Chapter 6
Conclusions and Recommendation

6.1 Conclusions

This research work attempted to model optimal operation of Nam Ngum-1 reservoir for better performance of the power plant by HEC-ResSim3.0 software. Reservoir operation has been carried out using data of 10 years. There are average monthly water inflow, water outflow, water elevation and electricity production data during year 2003 to 2012 from Nam Ngum-1 hydropower plant. That is obtained for electricity generation and analyzed for the downstream water release**.** The main input data are hydro-metrological data, physical data, operational data and geography data for the model.

Modeling of the reservoir is carried out using three modules. These are watershed setup, reservoir network and simulation module. In the watershed setup module, Arc view-GIS shape file is taken from outside as a background image and from this image, the main river within its tributary are drawn and the reservoir is placed in its appropriate location. In the reservoir network setup, all the physical and operational data are configured to the model. Then pool and dam components are allocated with their input parameters. The stage-area-volume curve and evaporation loss are set to the pool component while low level outlet, maximum outlet, minimum outlet, power capacity and tail water rating curve with their capacities are set to the dam component. In addition to setup of input parameters to the reservoir net work, alternatives are created in this module. Three alternatives are taken to determine the optimal operation of Nam Ngum-1 reservoir by alternating the rule curve setting arrangements in the level. Finally the simulation module is used and simulation carried out for each alternative and a number of iteration should be carried out to determine the best one with optimal operation of the reservoir. The reservoir management analyzed the relation of water inflow, water outflow, water elevation and other factors. That finds out to revise rule curve and optimum electricity production to

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planning. This study will separate the data into three cases as wet, drought and normal year cases.

Each case will be separated by three steps for detailed analysis as step one, step two and step three of the three cases. The step three of drought case can provide the new rule curve for optimum electricity production of 903.06 GWh/y which is 34.5 GWh/y (3.82%) higher than the actual recorded data (868.6 GWh/y). For the normal year case, the adjusted rule curve provides the optimum electricity production equals 1,082.7 GWh/y, which is 48.0 GWh/y (4.43%) higher than the actual recorded data (1,034.7 GWh/y).And, for the wet year case, the adjusted rule curve provides the optimum electricity production equals 1,189.7 GWh/y, which is 68.1 GWh/y (5.72%) higher than the actual recorded data (1,121.7GWh/y).The average increment of electricity production for the all cases is 1,058.5 GWh/y which is 50.20 GWh/y higher the average recorded data. The average percentage of increment is 4.74 %. Finally, the results of three cases are best alternative choice for reservoir management of Nam Ngum-1 hydropower plant to optimize electricity production. The detailed is shown in Table 6.1.

Table 6.1 Result of simulation model

Alternative	Location/Parameter	Units	Result of Simulation		
			Drought case	Normal case	Wet case
			Step three	Step three	Step two
	Start elevation	(m.a.s.l)	208.91	209.40	207.87
	End elevation	(m.a.s.l)	206.68	207.69	208.59
	Water inflow	(cms)	100.52	119.16	162.32
	Energy actual	(GWh/y)	868.60	1,034.70	1,121.69
	Energy simulation	(GWh/y)	903.06	1,082.71	1,189.70
	Turbine release	(cms)	108.30	124.86	159.00
	Spillway release	(cms)	0.00	0.00	8.92
	Time of spill	(days)	0.00	0.00	44.00
	Total release	(cms)	108.30	124.86	167.92

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The optimal operation can generate maximum energy and minimize water discharge to downstream area. The revised upper and lower rule curve from HEC-ResSim3.0 simulation model is summarized in Table 6.2. Results of case provide optimum electricity production.

Table 6.2 Result of simulation model

Month	Old Rule Curve (m.a.s.l)		Drought case		Normal case		Wet case	
			Step three		Step three		Step two	
			New Rule Curve (m.a.s.l)		New Rule Curve (m.a.s.l)		New Rule Curve (m.a.s.l)	
	URC	LRC	URC	LRC	URC	LRC	URC	LRC
1	212.00	208.30	210.00	205.00	212.00	207.50	212.20	207.30
2	212.00	206.90	210.00	205.00	212.00	206.00	212.20	205.00
3	212.00	204.70	210.00	204.50	211.00	204.50	210.20	202.50
4	208.90	202.30	208.90	202.00	209.00	203.00	206.90	200.00
5	206.20	199.00	206.20	199.00	207.20	201.50	203.50	197.50
6	203.90	196.40	203.90	196.40	205.90	200.50	202.00	197.00
7	202.30	196.00	202.30	196.00	206.30	201.00	205.50	197.50
8	203.10	200.40	203.10	199.40	208.10	204.40	211.00	201.00
9	206.90	205.50	206.90	203.50	210.50	207.50	212.20	206.00
10	210.80	209.60	210.30	206.90	211.80	210.00	212.20	210.00
11	212.00	210.80	210.00	206.90	212.00	209.80	212.20	210.00
12	212.00	210.20	210.00	205.40	212.00	208.50	212.20	209.30

Thus, this study has provided general operation strategies for reservoir releases according to the current reservoir level, hydrological conditions and the time of simulation for the maximum electricity production, water release to downstream by revising the rule curve annual on July of the year.

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6.2 Recommendation

For better reservoir management of Nam Ngum-1 hydropower plant, this thesis recommends the following studies to be carried out in Nam Ngum-1 reservoir operation modeling:

1. This study considers the existing or historical hydrologic data to the electricity production and activities upstream of the reservoir because the inflow of the reservoir area is provided from Nam Ngum 2, Nam Song and Nam Leuk hydropower plants as natural inflow from tributary data are not possible since the metrological stations have not enough data.
2. This study does not consider the activities downstream of the reservoir because, the gauging stations in the downstream area do not have long term flow data and even generation from model is not possible since the metrological stations have not enough data.
3. To keep the reservoir elevation at the rule curve level, it is recommended to release more water and generate more power during the high flow season and minimize release during the low flow season. For low flow season, the energy shortage should be compensated from other sources in the power grid.
4. This study proposes to develop water release in the downstream area of the reservoir but still it needs further study on the water effect to downstream from downstream release of Nam Lik1-2, Nam Song, Nam Mang-3 hydropower plants and other water sources.
5. Water quality and water supply aspect downstream of power plant should be considered for further analysis.

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