Eastern Nile Power Toolkit - Quick guide

Eastern Nile Power Toolkit

Scope of the tool

The model is developed using excel database with macros and VB codes for the interface. The main objectives of EN Power Toolkit are to provide users with comprehensive profile information related to hydropower production and potentials in EN basin. The model is structured in four main sections: a Reservoir Database with a detailed and complete information about reservoirs/dams; Design Sheets with application of mathematical formulas; a Reservoir Simulation that calculates and displays reservoir variables, operations, plant capacity, releases etc. starting from reservoir database and flow data; and an economic and financial analysis.

It is one of the most complete toolkits, that is possible to use as a database for other models.

Main functions and structure

The model is organized in four sections, as can be observed in the homepage of the toolkit.

Figure 94: Homepage of the Eastern Nile Power toolkit

Reservoir Database

The section of the Reservoir Database provides a very detailed and comprehensive summary of the main characteristics of 26 reservoirs in the Nile Basin. In detail, the given information is the following:

- Location
- Reservoir Characteristics
- Dam Characteristics
- Power Plant Characteristics
- Turbine Characteristics
- Generator Characteristics
- Transformer Characteristics
- Power House
- Spillway Characteristics
- Headrace Tunnel

- Tailrace Tunnel
- Penstock
- Stage-Power Plant Energy Coefficient Relation
- Rainfall Evaporation Relation
- Average Monthly Reservoir Inflow
- Environmental Flow Requirements
- Tailwater Discharge Rating Curve
- Tailwater Elevation
- Project Cost Estimate
- Summary of Economic and Financial Analysis
- Hydrology
- Sediment Estimate
- Flood Analysis
- Reservoir Simulation Results
- Impacts on Environment

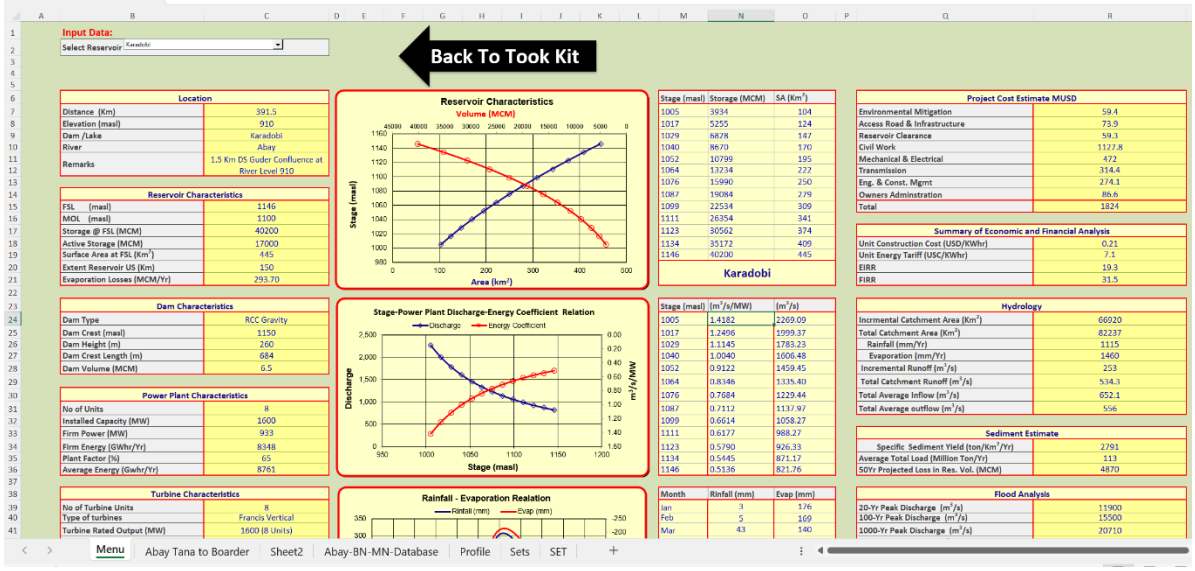


Figure 95: Reservoir Database section of Eastern Nile Power Toolkit

Design Sheets

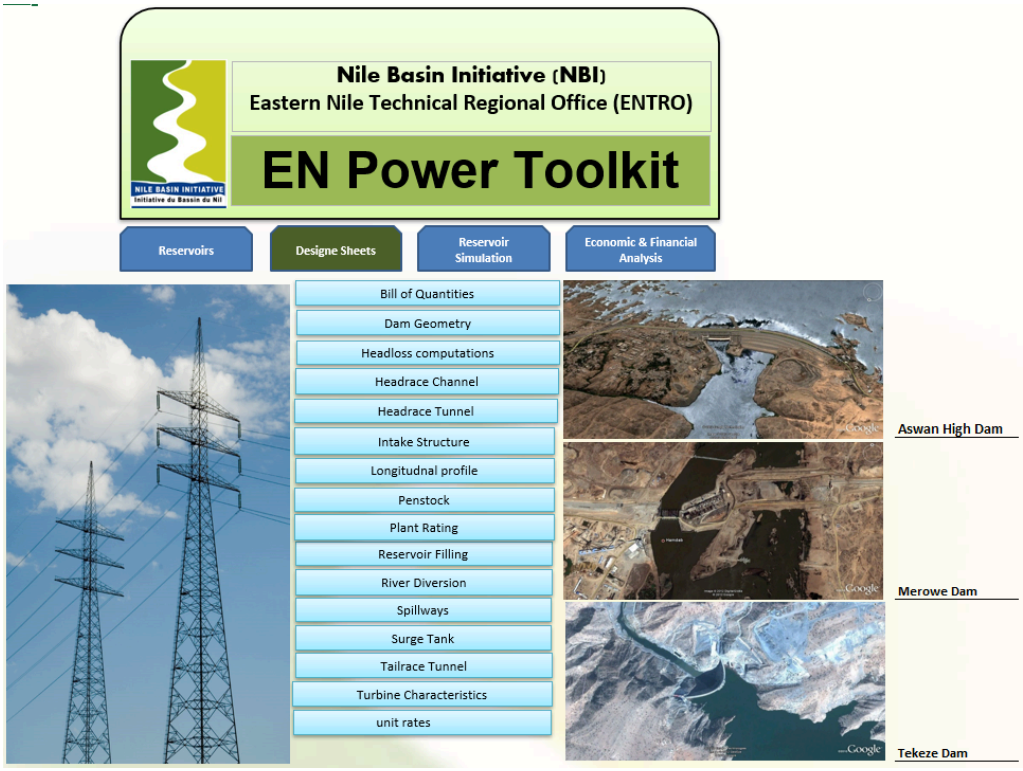


Figure 96: Design sheets section in the Eastern Nile Poer Toolkit

The design sheets section contains many sheets for different structure design of the reservoirs:

- Bill of quantities
- Dam geometry
- Headloss computations
- Headrace channel
- Headrace Tunnel
- Intake structure
- Longitudinal Profile
- Penstock
- Plant Rating
- Reservoir Filling
- River Diversion
- Spillway
- Surge Tank
- Tailrace Tunnel
- Turbine Characteristics
- Unit rates

Design of Intake Structure and Intake Gate

Input Data:

Design Variable			Default	Adjust Value	Design	Units
Type of Intake Structure		Slope S_0	<90 Deg.	518	51.8	%
Select Design Discharge					400.00	m^3/s
Select No of Intake Structures			4		4	NA
Chainage at start of Intake Structure			0	0	0.00	m
Chainage at End of Intake Structure				500 485	48.50	NA
Sill Elevation at Intake				9820	982	m
Intake Shape		Width/Diameter Intake Structure		160	16	m
Height of Intake Structure				190 19	19	m
Reseervoir Minimum Operation Level (MOL)				11000	1100	masl
Reservoir Maximum Operation Level (FSL)				10620	1062	masl
Select Allowable Design Velocity for Trash-Rack			0.5	50	0.5	m/s
Select Trash Rack Bar Spacing			5	54	5.4	cm
Design Degree of clogging Trash-Rack			50	500	50	%
Options for Intake Gate				Intake Gate Provided		
Select the Internal Diameter of the Headrace Tunnel			10.64	122	12.20	m
Select Inlet Transitional Length			3.48	416 41.6	41.60	m

Results:

Figure 97: Design of an Intake structure in the Easter Nile power Toolkit

Reservoir Simulation

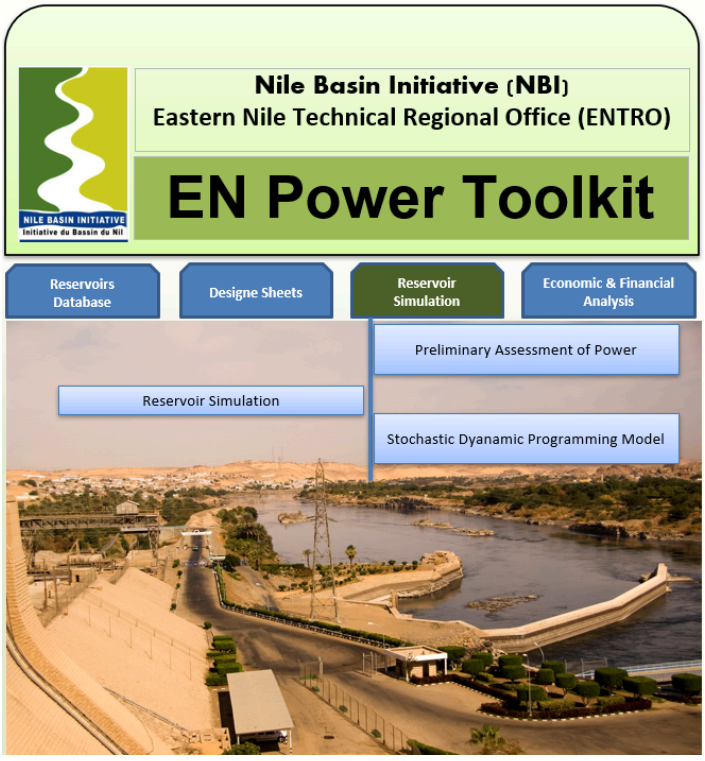
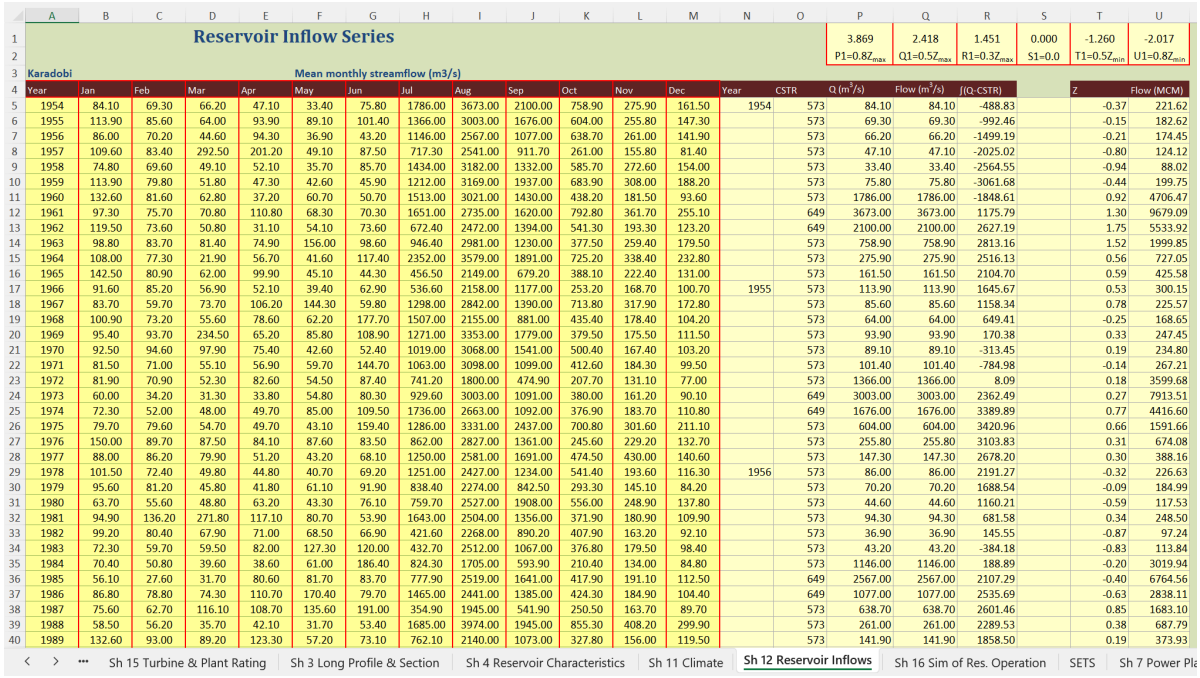


Figure 98: Reservoir simulation section in the Eastern Nile Poer Toolkit

This section lets simulate the functioning of a reservoir. The user can provide the operational characteristics of a reservoir, and the model will give the outcome for that operational set. The section contains also a huge quantity of flow data in the different rivers and reservoirs.

The different sheets for the simulation are the following:

- Turbine characteristics
- Turbine and Plant Rating
- Longitudinal Profile and Section
- Reservoir Characteristics
- Climate
- Reservoir Inflows
- Simulation of Reservoir Operations
- Power plant Des and Releases
- Spillway and Outletpipe



Reservoir Inflow Series

																3.869	2.418	1.451	0.000	-1.260	-2.017
																$P1=0.8Z_{max}$	$Q1=0.5Z_{max}$	$R1=0.3Z_{max}$	S1=0.0	$T1=0.5Z_{min}$	$U1=0.8Z_{min}$
Karadobi						Mean monthly streamflow (m3/s)															
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	CSTR	Q (m^3/s)	Flow (m^3/s)	∫(Q-CSTR)		Z	Flow (MCM)
1954	84.10	69.30	66.20	47.10	33.40	75.80	1786.00	3673.00	2100.00	758.90	275.90	161.50	1954	573	84.10	84.10	-488.83		-0.37	221.62
1955	113.90	85.60	64.00	93.90	89.10	101.40	1366.00	3003.00	1676.00	604.00	255.80	147.30		573	69.30	69.30	-992.46		-0.15	182.62
1956	86.00	70.20	44.60	94.30	36.90	43.20	1146.00	2567.00	1077.00	638.70	261.00	141.90		573	66.20	66.20	-1499.19		-0.21	174.45
1957	109.60	83.40	292.50	201.20	49.10	87.50	717.30	2541.00	911.70	261.00	155.80	81.40		573	47.10	47.10	-2025.02		-0.80	124.12
1958	74.80	69.60	49.10	52.10	35.70	85.70	1434.00	3182.00	1332.00	585.70	272.60	154.00		573	33.40	33.40	-2564.55		-0.94	88.02
1959	113.90	79.80	51.80	47.30	42.60	45.90	1212.00	3169.00	1937.00	683.90	308.00	188.20		573	75.80	75.80	-3061.68		-0.44	199.75
1960	132.60	81.60	62.80	37.20	60.70	50.70	1513.00	3021.00	1430.00	438.20	181.50	93.60		573	1786.00	1786.00	-1848.61		0.92	4706.47
1961	97.30	75.70	70.80	110.80	68.30	70.30	1651.00	2735.00	1620.00	792.80	361.70	255.10		649	3673.00	3673.00	1175.79		1.30	9679.09
1962	119.50	73.60	50.80	31.10	54.10	73.60	672.40	2472.00	1394.00	541.30	193.30	123.20		649	2100.00	2100.00	2627.19		1.75	5533.92
1963	98.80	83.70	81.40	74.90	156.00	98.60	946.40	2981.00	1230.00	377.50	259.40	179.50		573	758.90	758.90	2813.16		1.52	1999.85
1964	108.00	77.30	21.90	56.70	41.60	117.40	2352.00	3579.00	1891.00	725.20	338.40	232.80		573	275.90	275.90	2516.13		0.56	727.05
1965	142.50	80.90	62.00	99.90	45.10	44.30	456.50	2149.00	679.20	388.10	222.40	131.00		573	161.50	161.50	2104.70		0.59	425.58
1966	91.60	85.20	56.90	52.10	39.40	62.90	536.60	2158.00	1177.00	253.20	168.70	100.70	1955	573	113.90	113.90	1645.67		0.53	300.15
1967	83.70	59.70	73.70	106.20	144.30	59.80	1298.00	2842.00	1390.00	713.80	317.90	172.80		573	85.60	85.60	1158.34		0.78	225.57
1968	100.90	73.20	55.60	78.60	62.20	177.70	1507.00	2155.00	881.00	435.40	178.40	104.20		573	64.00	64.00	649.41		-0.25	168.65
1969	95.40	93.70	234.50	65.20	85.80	108.90	1271.00	3353.00	1779.00	379.50	175.50	111.50		573	93.90	93.90	170.38		0.33	247.45
1970	92.50	94.60	97.90	75.40	42.60	52.40	1019.00	3068.00	1541.00	500.40	167.40	103.20		573	89.10	89.10	-313.45		0.19	234.80
1971	81.50	71.00	55.10	56.90	59.70	144.70	1063.00	3098.00	1099.00	412.60	184.30	99.50		573	101.40	101.40	-784.98		-0.14	267.21
1972	81.90	70.90	52.30	82.60	54.50	87.40	741.20	1800.00	474.90	207.70	131.10	77.00		573	1366.00	1366.00	8.09		0.18	3599.68
1973	60.00	34.20	31.30	33.80	54.80	80.30	929.60	3003.00	1091.00	380.00	161.20	90.10		649	3003.00	3003.00	2362.49		0.27	7913.51
1974	72.30	52.00	48.00	49.70	85.00	109.50	1736.00	2663.00	1092.00	376.90	183.70	110.80		649	1676.00	1676.00	3389.89		0.77	4416.60
1975	79.70	79.60	54.70	49.70	43.10	159.40	1286.00	3331.00	2437.00	700.80	301.60	211.10		573	604.00	604.00	3420.96		0.66	1591.66
1976	150.00	89.70	87.50	84.10	87.60	83.50	862.00	2827.00	1361.00	245.60	229.20	132.70		573	255.80	255.80	3103.83		0.31	674.08
1977	88.00	86.20	79.90	51.20	43.20	68.10	1250.00	2581.00	1691.00	474.50	430.00	140.60		573	147.30	147.30	2678.20		0.30	388.16
1978	101.50	72.40	49.80	44.80	40.70	69.20	1251.00	2427.00	1234.00	541.40	193.60	116.30	1956	573	86.00	86.00	2191.27		-0.32	226.63
1979	95.60	81.20	45.80	41.80	61.10	91.90	838.40	2274.00	842.50	293.30	145.10	84.20		573	70.20	70.20	1688.54		-0.09	184.99
1980	63.70	55.60	48.80	63.20	43.30	76.10	759.70	2527.00	1908.00	556.00	248.90	137.80		573	44.60	44.60	1160.21		-0.59	117.53
1981	94.90	136.20	271.80	117.10	80.70	53.90	1643.00	2504.00	1356.00	371.90	180.90	109.90		573	94.30	94.30	681.58		0.34	248.50
1982	99.20	80.40	67.90	71.00	68.50	66.90	421.60	2268.00	890.20	407.90	163.20	92.10		573	36.90	36.90	145.55		-0.87	97.24
1983	72.30	59.70	59.50	82.00	127.30	120.00	432.70	2512.00	1067.00	376.80	179.50	98.40		573	43.20	43.20	-384.18		-0.83	113.84
1984	70.40	50.80	39.60	38.60	61.00	186.40	824.30	1705.00	593.90	210.40	134.00	84.80		573	1146.00	1146.00	188.89		-0.20	3019.94
1985	56.10	27.60	31.70	80.60	81.70	83.70	777.90	2519.00	1641.00	417.90	191.10	112.50		649	2567.00	2567.00	2107.29		-0.40	6764.56
1986	86.80	78.80	74.30	110.70	170.40	79.70	1465.00	2441.00	1385.00	424.30	184.90	104.40		649	1077.00	1077.00	2535.69		-0.63	2838.11
1987	75.60	62.70	116.10	108.70	135.60	191.00	354.90	1945.00	541.90	250.50	163.70	89.70		573	638.70	638.70	2601.46		0.85	1683.10
1988	58.50	56.20	35.70	42.10	31.70	53.40	1685.00	3974.00	1945.00	855.30	408.20	299.90		573	261.00	261.00	2289.53		0.38	687.79
1989	132.60	93.00	89.20	123.30	57.20	73.10	762.10	2140.00	1073.00	327.80	156.00	119.50		573	141.90	141.90	1858.50		0.19	373.93

Sh 15 Turbine & Plant Rating | Sh 3 Long Profile & Section | Sh 4 Reservoir Characteristics | Sh 11 Climate | Sh 12 Reservoir Inflows | Sh 16 Sim of Res. Operation | SETS | Sh 7 Power Pla

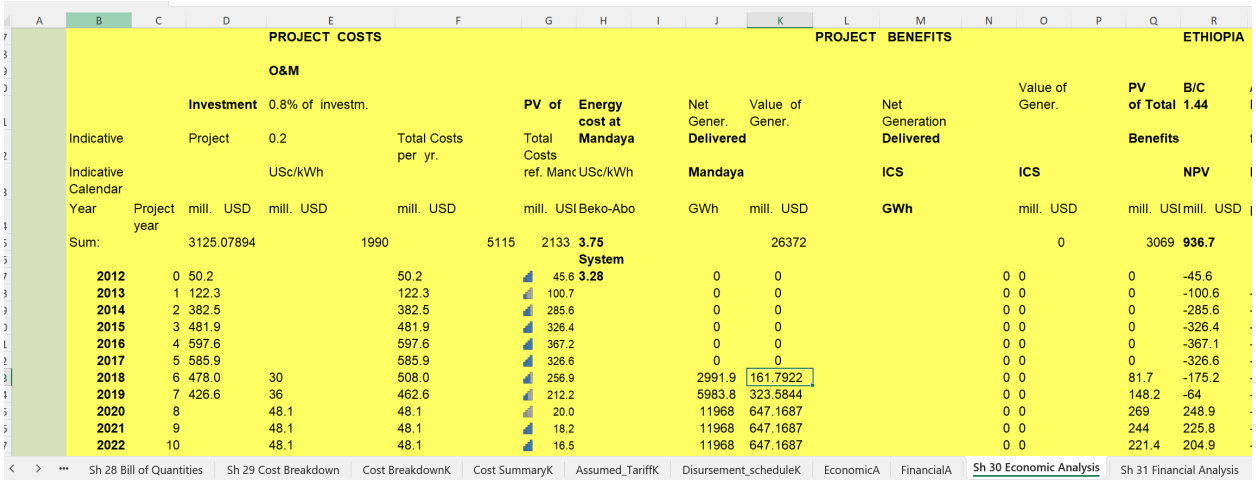
Figure 99: Flow data in Eastern Nile Power Toolkit

Economic and Financial Analysis

The section about Economy and Finance gives the possibility to evaluate the costs and benefits of the structures and to perform an analysis.

The input of the analysis are the costs of the different components, given the proper bills of quantities, costing rates, cost methodology and cost breakdown of each specific component. Also the benefits given by energy production are considered.

The output is an analysis of the balance between costs and benefits for each year, with the evaluation of economic and financial parameters such as payback period, return of investment and net present value.



				PROJECT COSTS								**PROJECT BENEFITS**					**ETHIOPIA**
				O&M													
			Investment	0.8% of investm.		**PV of**	**Energy cost at**	Net Gener.	Value of Gener.		Net Generation		Value of Gener.		**PV of Total**	**B/C 1.44**	
	Indicative		Project	0.2	Total Costs per yr.	Total Costs	**Mandaya**	**Delivered**			**Delivered**				**Benefits**		
	Indicative Calendar			USc/kWh		ref. Manc	USc/kWh	**Mandaya**			**ICS**		**ICS**			**NPV**	
	Year	Project year	mill. USD	mill. USD	mill. USD	mill. USI	Beko-Abo	GWh	mill. USD		**GWh**		mill. USD		mill. USI	mill. USD	
	Sum:		3125.07894	1990	5115	2133	**3.75**		26372				0		3069	**936.7**	
							System										
	2012	0	50.2		50.2	45.6	**3.28**	0	0		0	0	0		0	-45.6	
	2013	1	122.3		122.3	100.7		0	0		0	0	0		0	-100.6	
	2014	2	382.5		382.5	285.6		0	0		0	0	0		0	-285.6	
	2015	3	481.9		481.9	326.4		0	0		0	0	0		0	-326.4	
	2016	4	597.6		597.6	367.2		0	0		0	0	0		0	-367.1	
	2017	5	585.9		585.9	326.6		0	0		0	0	0		0	-326.6	
	2018	6	478.0	30	508.0	256.9		2991.9	161.7922		0	0	81.7			-175.2	
	2019	7	426.6	36	462.6	212.2		5983.8	323.5844		0	0	148.2			-64	
	2020	8		48.1	48.1	20.0		11968	647.1687		0	0	269			248.9	
	2021	9		48.1	48.1	18.2		11968	647.1687		0	0	244			225.8	
	2022	10		48.1	48.1	16.5		11968	647.1687		0	0	221.4			204.9	

Sh 28 Bill of Quantities | Sh 29 Cost Breakdown | Cost BreakdownK | Cost SummaryK | Assumed_TariffK | Disursement_scheduleK | EconomicA | FinancialA | Sh 30 Economic Analysis | Sh 31 Financial Analysis

Figure 100: Economic analysis of a reservoir in the Eastern Nile Power Toolkit