A New Cascaded HydroPower Plants On El Sheikh Zayed Canal In The New Valley In Egypt

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Abstract

With the streaks of light looming in the horizon, heralding the dawn of the 21^{st} century and the closing of the 20^{th} century, the whole people of the world specially the sons of Egypt are full of hopes and dreams.
The south Egypt development project is translation of this concept viewed from a comprehensive strategic vision embracing a number of development fields covering activities in the field of agriculture, industry transport, communication and roads as well as social aspects services such as health and education that would drive Egypt to the horizons of the 21th century. This new projects are: Toshka, New Valley or New Delta, Sheik Zayed which will feed more than a million feddans, transfering the desert into a green carpet, turning the wheels of industries and shedding off the stiffing nightmare of the choking narrow valley.
This paper presents a new idea and application to how to use the water flow from Nasser lake after raising and pumping with certain speed according to the ground slope.
A series of hydro power plants are designed on certain interested points on El Sheikh Zayed canal to general electrical energy which will be required to feed several projects in this new valley.
The results show the comparison between these eight hydro power plants w.r.t: it's generated electrical energy water release, water contents and the head of water inside each one.
Also, the study contains the mathematical models of each hydropower station and the mathematical description of each of reservoir, barages and power stations.

Keywords
Hydro Power Plant, Mathematical Model , El Sheikh Zayed Canal , Toshka Area .

1.Introduction

It is wrong to believe that the project is one of irrigated agriculture in the first place. It is a national integrated development project aiming mainly to creat a balanced re-organized Egyptian map from the demographic, habitation, economic and security points of view, providing the south with its right to development just like Egypt's other civilized Governor boosting the efficiency of such communities North and south, creating the new balance between them,Literature [2] .
The major water resource for the canal would be lake Nasser, by pumping water from the minimum level of the resrvsir take (147.5m) guaranteeing to continue pumping of water to El Sheikh Zayed Canal, so this will be the main input inflow to the Water Resources [4] . This work services the new developments and projects in New Vallley in Egypt.
It presents a design of set of hydro power plants in cascaded on El Sheikh-Zayed canal to generat electrical energy to feed the suitable electrical load of these new projects.

2.El Sheikh Zayed canal

If Egypt's annual share in the Nile waters is estimated at 55 billion cubic meters, the Egyptians have to manage and utilize this share in every possible form of development, because no kind of development can be imagined without the availability of the water resources necessary for agricultural, industrial, river transport, drinking and power generation activities. The pormotion of the utilization of the river waters embodies great and wide hopes to extend new branches and arteries to expand the circle of development in Egypt. Consequently, the Sheikh Zayed Canal which carries water from Lake Nasser to the south Egypt Development project shall widen the circle development to reach a boarder and more appropriate scope of the new inhabitants realizing a step lowoards the dream of exodus from the old valley.

3.System description

The Irrigation Networks offer another opportunity to install hydroelectric stations at significantly lower cost than new "green-field" installations. Dams and well lined irrigation canals can be used for irrigation purposes and electricity generation at the same time, e.g by locating the power house at the lower end of the spillway Prime energy sources in use for electric power generation can be broadly classified as either renewable (hydropower solar, wind,) or nonrenewable resources (oil, natural gas, coal and nuclear fuel) . In this endeavour emphasis is given to hydropower generation for a set of hydroplants on the same canal Fig.(1).

The system under consideration is composed of set of various hydroplant (m) in cascaded on the same canal basin and other sets on it's four branches, Fig.(2).

For this chain, we introduce, the following notation,

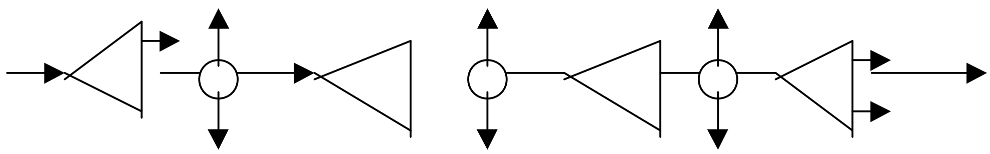

Fig.(1) Sketch Describing m-hydrostorage chain in the same strem,Faten [1]

Each of hydro power plant can be represented by it's mass balance equation:
i.e $\sum$ Inflow of each reseruoir = $\sum$ outflow for each unit (barrge) (m) at every instant (i)

i.e $$X_{ji} = X_{j,i-1} + y_{ij} - u_{ji} - L_{ji} \qquad (1)$$

Also the inflow into each barrage can be considered equal to the release of barrage that are located before it in location

i.e $$Y_{ij} = u_{i,j-1} \qquad (2)$$

4.Mathematical model subsystem

Depending on equation (1,2), the mathematical model of each reservoir and hydro plant can be represented as follows:

$$\frac{1st\ Barrage: \quad j=1 \ , i=1,....n}{X_{1,l} = X_{1,i-1} + y_{1,i} - u_{1,i} - L_{1,i}} \qquad (3)$$

where $y_{1,i}$ = main inflow & input from Nasser Lake

$$\frac{j=2, \quad 2^{nd}\ Bamage \quad i=1,...n}{X_{2,i-1} \ \ y_{2,i} - u_{2,i} - L_{2,i}}$$

$$y_{2,i} = u_{1,i}$$

$$\therefore \quad X_{2,i} = X_{2,i-1} + u_{1,i} - u_{2,i} - L_{2i} \qquad (4)$$

at J=3, i=1,…,n, 3^{rd} Barage: (5)

$$X_{3,i} = X_{3,i-1} + y_{31i} - u_{3,i} - L_{3,i}$$

but $y_{3,i} = u_{2,i}$

$$\therefore \quad X_{3i} = X_{3,i-1} + u_{2,i} - u_{3i} - L_{3i} \qquad (6)$$

J=4, I=1…n, 4^{th} barrage:

$$X_{4,i} = X_{41i-1} + y_{41i} - u_{41i} - L_{4,i}$$

$$y_{4,i} = u_{31i}$$

$$= X_{4,i} = X_{4,i-1} + u_{3,i} - u_{u,i} - L_{u,i} \qquad (7)$$

After the 4^{th} barrage, sheikh zayed canal is branched into 4 branches (30m depth and total distance is 170Km). Thus, there is one hydro plant at each branch basin (2.5Km distance).

$\therefore \quad J = 5,....8,$ the following equations are belong to the mathematical model of hydro power plants:

$$X_{5,i} = X_{5i-1} + u_{4,i} / 4 - u_{5,i} - L_{5i} \qquad (8)$$

$$X_{6,i} = X_{6,i-1} + u_{4i} / 4 - u_{6,i} - L_{6,i} \qquad (9)$$

$$X_{7,i} = X_{7,i-1} + u_{ui} / 4 - u_{71i} - L_{7,i} \qquad (10)$$

$$X_{8,i} = X_{8,i-1} + u_{ui} / 4 - u_{8,i} - L_{8,i} \qquad (11)$$

5.The hydro power plant design ,Peter[3]

To choose the suitable Turbine, it is dependent on head and water discharge. To do this generally depends on engineering some way so that water can be tapped from a river of a certain level, passed through a turbine and discharged back into the stream (the river) at a lower level.

The general fomula for any hydro power system is:

$$P = m\, g\, Q\, H \qquad (12)$$

P = is the power produced (watt)
m = is the efficiency of turbine system (80%-90%)
g = is the acceleration due to gravity = 1 for water
Q = is the flow rate of the water
H = is the effective head (meter)

We choose microhydro impulse pelton Turbine which is distinguished by the runner being mounted in an air filled casing. This turbine consists of a wheel with a series of split buckets sets around its rim, a high velocity jet of water is directed tangentially at the wheel. Nearly all the energy of the water goes into propelling the bucket and the defected water is reduced in speed and falls into a discharge channel bellow.

6.The power produced

Sheikh Zayed Canal hydropower systems have been presented by it's own power P_{ij}, equations depicted as a function of head difference (ΔH_{ij}) and water dischage (u_{ij}) for each plant (j) at every instant (i):

$$P_{1,i} = 0.011 \quad \Delta H_{1i}\, u_{1i} - 3.750X1\overline{0}^{5}\, u_{1i}^{2} \qquad (13)$$

$$P_{2,i} = 0.013 \quad \Delta H_{2i}\, u_{2i} - 3.7X1\overline{0}^{5}\, u_{2i}^{2} \qquad (14)$$

$$P_{3,i} = 0.025 \quad \Delta H_{3i}\, u_{3i} - 3.7X1\overline{0}^{5}\, u_{3i}^{2} \qquad (15)$$

$$P_{u,i} = 0.028 \quad \Delta H_{4i}\, u_{ui} - 3.7X1\overline{0}^{5}\, u_{ui}^{2} \qquad (16)$$

$$P_{5,i} = 0.035 \quad \Delta H_{5,i}\, u_{5i} - 3.7X1\overline{0}^{5}\, u_{5i}^{2} \qquad (17)$$

$$P_{6,i} = 0.035 \quad \Delta H_{6,i}\, u_{6i} - 3.7X1\overline{0}^{5}\, u_{6i}^{2}\, ? \qquad (18)$$

$$P_{7,i} = 0.035 \quad \Delta H_{7,i}\, u_{7i} - 3.7X1\overline{0}^{5}\, u_{7i}^{2}\, ?? \qquad (19)$$

$$P_{8,i} = 0.035 \quad \Delta H_{8,i}\, u_{8,i} - 3.7X1\overline{0}^{5}\, u_{8,i}^{2} \qquad (20)$$

7.Results

A case study is for Egyptian hydropower system. This system presents several hydroplant located at the Sheihk Zayed canal for the horizontal part and for equal four branches. All the results are indecated in figures (3-6) .

The water heads, reservoir contents, water release and the generated electrical power are the main interested variables to build the mathematical model and design the series of Electro hydro power plants.

Due to the relative sizes of reservoirs, it can be seen that the first plant generates the highest amount of energy in comparison with rest of the system as the generated power is function of water release and the head difference of water, corespondingly these two variables are the highest value at the first reservoir.

All the values of heads, reservoir contents, water releases and electrical energy are decreased gradualy through the alignment of the Sheikh Zayed Canal.

The four plants of the four branches of the last stage of the canal have equal sizes and generat same electrical energy to feed the suitable load.

At the end of day hours, the head and reservoir content have the highest value, while water release has the lowest values.

Finally, it can be pointed out that the results are satisfactory and corespond well with actual conditions.

8 .Conclusion

In this work, the operating policy of a hydropower plant chain is connected with a complete power networks has been studied. The proposed system comprises eight plants connected in cascaded on El Sheihk Zayed Canal, fourunits on the straight part of Canal and other four units on the four branches of Canal. The mathematical model of each of hydropower plant is developed. This model considers all the interested parameters of plant (Release, head and reservoir contents). The suggested approach have been applied to real case of hydropower generation in Egypt. The developed dynamic model is a linear discrete dynamic one and represents the hydropower multireservoir system.

This developed design is very useful and needed to plan the new projects and development. These hydroplants will serve several fields: agriculture, electricity, industry and building new cities. Thus, this paper will solve several problems of new projects and developments.

The importance of this paper is the applicabilty to carry out for the new projects and development plan of Egypt during New next century 21st .

9.References

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GLOSARY

X_{ji} water content of reservoir (j) at time i.
(m^3/time)

y_{ji} water inflow to reservoir (j) at time i.
(m^3/time)

L_{ji} Total Losses for reservoir j at time i.
(m^3/time)

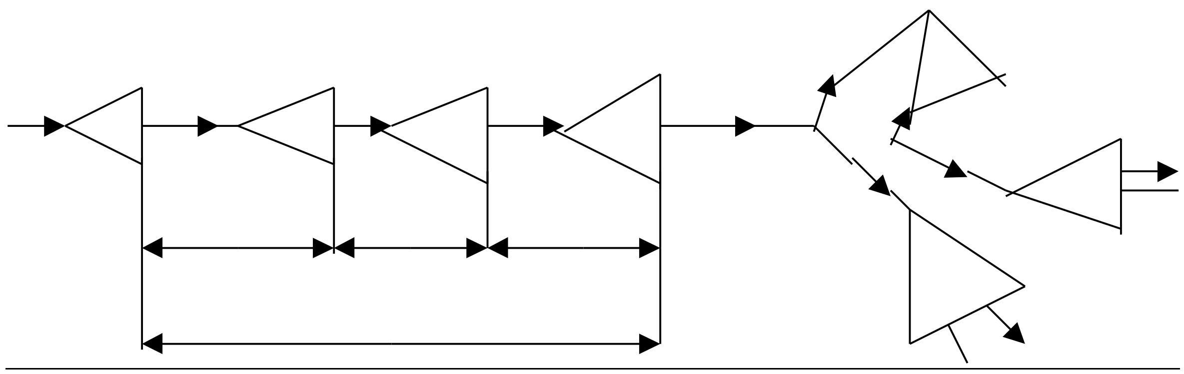
u_{ji} water release from reseroir j at time i.
(m^3/time)

P_{ji} electrical power generated at hydropower plant j at time i.
(watt)

$X_{j,i-1}$ water content of reservoir j of time i-1

$u_{i,j-1}$ water release from reservoir j-1 of time i.

$\Delta H_{i,j}$ the water head difference of unit I at time j.



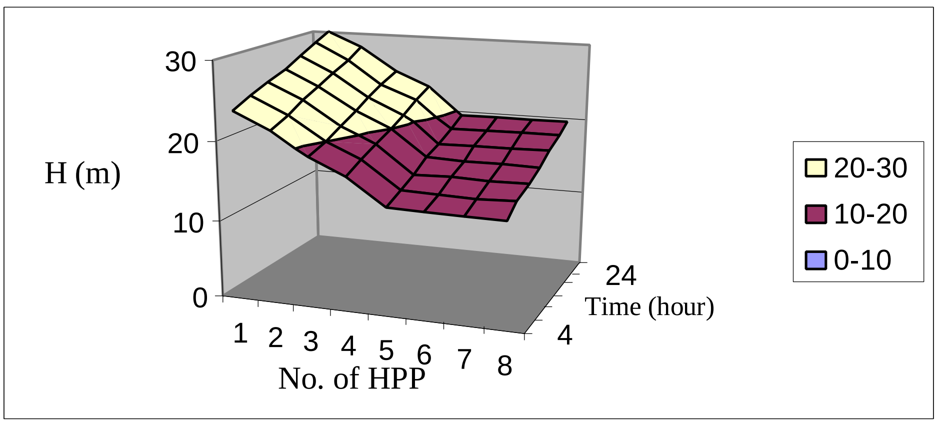


Fig. (1) The water head of the reservoirs.

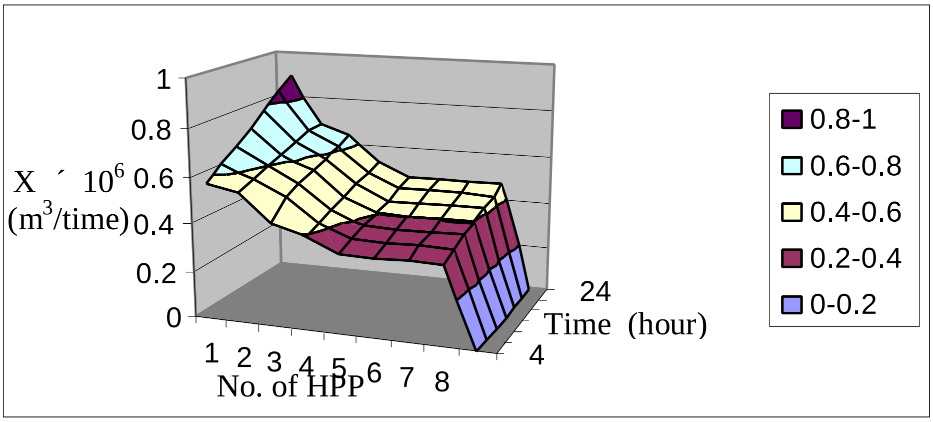


Fig. (2) The variation of the reservoirs contents during one day.

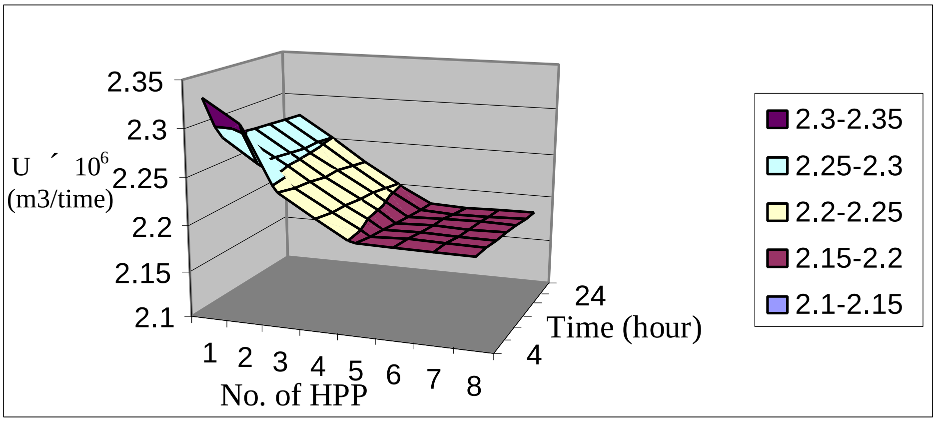


Fig. (3) The release of the reservoirs during one day.

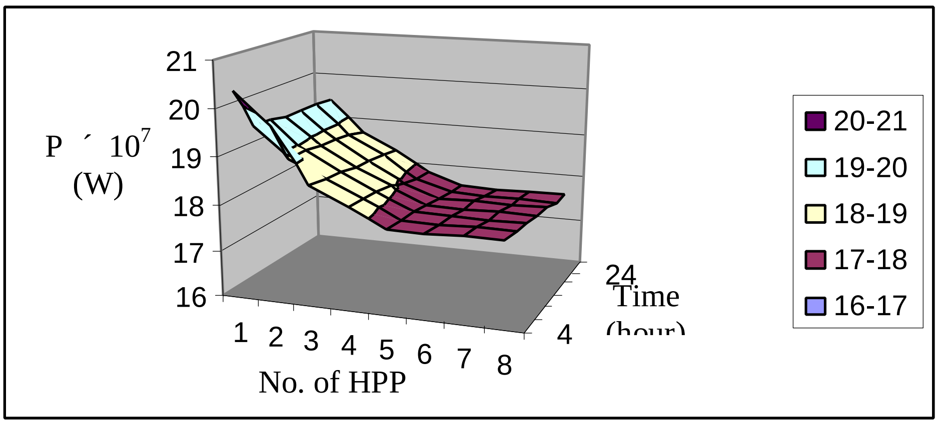


Fig. (4) The generated electrical