EFFICIENCY OF SOME MEASURE TO REDUCE ENERGY AND WATER DEMANDS FOR IRRIGATION, IN ARRANGEMENTS FROM PRUT RIVER BASIN

EFICIENȚA UNOR MĂSURI PENTRU REDUCEREA CERINȚELOR DE ENERGIE ŞI DE APĂ PENTRU IRIGAȚII, ÎN AMENAJĂRILE DIN BAZINUL HIDROGRAFIC PRUT

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Abstract. *The analysed arrangements needs rehabilitation and modernisation works in order to reduce energy and water consumptions. To reduce the specific energy consumption related to 1000 cubic meters water distributed to AUAI, has been analysed increasing of efficiecy to base and re-pumping stations, also rehabilitation of main canals. Specific energy reduction in distribution network comprise rehabilitation measures in distribution network, modernisation of methods and watering instalation, water scheduling, emphasizing the limits of each measure.*

Rezumat. *Amenajările analizate necesită lucrări de reabilitare şi modernizare cu scopul de a reduce consumul de energie şi apă. Pentru a reduce consumul specific de energie raportat la 1000m^3 apă distribuită AUAI, se analizează eficiența îmbunătățirii randamentului energetic al stațiilor de pompare de bază şi repompare şi reabilitarea îmbrăcăminților canalelor de aducțiune. Reducerea consumului specific de energie în rețeaua de distribuție cuprinde măsuri de reabilitare a rețelelor de distribuție (ploturi), modernizarea metodelor şi instalațiilor de udare şi programarea udărilor.*

INTRODUCTION

In Prut River land and its adjacent zone were realized before 1989, irrigation arrangements on 75000 hectares approximately, spread in Botosani, Iasi, Vaslui and Galati counties. Also, there are smaller irrigation arrangements in hydrographic basins of Prut River tributaries, which use water from lakes.

Irrigation necessity is done by precipitations temporary variability and by frequency and intensity increasing of droughts in this part of country, due to global climatic change. The irrigation's profit is determined by several factors as well as commercial value of crops increase (related to quality and quantity of agricultural products), by irrigation costs – in which water costs are included etc. From profitable point of view, the greatest part of these irrigation arrangements is occupied by vegetables cultures.

In actual arrangements, the relative great expenses for energy consumptions and water pumping, affects farmer profitability and make irrigation unprofitable for crops with smaller economic value. Therefore, is interesting for specialists from National Irrigation Agency, also for farmers from AUAI, to know the factors who influence consumptions and measures for its reduction corresponding for each involved. Therefore are interesting establishing the competence's domain, possibility of actions and its successive in time interventions. The analyses that were done refer to these aspects, in specific conditions of some representative arrangements from zone.

These measures represent the objectives of rehabilitation and modernization program with other measures as well as sustainable irrigation (soil and underground water pollution risk reduction).

SPECIFIC ENERGY CONSUMPTION IN ACTUAL ARRANGEMENTS

Part of these arrangements has more pumping steps in land zone also, function by topographic conditions another 1-2 pumping steps on Prut river terraces and inter basins platforms.

Specific energy consumption could be analyzed per unit water volume at entrance into the farm or per surface irrigated unit.

The first way of expression is:

$$C_{Sp} = \frac{9.81 \cdot H_p}{3600 \eta_p \eta_t} \text{ (Kwh/1000 water cubic meter)},$$

where: H_p represents total pumping head; η_p - energetic efficiency of pumping stations; η_t – hydraulic efficiency of transport network of irrigation systems.

$$\eta_t = \eta_a \, \eta_d$$

where: η_a represents main network efficiency; η_d – distribution network efficiency (buried pipes under pressure).

The main objective of irrigation systems administration is reduction of this consumption. This consumption depends by energetic efficiency of pumping station, also by hydraulic efficiency of main canals. Specific consumption is affect by canals utilization degree, considered as a ratio between effective discharge and maximum capacity of canal. This is due to that in exploitation, canals are maintained with higher water levels indifferent by discharge, in this situation the water loses from canal doesn't depends by effective discharge.

Hydraulic efficiency of main network directly depends by water loses from canal and discharge, by relation:

$$\eta_a = 1 - \frac{Q_p}{Q_{tr}}$$

where: Q_p represents discharge of water loses from main canal (by filtration); Q_p – transition discharge.

The values of specific consumption in actual conditions, considering as a medium η_p = 0.7 and filtration water loses as 400 l/m^2 and day (measured in Sud Solonet irrigation system) [1], are shown in table 1.

It is remark that a utilization degree more than 20-25 % is more important for specific consumption diminishing, especially on higher pumping steps.

Table 1

Specific energy consumption (Kwh/1000 water cubic meter), on arrangements, pumping steps and different utilization degree [2]

Irrigation system	Pumping step	Surface (hectares)	Utilization degree (%)				
			10	25	50	75	100
Stanca Ripiceni	I	610	0.58	0.48	0.46	0.46	0.45
	II	2415	4.10	1.12	0.91	0.86	0.84
Nord Solonet	I	3390	0.58	0.58	0.58	0.58	0.58
	II	2588	0.84	0.84	0.84	0.84	0.84
Sud Solonet	I	2541	1.32	0.68	0.61	0.59	0.58
	II	1739	2.27	1.15	1.01	0.98	0.96
Lunca Trifesti Sculeni	I	7288	0.39	0.33	0.32	0.32	0.32
Albita Falciu subsistemul Bumbata	I	4193	0.36	0.31	0.29	0.28	0.28
	II	910		0.83	0.53	0.49	0.48
Campia Covurlui	I	5545	0.25	0.24	0.24	0.24	0.24
	II est	3066	4.37	1.69	1.39	1.32	1.29
	III est	2769	15.23	3.12	2.25	2.04	1.95
	II vest	47232	0.95	0.36	0.34	0.33	0.33
	III vest	25929	1.93	1.09	0.87	0.83	0.82

MEASURES FOR ENERGY AND HYDRAULIC CONSUMPTION DIMINISHING IN PUMPING INFRASTRUCTURE AND WATER TRANSPORT

Due to length of service and wear, the energetic efficiency of pumping and re-pumping station components has small values (0.6 and less in some cases). By replacement with new components could be increased the energetic efficiency up to 0.8, which permit energetic consumption diminishing up to 25 % by actual consumptions.

In other wise it is interesting to study rehabilitation of canal lining. The most canals are into a critical physic and functional stage due to of lack maintenance. Rehabilitation is justified to those canals and part of canals with higher utilization degree. It could be approached step by step from upstream to downstream. The recommended materials are plastic membranes by synthetic rubber or by bentonite composite cover with ground, or concrete guniting.

The opportunity rehabilitation from economic point of view results from comparison between costs of new lining and saved water. The economic calculus shows that the geomembrane cover with ground could be a solution for canals situated on the pumping step with pumping head more than 20 meters, if the yearly utilization of canal is 100 days and for pumping steps with pumping head more than 33 meters if utilization time is 60 days yearly (life time for lining is considered 20 years). The concrete lining is more expensive but has a lifetime greater than geomembrane (50 years). This solution is justified for pumping heads higher than 30 meters for a yearly utilization of canal up to 100 days and for pumping head more than 50 meters (60 days).

These elements were established taking into account that actual water loses are 300 l/m^2 and day and after rehabilitation decreases to 30 l/m^2 and day.

The actual physic stage of lining differs from an arrangement to anther, which impose measurements in specific conditions for each irrigation system. After that, we could establish the rehabilitation efficiency and the specific solution to use.

In some cases are necessary only few operating repairs of joints and settlement of some discharge valve on the end of drains if degradation of lining is due to rise of water table ground.

MEASURES TO REDUCTION OF WATER AND ENERGY CONSUMPTION IN PLOTS

The energy consumption in these conditions is more appropriate to relate at surface unit (hectare):

$$C_{Sp} = \frac{9.81 \cdot H \cdot M}{3600 \cdot \eta_p \cdot \eta_d \cdot \eta_u}$$

where: H represents pumping head at SPP; M – yearly effective water rate; η_p – energetic efficiency of SPP; η_d – hydraulic efficiency of distribution network; η_u – watering efficiency.

Performance of watering is defined as follows:

$$E_a = E_d \cdot E_u$$

where: E_d represents performance of irrigation method and technique and depends by amount of water loses through percolation, evaporation and flooding; E_u – performance related to non-uniformity of water distribution.

Mean value of E_d is 60-90 % for surface irrigation (maximum values are for cablegation installation with intermittent supplying or water recirculation); 65-70 % for irrigation with mobile installations; 60-70 % for irrigation with traveling sprinkler; 75-90 % for irrigation with pivot center linear-moving system; 70-85 % for irrigation with fixed microsprincklers; in mean 90 % for drip irrigation [4].

Performance of watering from sprinklers increase during the night.

E_u depends by uniformity watering coefficient (Cu):

$$E_u = 0.5 \cdot \left(1 + \frac{CU}{100}\right)$$

In some conditions E_u could decrease: higher wind velocity for sprinklers (more than 8 km/h), great shape of land (more than 12%), if watering intensity exceed soil infiltration capacity.

In the last decades the farmers acquired new drip and sprinklers installations with higher performance.

It could be obtain a 23% reduced energy in case of use hose-drawn travelers with low pressure (medium performance 85%) instead of the old sprinkler laterals (medium performance 65%). In the same time, the better performance of new irrigation equipments is reflected in reduction of irrigation demands (defined as ratio M_{net}/E_a). In fact, improvement of water distribution give more water and energy economy because of the non-uniform watering constrains the farmers to increase watering duration in order to obtain a amount of water at least equal with water rate on the whole surface. In this case result an exceeding water amount on the most part of irrigated surface.

a. Water scheduling

Water scheduling used in this aim could become an approach to reduce water energy consumptions. The used method is monitoring of hydric balance of soil, which needs a daily evaluation of evapotranspiration differentiated on zones uniforms from pedoclimatic conditions and crops point of view. In several countries there are web sites where farmers could obtain information about evapotranspiration evolution and software for download.

A problem with major implication in irrigation water consumption reduction is degree of utilization of natural precipitations. Although quantitative precipitation forecast is not possible, in software is necessary to be included precipitation with some probabilities for the time interval considered.

Other measure is to stop the watering when in soil is recorded a humidity level at 85-90 % from water field. In this case, the water rates will be reduced (300-350 mc/ha for a soil depth 0.5 m). In this way is assured a soil space reserve used for increasing degree of availability for unexpected precipitations, which could occurs after watering.

b. Succession of measures implementation

Some measures regarded the system administration and other by AUAI and farmers. All of them are components of rehabilitation and modernization program for irrigation systems. Before initiating of these programs is necessary to implement the institutional reforms and constituting AUAI, respectively.

Approach agenda is related to utilization degree, which is recorded on each pumping step and plots.

Anyway, the first actions are refers to base pumping station. Function by plots located areas with minimum utilization degree is necessary to modernize the main canal, repumping station, and of course, SPP and distribution networks from plots.

Energy consumption at SPP could be reduced by many ways:

- by replacement of some components with new ones with great efficiency;
- pressure at SPP could be reduced especially for high zone with less water demand;

- could be reduced the working pressure at hydrant to 2-3 bar, instead of 4 bar in present, if it is replaced the actual irrigation equipment.

In condition of some plots where location of irrigated crops differs from year to another, is more efficient to abandon the actual network and SPP and to irrigate directly from main canals using thermic aggregates with supra terrain lines (from drip and microirrigation or from traveling sprinkler irrigation)[2].

Acquisition of performing irrigation equipments is main interest for farmers from actual irrigation arrangements. In order to minimize the risk of utilization of actual infrastructure, farmers could use an alternative water sources (lakes etc).

CONCLUSIONS

Measures to reduce water and energy consumption in irrigation arrangements from Prut River basin, must approached in associated way, taking into account that transport and water distribution is done by pumping.

The main objective represents reduction of energy consumptions that has great values especially in case of less utilization degree of main canals. Therefore, before starting rehabilitation and modernization program, is necessary institutional reform.

Possibilities with great impact in reduction of energy consumption for pumping and transport infrastructure are: pumping equipment replacement and lining rehabilitation with cheap solutions (geomembranes covered by ground).

In plots, the energetic efficiency could be improved by replacement pumping equipments from SPP, revise of distribution network and acquisition by performed irrigation equipments.

Implementation of water scheduling as a component of irrigation management with considering weight of precipitations, assure an important reduction of water demands and water taxes for farmers. Also this measure will reduce energy consumptions at arrangements level and soil levigation phenomena and underground water pollution with chemical substances.

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