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Aspect regarding the use of renewable energy into vegetable farms of agritouristic pensions

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ABSTRACT

The main goal in the agritouristic pension design is that tourists can consume organic plant products produced in the guest house farm or its immediate neighborhood. This paper aims are on one hand to design a vegetable farm based on the necessity of specific products needed for the operation of a medium pension with 9 rooms, and secondly to assess the possibility of using photovoltaic energy for powering the micro-drip irrigation system. Starting from the amount of vegetable needs for tourists from an average agritouristic pension, it was calculated the number of plants, the required surface for the plants and the amount of water needed. Based on daily and monthly needs there were established technical and constructive parameters of the solar drip irrigation installation (diameter and length of hoses, flow, pressure and pump power and solar panel characteristics). The model can be easily adapted to other size pensions or to different climatic conditions.

1. Introduction

Climate change, coupled with concerns about high oil and energy prices, is driving a global trend towards the increased use of renewable energy. Unlike fossil fuels which are rapidly being depleted, renewable energy sources such as sunlight and wind are naturally replenished and therefore sustainable. Indeed, it is the perceived notion of sustainability that is driving governments around the world to introduce legislation promoting the use of renewable energy. [1]

Agritouristic pensions currently attract an increasing numbers of tourists because of the possibilities to consume organic plant products, acquired in own farms. [9]

Achieving high quality vegetable products require intensive irrigation activity in most parts of Central and S-E of Europe. Therefore, in the particular case of an agritouristic pension with vegetable farm, irrigation is essential for achieving enough vegetable quality to support catering activities.

For economic efficiency of vegetable productions on irrigated land areas, the issue is set on reducing energy consumption, together with the use of renewable energy sources.

Integration of modern drip irrigation while using photovoltaic solar energy to drive the water pump in the vegetable farm of a pension produces effective social and economic challenges

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by promoting the concept of "Green Economy" to the masses, by reducing costs and increasing the farm independence rank of utility networks in rural areas.

2. Problem statements

The study proposed in this paper focuses on designing solar drip irrigation system at a vegetable farm of a pension with a capacity of approx. 18 beds, consisting of 2 single rooms, 5 double rooms and 2 suites. The vegetable farm will be irrigated with a micro-drip irrigation system, water supply being achieved by using a submersible pump powered by a photovoltaic panel.

Calculation method involves the following steps: calculation of raw materials (vegetables) in the kitchen; of ground surface and water quantity needed for each vegetable species; of drip irrigation installation; of the water supply pump; calculation and selection of solar panels.

2.1. Calculation of raw materials in the pension kitchen

Considering a suggestion of a menu based on traditional recipes with specific diets rich in vitamins, minerals and natural fibres, it was obtained the final gross amount of raw materials by adding elements used in each preparation, taking into account the losses that occur after cleaning and thermal processes.

Tabel 2.1. Balance of raw materials required for preparing the main menus (required for 1 person /day)

Vegetables and fruits	Appetizer	Salad	Soup	Main dishes	Steak	Garnish	Desert	Total
Potato	100 g	150 g	100 g	450		800 g		1600 g
Onion	10 g	30 g	50 g	100		30 g		210 g
Tomato	160 g	160 g		40 g				360 g
Eggplant	500g			50 g				550 g
Zucchini			30 g	30 g				60 g
Cucumber		50 g						50 g
Peas				400 g	10 g			410 g
Salad		50 g						50 g
Pepper		15 g	20 g	20 g		25 g		80 g
Carrot			60	40 g	10 g			110 g
Parsley			10 g	15 g				25 g
Celery			15 g					15 g
Beans			20 g					20 g
Spinach	150 g	100 g	150 g					400 g
Mushrooms	250 g			60 g				310 g
Corn					10 g			10 g
Dill	3 g		3 g					6 g
Garlic	10 g							10 g
Apple							300 g	300 g
Quince							150 g	150 g
Nuts							50 g	50 g

The menu consists of: 4 types of appetizers; 4 types of salad; 3 types of soups; 4 main dishes; 4 types of steaks; 3 types of garnish; 3 types of desert. In order to obtain the necessary raw materials per day, the 25 menu portions are divided to the daily average client number, namely to 10. Thus, there was obtained 2.5 items. Next, is calculated:

Daily requirement: $Y = Item \times X\ kg$ *(1),* where: Item – 2.5; X – product.

Monthly requirement: $Z = Y \times 30$ *(2),* where: Y necessary product/day

Annual requirement: $W = Z \times 12$ (3) where: Z – Necessary products/month, W - Necessary products /year;

In table 2.2. is presented synthetically the calculated amount of vegetables needed for: raw materials necessary for the menu – daily, peeled raw materials (2nd column); quantity of raw vegetables (including losses due to initial processing – peeling, seed removal, etc. 3rd column); quantity of raw vegetables – required monthly amount – 4th column; quantity of raw vegetables – required annual amount – 5th column.

In the case of potatoes for example, Pmm = Product mass to use in menu; L = Loss %; Rpm = Raw product mass; Rpm =Pmm+L*Pmm = Pmm*(1+L)

Table 2.2. Overall material balance for pensions cuisine

Vegetables and fruits	Required daily amount (kg)	Percentage losses in primary processing (%)	Required daily raw vegetables	Required monthly raw amount (kg)	Annual raw amount required (kg)
Potato	4	15	4,6	138	1656
Onion	0,5	12	0,6	17,6	211,7
Tomato	0,9	5	0,945	28,35	340,2
Eggplant	1,4	20	1,68	50,4	604,8
Zucchini	0,15	30	0,195	5,85	70,2
Cucumber	0,05	25	0,06	1,87	22,5
Peas	1,1	10	1,21	36,3	435,6
Salad	0,125	20	0,15	4,5	54
Pepper	0,08	10	0,088	2,64	31,7
Carrot	0,275	25	0,34375	10,3125	123,8
Parsley	0,063	25	0,07875	2,3625	28,4
Celery	0,038	30	0,0494	1,482	17,7
Beans	0,05	10	0,055	1,65	19,8
Spinach	1	25	1,25	37,5	450
Mushrooms	0,775	25	0,96875	29,0625	348,75
Corn	0,025	10	0,0275	0,825	10
Dill	0,015	25	0,01875	0,5625	6,7
Garlic	0,025	22	0,0305	0,915	10,9
Apples	0,75	27	0,9525	28,575	342,9
Quince	0,375	28	0,48	14,4	172,8
Nuts	0,125	35	0,16875	5,0625	60,7

2.2. Calculation of the area of land and water requirement for each vegetable species

Based on the demand of vegetables in the kitchen there are made calculations for each species separately, as following: required annual gross in kitchen, [kg] (Rak); required annual gross in vegetable warehouse, [kg] (Raw); minimum area required for each species [m²] (Amin); adopted surface for each vegetable layer [m²] (As); actual production [kg] (Ap); quantity of water needed for each vegetable species [m³] (Q). In the table 2.2 it can be established that the needed amount of potato in the kitchen is Rak = 1656 kg. Knowing the average losses during storage (L = 20%), results:

$$Raw = Rak \times (1+L) = 1656 \times (1+0,2) = 1987,2 \text{ kg}, (4);$$

Knowing Yha =16000 kg/ha, it is calculated the minimum area needed for the potato layer:

$$Amin = Raw/Yha * 10000 = 1987,2/16000 * 10000 = 1242 m^2 \ (5);$$

Adopted area will be Aa = 1500 m², respectively a plot with the following size of 30 x 50 m; from the adopted area, the actual production (Ap) will be:

$$Ap = Aa \times Yha/10000 = 1500 \times 16000/10000 = 2400 \text{ kg} \ (6);$$

From the table of irrigation rules [5], [6], for potatoes are recommended watering of 600-1000 m^3/ha between April...July. Are chosen monthly irrigations of 600 m^3/ha in April....May, 300 m^3/ha in June and 150 m^3/ha in July. Therefore the adopted area (Aa), requires a monthly amount of water of: *Q = Aa x Ir / 10000 = 1500 x 600/10000 = 90 m^3 (7) - for April....May;*

Q = Aa x Ir / 10000 = 1500 x 300/10000 = 45 m^3 (8) - for June;

Q = Aa x Ir / 10000 = 1500 x 150/10000 = 22,5 m^3 (9) - for July;

Where: Q - Quantity of water needed for each vegetable species, [m^3]; Ir – Irrigation rate, [m^3]. Results from similar calculations made for all the other vegetables, can be found in table no. 2.3. These amounts are averages values, specific for Romanian geo-climate conditions. [2], [7], [8].

Table 2.3. Calculation of surface and needed vegetables

Vegetables and fruits	Required annual gross in kitchen [kg]	Losses during storage %	Required annual gross in vegetable warehouse [kg]	Yield per ha [kg]	Minimum area required for each species [m²]	Adopted surface for each vegetable layer [m²]	Actual production [kg]
Potato	**1656**	**20 %**	**1987,2**	16000	**1242**	1500 (30 x 50 m)	2400
Onion	**211,7**	**20%**	**254,0**	40000	**63,5**	80 (8 x 10)	320
Tomato	**340,2**	**30%**	**442,3**	55000	**80,4**	100 (10 x 10)	550
Eggplant	**604,8**	**5%**	**635,0**	40000	**158,7**	180 (10 x 18)	720
Zucchini	**70,2**	**5%**	**73,7**	20000	**36,8**	40 (4 x10)	80
Cucumber	**22,5**	**35%**	**30,4**	35000	**8,7**	25 (5 x 5)	87,5
Peas	**435,6**	**5%**	**457,4**	10000	**457,4**	460 (10 x 46)	460
Salad	**54**	**15%**	**62,1**	17000	**36,5**	40 (4 x 10)	68
Pepper	**31,7**	**10%**	**34,8**	34000	**10,2**	20 (2 x 10)	68
Carrot	**123,8**	**25%**	**154,7**	25000	**61,9**	64 (8 x 8)	160
Parsley	**28,4**	**15%**	**32,6**	30000	**10,8**	10 (2 x 5)	30
Celery	**17,7**	**20%**	**21,4**	25000	**8,5**	10 (2 x 5)	25
Beans	**19,8**	**5%**	**20,8**	7000	**29,7**	35 (5 x 7)	24,5
Spinach	**450**	**5%**	**472,5**	22000	**214,7**	220 (10 x 22)	484
*Mushrooms	**348,75**	**5%**	**366,1875**				
Corn	**10**	**5%**	**10,5**	3000	**35**	35 (5 x 7)	10,5
Dill	**6,7**	**15%**	**7,7**	20000	**3,8**	8 (2 x 4)	17,6
Garlic	**10,9**	**5%**	**11,5**	5000	**23**	25 (5 x 5)	12,5
**Apple	**342,9**	**35%**	**462,9**	60000	13 trees = **77,1**	80 (8 x 10)	
**Quince	**172,8**	**30%**	**224,6**	50000	8 trees = **44,9**	50 (5 x 10)	
**Nut	**60,7**	**10%**			3 trees = **60**	18 (2 x 9)	
Total					**2663,6**	**3000**	**5517,6**

* Mushrooms will be purchased from the nearest mushroom place mushroom farm and are not subject to the calculation of the surface;

** 1 tree = 6mp. Fruit trees do not need extra water for irrigation, the wastewater stored in deep layers at 1-2 m from the nearby vegetable crops being sufficient. [8].

The amount of water was calculated using data from the table of irrigation rules multiplying the amount required to ha with the number of days in the three months of irrigation Ex. Potato: 400 m^3 at 5 days; 90/5=18 days x 400 m^3=7200.

Considering the data from the literature [3], for the classical irrigation rules and taking into account the significant reduction in water demand for irrigation by using micro-drip system, for the main vegetables data has been gathered, and it is presented in the table bellow:

Table 2.4. Irrigation rates

Vegetables	**Micro-drip irrigation rates (Ir), m³**						
	March	April	May	June	July	August	Total m^3 of water/species/whole period
Potato		90	90	45	22,5		**247,5**
Onion	2,4	2,4	1,2	1,2			**7,2**
Tomato	3	3	1,5	1,5	0,75	0,75	**10,5**
Eggplant	5,4	5,4	2,7	2,7	1,35	0,67	**18,22**
Zucchini	1,2	0,6					**1,8**
Cucumber	0,75	0,75	0,75	0,37	0,37	0,18	**3,17**
Peas		1,38	0,69	0,34			**2,41**
Salad		1,2	0,6	0,3			**2,1**
Pepper	0,6	0,6	0,3	0,15	0,15		**1,8**
Carrot	1,92	1,92	0,96	0,48			**5,28**
Parsley	0,3	0,15	0,07				**0,52**
Celery		0,3	0,15				**0,45**
Beans		1,05	0,5	0,25			**1,8**
Spinach	6,6	3,3	1,65	0,8			**12,35**
Corn		1,05	0,5				**1,55**
Dill	0,24	0,12	0,12				**0,48**
Garlic	0,75	0,37					**1,12**
Total	**23,16**	**113,59**	**101,69**	**53,09**	**25,12**	**1,6**	**318,25**

2.3. Calculation of micro-drip irrigation installation

2.3.1. Calculation of pipelines

From literature [11], [12], [13], [14] for pipelines with flows of 100-300l/h for lengths of up to 100m it is recommended a diameter of 19 mm.

According to image 2.1 there were defined 3 pipelines A, B, C with lengths of 50m for: A – potato; B - peas, zucchini, eggplant, tomatoes and spinach; C - salad, onion, pepper, carrot, beans, cucumbers and other spices.

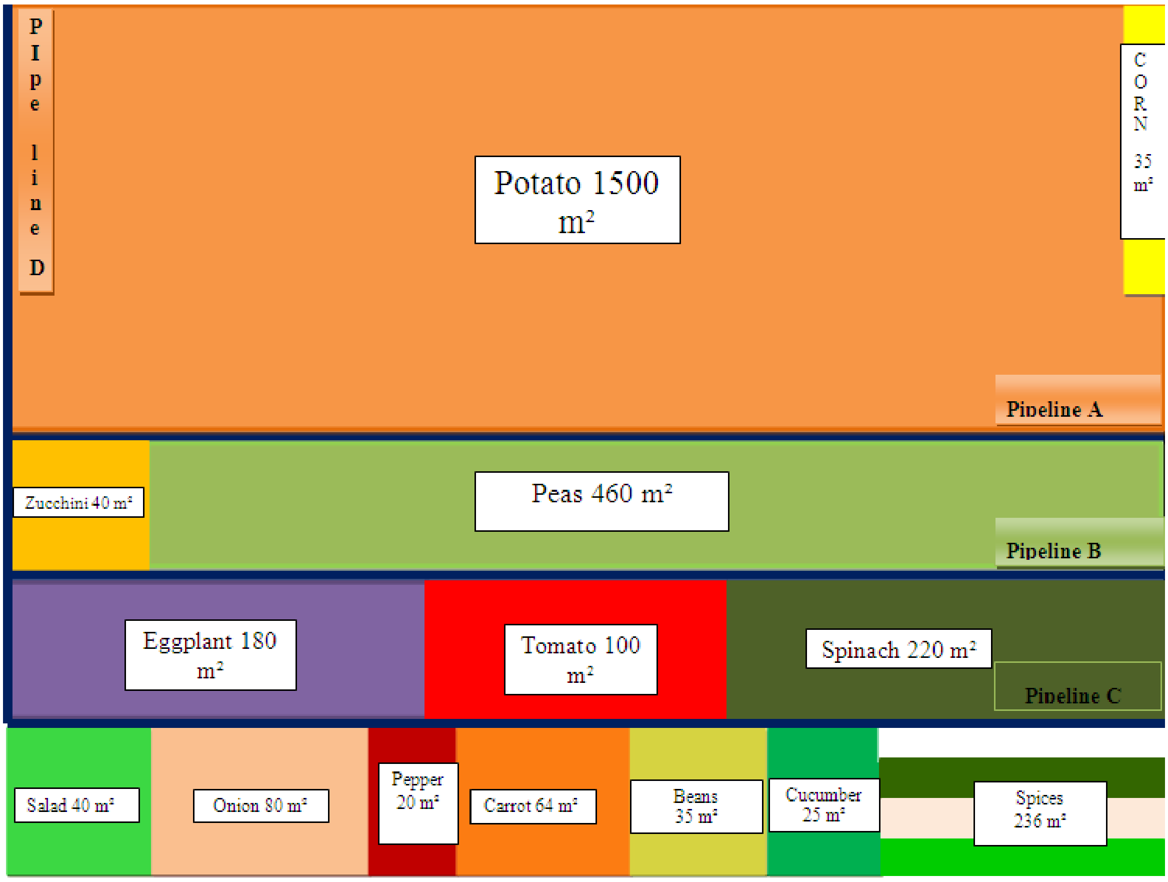

Figure 2.1. Pipelines layout and vegetable layers in the farm

Power for the 3 pipelines A, B and C, is made through the D water pipe with a length of 55 m and diameter of 55mm, which is connected to the water tank from the vicinity of the vegetable farm.

2.3.2. Hose sizing of vegetable layers

For potato rows, given the distance between two rows must be between 50 and 70 cm, and between nests along the line between 35-50cm, [13] for a surface of 1500m², with a length of 50 m and width of 30m, the number of rows (Nrp) is calculated using the formula:

$Nrp = L/d = 50/0{,}5 = 100$ *rows (10)*, where, L = lenght of potato row – L = 50m; d = distance between two rows– select d= 0,5m;

Results a number of 3000m of hose, 100 connectors and 100 plugs, as shown in the micro-drip installation diagram, figure 2.2. The hoses diameter is adopted from the literature, for a flow of one l/h at a value of 10mm. The number of potato nests (Npn) will be calculated with the following formula:

*Npn = l/dn * Nrca = 30/0,5 * 100 = 6000 nests (11)*, where: dc – distance between nests; l – row width.

In similar ways are made calculations for the other rows of other vegetables and synthesis calculations are presented in table 2.5.

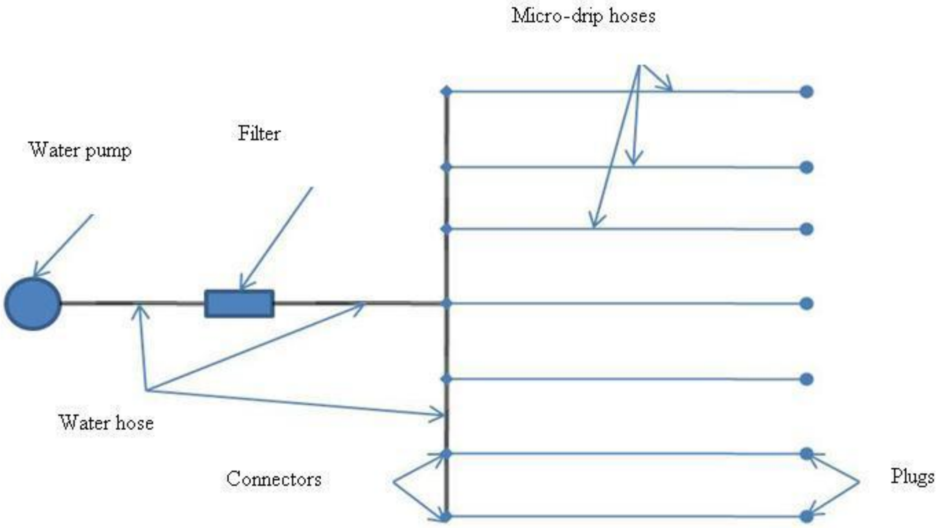

Figure 2.2. Micro-drip installation diagram [18]

Table 2.5. Irrigation accessories needed

Vegetables	**Plot surface** (m^2)	**The total length of used hose** (m)	**Connectors and Plugs** (pcs)
Potato	1500	3000	100
Peas	460	1530	153
Zucchini	40	40	4
Eggplant	180	300	30
Tomato	100	400	40
Spinach	220	1100	110
Salad	40	200	20
Onion	80	200	20
Pepper	20	50	5
Carrot	64	160	16
Beans	35	70	7
Cucumber	25	50	5
Spices	236	1180	118
TOTAL	**3000**	**8280**	**628**

2.4. Calculation of water supply pump

The water pump is chosen taking into account the pressure and the flow needed to supply. [4], [5], [18]. The pump debit is deducted from the maximum monthly consumption, which is in April, with an amount of 113,59 m^3 (Qm), resulting the daily water flow:

$Qm/30 = 3,78\ m^3$ *(12)*, where: Qm- Monthly debit value.

The pressure required is calculated taking into account the maximum depth at which the pump can work well in the worst case of declining groundwater levels. In most cases the ground water is found at 20m depth, during dry periods can descend to a maximum depth of 25m. At this height it is added the distance between the ground and the upper part of the water basin, which is adopted to be equal to 5m. Drilling depth HD is 25m (drill height), HB is 5 m (basin height) and HT=25+5=30m (total height).

For the micro drip irrigation systems using photovoltaic energy, on market were imposed Lorentz series pumps with different pressure and flow characteristics. [19]. Given the parameters calculated above, the pump PS 200 is choosen, the LPP00028 model with the following technical characteritcs [17].

Table 2.6. Technical characteristics of pump PS 200 HR 204 (LPP00028) [20]

Characteristics, unit measure	Value	Presentation
Pumping capacity [m]	50	
Debit [m^3/h]	0,8	
Efficiency [%]	60	
Solar operation [VCC]	24	
Open circuit voltage [VCC]	100	
Solar energy source [Wp]	80-300	

Since the flow is 0.8m^3 per hour, results the minimum operating time equal with Qal/qp= 3,78/0,8= 4,7 h/day

2.4.1. Electronic pump controller

Lorentz pump model LPP00028 is acquired with:

Controller PS200, has the following characteristics: Electrical protection IP 54; 88% efficiency (motor and controller); Reverse polarity protection; Operating system MPPT (Maximum Power Point Tracking).

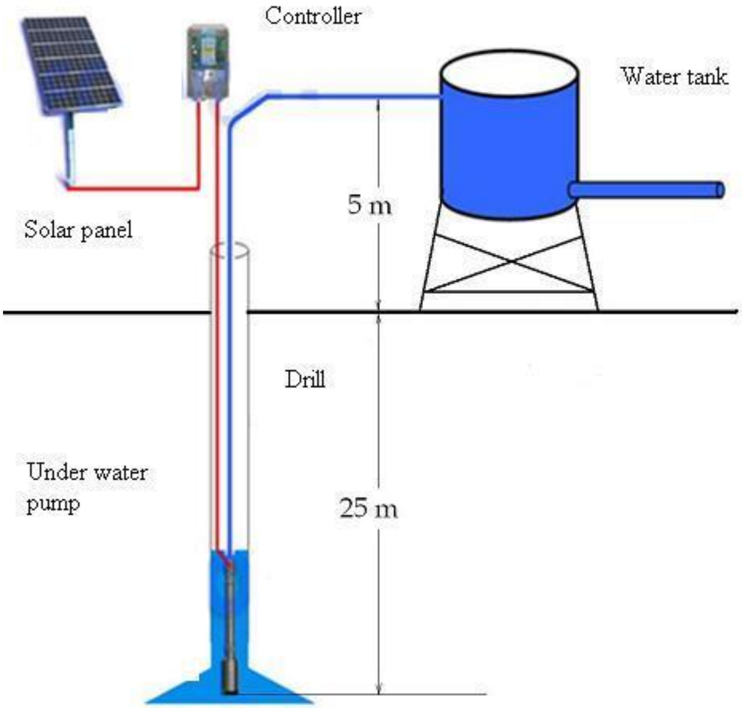

Figure 2.3. Diagram of solar pump type installation used for micro-drip irrigation

2.4.2. Solar panel selection

Given that the maximum height of the pumping flow needs an electrical power of 300W, there are selected 3 solar panels, polycrystalline photovoltaic, model ET-P636120-120W with the following characteristics:

Table. 2.7. ET-P636120-120WSolar panel characteristics [15]

Maximum power	120W
Voltage	24V
Cell number	36
Operating temperature	45,3°
Dimensions	156mm x 156mm

Total power delivered by the solar panels is 3x120W =360W, fulfilling the needs of pump consumption.

2.4.3. PV installation

In synthesis the micro-drip irrigation installation powered by a photovoltaic panel is composed from the components presented in table 2.8. The total investment of the installation including VAT is **8192,7 lei (1862 euro).**

Table 2.8. Value of inventory objects for the irrigation installation

No.	**Name**	**Required material** (pcs)	**Unit value** (lei/pcs)	**Total value** (lei)
A. Irrigation installations				
1.	Artery terminator	5	2	10
2.	Row terminator	628	0,5	314
3.	Timer	1	160	160
4.	Voltage stabilizer	1	150	150
5.	Water filter	2	40	80
6.	One way valve	2	25	50
7.	Water tank	3	500	500
8.	Tank support	3	100	300
9.	Valve for artery	5	9,72	48,6
10.	Connectors	650	0,56	176
11.	Curves	10	3,5	35
12.	Solar panel ET P636120-120W	3	1000	3000
Total A.				**5823,6**
B. Hoses		**m**	**lei/m**	**Total value**
13.	Hose for artery	255	0,26	58,5
14.	Hose for rows	8280	0,15	1242
Total B.				**1300,5**
Installation total value				**7124,1**
Transportation and installation expenses (15 % from installation value)				1068,6
Total value of irrigation installation under assembling				**8192,7**

Conclusions

1. The study on the concept of a micro-drip irrigation system of a vegetable farm, using solar photovoltaic energy, constitute a constructive approach, of efficient use of renewable energy, in the context of the global promotion of the GREEN ECONOMY concept.

2. Starting from an example menu typical for the studied geographic area, were calculated daily, monthly and annual vegetable needs for the pension kitchen.

3. From the existing irrigation systems the micro-drip method was selected because of its advantages (low water consumption, easy maintenance, reduction of the number of crop maintenance works), but also beacuse of the possibility of water supply through equipments like solar pumps.

4. Among the studied technical solutions it was selected the Lorentz type solar pump (with brushless motor and high efficiency), powerd by a nomber of 3 photovoltaic panels, with a total power of 360W. For carrying water up to the plant, there were studied different micro-drip systems; the most suitable for the agritouristic vegetable farm was the Gardena system, distributed through 3 pipelines to the entire vegetable farm surface.

5. Integrated analysis of the agritouristic pension concept with a vegetable farm shows the viability of the idea, sustainability of the micro-economic environment model and not least business profitability and positive social impacts.

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