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Reservoir Enlargement and Energy Production Comparison of Dry, Normal and Wet Year at Nam Sana1 Hydro Power Plant Kasy District, Vientiane Province

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A B S T R A C T

Enlargement of reservoir is one of the technical aspects to increase the storage volume in order to store water and produce more energy. Consequently, the study is to identify the dimension of the new reservoir volume at the Nam Sana1 weir site and also calculate the energy production, the results are found that dimension of the new reservoir the maximum water volume in the reservoir is 264,870 m3, average soil excavate depth from 643.00 to 638.00 masl is 5 m, and soil excavate volume is 332,156 m3, which is the level between the water level at the 642.00 to 638.00 masl

INTRODUCTION

Due to the energy production from 2015 to 2018 has not met the target of energy production as planned. Because the dry season energy production is less than the data in feasibility study report, water inflow to the reservoir is very low and also during dry season water flow becomes low. Therefore, it causes less energy production [1]. However, in the rainy season the water inflow to the reservoir is consistence with the feasibility study report[2], the amount of water flow to the reservoir is normal and as well as energy production. It is reached and met the target of the project. In order to maximize the energy production during the rainy season, it is necessary to enlarge and excavate the area around upstream of the weir site for enlargement of the reservoir's volume to store the water flow through spillway, in some days[3]

LITERATURE REVIEW

Nam Sana1 hydropower plant is runoff river type, no storage water volumes, when water inflow to the reservoir more than 11.56 m3/s for turbine use in power generation, water remaining from turbine use is overflow through spillway, somedays, water volume is not able to store and use in power generation in time when there is no rainfall and in case of generator emergency stops, transmission line emergency has failure and operation unit stops to clean the trash rack intake, when rubbish or timber flow to the reservoir, water will over flow through spillway cannot store water volumes for generate electricity.

METHODOLOGY

New Reservoir Area

The potential site is proposed where can control a catchment of about 96 km^2, it is located in a tributary of Nam Lik River, near Kasy district and in the North of Vientiane Province, Lao PDR [6], as illustrated in Figure 1, to store the water volume used for power generation, it is necessary to construct the regulating pond at Nam Sana 1 weir site. Regulating pond has a small reservoir which can control the water flow in a short time [7]. The power generation can be controlled in accordance with the requirements better than Runoff River [8].

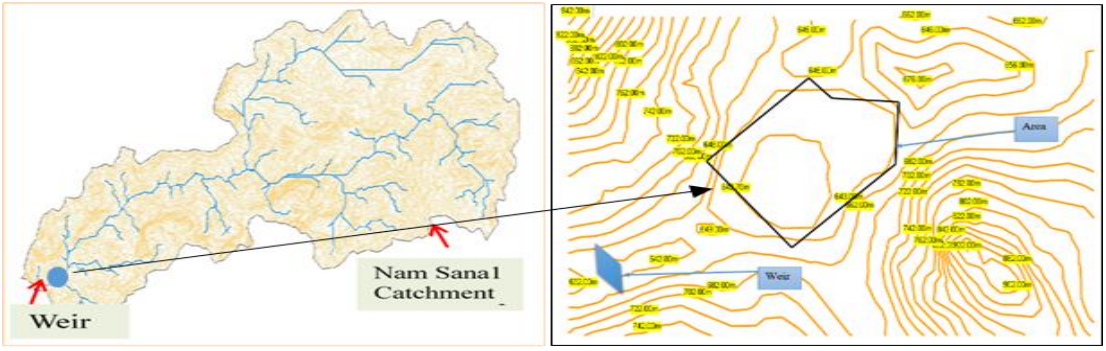

Figure1. Namsana1 Hydropower Study Site

Nam Model

The new reservoir enlargement volume and designed power generation will also base on the feasibility of water inflow to the reservoir by NAM Model [9]. Hydrological data and power generation data are collected from Nam Sana1 hydropower plant on the actual operation from 2015 to 2018 and data from feasibility of the project report to compare, technical data are extracted from the feasibility study as indicated in Table1 [10].

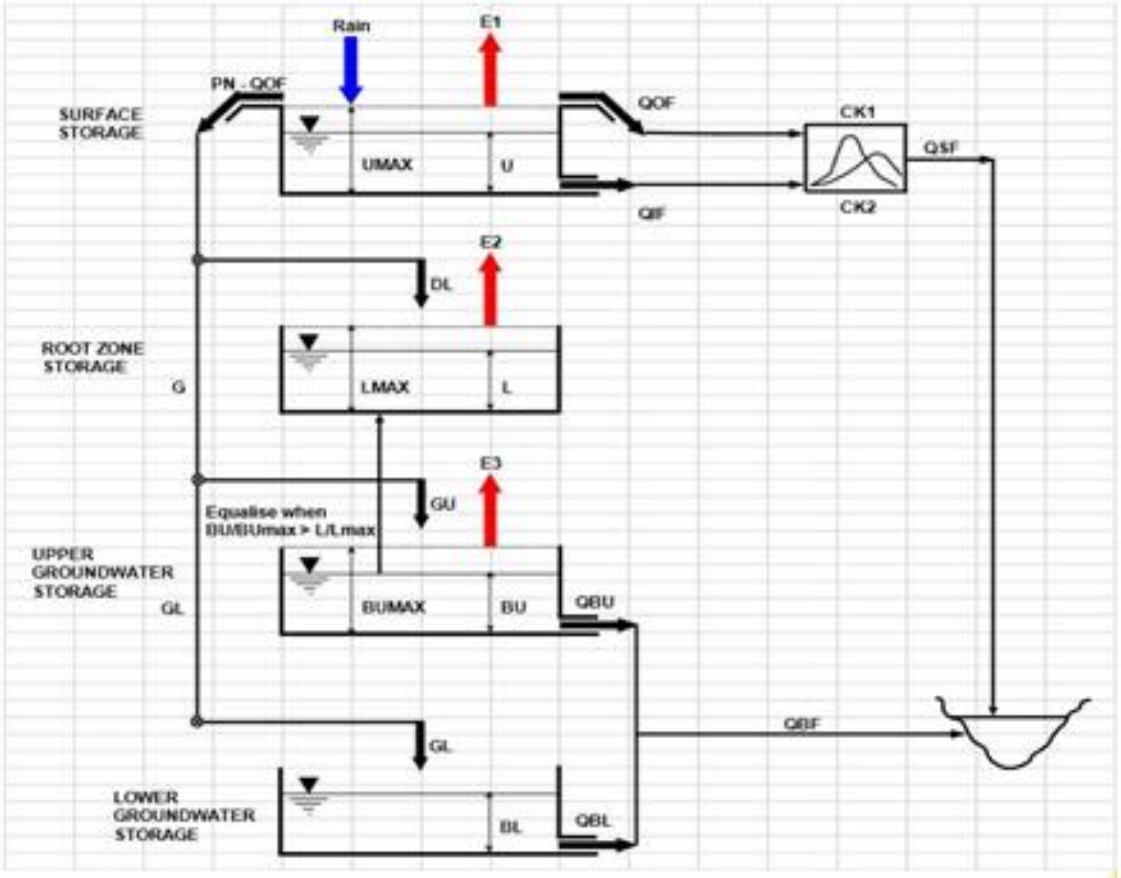

Figure2. NAM Model Structure

Table1. Comparative Water Inflow Data of Nam Sana1 Hydropower Plant

Year	Observe water data 2015-2018			Average water inflow NAM Model 2015-2018	Feasibility data	
	Inflow (Qin) (m^3)	Turbine discharge (m^3)	Over Spill way+ Sand Sluice Gate (m^3)	Inflow (Qin) (m^3)	Inflow (Qin) (m^3)	Over Spill way (m^3)
2015	168,807,702	99,773480	69,034,222	162,877,098	188,000,000	42,700,000
2016	172,304,531	129,096,120	43,208,411	175,342,519		
2017	135,058,206	122,879,440	12,178,766	137,590,128		
2018	190,374,735	134,597,400	55,777,335	189,415,585		
average	166,636,294	121,586,610	45,049,684	167,449,411		

Data Analysis.

The climatological station in the project area is available, so the climatological data from January 1st 2015 to the end of December 31st 2018, at the Nam Sana1 hydropower plant[11]. The precipitation-evaporation data that is gathered from meteorological observatory stations as the hydrograph is presented in Figure 3[12].

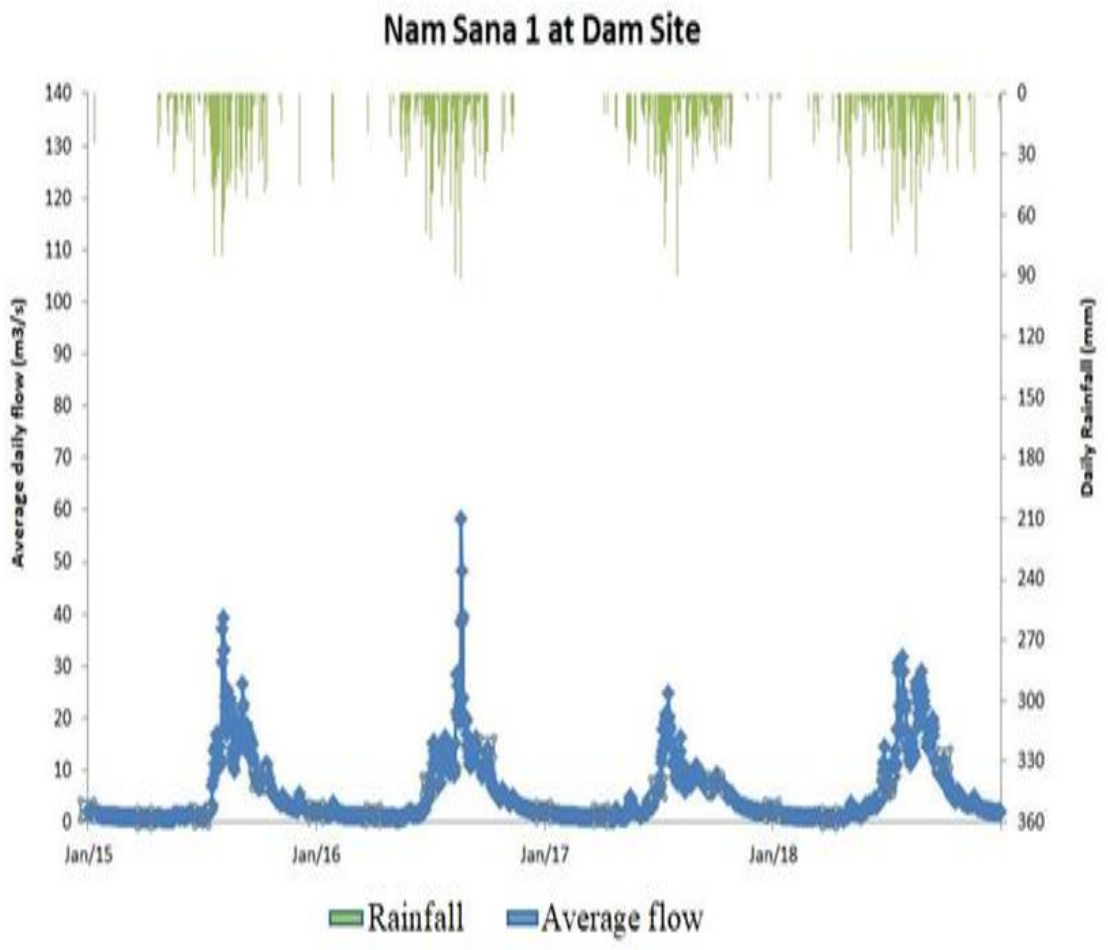

Figure 3. Comparison Of Daily Rainfalls And Inflow by Observation for 2015-2018.

Applied Formula Equations

Water volume and soil excavate are calculated by the below equation [13]

$$Vw = \frac{1}{3}Hw(A1 + A2 + \sqrt{(A1xA2)})$$

Where:

V_W: Water volume (m^3)

$$Vs = \frac{1}{3}Hs(A1 + A2 + \sqrt{(A1xA2)})$$

Where:

Vs: Volume of soil excavates (m^3)

RESULTS AND DISCUSSION

Topography of The New Reservoir Area and Design.

The Nam Sana1 River, which is a stream of water flowing out to the Lik River. The water is located in the Long Mark Kai village, it is about 25 km from the weir to the east north. Catchment area is about 96 km^2 as illustrated in Figure 1. The needed area for enlargement of the new reservoir that is the cultivation area, it is the small area and flat plain lies in a mountainous region. General morphology of the area is dominated by ridges of narrow, steep sloped mountain valley. The ground elevation of new reservoir area before enlargement is about 643.00 masl, it is approximately 1m higher than the weir that indicates in Figure 4 and there is a convenient way to transport soil out of the area, that it is far from the weir to the north about 60 m, so that the weir has no impact on the water leakage. Figure 4 indicates A is active storage > 639.00 masl, B is dead storage < 639.00 masl, and S is side view of area to excavate.

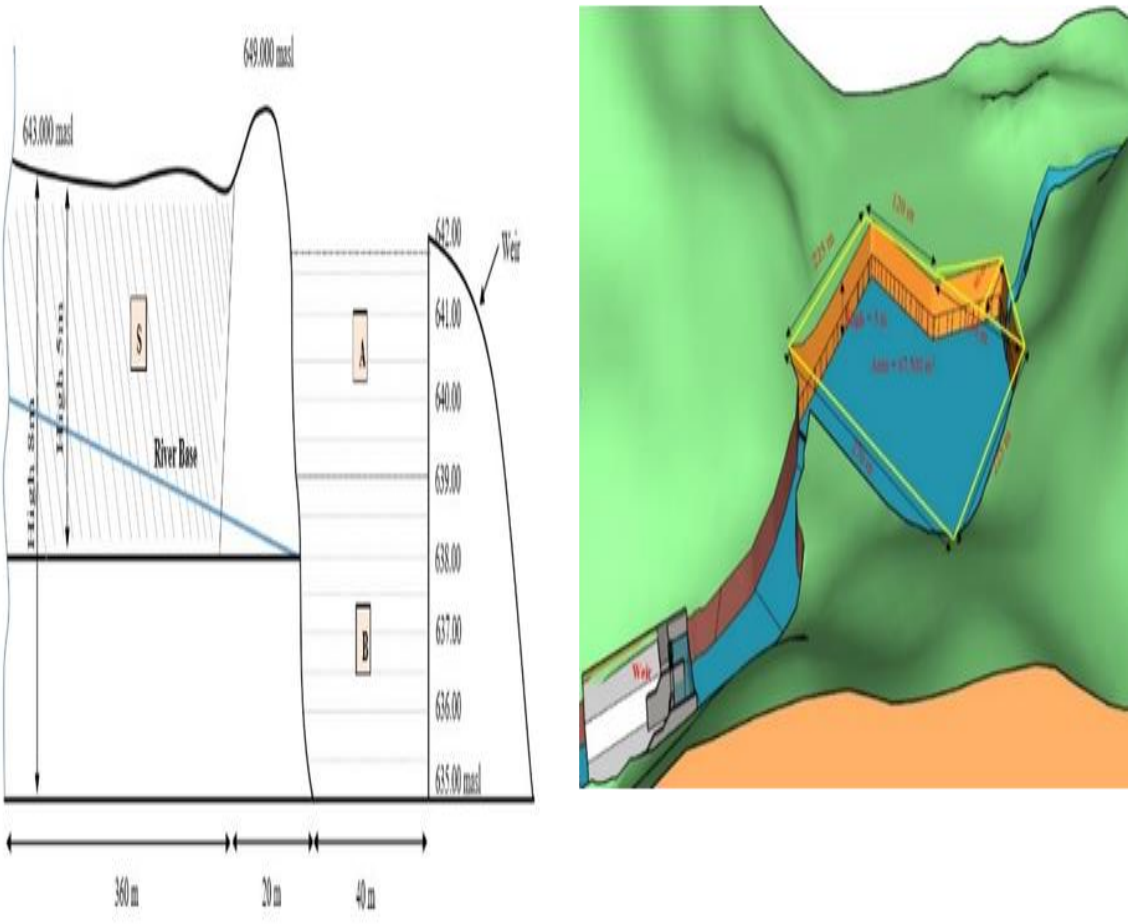

Figure 4. Enlargement of New Reservoir and Side View of Weir and Area to Excavate

New model of reservoir enlargement, elevation of surface soil area will be 643.00 masl, depth of soil will excavate is 5 m, new reservoir area will excavate is 67,500 m^2, full supply water level is 642.00 masl and reservoir bed level is 638.00 masl.

Calculation of Soil Excavate Volume.

The details of new reservoir dimension, it depends on the scope of the excavated area as shown in Figure 5 and the calculation of the soil quantity excavated as below:

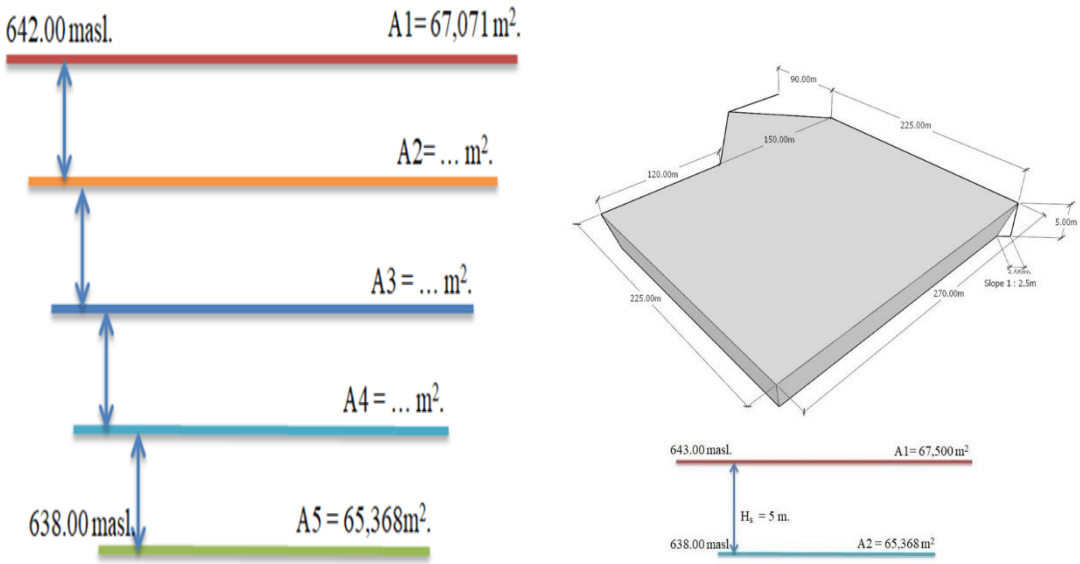

Figure5. The Detail of New Reservoir Area and Soil to Excavates

Volume of soil excavation is managed at soil level at: 643.00 masl.

$$Vs = \frac{1}{3}5(67{,}500 + 65{,}368 + \sqrt{(67{,}500 + 65{,}36)}), Vs = 332{,}156 \text{ m}^3$$

Study and Analyze The Water Volume in The New Reservoir.

According to the study data, the reservoir area of Nam Sana1 weir increased to 67,500 m^2 at the level: 643.00 masl and area at full supply water level is 67,071 m^2 at the level: 642.00 masl, the water volumes of Nam Sana1 weir increased to 264,870 m^3 as indicated in Table2 and the water volume used for energy production is 199,291 m^3, according to the increase in the reservoir size for the detail in Table3. Calculate the water volume in the new reservoir area, Full supply water level at: 642.00 masl.

$$Vw = \frac{1}{3}4(67{,}500 + 65{,}368A1 + \sqrt{(67{,}500 + 65{,}368)}),\ Vw = 264{,}870\ \text{m}^3$$

Table2. The New Reservoir Water Data at Nam Sana1 Hydropower Plant.

Reservoir			Reservoir		
HWL (masl)	Area (m2)	Volume (m3)	HWL (masl)	Area (m2)	Volume (m3)
642.00	67,071	264,870	639.90	66,174	124,964.07
641.90	67,028	258,165	639.80	66,132	118,348.78
641.80	66,985	251,465	639.70	66,089	111,737.75
641.70	66,942	244,768	639.60	66,047	105,130.97
641.60	66,900	238,076	639.50	66,004	98,528.45
641.50	66,857	231,388	639.40	65,961	91,930.17
641.40	66,814	224,705	639.30	65,919	85,336.15
641.30	66,771	218,026	639.20	65,877	78,746.37
641.20	66,729	211,351	639.10	65,834	72,160.85
641.10	66,686	204,680	639.00	65,792	65,579.56
641.00	66,643	198,013	638.90	65,749	59,002.53
640.90	66,600	191,351	638.80	65,707	52,429.73
640.80	66,558	184,693	638.70	65,664	45,861.18
640.70	66,515	178,040	638.60	65,622	39,296.87
640.60	66,472	171,390	638.50	65,580	32,736.80
640.50	66,430	164,745	638.40	65,537	26,180.97
640.40	66,387	158,104	638.30	65,495	19,629.38
640.30	66,345	151,468	638.20	65,452	13,082.02
640.20	66,302	144,835	638.10	65,410	6,538.89
640.10	66,259	138,207	638.00	65,368	0.00
640.00	66,217	131,584			

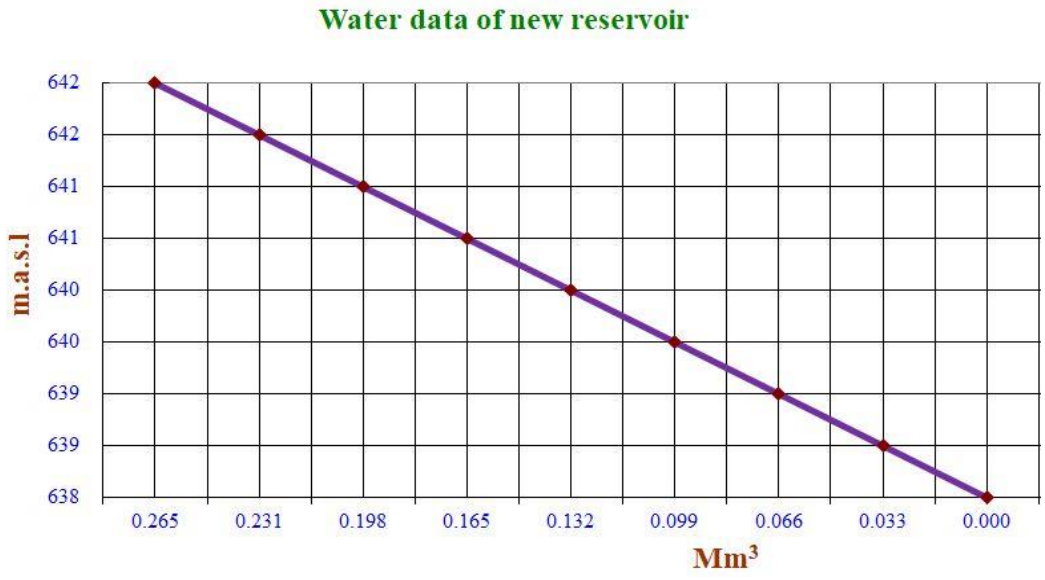

Figure 6. Water Data of New Reservoir

The results of the study indicated the capacity of the new reservoir after enlargement can accommodate the maximum water volume in the reservoir is 264,870 m^3, which is the negative between the water level at the 642.00 masl level and the lowest water level 638.00 masl. Water volume use for generate electricity is 199,291 m^3 , full supply level (642.00 masl) is 264,870 m^3 and active storage at 639.00-642.00 masl is 199,291 m^3, that is water level from 639.00 masl to maximum water level 642.00 masl that can be generated electricity. As the active water volume in the reservoir can be stored in short time of the day that means regulating pond weir type to increase power production during the rainy season. The dry season can store water volume use to generate electricity during peak load demand. When water is over spillway or maximum inflow to the weir, from the statistic recorded in 2018 maximum upstream water level is 642.80 masl. Consequently, it has to determine suitable and effective volume of excavation in this area as maximum according to detail of topographic survey that area can excavate about 67,500 m^2.

As indicated in Table 4, in dry year, the energy production is increased from 42,082,000 kWh/year to 43,723,494 kWh/year. Energy production is developed by1,641,494 kWh/year and increase plan factor from 34.31 % to 35.65 %. In normal year, the energy production is increased from 44,211,000 kWh/year to 46,971,290 kWh/year. Energy production is developed 2,760,290 kWh/year and increase plan factor from 36.05 % to 38.30 %. In wet year, the energy production is increased from 46,095,000 kWh/year to 49,372,933 kWh/year. Therefore, the energy production is developed 3,277,933 kWh/year and also increase plan factor from 37.59 % to 40.26 %. Therefore, an average, the energy production is increased to 2,559,906 kWh/year and also increase to 2.09 % of plant factor 2.09 %. An average revenue is increased to 1,505,224,744 Kip/year.

Table3. The Enlargement of Reservoir Volume

Status	Reservoir area (m^2)	Average soil excavate Depth (m)	Soil excavate volume (m^3)	Reservoir water volume (m^3)	Active water volume (m^3)
Before	0	0	0	0	0
After	67,500	5	332,156	264,870	199,291

Table4. Comparison of Values After Enlargement of Reservoir Volume in Dry, Normal and Wet Year

Year	Status	Total energy production (kWh/Year)	Total revenue (Kip/Year).	Plan factor %	Increase energy (kWh/Year)	Increase revenue (Kip/Year).
Dry	Before	42,082,000	24,744,216,000	34.31	0	0
	After	43,723,494	25,709,414,726	35.65	1,641,494	965,198,726
Normal	Before	44,211,000	25,996,068,000	36.05	0	0
	After	46,971,290	27,619,118,774	38.30	2,760,290	1,623,050,774
Wet	Before	46,095,000	27,103,860,000	37.59	0	0
	After	49,372,933	29,031,284,733	40.26	3,277,933	1,927,424,733

CONCLUSIONS

Enlargement of the reservoir volume is to increase power generation of Nam Sana1, the study uses actual historical data from 2015 to 2018 which includes water inflow, energy production. That separates the water inflow as the three cases such as: water inflow in dry, normal and wet year, then the study is emphasized in two cases such as: before and after enlargement volume of the reservoir, power generation of Nam Sana1. The findings indicated significantly that when reservoir volume is enlarged energy production and revenue are also increased. The average water volume loss in 2015 to 2018 was 7.5 million cubic meters per year, if the reservoir can store this water volume, there will be good reason to enlarge the volume in order to increase power generation of Nam Sana1, for more accurate and correct study, this study has to determine the new volume of the reservoir that can be having more benefit. Therefore, the study will

recommend to develop the volume of the reservoir. By Excavation area is 67,500 m^2, average soil excavate depth will be between 643.00-638.00 masl is 5 m, and soil excavate volume is 332,156 m^3.

In addition, energy production is developed and increased when comparing between before and after, therefore, in dry year is 42,082,000 kWh/year and 43,723,494 kWh/year, in normal year is 44,211,000 kWh/year and 46,971,290 kWh/year and wet year is 46,095,000 kWh/year and 49,372,933 kWh/year.

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