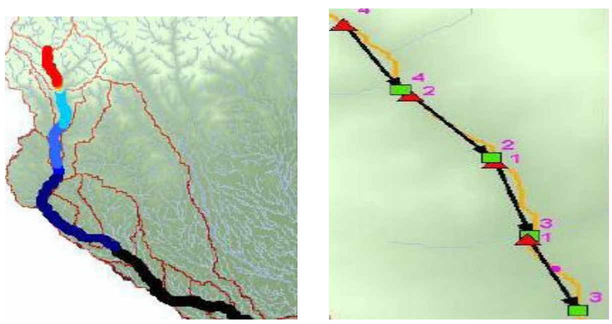

Fig 6. The modeled utile fall and the possible developments

Note: with green are noted the possible future hydropower plant and with red the water intakes.

From the Siret river basin, they are selected three rivers for modeling; the initial database are presented in Table VI and the obtained results in Table VII [6].

TABLE VI.
INITIAL PARAMETERS

Nr	Data parameters	Method	R1	R2	R3
1	Area F_{BH} [km^2]	Plane map	10	16	18
2	Average Altitude H_m [m]	Direct read	1000	120	150
3	Average Length L_m [m]	Direct measurement	5100	380	440
4	Cote upstream C_{am} [mdM]	Direct read	810	850	800
5	Cote upstream C_{av} [mdM]	Direct read	608	700	600
6	Crude fall H_{br}[m]	Calculation	-	-	-
7	Annual average flow Y_0[mm]	Direct read[1]	800	840	820
8	Surface leakage S_0[mm]	Direct read[2]	400 500	440 510	420 500
9	Evaporation transpiration Z_0[mm]	Direct read[3]	280 340	280 300	280 320
10	The total wet soil W_0[mm]	Direct read[4]	710 700	700 700	700 700
11	Underground alimentation coefficient K_{u0}[mm]	Direct read[5]	0,36 0,4	0,4 0,4	0,4 0,4
12	Average annual rainfall X_0 [mm]	Direct resd	1000	110	120
13	Min. leakage q_{min} [l/sxkm^2]	Direct read[5]	4,8	5,5	4,2
14	Minimum flow Q_{min}[m^3/s]	Calculation	0,04	0,08	0,08

Where: ^{1}=Y_0=f(H_m), ^{2}=S_0=f(H_m), ^{3}=Z_0=f(H_m), ^{3}=W_0=f(H_m) ^{4}= K_{u0}=f(H_m), ^{5}=q_{min}=f(H_m)

TABLE VII.
OBTAINED RESULTS

Nr	Data parameters	R1	R2	R3	Formula
1	F_{BH} [km^2]	10	16	18	Yes, by statistic data
2	H_{med} [m]	1300	1400	1350	Yes, by statistic data
3	L_m [m]	4700	3500	400	Correlated with decreasing altitude
4	C_{am} [mdM]	790	820	802	Confirmed GPS
5	C_{av} [mdM]	580	670	610	Confirmed GPS
6	H_{br}[m]	210	150	192	H_{br}=C_{am}-C_{av}
7	Y_0[mm]	800	780	790	Adopted minimum value
8	S_0[mm]	450	470	450	Adopted average value
9	Z_0[mm]	290	280	280	Adopted average value
10	W_0[mm]	700	704	706	Confirmed value
11	K_{u0}[mm]	0,38	0,4	0,39	Adopted average value
12	X_0[mm]	1100	1050	1100	Consider arithmetic mean
13	Annual average flow Q_m[m^3/s]	^{1}) 0,253	0,405	0,456	^{1})
		^{2}) 0,220	0,380	0,418	^{2})
		^{3}) 0,256	0,410	0,462	^{3})
14	Q_{min}[m^3/s]	0,049	0,088	0,0756	Calculation
15	Max. specific flow rate insurance of 1%	71	113	27	Extrapolation Q_{max}=7100 l/s x km^2

^{1}) Direct Method

Ts = (8760 x 3600) [s]

$$\frac{F\left(km^2\right)\times Y_0\left(mm\right)\times 10^3}{T_s\left(s\right)} \tag{3}$$

^{2}) Water balance method-Variant I

$$\frac{F\left(km^2\right)\times\left(S_0+K_{u0}\times W_0\right)\times 10^3}{T_s\left(s\right)} \tag{4}$$

^{3}) Water balance method-Variant II

$$\frac{F\left(km^2\right)\times\left(X_0-Z_0\right)\times 10^3}{T_s\left(s\right)} \tag{5}$$

$$q_{min}\left(l/s\times km^2\right)\times F\left(km^2\right)\times 10^{-3} \tag{6}$$

Where S_0- Surface leakage S_0[mm], F - the hydrographic basin F[km2], Ts(s) – significant time value, Evaporation –transpiration Z_0[mm], Average annual rainfall X_0 [mm], Minimum leakage q_{min} [l/sxkm^2], Y_0[mm]- the Annual average flow layer, W_0[mm]- The total wet soil, Underground alimentation coefficient K_{u0}[mm], [7].

In Figs.7-9 are presented some obtained results [8].

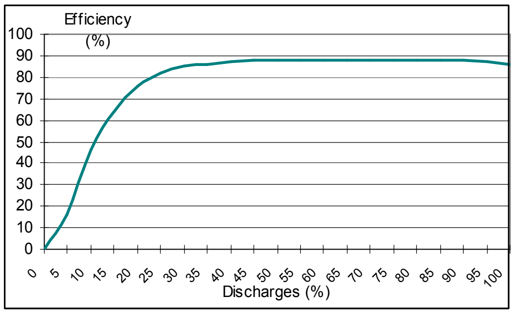

Fig 7. The efficiency curve

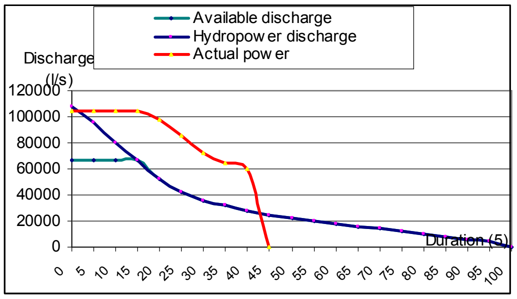

Fig 8. The flow and the Duration curves

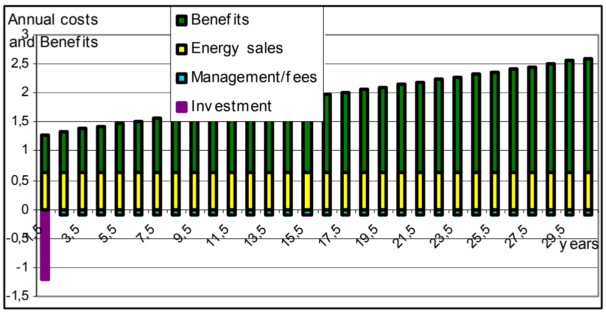

Fig 9. The Benefits and the Costs breakdown

VI. Conclusion

SHP represents a distinct category, both in terms of technical and financial as to use the relatively small hydraulic energy resources. They are ideal for promoting the interests of the local communities and industry, for small and medium entrepreneurs. It is a solution to recovery of a body of water and has many advantages:

- Small and medium unit <10 MW that can be controlled, constructed, and operated in less than two years, with the immediate production of the income
- Reduce the environmental impact
- Suited to the industrial, commercial, and residential area of the network
- The investment project can be developed modular as to cover the increasing of the consumption
- The Complexity and simple maintenance
- The cost of a unit of electricity can be determined with certain accuracy.
- Is ideal for application of the control technology systems, smart meters at customers premises, points of connection in the main nodes, to determine the flow rate
- The real-time charging and billing

By modeling with this software, Valpidro-Aste it can be achieved [10]:

- Identify the optimal locations as to determine the number possible SHP to be built
- The Yearly analysis of the cost-benefits
- The Model is adaptive at local topography
- Estimate the technical and economic feasibility

The wind rotor mentioned in this article, presented, and aerodynamic tested, in concrete natural conditions is a Romanian patent, awarded also and at the Inventors Fair in Geneva. The rotor has a great advantage by starting to rotate at low wind speeds. It may be used in areas where the wind intensity is lower.

For the implementation of the Pilot Station, it was selected an area, with an existent SHP Racaciuni, in the south part of Moldavia. The area is also favorable for utilization of solar and wind renewable resources. To test is realized a Solar Power Plant made by 10 panels, each one of 1.4 KW, meaning 14 KW, capable of delivering electric energy if necessary. Regarding the wind potential energy, the Pilot plant is placed into the Siret basin. The wind measurements made into the selected area confirm values of wind velocity constant between 6.8 – 18.5 m/s, at 60 m above the ground. Even in the hot days of summer, the wind is blowing. Another advantage of the selected area is represented by the relative constancy of the wind direction: 6 months it blows from N-E to S-W and 6 months from S-W to N-E. In present, there is also tested the prototype REVIR rotor. For the Pilot Station was implemented a wind turbine model EWT DW61, of 1 MW. A real advantage of the position of the Pilot station consists of the existent electric line of transport, near the Pilot Stations, due to the existing SHP [12].

Finally, in Fig. 10 are presented images with the Racaciuni SHP, before, and after rehabilitation.

Fig 10. The SHP Racaciuni before, and after rehabilitation

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