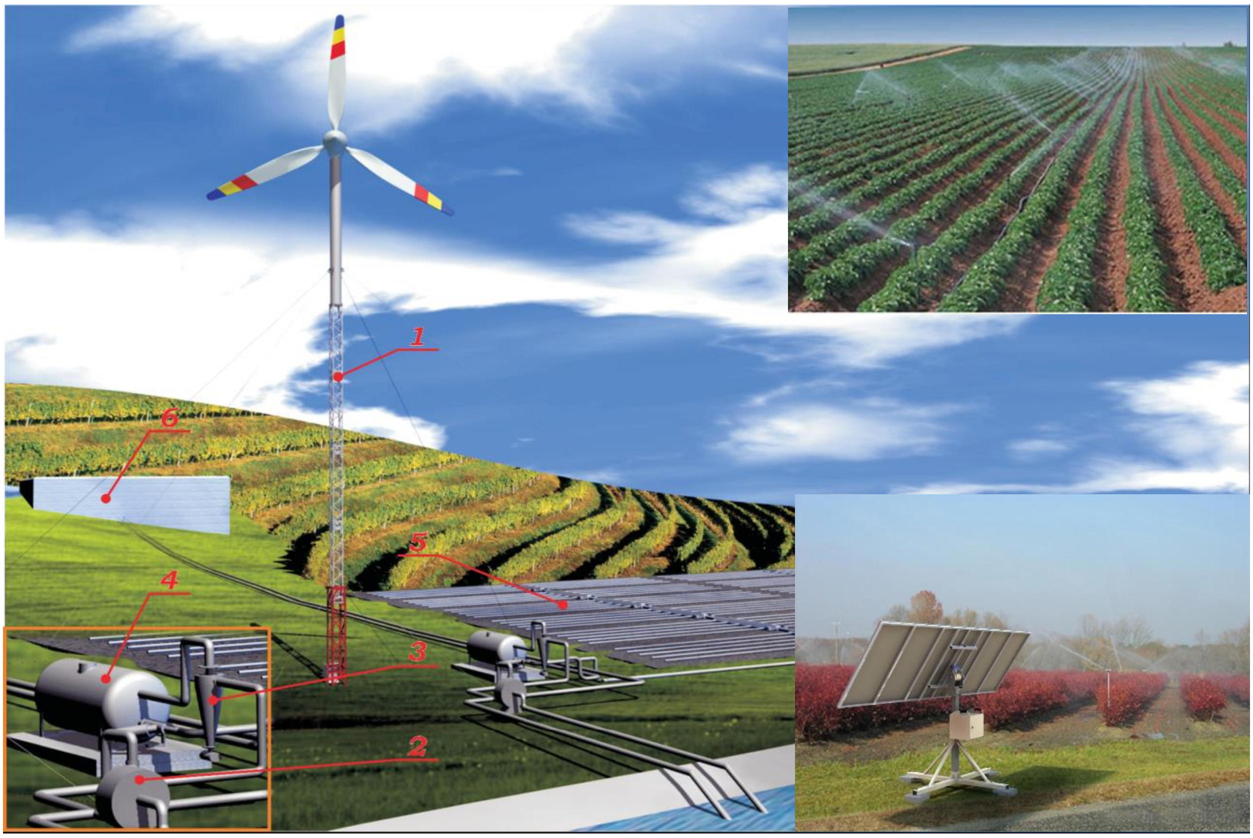
PROGRESS REPORT

United Nations Development Programme
REPUBLIC OF MOLDOVA

Autonomous integrated irrigation systems based on wind turbines, small hydro and photovoltaic installations

Second stage

(30.11.2016)



Reporting Period	01.04.2016 – 30.11.2016
Donor	*Romanian Government, Ministry of Foreign Affairs*
Country	REPUBLIC OF MOLDOVA
Project Title	*Autonomous integrated irrigation systems based on wind turbines, small hydro and photovoltaic installations*
Project ID (Atlas Award ID) Outputs (Atlas Project ID and Description) Strategic Plan and/or CPD Outcomes	***00055003***
Implementing Partner(s)	*Ministry of Agriculture and Food Industry; Agricultural enterprise "Fortina-Lapis", v. Floreni, distr. Ungheni; Agricultural enterprise "Triden" LLC, v.* Criuleni.
Project Start Date	*20.11.2015*
Project End Date	20.11.2017
[Year] Annual Work Plan Budget	*USD 63,022 for period 01.11.2015-31.12.2016.*
Total resources required	**USD 90,481**

Revenue received	• Regular USD
	• Other
	  ○ Donor USD
	  ○ Trust Fund Cost Sharing USD
	  ○ Thematic Trust Fund C/S USD
	  ○ Special Activities USD
	  ○ EU funding USD
	• Total USD

Unfunded budget	USD
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Table of Content

I. Executive summary

During the reporting period (01.04.2016 – 30.11.2016) all planned project activities were carried out. It was fully completed activity GA3 "*The design of autonomous drip and sprinkler irrigation systems integrated with wind turbine and photovoltaic",* in which the drip (Floreni, Ungheni) and micro-sprinkler (Criuleni) autonomous systems irrigation were designed. For agricultural enterprise "TriDenal" SRL were designed micro-sprinkler (Criuleni) autonomous system irrigation integrated with 44 PV panels.

For "Fortina-Lapis" agricultural enterprise (Floreni, Ungheni) there planed elaboration of autonomous drip systems irrigation integrated with PV panels and wind turbine. The measurements and calculation of wind characteristics of location and capacity factor of wind turbine showed on the inefficiency to use the wind turbine in irrigation during April-September. The solar potential in Floreni is identical to that of Criuleni. From this was redesigned the autonomous drip systems irrigation integrated only with PV panels.

During the project implementation, stating advantages of the location, the scheme of photovoltaic panels' placement was changed. This would allow the optimization of photovoltaic panels' group orientation to the sun and will capitalize on a patent application.

Also, it was fulfilled part of activity GA3 "*Production and completion of standardized components pilot prototyping drip and sprinkler irrigation system integrated with wind turbine, micro hydropower and photovoltaic"*, in which the following activities were carried out: were purchased photovoltaic panels; were designed the steel structures for photovoltaic panels installation; established the solar pumps set parameters and manufacturing companies.

The manufacture of steel structures for photovoltaic panels started.

In financial terms, there were established units to be purchased by partners in order to realize the irrigation systems, and the procedure for their acquisition.

II. Progress Review

3. GA3. The design of autonomous drip and sprinkler irrigation systems integrated with wind turbine and photovoltaic

3.1. Design of automated control system for monitoring and optimization to ensure irrigation processes, application of nutrients and pesticides, climate data acquisition units, unit information processing and automatic driving unit.

As was described in the precedent report, the electronic control for the case to be conducted on three levels. On the first level is a turbine control and irrigation installations for:

a) the protection of strong wind turbine generator from overheating and monitoring of the rectifier ;

b) adjusting the position to optimize power generation station.

c) remote data acquisition from integrated sensors from the plantations;

d) remote control with valves of irrigating system from the plantations.

It was decided, that the control must be performed by an average performance microcontroller, which will operate autonomously and is monitored and guided by the two most powerful controllers by radio communication at short distances (up to 2-3 km). It was designed and realized the functional schema and real equipment of integrated sensors and valve control modules for irrigation system. The most important sides both of this modules are the autonomous electrical power subsystem with 20W photovoltaic panel and accumulator and remote data acquisition and control by means of radio communication. The integrated sensor includes a set of sensors: air humidity and temperature, soil humidity and temperature at 2 levels; rain sensor, luminosity; photovoltaic panel and accumulator voltage (fig. 1). The valve control module can open/close 2 valve with DC electro-motors and communicate the states of the valves (fig. 2). One important performance is high velocity of data acquisition (all data may be received by 1 sec) and the low cost – about 180 dollars per unit.

It was performed the maps of integrated sensors and valve control modules for irrigation system for the concrete destinations: the partner farms TRIDEN (CriulenI) and Fortuna Lapis (Ungheni) (fig. 3 and 4).

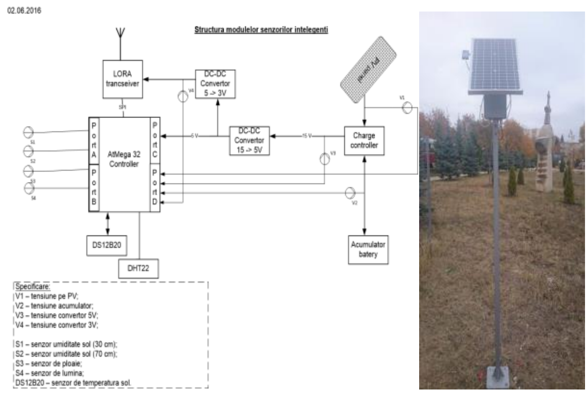

Figure 1. Functional schema and real view of integrated sensors module for irrigation system.

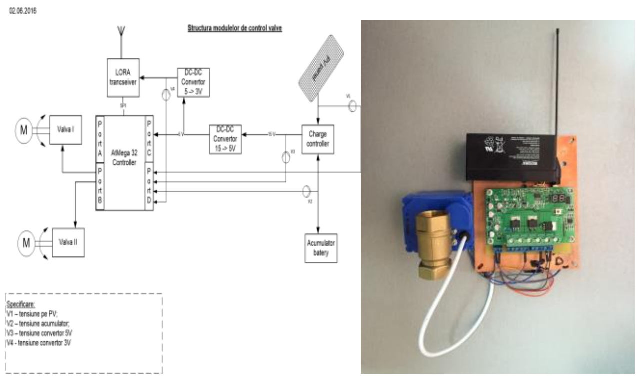

Figure 2. Functional schema and real view of the valve control module for irrigation system.

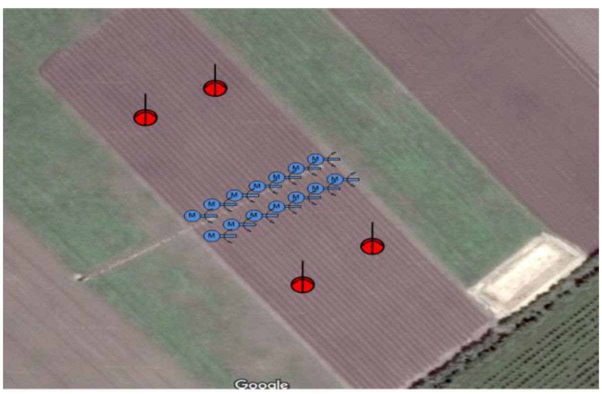

Figure 3. Emplacement map of the integrated sensors module and the valve control module for irrigation system on Triden (Criuleni) farm.

Figure 4. Emplacement map of the integrated sensors module and the valve control module for irrigation system on Fortuna Lapis (Ungheni) farm.

It was decided to use one valve control module and one integrated sensor for 2 parcels (total 6 integrated sensor and 12 valve control modules) on the Fortuna Lapis farm and (total 4 integrated sensor and 14 valve control modules) for the "Triden" LLC farm with the goal to minimize the cost of these equipment.

Also, it was designed and tested the functionalities of the control modules for the wind turbines and PV panels (fig. 5). In this case the important functions are:

- he protection of strong wind turbine generator from overheating and monitoring of the rectifier ;
- adjusting the position to optimize power generation station.
- remote data acquisition from integrated sensors from the plantations;

The early described module been based on the microcontrollers, it is clear that the software of these modules is the key of success. This software includes some components, such as: micro operation system, data acquisition and preliminary processing, control of the actuators and communications modules. The most important are the communications modules, which assure the compatibility of communication protocols with the high level components of the system.

There is a farm plantation control module for irrigation system that coordinate all the processes for irrigation installation and for communication with high level (servers). For this case, it is proposed the Rasberry controller with a higher computing performance and low cost. It was developed the

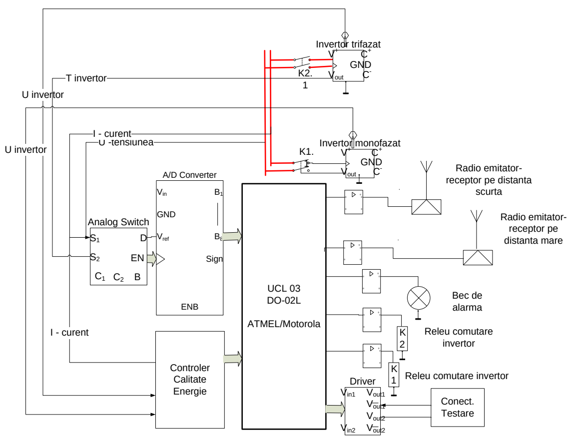

Figure 5. Functional schema of the Turbines and PVs control module for irrigation system.

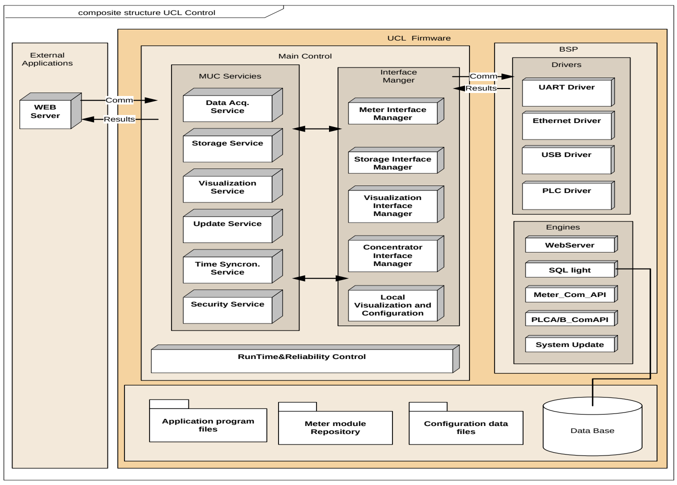

Figure 6. Functional schema of the farm plantation control module for irrigation system.

software for this controller, that is presented in the fig. 6 which include more components for the coordinating the communication between low level modules and the servers.

It is realized as local server with local database for acquisition data, state of the valve, pumps, wind turbine, PV-panels. Also, this controller assure the connection between low level and servers by means of the mobile communication (fig. 7).

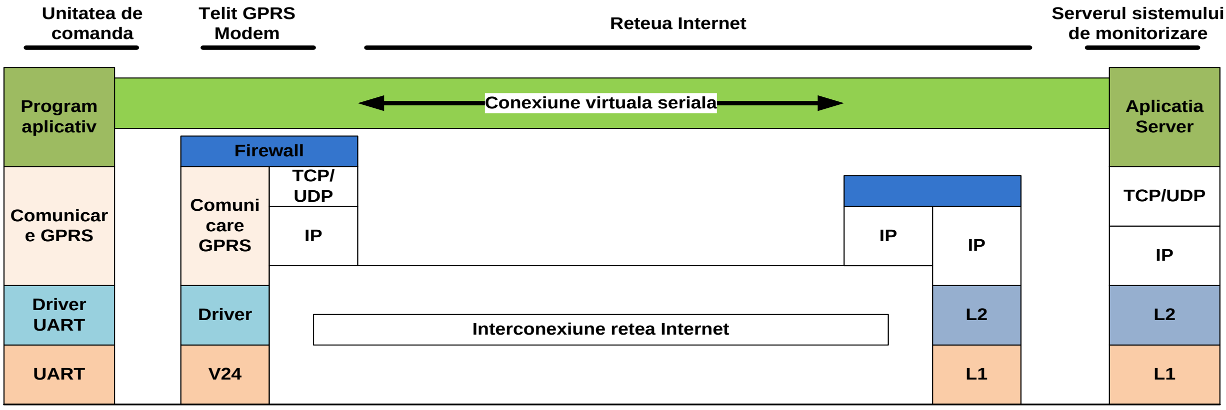

Figure 7. Connection schema between low level and servers by means of the mobile communication.

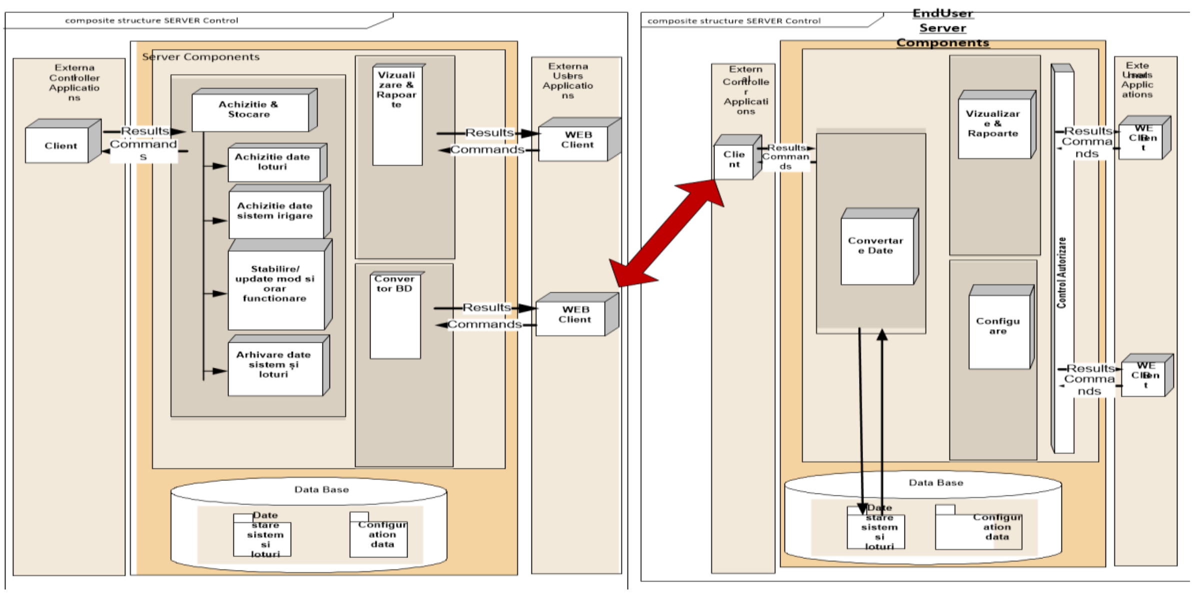

Figure 8. Functional schema of public and background servers of information system for irrigation system.

Taking in account the specifics of irrigation systems, it was proposed the architecture of the high level of control and information system. It is based on 2 servers with different destination (fig. 8). First server, named ”background” is organized on ”IOT-technology” (Internet of Things) and have a destination for intensive communication with all local controllers of the irrigation installations (fig. 9). Its advantage is to operate with a lot of crude data, without special formatting. But this server is accessible only for the administrator, not for the end-users. The second server, named public server have the destination to store the data about farm plantation, irrigation system and assure a friendly interface for the end-users (fig. 10).

It was performed database structure of the monitoring system, which reflects all the necessary components: plantations, plots, irrigation rules, composition and condition of facilities, etc. for the both servers (some examples see fig. 11). Conceptually, the structure of databases is similar, but

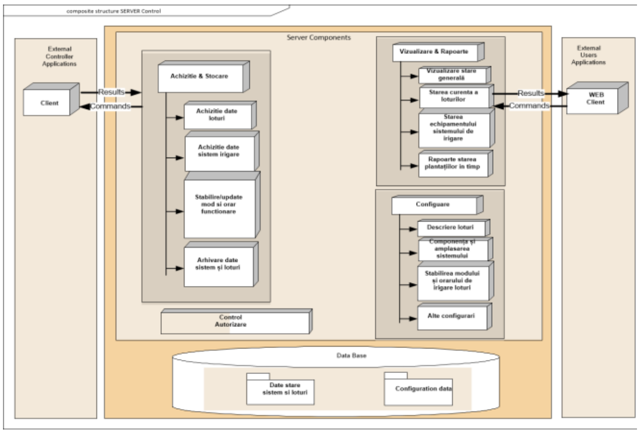

Figure 9. Functional schema of background servers of information system for irrigation system.

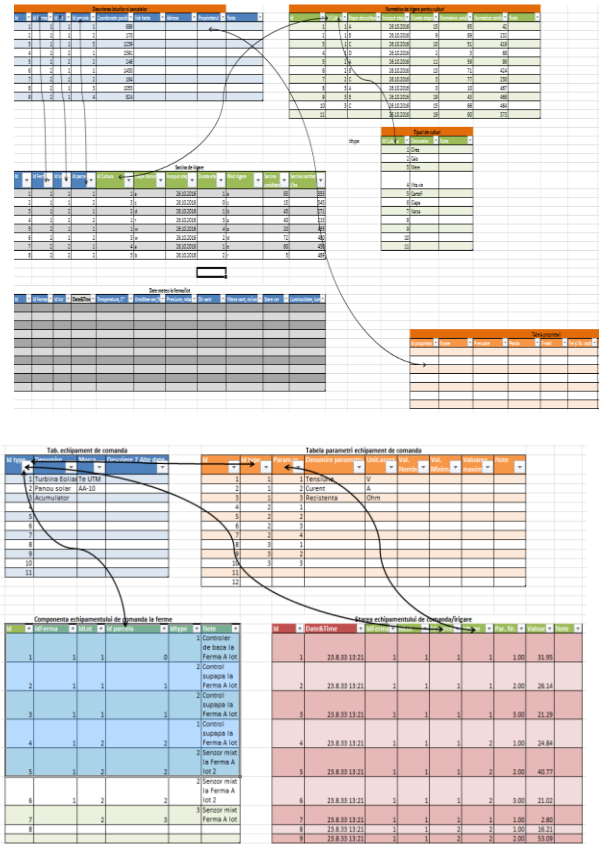

Figure 11. Some examples of table from irrigation system data base.

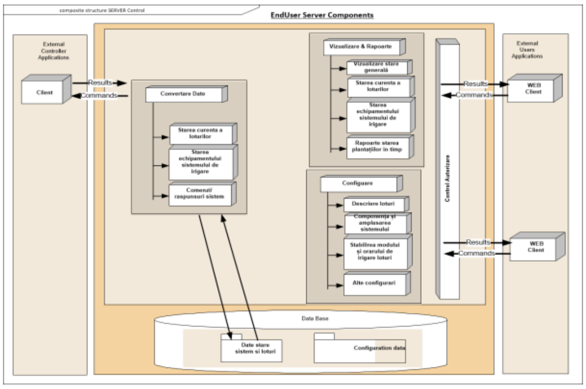

Figure 10. Functional schema of public servers of information system for irrigation system.

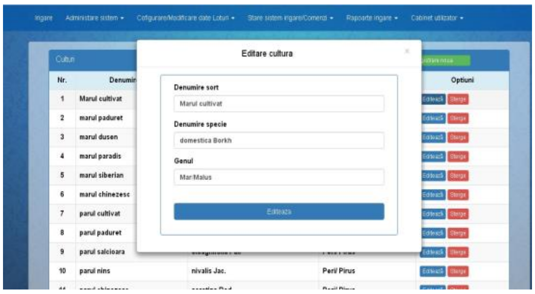

Figure 12. Example o application interface for end-user on the public server.

Figure 13. Example o application interface for adiminstrator/user on the background server.

logical and physical structure a very different. It was developed some application for data management for public server database (fig. 12) and some applications for graphical viewing of the current data from irrigation system.

Conclusion

It was developed the hardware of acquisition, processing and communication for the remote control and management of irrigation installation. Also, it was designed and realized the software of the low level of the remote control. For the high level, it was designed architecture, software structure for the background and public servers. The convertor for transforming of data base structure was designed. For the next phase of the project, it is planned to realize all the applications for the both servers, to complete the database with necessary data, to implement it for real conditions and make a complex testing of all the component of the system.

GA4. Production and completion of standardized components pilot prototyping drip and sprinkler irrigation system

4.1 Standardized components for irrigation systems

After discussions with agricultural partners have agreed to select for both enterprises the same type of surface solar pump with diurnal flow rate of about two times higher than indicated in the progress report on the stages GA2 and GA3. The main argument of the partners was a desire to increase the irrigated areas.
Below we present brief technical characteristic of selected standardized components.

4.1.1 Solar Surface Pump System

System Overview:
Head max. 50 m;
Flow rate max. 33 m^3/h.

Controller PS7k2

- Control inputs for dry running protection, remote control etc.;
- Protected against overload and overtemperature;
- Integrated MPPT (Maximum Power Point Tracking).

Power - max. 8,0 kW
Input voltage - max. 850 V
Optimum - Vmp > 575 V
Motor current - max. 13 A
Efficiency - max. 98 %
Ambient temp. - 30...50 °C
Enclosure class - IP54

Motor AC DRIVE CS-F 5.5kW

- Highly efficient 3-phase AC motor;
- Frequency: 25...50 Hz

Motor speed - 1.400...2.850 rpm;
Power factor - 0,84;
Insulation class – F;
Enclosure class - IPX4.

Figure 14. Pump system PS7 k2 CS-F20-5

Pump End PE CS-F20-5

- Premium materials
- Optional: dry running protection
- Centrifugal pump

Standards: 2006/42/EC, 2004/108/EC, 2006/95/EC, IEC/EN 61702:1995, IEC/EN 62253 Ed.1

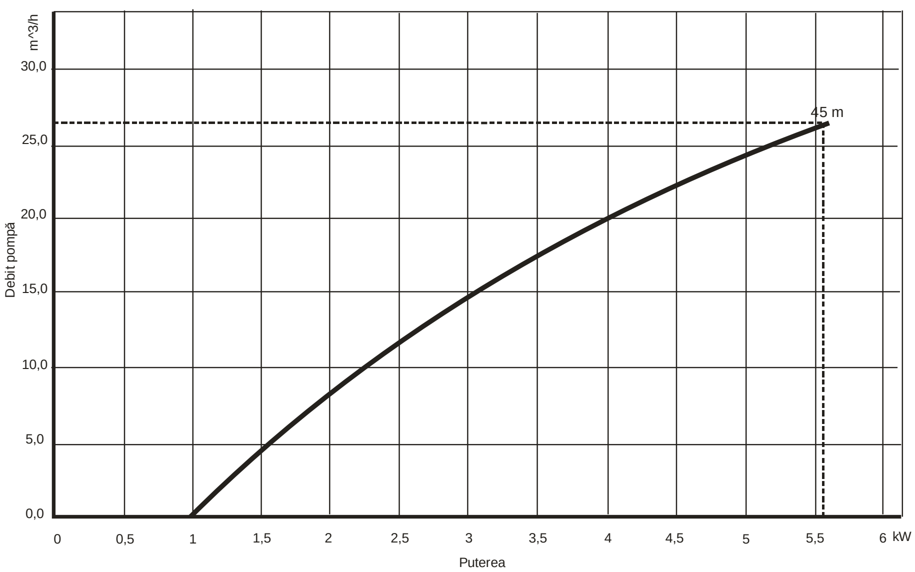

Figure 15. Pump system output characteristic

4.1.2 PV module

1. Module type AFP-255 ALTIUS, Romania;
2. Rated power - P_{PVmax} = 255 W;
3. Cell efficiency, η_C = 17,9-18,1 %
4. Module efficiency, η_M = 15,7 - 16,0 %;
5. Open circuit voltage, U_0 = 37,1 V;
6. Short circuit current, I_{sc} = 9,0 A;
7. Maximum power point voltage, U_M = 30,3 V;
8. Maximum power point, I_M = 8,43 A.
9. External dimensions 1640x992x40 mm.
10. Weigh 19 kg.

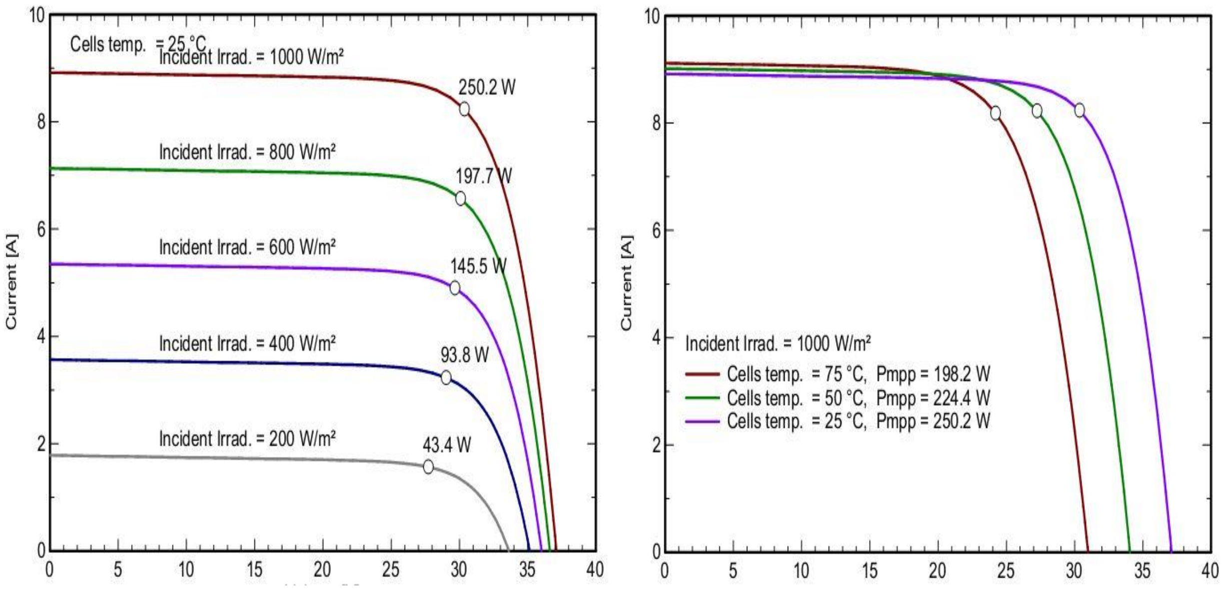

Figure 16. PV module technical data

The total number of modules - 44, maximal photovoltaic panel power is equal to 11 kW. The circuit diagram is shown in Figure 4.

4.1.3 Pump system electrical diagram, hour and diurnal output

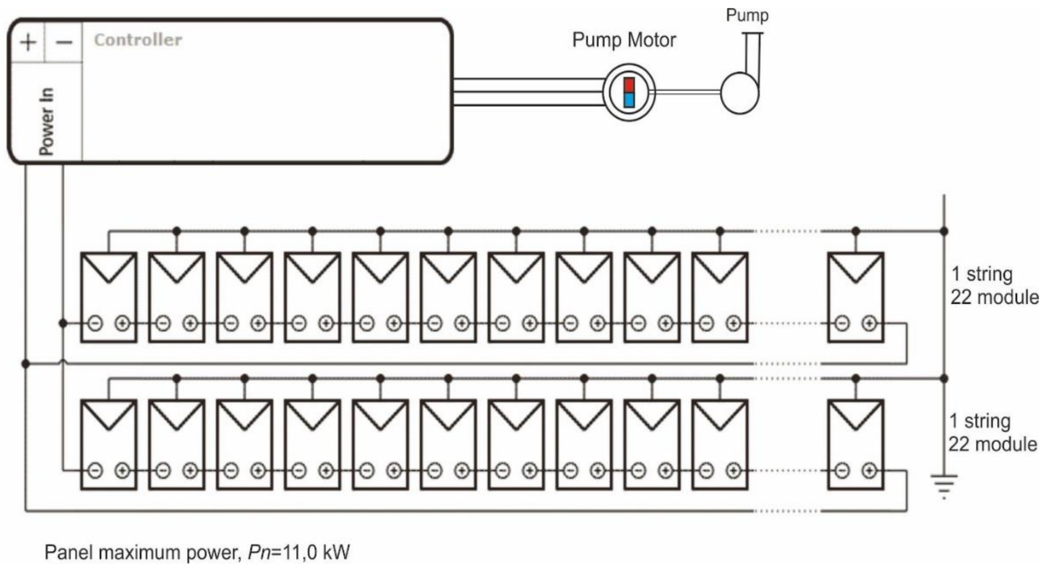

Figure 17. Electrical schema

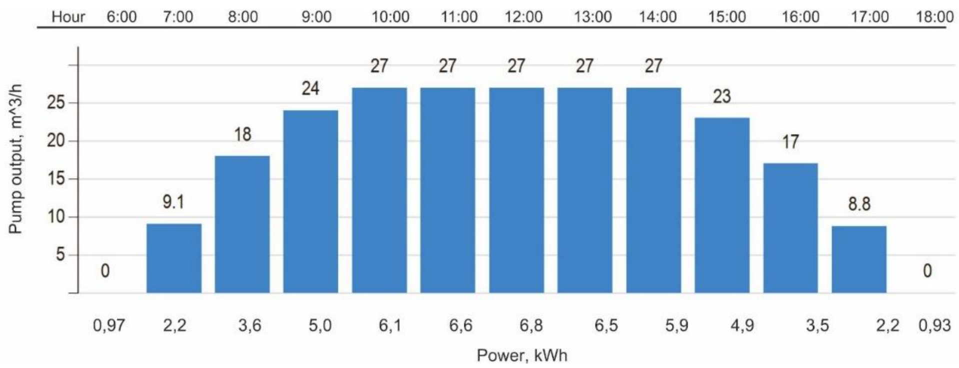

Figure 18. Pump hour output

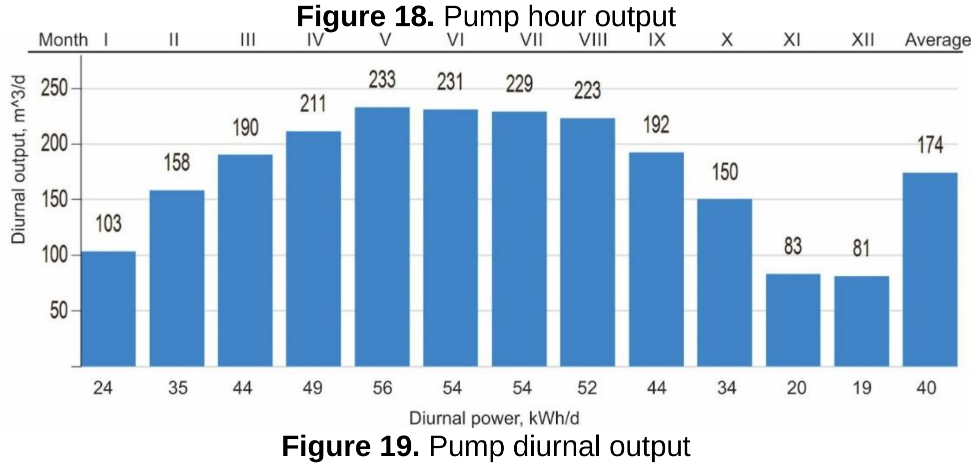

Figure 19. Pump diurnal output

From Figures 18 and 19 it follows:

1. During the period of 7 hours, between 9^{00} and 15^{00} hourly pump flow is approximately constant and equal to 26 m^3 / h
2. On irrigation period, from April to September, the average daily pump flow is equal to 220 m^3/d.

For enterprise "TriDenal" LLC, Criuleni water volume pumped by above system will ensure irrigation of 3,5 ha of cherry orchard, and in the future this area can be doubled.

For enterprise "Fortina Labis" SRL, village Floreni, Ungheni the same water volume will provide irrigation to about of 9 ha of orchard plum.

4.2. Designing and manufacturing of steel structure for photovoltaic panel's installation

During the project implementation, stating advantages of the location, the scheme of photovoltaic panels' placement was changed. Photovoltaic panels will be installed on the roof. This would allow the optimization of photovoltaic panels orientation to the sun only in azimuthal plane.

For this it was elaborated the steel structure design of photovoltaic panels installed on the roof.

The manufacture of steel structures for photovoltaic panels started.

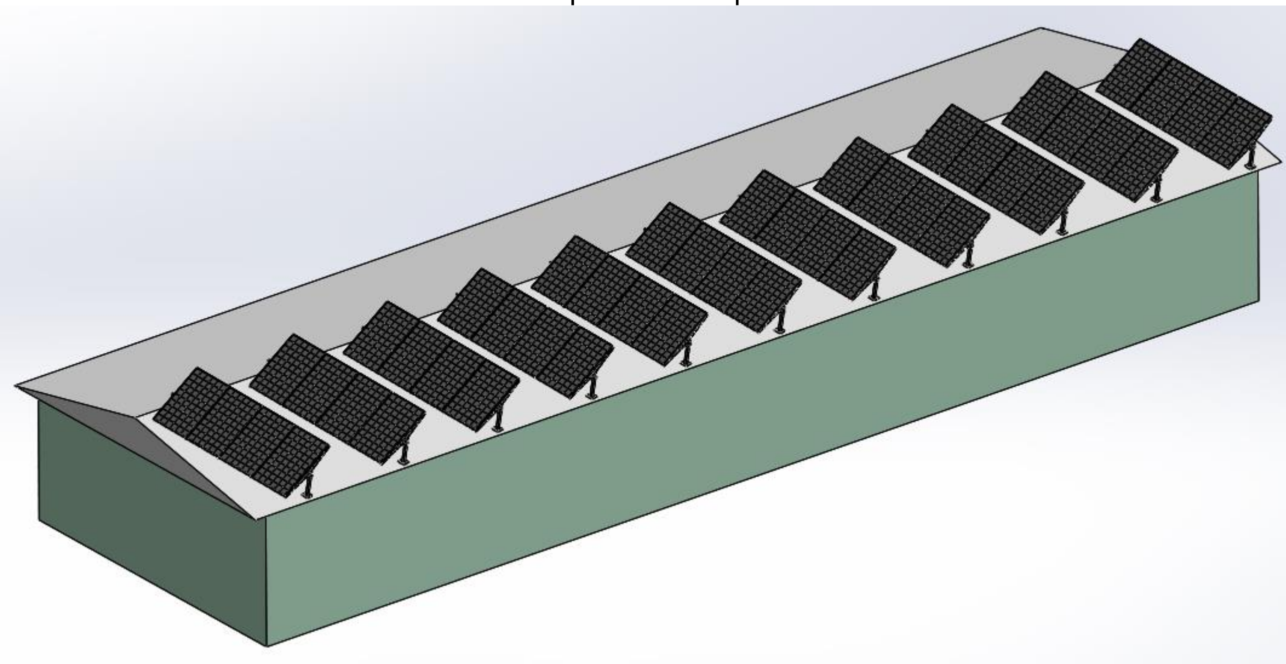

Figure 20. Photovoltaic panels installation scheme on the roof.

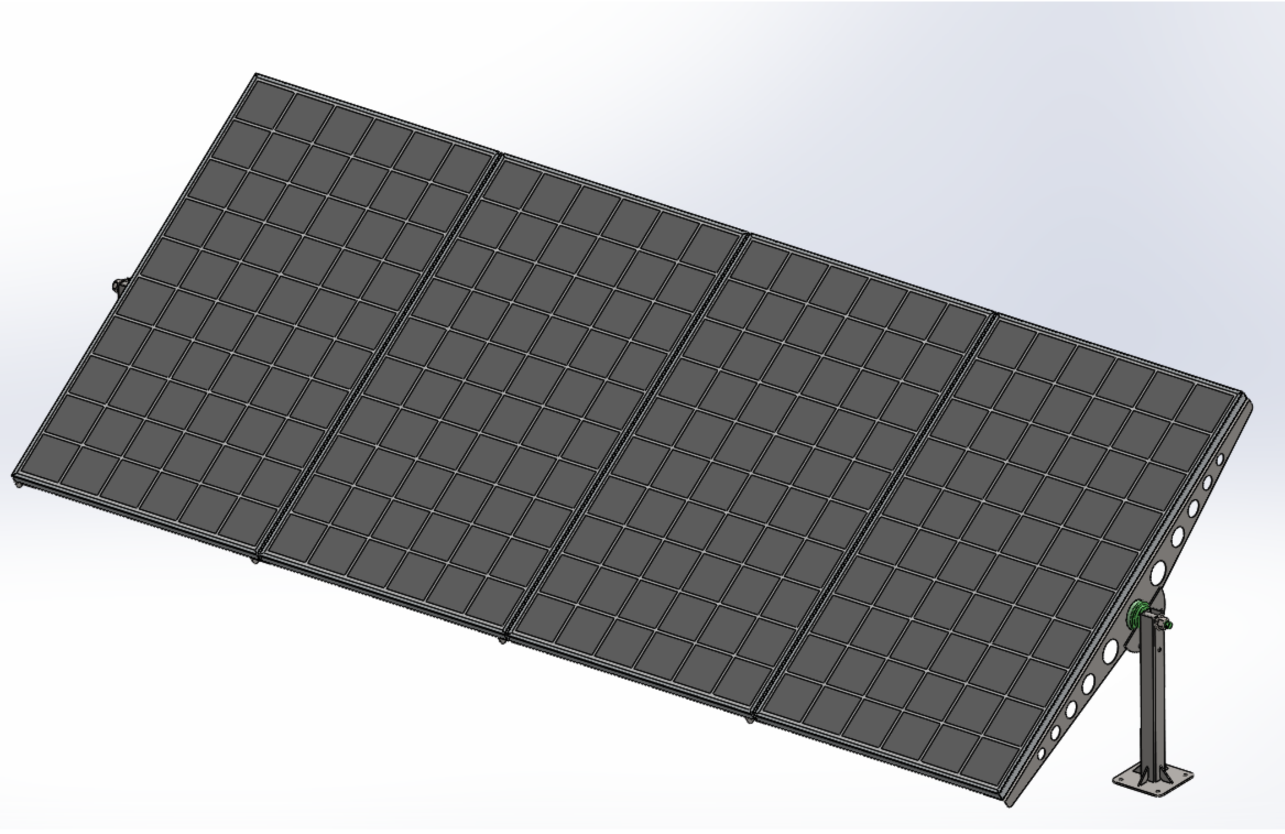

Figure 21. The design of PV installation.

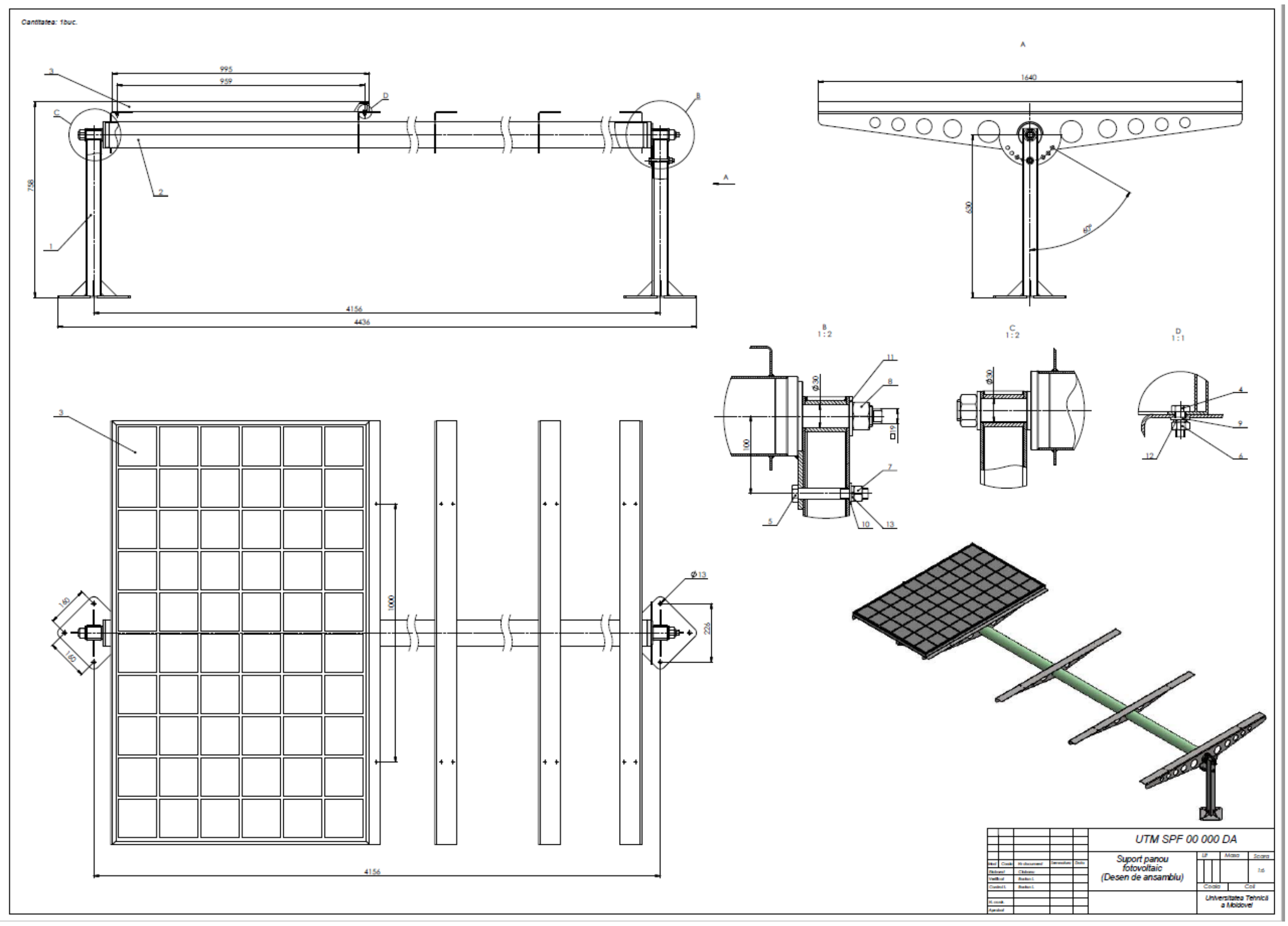

Figure 22. The design of PV installation structure.

III. Dissemination of the results:

Patents:

1. BI nr. 1052 Y (MD), 2016.06.30. MD. Int. Cl. F24J2/38. *Biaxial orientation system of a photovoltaic panel.* / Bostan I., Dulgheru V., Ciobanu R., Ciobanu O. UTM.– Nr. deposit S 2015-0154; Data deposit 16.11.2015.

2. BI nr. 4419 (MD). Int. Cl. B60K 16/00. *Sun system guidance of a photovoltaic panels*). / Bostan I., Dulgheru V., Dumitrescu C., Ciobanu R., Ciobanu O., Cozma I. UTM., Institutul de Cercetări pentru Hidraulică şi Pneumatică, Bucureşti – Nr. deposit a 2015-0114; Data deposit 16.11.2015. BOPI nr. 5/2016. 2016.05.31.

3. BI nr. 4401 (MD). CIB B60K 16/00. *Sun system guidance of a group of photovoltaic panels.* / Bostan I., Dulgheru V., Dumitrescu C., Ciobanu R., Ciobanu O., Cozma I. Univ. UTM., Institutul de Cercetări pentru Hidraulică şi Pneumatică, Bucureşti – Nr. deposit 2015-0093; Data deposit 30.09.2015. BOPI nr. 2/2016. 2016.02.29.

4. BI 934Z(MD) CIB. F03D 3/02. *Vertical axis wind plant (variants)*. / Bostan I.,Dulgheru V., Porcescu G. UTM. – Nr. depozit 2015-0042; Data depozit 26.03.2015; Publ. 31.07.2015. BOPI. – 2015. – Nr 7. – P. 30-31.

Appeciation at the *Internaţional Salons of Inventions:*

1. *Bostan Ion, Dulgheru Valeriu, Bostan Viorel, Dumitrescu Cătălin (RO), Ciobanu Radu, Ciobanu Oleg, Cozma Ion.* Sistem de orientare a unui grup de panouri fotovoltaice. *Expoziția Europeană de Creativitate și Inovație EUROINVENT 2016, EDIŢIA A VIII-a, Iași, România 19-21 mai 2016.* **DIPLOME AND GOLD MEDAL.**

2. *Bostan Ion, Vișa Ion (RO), Dulgheru Valeriu, Porcescu Gavril.* Instalație verticală cu ax vertical. *Expoziția Europeană de Creativitate și Inovație EUROINVENT 2016, EDIŢIA A VIII-a, Iași, România 19-21 mai 2016.* **DIPLOME AND GOLD MEDAL.**

3. *Bostan Ion, Dulgheru Valeriu, Dumitrescu Cătălin (RO), Ciobanu Radu, Ciobanu Oleg, Cozma Ion.* Sistem de orientare a unui grup de panouri fotovoltaice. *Al XIX-lea Salon Internațional de Invenții și Tehnologii Inovative din Moscova, ARHIMED 2016. Moscova, Rusia, 29 martie-1 aprilie 2016.* **DIPLOME AND BRONZ MEDAL.**

4. *Bostan Ion, Bostan Viorel, Dulgheru Valeriu, Sobor Ion, Vaculenco Maxim, Bodnariuc Ion, Dicusară Ion, Trifan Nicolae, Ciobanu Radu, Ciobanu Oleg, Odainâi Valeriu, Guțu Marin, Gladîș Vitalie, Porcescu Gavril.* Turbină eoliană cu ax orizontal cu orientare mecanică la direcția vântului. Societatea Internațională al Inovațiilor și Inventicii din China CIIS 2016. China, Taiwan, *în cadrul al XIX-lea Salon Internațional de Invenții și Tehnologii Inovative din Moscova, ARHIMED 2016. Moscova, Rusia, 29 martie-1 aprilie 2016.* **DIPLOME AND SPECIAL AWARD.**

5. *Bostan Ion, Dulgheru Valeriu, Dumitrescu Cătălin (RO), Ciobanu Radu, Ciobanu Oleg, Cozma Ion.* Sistem de orientare a unui grup de panouri fotovoltaice. *Societatea Inventatorilor și Inovatorilor din Rusia VOIR, regiunea Sankt Petersburg și Leningrad, în cadrul al XIX-lea Salon Internațional de Invenții și Tehnologii Inovative din Moscova, ARHIMED 2016. Moscova, Rusia, 29 martie-1 aprilie 2016.* **DIPLOME AND SPECIAL AWARD.**

6. *Bostan Ion, Bostan Viorel, Dulgheru Valeriu, Sobor Ion, Vaculenco Maxim, Bodnariuc Ion, Dicusară Ion, Trifan Nicolae, Ciobanu Radu, Ciobanu Oleg, Odainâi Valeriu, Guțu Marin, Gladîș Vitalie, Porcescu Gavril.* Turbină eoliană cu ax orizontal cu orientare mecanică la direcția vântului. Asociația Inventatorilor din Croația, Zagreb *în cadrul al XIX-lea Salon Internațional de Invenții și Tehnologii Inovative din Moscova, ARHIMED 2016. Moscova, Rusia, 29 martie-1 aprilie 2016.* **DIPLOME AND GOLD MEDAL**

7. *Bostan Ion, Dulgheru Valeriu, Dumitrescu Cătălin (RO), Ciobanu Radu, Ciobanu Oleg, Cozma Ion.* Sistem de orientare a unui grup de panouri fotovoltaice. *Salonul Internațional de Invenții și Tehnologii Noi „Novoe Vremea", Sevastopol, Ucraina în cadrul al XIX-lea Salon Internațional de Invenții și Tehnologii Inovative din Moscova, ARHIMED 2016. Moscova, Rusia, 29 martie-1 aprilie 2016.* **DIPLOME AND GOLD MEDAL**

8. *Bostan Ion, Dulgheru Valeriu, Bostan Viorel, Dumitrescu Cătălin (RO), Ciobanu Radu, Ciobanu Oleg, Cozma Ion.* Sistem de orientare a unui grup de panouri fotovoltaice. *Al 20^{LEA} SALON*

INTERNAŢIONAL DE CERCETARE, INOVARE ŞI TRANSFER TEHNOLOGIC INVENTICA 2016, IAŞI, 29.06 -01.07.2016. **DIPLOME AND GOLD MEDAL.**

9. *Bostan Ion, Dulgheru Valeriu, Bostan Viorel, Porcescu Gavril.* Instalație verticală cu ax vertical. *Al 20[LEA] SALON INTERNAŢIONAL DE CERCETARE, INOVARE ŞI TRANSFER TEHNOLOGIC INVENTICA 2016, IAŞI, 29.06 -01.07.2016.* **DIPLOME AND GOLD MEDAL.**

10. *Bostan Ion, Bostan Viorel, Dulgheru Valeriu, Sobor Ion, Sochireanu Anatol, Ciobanu Oleg, Ciobanu Radu, Gladîș Vitalie.* Turbină eoliană cu ax orizontal cu orientare mecanică la direcția vântului. *Al 12[-lea] Salon Internaţional de Invenţii şi Tehnologii „NOVOE VREMYA" 2016, Sevastopol, 28.09-30.09.2016.* **DIPLOME AND GOLD MEDAL.**