Task 4 – Economic and Financial Assessment

Detailed Feasibility Studies: Transmission Projects in Nepal

Volume 4 (Report)

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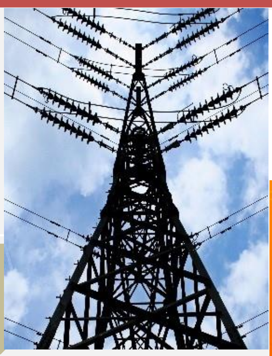

TETRA TECH

Detailed Feasibility Studies: Transmission Projects in Nepal

Volume 4 (Report)
Task 4: Economic and Financial Assessment

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Acronyms

CAPEX	Capital expenditures
DFS	Detailed feasibility study
EBITDA	Earnings before interest, taxes, depreciation, and amortization
EIRR	Economic Internal Rate of Return
FMRR	Financial management rate of return
GoN	Government of Nepal
IPP	Independent power producer
LNG	Liquefied natural gas
MLA	Multi-lateral Lending Agencies
NEA	Nepal Electricity Authority
NPV	Net present value
O&M	Operations and maintenance
PPA	Power purchase agreement
PV	Present value
WACC	Weighted average cost of capital
WTP	Willingness to pay

Executive Summary

The economic and financial assessment of the proposed transmission system investments is intended to 1) determine the benefits of the proposed MCC investments and calculate the economic internal rate of return for these projects, and 2) provide quantitative findings on the level of tariffs required to sustain the MCC investments within the NEA system.

Objectives of the Economic and Financial Assessments

In addition to these two major objectives, Tetra Tech was requested to assess the net benefits of exports and imports for Nepal and the extent to which success in MCC's program depends on new generation capacity in the country.

To meet these objectives and support this assessment, MCC requested that the Tetra Tech team provide its independent assessments and data on the following key elements:

1. Specification of baseline conditions in Nepal – what happens if MCC does not invest?
2. Projections of future demand for electricity in Nepal by region and (broad) customer class.
3. Generation expansion plans – what is realistic, hopeful, and pessimistic over the next 15 years?
4. What levels of loss reduction and load shedding mitigation are reasonable?

Key Activities and Modeling Work

The information we developed on demand, generation, trade with India, and technical benefits must be put into a modeling framework before assessing which proposed investments will be worthwhile for the country. Providing this assessment required the Tetra Tech team to develop both economic and financial models.

MCC is responsible for developing the economic model that will be used to make recommendations to the Board. The MCC model is based on a consumer surplus approach to benefits that includes both output benefits and cost savings benefits. As part of the Tetra Tech team's assistance to MCC in developing the economic model, Tetra Tech was asked to provide an approach to valuing the various benefits and incorporating them into an economic framework. This work became the consultant's version of the economic model when it became clear that in the interest of a timely reporting of results in this project's compressed time frame, it would be necessary for the consultant to complete an initial version of the economic model. The financial model is structured in a manner almost identical to the economic model and permits MCC to see whether and to what extent the Nepal Electricity Authority's (NEA) tariff structure and other programs can sustain the MCC investments.

The models were run on the agreed scenarios and variations in demand and generation. In addition, each model allows the user to vary a number of key parameters with regard to efficiency, pricing, valuation of electricity, valuation of trade with India (imports and exports), and various system-wide parameters covering transmission costs, generation costs, among others.

The team estimated the technical benefits of the MCC investments on the assumption that the generation expansion program will continue to be implemented more slowly than is shown in NEA's latest forecast. Technical benefits with and without the MCC projects were evaluated for several scenarios, including the Counterfactual (Without Project) Base Case. These scenarios are:

- Counterfactual Base Case
- Base Case + NR1
- Base Case + NR1 + XB1
- Base Case + NR1 + XB1 + T2' + T3
- Base Case + NR3
- Base Case + NR4
- Base Case + T8
- Base Case + All MCC Projects
- Base Case + All MCC – XB1 (restricted trade with India).

For each of these scenarios the following technical results were calculated using the PSS®E model for years 2023 and 2030:

- Annual GWh supply
- Annual GWh consumption
- Annual GWh loss
- Annual GWh load shedding
- Annual GWh import
- Annual GWh export
- Annual GWh generation not utilized.

The Counterfactual and All-MCC scenarios were tested for sensitivity against variations in demand and generation higher and lower than the baseline cases.

Findings

MCC's investments carry three major categories of economic and financial benefits:

1. Increased supplies to domestic consumers through improved transmission of domestically generated and imported electricity
2. Increased supplies to domestic consumers through reduced load shedding and technical losses
3. Increased revenues for domestic generation through exports to India.

In quantitative terms, the benefits to domestic electricity users outweigh the value of additional exports by several fold. For example, the value of increased domestic consumption through more imports far exceeds the cost of such imports in the economic model. However, the export earnings made possible by improved transmission may be crucial in the decisions to invest in new generation, thereby creating the large benefits for domestic electricity users.

Only three of the scenarios were consistently feasible in the economic model. The *All MCC,* the *NR1+XB1+T2'+T3*, and the *NR1+XB1* scenarios provide significant increases in supply to domestic users with both greater utilization of domestic generation and increased supply from India during the dry season to remedy load shedding. Other scenarios do not boost consumption by domestic users, as they fail to reduce load shedding much. Though generating some benefits, these export-oriented packages do not provide system-wide net benefits for Nepal. For the economically infeasible packages:

- NR1 *without* XB1 is infeasible under all conditions since there is no additional supply of imported energy to Nepali consumers
- T8 is generally infeasible because there are few domestic benefits and the net reduction in imports is small. In strict isolation (i.e., without the Nepali system to support) T8 *may* show positive net benefits if export prices are very high, and is also positive when integrated in the *All MCC* package
- NR3 and NR4 are infeasible because they do not provide relief from load shedding or additional energy to domestic users
- All MCC *without* XB1 is infeasible since the reduced level of dry season imports fails to reduce load shedding adequately.

Valuation of electricity is critical. In the economic model, additional net supplies of electricity to domestic users must be valued at the highest applicable current tariff, called "marginal tariffs" in the model (see Table 1). Load shedding relief must be valued at the opportunity cost of the defensive measures used by consumers to mitigate the adverse impacts of the load shedding. The opportunity cost of these defensive measures is higher than the marginal tariff for each class of consumer.

Table 1: Average and Marginal Electricity Tariffs in Nepal				
Consumer Category	Average Price per kWh		"Marginal" Price per kWh	
	USD	NRs	USD	NRs
Domestic	0.100	10.918	0.120	13.102
Commercial	0.125	13.648	0.150	16.377
Industrial	0.080	8.735	0.095	10.372
Average per kWh Sold	**0.097**	**10.608**	**0.116**	**12.694**
Note: tariffs from current NEA schedule were converted to values shown in table by including fixed monthly fees and demand charges converted to kWh basis.				

The financial model introduces taxes, depreciation, and other elements not included in the economic model. However, the general findings are similar:

- The *All MCC* and the *NR1+XB1+T2'+T3* are feasible under most foreseeable circumstances. However, these projects all require that NEA move to a higher tariff based on its current marginal tariffs for each customer category;
- The All MCC package shows considerable variability with respect to valuations and prices for additional energy supplied, and trade with India;
- *NR1+XB1* is feasible with current export prices, even without capacity credit for displaced new power plants in India, relying on just the energy valuation for the exports;
- The *ALL MCC* and *NR1+XB1* packages are sensitive to import prices and a move to LNG-based prices for imports from India will require continued high valuations for electricity consumers in Nepal;
- *T8* is almost feasible with high export prices, and likely to be feasible in isolation;
- The packages without *XB1 (restricted exports & imports)* are not feasible even with high prices;
- *NR3* and *NR4* remain infeasible for NEA without the domestic market tie-ins; and
- The *All MCC-XB1* (restricted trade with India) is infeasible under all conditions save extremely high valuations/prices for domestic energy consumption and reduced load shedding.

Low valuation of electricity will drop all projects except the *All MCC* package to negative present worth. The *NR1+XB1+T2'+T3* is almost feasible (EIRR=9.02%), but the NR1+XB1 package presents and EIRR of 2%. This indicates that the results of the willingness to pay (WTP) study (being conducted by MCC's due diligence consultants, for which results are not yet available) will be a key to confidence in the robustness of modeling results and project feasibility.

Table 2: Economic & Financial Results for Feasible MCC Investment Packages			
Scenario	EIRR (%)	FMRR (%)	Notes
ALL MCC – Baseline	40.03	34.81	EIRR generally more volatile than FMRR due to calculation method
ALL MCC – High Valuations & prices	55.24	49.94	High Gx scenario
ALL MCC – Low Valuations & Prices	-2.49	-8.93	Low Gx scenario
NR1+XB1 – Baseline	19.64	17.34	Package features fewer exports to India than ALL MCC package
NR1+XB1 – High Valuations & prices	20.89	23.35	
NR1+XB1 – Low Valuations & Prices	7.88	7.33	
NR1+XB1+T2'+T3 – Baseline	25.96	23.52	Most stable of packages due to higher proportion of domestic benefits
NR1+XB1+T2'+T3 – High Valuations & prices	32.68	33.26	
NR1+XB1+T2'+T3 – Low Valuations & Prices	17.70	14.34	
Note: N/A means the model was not able to calculate a result, generally due to the absence of positive cash flows in any year.			

One finding of the economic analysis is that if Nepal were able to increase generation significantly without MCC's network investments, that is, if other planned network expansion projects were able to carry some of the increased throughput, then the return to those MCC investments would fall.[1] The increased supply in the Without MCC Project case would reduce the differential between the With Project and Without Project throughput. Since net benefits are calculated on the basis of this differential then the value of net benefits would fall as well. This calls for a high degree of coordination between MCC, other donors, and NEA. Such a finding would mean that others are funding network expansion aside from the MCC's proposed investments and that this expansion permits some increased throughput in the network, thereby making additional Gx investments more feasible. See Table 3 for a list of ongoing network investments in transmission from other donors, worth more than $360 million.

Financial analysis results are generally sensitive to domestic tariffs and export prices. The weighted average cost of capital (WACC) does not much influence the results for the three feasible projects. However, the NEA hurdle rate does affect these results. Free cash flow values show that the three feasible packages can generate a great deal of investable resources for NEA, even after accounting for taxes and ongoing operations.

Table 3: Other Transmission Projects Currently Under Way in Nepal

Project	Donor	Commitment	Currency	USD Equiv
Upper Trishuli 3 A Hydroelectric Project	EXIM China	640,000,000	RMB	92,928,000
Trishuli 3 A -Kathmandu 220 KV TL Project	EXIM China	154,000,000	RMB	22,360,800
Kabeli Transmission Project	IDA	17,300,000	SDR	23,370,397
Nepal India Electricity Transmission & Trade Project	IDA	53,800,000	SDR	72,677,882
Electricity Trans. Exp. & Supply Imp. Project	ADB	35,550,000	SDR	48,024,140
NIETTP Additional Financing	IDA	24,600,000	SDR	33,231,894

[1] PSS/E simulations indicate that such an eventuality is, indeed, feasible, as the other parts of the network are not at full capacity 100% of the time and could, therefore, carry some additional energy.

Chilime Trishuli 220 KV TL system Project	KfW	7,000,000	EURO	7,368,421
ETE Trishuli LDC Upgrade Project	KfW	7,000,000	EURO	7,368,421
Power System Expansion Project (SASEC)	EIB	95,000,000	EURO	100,000,000

1. Economic and Financial Assessment of Network Improvements

1.1 Introduction

1.1.1 Background

The electricity system of Nepal has suffered from serious shortages of supply to local electricity consumers for many years. The country relies primarily on hydroelectric generation with some seasonal storage to meet demand. Current generation capacity stands at just under 1,000 MW.

The demand for electricity by all categories of consumers far exceeds current and near-term projected supplies. Electricity shortages have inhibited industrial activities and investments, and left residential and commercial users without power for hours at a time almost every day. The last year without load shedding was more than 10 years ago. Present levels of load shedding average 47 hours weekly in the wet season and more than 90 in the dry season.

NEA's generation for 2015/16, representing roughly 40% of current supply, totaled 2,123 GWh, of which 99% came from the NEA's hydroelectric plants. The other 60% of the approximately 5,100 GWh of supply is split between independent power producers (IPPs) and imports from India, 22% and 35% of supply, respectively. There is substantial private diesel generation as well, mostly at manufacturing plants and large hotels. Peak demand in the system is almost 1.4 GW, some of which is met by purchases from India.[2]

Despite increased supply from IPPs, NEA's own generation plants, and cross-border supplies, load shedding remains a grave problem. There is neither sufficient domestic generation capacity nor sufficient network capacity to move electricity to load centers so that even with IPPs and increased trade with India, load shedding is expected to remain a significant problem for many years to come.

Load shedding arises from both a lack of sufficient generation and the absence of transmission network capabilities in key regions of the country. It is something of a chicken-and-egg problem. Private investors will not commit to new generation without the ability to move that generation to markets, especially in the case of surplus wet season supplies. Hence, additional network capacity is a must to enable future generation investments. At the same time, much of the network investment must be done in concert with either new generation projects or enhanced trading arrangements with India in order to make the best use of the additional network capabilities presented by new transmission and substation investments.

[2] NEA Annual Report 2015/16, page 137.

All through this process, NEA continues to add to its distribution system, connecting 120,000-130,000 new customers annually.[3] Most customer additions and more than 90% of all customers fall into the "domestic" (i.e., residential) consumer category. Roughly 1-3% of annual customer additions consist of industrial users, and 1-2% of new customers fall into the "commercial" category.[4]

For many years, the NEA, Indian states bordering Nepal, and private investors have understood that the combination of the vast hydro potential of Nepal's mountains and the almost insatiable appetite for electricity in India would permit the development of a significant fraction of this potential generation. However, these investments, which would represent a major contribution to Nepal's economy, have lagged in recent years due to a lack of sufficient network capacity for moving the electricity from generation to consumers, whether in Nepal or India. There is potential to develop more than 40,000 MW of generation capacity, based on sites already surveyed in the country's mountainous valleys and streams.

Financially, NEA has not yet found a combination of tariffs and costs that enable the company to show positive cash flow. Losses remain high, at around 25% of energy throughput, much of this non-technical. Tariff adjustments generally lag changes in cost. Most new customers consume little electricity and are subsidized by the smaller numbers of commercial and industrial users. NEA's losses, NRs 11.7 billion ($107.2 million), in FY 2016 remain stubbornly high so that investments must be funded from government subsidies or foreign loans.

Despite all these headwinds, Nepal remains committed to continued growth in all segments of the electricity business, from private generation to mini-grids.

1.1.2 Task 4 Objectives

Task 4 features two primary objectives. These are:

- Determine the benefits of the proposed MCC investments and calculate the economic internal rate of return for these projects
- Provide quantitative findings on the level of tariffs required to sustain the MCC investments within the NEA system.

Briefly, these objectives are intended to help determine whether and to what extent the proposed MCC investments in Nepal's electricity transmission infrastructure will generate net benefits for the country and what kinds of pricing measures NEA can undertake to sustain the benefits provided by the new transmission lines and substations. Subordinate to these two major objectives are providing answers to the following questions:

- Are exports and imports on balance beneficial for Nepal?
- How dependent is the MCC investment program on increased success in adding generation capacity?

[3] NEA, *op cit*, page 138.

[4] This group consists of restaurants, hotels, offices, and other businesses. The current consumption split in Nepal is residential: 52.5%; commercial: 14.8%; and industrial: 32.7% of total electricity purchased from NEA, respectively.

To support the activities that will fulfill these objectives, a number of activities were launched to provide the quantitative information needed to populate the two models with documented data or estimates and projections.

1.1.3 Task 4 Scope

The scope of this task is to provide MCC with support for the development of its economic analysis model and to produce or modify a financial analysis model to calculate rates of return, required prices or valuations and the effects of changes in demand, supply, prices, and costs on the attractiveness of the proposed MCC investments. Both models will be provided to MCC's economists at the conclusion of this phase of the Tetra Tech work.

A number of related activities have been initiated by the Tetra Tech team in order to achieve the two primary objectives. Some of these activities will be reported separately or in an annex to this report. These related activities have either been folded into the main body of this section, included in one or both of the economic and financial analysis models, or have been assigned to one of the annexes that follow this main report body. Additional related activities include:

- Definition of scenarios - see Section 1.2.1.
- Baseline conditions – included in "Without Project" simulation results from PSS®E model; (see tables of outputs of PSS®E found in Task 1 section 3.1.5 Technical Benefits Studies)
- Demand forecasts – base case and high/low demand forecasts included in PSS®E model simulations and in economic/financial model prepared for MCC's use; spreadsheet to be provided to MCC.
- Assessment of generation expansion plans; current expectations for the period of MCC's investments are included in the generation forecasts included in the PSS®E simulations; as Annex C, at the end of this Task 4 volume.
- Comparison of electricity supplied to Nepali consumers from different levels of NEA loss reduction and management reform; this is endogenous to the economic/financial model provided to MCC.
- Estimate net benefits of exports to India; this is calculated in the economic/financial model and represents a specific scenario in the PSS®E simulations; a separate assessment was performed on the benefits to the country of trade with India (see Annex B) but has been superseded for now by the PSS®E results.
- Estimate the weighted average cost of capital. We used data on NEA's existing project loans to derive a WACC of 7.7%; this figure is used in the financial model
- Estimate tariffs that recover the full cost of service for this project and related investments – the transmission and distribution use of system charges, the ongoing transmission system investment requirements, generation and import costs are all included in the financial model. That model then tests various tariff levels for the three main classes of consumers to determine an appropriate tariff capable of supporting NEA in implementation of the economically feasible projects.

In addition to the two models, all the relevant files containing estimates of future demand, generation, and tariff or willingness to pay (WTP) matters will be provided to MCC at the conclusion of the current project work. Table 4 describes the major activities and elements of the two models, economic and financial, produced.

Table 4. Activity Descriptions

Activity	Brief Description	Form of Deliverable/Comment
Economic Analysis Model/Financial Analysis Model	Parameters	Discussed in text, contained in separate model sheet, many parameters are controllable from Summary Worksheet.
	Project Benefits	Technical benefits in PSS®E output files, ported to Benefits Worksheet and transformed into form usable by model. PSS®E output gives energy supplied, energy consumed, load shedding, energy imported and exported, and generation not utilized.
	Project Costs	From Tasks 1, 2, 3 on separate worksheet
	Demand	From demand estimates, current demand worksheet not used
	Supply	Supply figures from PSS®E output. Separate supply worksheet not used in this version
	Generation	Generation worksheet uses only Base Case projection. Supply figures for current version come from PSS®E output.
	Results Worksheets There is one per Package, and data are read off cost and benefit worksheets.	Each package has its own worksheet showing throughput, losses, load shedding, exports, and imports with and without project by year. There is a Summary worksheet that shows results for all packages and allows user to control key scenario parameters.
Scenario Definitions	Worked with Task 1 to devise appropriate packages of projects and scenarios	Described in Section 1.2.1. Technical benefits for each scenario are show in Project Benefits Worksheet in both Economic and Financial models.
Demand Forecasts	Loads for 2020 and 2025 were estimated for 65 busses in the Nepal system, and provided by MCC (from due diligence consultants WSP). The busses are categorized in terms of NEA's six regions.	Reports were prepared on current and future loads, including peak demand and energy sales. These forecasts were divided among the three main classes of consumers, domestic, commercial, and industrial according to the existing split in customer classes.
Generation Projections	Listing of all planned and expected generation plants categorized by project status, expected year in service, type of plant	Spreadsheet used as basis for generation scenarios used in models.
Financial Assessment of NEA	NEA's financial condition during the past 4 years was assessed by the Tetra Tech Team. The financial analyst looked at financial performance, financial	Sections of this report, plus addenda. The financial model uses some of the output to provide tariff adequacy judgements.

Table 4. Activity Descriptions

Activity	Brief Description	Form of Deliverable/Comment
	structure, satisfaction of loan covenants, among other things	
Notes/Comments: Demand and generation forecasts produced based on NEA projections may differ from the demand and supply figures used in the PSS®E simulations. Discrepancies are explained in the relevant sections of this Task description and generally owe to the MCC and team agreement to use more conservative forecast of future generation plant completion, in line with recent experience in that area.		

1.2 Approach and Methodology

The main activities of this task, constructing economic and financial models of the proposed MCC investments and estimating the various economic and financial measures of performance, were undertaken using standard economic and financial techniques. The key challenges involved formulating demand and generation scenarios that were appropriate to a conservative and accurate approach to assessing the MCC investments.

Both the economic and financial models are constructed on the same platform and use the same databases of project costs and technical benefits. An outline of the model is described in the Section 1.3.

MCC is responsible for developing the economic model that will be used to make recommendations to the Board. The MCC model is based on a consumer surplus approach to benefits that includes both output benefits and cost savings benefits. As part of our assistance to MCC in the development of the economic model, Tetra Tech was asked to provide an approach to valuing the various benefits and incorporating them into an economic framework. This work became the consultant's version of the economic model when it became clear that in the interest of a timely reporting of results in this project's compressed time frame, it would be necessary for the consultant to complete an initial version of the economic model.

1.2.1 Scenarios for Technical and Economic Analysis

The various disciplines on the Tetra Tech team worked together to define a set of scenarios and demand/supply variations that would provide MCC with some assurance that an appropriate range of options and contingencies had been included in the analysis. The initial report on these scenarios was provided to MCC as a part of the Conceptual Report and discussed at the November presentations in Nepal. The scenarios were finalized in mid-November and are shown in Table below. These scenarios were reviewed with MCC and finalized earlier in November. The scenarios and approach to simulation modeling is described in section 2.2. of the Task 1 volume.

The Baseline for the simulations is 2016, for which the Tetra Tech team developed data for the following items:

- Annual MWh supply
- Annual MWh demand (consumption)
- Annual MWh loss
- Annual load shedding in MWh
- Annual import/export amounts in MWh.

New PSS®E simulations were performed for 2023 and 2030. Annual results were computed based on the PSS®E simulations of the two system extremes: minimum demand during the wet season and maximum demand during the dry season. Demand growth for these cases was set at 7.5%, the historical average of recent years. Table below shows the 28 cases that were examined using PSS®E, of which 8 were subjected to follow-up sensitivity analysis:

Power Flow Scenarios Considered for Analysis

Case	Supply/Demand	Set of MCC Projects Included
1	2023 Drypeak	CF Base Case
2		CF Base Case + NR1 + XB1
3		CF Base Case + NR1+ XB1 + T2' + T3
4		CF Base Case + NR3
5		CF Base Case + NR4
6		CF Base Case + T8
7		CF Base Case + all MCC Projects
8	2023 Wetmin	CF Base Case
9		CF Base Case + NR1 + XB1
10		CF Base Case + NR1+ XB1 + T2' + T3
11		CF Base Case + NR3
12		CF Base Case + NR4
13		CF Base Case + T8
14		CF Base Case + all MCC Projects
15	2030 Drypeak	CF Base Case
16		CF Base Case + NR1 + XB1
17		CF Base Case + NR1+ XB1 + T2' + T3
18		CF Base Case + NR3
19		CF Base Case + NR4
20		CF Base Case + T8
21		CF Base Case + all MCC Projects
22	2030 Wetmin	CF Base Case
23		CF Base Case + NR1 + XB1
24		CF Base Case + NR1+ XB1 + T2' + T3

Power Flow Scenarios Considered for Analysis		
Case	Supply/Demand	Set of MCC Projects Included
25		CF Base Case + NR3
26		CF Base Case + NR4
27		CF Base Case + T8
28		CF Base Case + all MCC Projects

Power Flow Scenarios for Sensitivity Studies		
Case	Supply/Demand	Set of MCC Projects Included
1	2023 Drypeak	CF Base Case
7		CF Base Case + all MCC Projects
8	2023 Wetmin	CF Base Case
14		CF Base Case + all MCC Projects
15	2030 Drypeak	CF Base Case
21		CF Base Case + all MCC Projects
22	2030 Wetmin	CF Base Case
28		CF Base Case + all MCC Projects

In the Counterfactual base case, it was assumed that all of the 2020 generation projects shown in the WSP supply forecast would be completed by 2023. The 2025 generation projects would be completed by 2030 for the Counterfactual case. These delays are in keeping with the country's history of completion in the generation area.

The sensitivity of the results to changes in demand or supply were examined for the Counterfactual cases and for the All MCC projects cases for 2023 and 2030. The following sensitivity cases were used for demand variations:

- Low forecast – demand growth at 5% per year
- High forecast – demand growth at 10% per year.

The 7.5% growth rate represents Nepal's recent historical experience. The other two rates were used to bracket low and high cases for sensitivity testing.

To assess variations in supply/generation the following changes were made in the Baseline assumptions:

- Low forecast for 2023 is 64% of Base Case
- High forecast for 2023 is 111% of Base Case
- Low forecast for 2030 is 63% of Base Case
- High forecast for 2030 is 141% of Base Case.

These figures were derived by looking at individual generation projects, their locations in the country's network, and the commercial/financial/regulatory attributes of the project – e.g., is there a known sponsor, a power purchase agreement (PPA), financial closure? No assumption of continuing supply growth beyond 2030 was used to avoid in appropriate attribution of benefits to the MCC projects.

1.2.2 Valuation of Benefits

The PSS®E load flow model was used to calculate the technical benefits of the various projects shown in Table 5 and Table 6, below. The load flow model was run for two years, 2023 and 2030. Results, technical benefit measures were provided for each scenario in the following form:

Table 5: Technical Benefits Used in Base Case Economic and Financial Models for 2023 and 2030

Scenario For Year 2023	Annual GWh supply[1]	Annual GWh consumption[4]	Annual GWh loss	Annual GWh load shedding	Annual GWh import[2,3]	Annual GWh export[2,3]	Annual GWh generation not utilized
Counterfactual Base Case	**12,220**	**12,987**	**377**	**3,925**	**3,571**	**2,427**	**8,482**
Base Case + NR1	12,180	13,012	273	3,899	3,570	2,465	8,522
Base Case + NR1 + XB1	12,605	15,185	347	1,726	5,823	2,896	8,097
Base Case + NR1+ XB1 + T2' + T3	15,577	15,313	400	1,598	4,911	4,774	5,125
Base Case + NR3	12,215	13,005	350	3,906	3,571	2,431	8,487
Base Case + NR4	12,217	12,985	374	3,926	3,571	2,429	8,485
Base Case + T8*	17,098	13,134	411	3,778	3,502	7,054	3,605
Base Case + All MCC Projects	**20,702**	**15,350**	**352**	**1,562**	**4,670**	**9,671**	**0**

Note: Sensitivity cases were run for the Counterfactual and for the All MCC Projects Cases for 2023 and 2030. The variations included low generation, high generation, low demand, high demand, and reduced trade with India (no XB1 line). No sensitivity simulations were performed for other packages.

Table 6. Technical Benefits Used in Base Case Economic and Financial Models for 2030

Scenario For Year 2030	Annual GWh supply[1]	Annual GWh consumption[4]	Annual GWh loss	Annual GWh load shedding	Annual GWh import[2,3]	Annual GWh export[2,3]	Annual GWh generation not utilized
Counterfactual Base Case	**19,305**	**18,636**	**740**	**9,453**	**4,463**	**4,392**	**12,870**
Base Case + NR1	19,651	19,915	660	8,173	5,316	4,391	12,524
Base Case + NR1 + XB1	23,853	24,924	1,072	3,165	10,616	8,473	8,322
Base Case + NR1+ XB1 + T2' + T3	26,802	25,026	1,155	3,063	9,983	10,604	5,373
Base Case + NR3	19,305	19,463	708	8,625	5,267	4,401	12,870
Base Case + NR4	19,286	19,418	758	8,670	5,281	4,391	12,889
Base Case + T8*	24,037	19,637	809	8,452	5,297	8,888	8,138
Base Case + All MCC Projects	**31,710**	**25,138**	**947**	**2,950**	**9,791**	**15,416**	**465**

Note: Sensitivity cases were run for the Counterfactual and for the All MCC Projects Cases for 2023 and 2030. The variations included low generation, high generation, low demand, high demand, and reduced trade with India (no XB1 line). No sensitivity simulations were performed for other packages.

Output benefits represent the additional power and energy flows due to the project. They are valued as consumers' willingness to pay (WTP) for additional electricity supplies minus the cost of that additional supply. Typically, the additional supply cost will consist of the cost of the MCC transmission investments plus the cost of generation for the additional electricity supplies, plus additional use of system charges for distribution and transmission to put the accounting stance for supplies and costs/prices in the same physical location in the electricity supply system.[5] The cost savings benefits (cost reductions to electricity users relative to existing sources of electricity) can be valued at either WTP or the opportunity cost of the substitute supplies during outages – e.g., standby generators and fuel, batteries. In the current economic model, the load shedding reductions due to the MCC investments are valued at the opportunity cost of defensive expenditures in the Base Case, though the user has an option to vary these valuations.

[5] In analyzing a transmission project, the costs of additional supply and the willingness to pay net out distribution costs and the relevant boundary of the cost-benefit analysis is the transmission-distribution substation. For example, PSS®E shows supply at high voltage, but WTP is measured at the consumer's low voltage location, after costs and losses in transmission and distribution.

Tetra Tech worked with NEA, MCC, and the local power team to develop values for the incremental cost of electricity, the various loss valuation elements, and WTP for new supplies. It is understood that the MCC has WTP studies ongoing and that these results will be available soon, and will be used by MCC's economists in the economic model.

The valuation equation has the following general form:

Value of Output Benefit = WTP – (Cost of project + Cost of additional electricity supply)

The **loss reduction[6] and the reduction in load shedding** are cost-savings benefits and are valued at the appropriate opportunity costs of alternative supplies. Loss reduction does not affect system capacity or generation capacity, and is generally valued at the marginal cost of generation. In Nepal, this may be either hydro, combustion, or imports from India depending on the marginal generating units or supply-demand balance in the system and the timing of most of the losses. In the current version of the model losses are valued equivalently to additional supply.

Valuing load shedding is a generally controversial area. The MCC team has been provided with upper and lower bounds for the value of reducing load shedding.[7] At the upper bound, reductions in load shedding are valued at the value of lost load, which is generally associated with the value of lost production in manufacturing.

However, a country such as Nepal, which suffers long-term and consistent load shedding, firms are not likely to value lost load so highly. Firms have and will continue to make defensive expenditures – standby generation, inverters, adjusting the factory schedule to the load shedding schedule, etc. At a minimum, reducing load shedding is worth the fuel plus O&M costs of standby generation, and if load shedding is almost entirely eliminated due to the project, then the value of that benefit rises to the fixed and operating costs of standby generation or other defensive expenditures. For other consumer categories, the value of avoiding load shedding will range from standby generation cost for hotels and other commercial users to car batteries, kerosene and candles for households. For some consumers, load shedding will simply result in an absence of services entirely. In other words, the willingness to pay measure is likely to be a good proxy for the value of lost load when load shedding is such a significant element in the lives of all classes of consumers.

The final category of benefits is the increased trade in electricity with India as a result of building the export lines, especially XB1. Both imports and exports can be valued straightforwardly. **Exports of electricity** will be valued at the sales price at the Nepal-India border minus the average incremental cost of generation. The wheeling charger exports is added to generation on the cost side of the model. The subtraction of network charges on the benefit side is to ensure that costs are allocated to the correct category – i.e., network – not to generation. This also ensures that there is no double counting of network charges as "benefits".

6 Loss reduction from additional Tx investment is calculated but is not a major element of project benefits.
7 These ranges are contained in the economic and financial models Parameters sheets. They may be revised as new data become available.

Imports of electricity will be valued at WTP minus the import price plus network costs and losses. In the financial model, other values are used, including multiple existing export/import prices between Nepal and India.

1.3 Economic Model (Provisional)

As noted above, Tetra Tech team constructed a provisional economic model of the proposed MCC projects to provide MCC's economists with assistance in constructing their own economic model. The valuation of benefits, discussed above, is handled in two worksheets. One, called Parameters, contains the various valuation and performance parameters and can be changed by the user. The other, named for each package, contains the calculations of costs and benefits for that package only. The general flow of data and calculations in the model is shown in Figure 1.

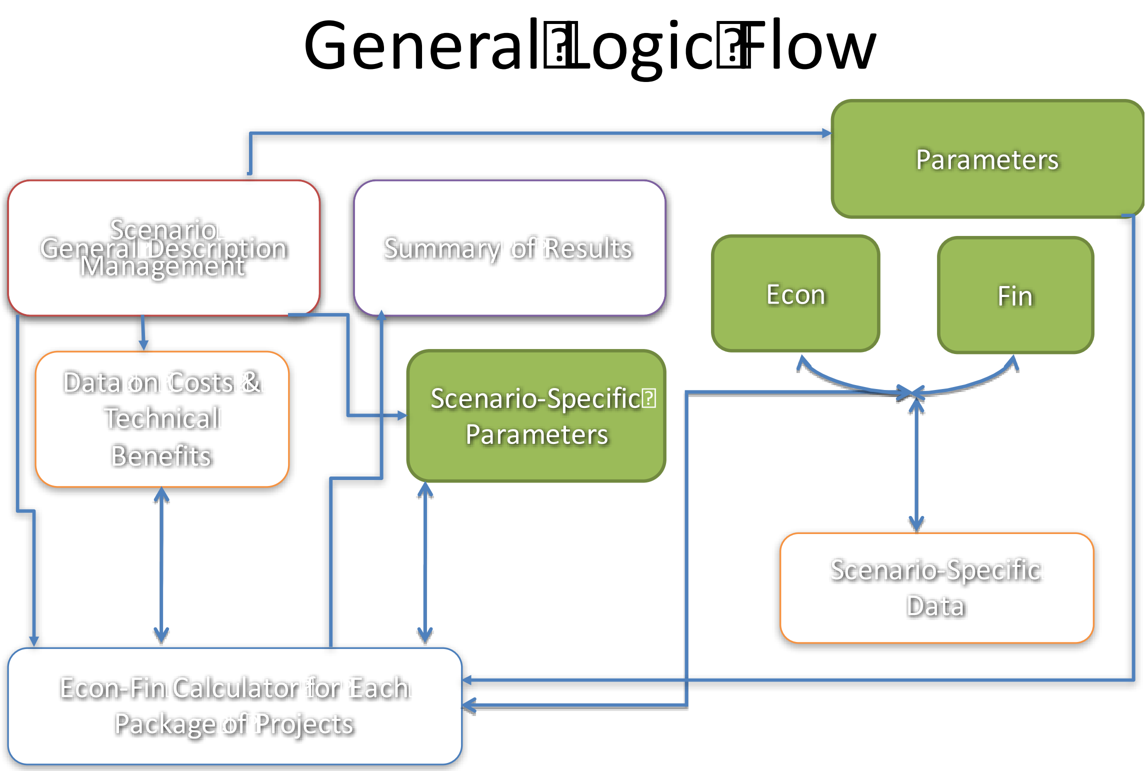

Figure 1: General Logic Flow

Users of the model are provided with a series of menus for choosing the appropriate valuation parameters. These choices can either be linked to other parameters as a scenario or be varied individually. Figure 2 shows a screen shot of the main menu system. These menus link to values on the Parameters sheet that can be modified by the user as appropriate, or as new data arise.

Project costs and other relevant costs, especially for network expenses for the additional energy owing to the MCC projects, can be chosen on the main menus and on the Parameters sheet. Such project benefits as electricity valuation are chosen on the main menu system. Other variations in project benefits come from the Parameters sheet or from the choice of scenarios, again part of the main menu system.

Reform Scenario ID	1	NEA's implementation of reforms, restructuring and new technology; 1 = poor performance, 4 = full implementation
Generation Scenario	1	Success in implementation of additional generation projects, 1=Base Case, 2=Above Plan, 3=Below Plan
Cost Overruns	2	Modifies EPC Costs, 1 is slightly under budget, 2 is on budget, 3 & 4 are over budget
Electricity Valuation	2	Values to be used in WTP, load shedding, and loss reduction; 1=based on current average tariffs, 2=marginal tariffs, 3=opportunity cost, 4=higher cost subsitutes
Demand Scenario	1	Values correspond to Base Case demand growth, slower growth, faster growth
Electricity Import Price	1	Current prices are choice 1; 2 is LNG MEC; 3 is LNG full cost; 4 is advanced coal newbuild
Electricity Export Price	3	Current price is choice 1, based on Bhutan export contracts to India, 2 is marginal energy cost (coal), 3 is MEC (LNG), and 4 is full
Generation Costs	2	1 is highest down to 4, lowest
Load Shedding Valuation	2	Valuation of supply regained due to reduced load shedding: 1 is marginal tariff, 2 is opportunity cost, 3 & 4 are higher
PSE/E Base Case Scenario	1	PSE/E: 1 is Base Case; 2 is Low Gx; 3 is High Gx; 4 is Low Demand; 5 is high Demand
PSE/E All MCC Scenario	1	PSE/E: 1 is Base Case; 2 is Low Gx; 3 is High Gx; 4 is Low Demand; 5 is High Demand

Figure 2. Economic Model Main Menus

The Reform Scenario parameter is a key to many features of the model, including spending on O&M, losses, deterioration of the network, if any, system benefit charges assigned to environmental and social compensation funds, if any, and other parameters.

The demand and generation scenarios contained in the models, which are derived from NEA and other sources, including previous ÉdF and WSP work, and modified by Tetra Tech, reflect the current range of supply and demand forecasts produced for Nepal. These forecasts remain in the economic model, but the specific numbers have been superseded at present by the results of the PSS®E scenarios. These scenarios are based on the main line supply and demand forecasts, albeit with modifications to the supply schedule based on discussions with MCC.[8] However, the model can be modified to generate its own demand and supply projections relatively easily. Figure 3 shows the current method of scenario management and reporting.

[8] **These scenarios as agreed with regard to supply modifications, were specified in the scenarios memo of October 13, 2016.**

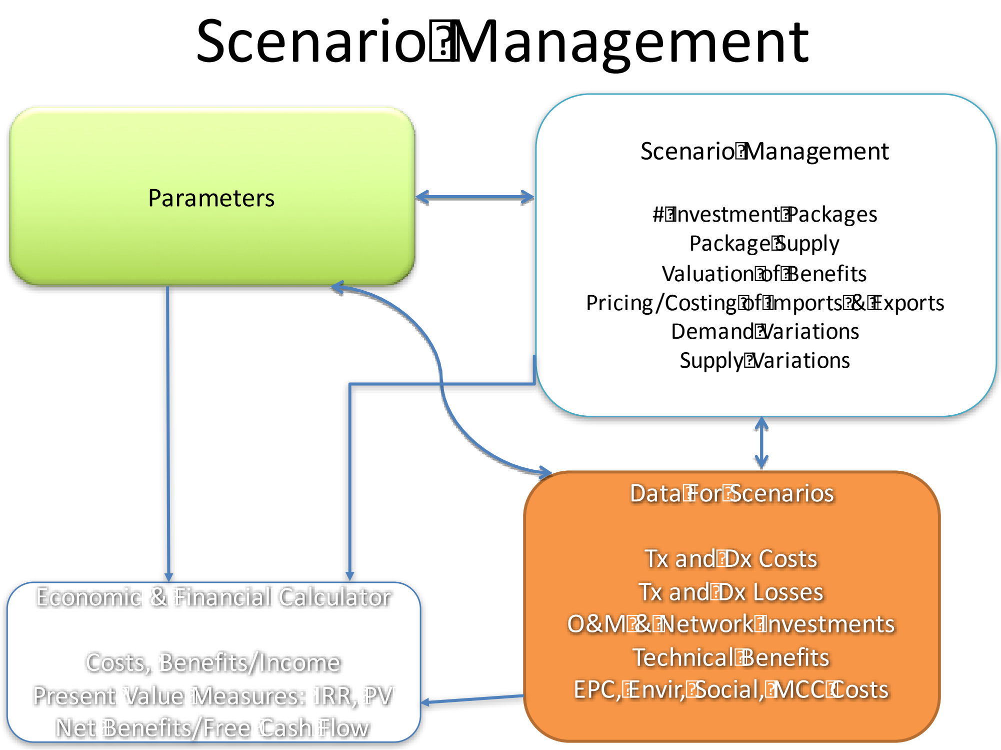

Figure 3. Scenario Management

1.3.1 Cost Estimates for MCC Projects

Cost Categories

Cost estimates for the proposed transmission investments have been assembled by the team's engineering staff from final design specifications. For both the economic and financial analyses, the following data have been included in the cost estimates that comprise the Project Cost worksheets of both models:

- Costs for proposed transmission lines and substations by project
  - Types of expenditures (for substations)
    - Preliminary works
    - Civil works
    - Switches and switch-yard equipment
    - Auxiliary DC power system
    - SCADA
    - Control structures
  - Cost phases
    - Material costs – quantities and prices
    - Erection and commissioning
    - Inspection and testing
    - Other costs – clearances, insurance, foreign exchange fees, etc.

- Timing of expenditures during project life
- Common purchases for multiple projects
- Contingencies

- This leads to a cost buildup of the following sort that the project engineers have used in their costing model provided to the rest of the Tetra Tech team:
  - Technical Cost
  - Technical Cost With Contingency
  - Environmental Cost
  - Social & resettlement Cost
  - MCC Management
  - Total Cost.

Costs by Project and Package. The economic and financial models aggregate these many project cost components into just a few categories by project and by package, as shown in Table 7.

Table 7. Aggregated Package and Project Costs for Nepal MCC

Package ID:	Technical Cost	Technical Cost With Contingency	Environmental and Social Cost	Resettlement Cost	MCC Management	Total Cost	Total Cost - MCC Mgt.
BC+NR1+XB1	395.4	395.4	7.6	53.1	28.0	484.1	456.1
BC+NR1+XB1 +T2'+T3	458.7	458.7	10.5	68.3	33.0	570.5	537.4
BC+NR3	15.8	15.8	2.0	1.7	1.2	20.7	19.5
BC+NR4	4.0	4.0	1.5	0.0	0.3	5.8	5.5
BC+T8	38.7	38.7	0.9	3.4	2.6	45.7	43.0
MCC	517.1	517.1	14.8	73.5	37.2	642.6	605.4
MCC-XB1	507.4	507.4	14.1	62.5	35.9	619.9	584.0
NR1	385.6	385.6	6.9	42.1	26.7	461.3	434.6
Contingency, forex, handling, engineering fees		0.00%		MCC Mgt. Fee	6.144%		

Note: forex fees apply only to financial model.

Enter Data here in GREEN cells only[9]							
NR1	385.6	385.6	6.91	42.12	26.7	461.3	434.6
XB1	9.8	9.8	0.69	10.98	1.3	22.8	21.5
NR3	15.8	15.8	1.99	1.74	1.2	20.7	19.5
NR4	4.0	4.0	1.46	-	0.3	5.8	5.5
T2'	25.3	25.3	1.12	6.22	2.0	34.6	32.6
T3	38.0	38.0	1.73	9.01	3.0	51.7	48.7
T8	38.7	38.7	0.89	3.42	2.6	45.7	43.0

[9] This is to reflect the inputs used in the model.

Data are entered by project and then aggregated as appropriate into the various packages. Each package sheet reads the appropriate cost data from this worksheet. Contingencies are incorporated into the cost estimates for each technical element and category, reducing the need for a universal contingency provision. The use of contingency factors reduces, but does not eliminate the need for a risk assessment on costs. As the electricity engineering and supply industries discovered in the 2004-2008 period, there is a need to distinguish between inflation adjustments and real changes in relative prices of equipment. The form of this table provides flexibility for future users to apply other cost and contingency figures as appropriate.

These cost elements are accounted for in a manner such that the amount and timing of the expenditure can be modified as needed for both the cost estimate and economic modeling activities. It is possible to modify these costs up or down using the scenario menus of both models. Operation and maintenance costs of the various major components, as well as the expected useful lifetimes, are shown in the Parameters worksheet.

Operations and Maintenance Costs. Tetra Tech prepared an analysis of NEA's costs to maintain its current and future network infrastructure. This information is contained in the Financial Assessment of Current NEA Operations Annex to this main report.

Operation and maintenance costs of the various major components, as well as the expected useful lifetimes, are shown in the Parameters worksheet. These O&M parameters are part of the overall menuing system so that they may rise or fall with the user's choice. The Base Case parameters for O&M are USD 0.25-0.65 per MWh, with $0.35/MWh as the initial parameter. This figure was derived from the NEA financial analysis[10] and was cross-checked with a transmission benchmarking study from a major utility with hydro based generation assets.[11] The financial model also contains an ongoing investment requirement for the network keyed to the additional MCC project throughput.

Project lifetime is in line with Government of Nepal (GoN) financial guidelines, at 50 years, and the depreciation rate in the financial model is taken as 2% annually as per the project lifetime. It is possible to shorten or lengthen the project lifetime and to accelerate the depreciation, if appropriate.

1.3.2 Calculations for Individual Packages

Each package identified in the scenarios has an associated worksheet that displays the summary information used to generate benefits and costs for that package; see Table 8 for an example of the representative output from the model summary table for a package. Each worksheet also computes the following intermediate results for the determination of package/project economic and financial returns. These are shown in Table 9.

- Throughput with and without Package
- Imports with and without Package

[10] See Addendum __.

[11] See Bonneville Power Administration, https://www.bpa.gov/finance/financialpublicprocesses/capitalinvestmentreview/cirdocuments/cap_investment_benchmark.pdf, 2011-2016.

- Exports with and without Package
- Load shedding with and without Package
- Losses with and without Package

Each of these items contains both benefits and costs. The additional throughput is divided between new supply and load shedding reductions. The cost of the additional throughput is the cost of acquiring the additional energy and moving it through the network to the customer, where the WTP/tariff measure is applied for the appropriate consumer category.

Table 8. Summary Table for Each Package (this table is representative and was produced from a different simulation than was Table 9.

NEA Reform Scenario is Little Reform; Generation Scenario is Base Case; WTP is Marginal Tariffs

Package ID:	Technical Cost	Technical Cost With Contingency	Environmental Cost	Social Cost	MCC Management	Total Cost
BC+NR1+XB1	392.60	462.09	12.36	36.31	16.92	527.68

Benefit Parameters attributable to this project package only									
		Without Project 2023		With Project 2023		Without Project 2030		With Project 2030	
		Number	Unit	Number	Unit	Number	Unit	Number	Unit
Throughput	Capacity	3215	MW	3317	MW	5080	MW	6276	MW
Hours for Capacity		8208	hours	8322	hours	8322	hours	8322	hours
Capacity of load shedding		895	MW	394	MW	2155	MW	723	MW
MWh Load Shedding		3,920,604	MWh	1,726,438	16.20%	9,440,214	MWh	3,164,741	16.90%
Losses in Distribution		23%	percent	23%	percent	23%	percent	23%	percent
Losses in Transmission, MWh; %		610,980	5.000%	630,240	5.000%	868,730	4.500%	1,073,376	4.500%
Outages		-	MWh	-	MWh		MWh		MWh
Trade with India		Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports
	MW	794	642	1294	431	992	1162	2359	1261
	MWh	3,571,100	2,427,200	5,823,194	1,628,860	4,462,700	4,391,700	10,615,880	4,765,849
	Net MWh	(1,143,900)		(4,194,334)		(71,000)		(5,850,031)	8.96%
Total Supply		12,219,600	MWh	12,604,800	MWh	19,305,100		23,852,800	
MWh delivered to Dx		11,608,620	MWh	11,974,560	MWh	18,436,371	MWh	23,222,560	MWh
Rate of Supply Growth 2018-2023		0.50%		0.25%		0.25%		0.25%	
Rate of Supply Growth 2024-2030		6.831%		-	-	3.24%		9.54%	

Note that exports Without Project in 2023 slightly exceed exports With Project. This means additional network capabilities permit greater use of electricity generation *within* Nepal. This is not true for all packages.

Table 9. Benefit Calculations for Individual Packages

			2018	2019	2020	2021	2022	2023
Package Benefits		Year	1	2	3	4	5	6
	Throughput without project							
	MWh/year		8,996,681	8,951,697	8,906,939	8,862,404	8,818,092	8,996,681
	Domestic		4,723,257	4,699,641	4,676,143	4,652,762	4,629,498	4,723,257
	Commercial		1,331,509	1,324,851	1,318,227	1,311,636	1,305,078	1,331,509
	Industrial		2,941,915	2,927,205	2,912,569	2,898,006	2,883,516	2,941,915
	Throughput with Project			*Phasing in of Benefits due to Generation Scenario:*				71%
	MWh/y		8,996,681	8,951,697	8,906,939	8,862,404	8,818,092	9,257,083
	Domestic		4,723,257	4,699,641	4,676,143	4,652,762	4,629,498	4,859,969
	Commercial		1,331,509	1,324,851	1,318,227	1,311,636	1,305,078	1,370,048
	Industrial		2,941,915	2,927,205	2,912,569	2,898,006	2,883,516	3,027,066
	Note to User: The difference between throughput With-Project and throughput Without-Project represents the total difference in MWh for the specific package formulation. Reductions in outages and load shedding represent a benefit that may be valued differently from additional energy output. If separate WTP or opportunity cost measures for this category exist they will be valued on that basis and not on the same basis as the pure output benefit. The value of outage reduction + load shedding is subtracted from the additional MWh for each year.							
	Imports without project (MWh/year)							3,571,100
	Domestic		1,874,828	1,874,828	1,874,828	1,874,828	1,874,828	1,874,828
	Commercial		528,523	528,523	528,523	528,523	528,523	528,523
	Industrial		1,167,750	1,167,750	1,167,750	1,167,750	1,167,750	1,167,750
	Imports with project (MWh)							5,823,194
	Domestic		1,874,828	1,874,828	1,874,828	1,874,828	1,874,828	3,057,177
	Commercial		528,523	528,523	528,523	528,523	528,523	861,833
	Industrial		1,167,750	1,167,750	1,167,750	1,167,750	1,167,750	1,904,185
	Value of Additional Supply to Consumers (USD)							
	Domestic		-	-	-	-	-	224,054,992
	Commercial		-	-	-	-	-	63,162,169
	Industrial		-	-	-	-	-	139,554,252
	Total		0	0	0	0	0	426,771,414
	Quantity of Reduced Load Shedding (MWh)							
	Domestic		0	0	0	0	0	1,151,937
	Commercial		0	0	0	0	0	324,736
	Industrial		0	0	0	0	0	717,492
	Total		0	0	0	0	0	2,194,165
	Value of Exports to India							
	Without Project		72,816,000	72,816,000	72,816,000	72,816,000	72,816,000	72,816,000
	With Project							(23,950,195)
	Project Benefit							(96,766,195)
	Total Project Benefits to Domestic Consumers							
	Domestic		0	0	0	0	0	225,206,929
	Commercial		0	0	0	0	0	63,486,906
	Industrial		0	0	0	0	0	140,271,745
	Total Project Benefits (includes exports)		0	0	0	0	0	332,199,385

Note that there are no project benefits until year 6. “Domestic” refers to the category of consumer sometimes called “residential”.

Costs are based directly on the with and without project values for throughput, imports, and exports. These costs include the acquisition cost of additional energy, network use of system charges and O&M, as shown in Table 10.

Table 10. Package Cost Calculations

Package Cos	**MCC Project Costs**						
	Investment Timing	10.00%	25.00%	25.00%	25.00%	15.00%	
	Investment & Monitoring Costs	48,411,493	121,028,733	121,028,733	121,028,733	72,617,240	
	Project Costs to NEA With Project						
	Transmission	0	0	0	0	0	6,690,073
	Use of System						
	Fixed O&M						6,690,073
	Variable O&M						
	Substations						
	New Investments						
	Distribution connections	0	0	0	0	0	6,510,070
	Use of System						6,510,070
	Fixed O&M						
	Variable O&M						
	Substations						
	New Investments						
	Generation and Supply	0	0	0	0	0	573,335,965
	IPPs						451,899,502
	NEA own Gx						
	Imports						121,436,463
	Total Costs to NEA	**0**	**0**	**0**	**0**	**0**	**586,536,108**
	Total Package Costs	**48,411,493**	**121,028,733**	**121,028,733**	**121,028,733**	**72,617,240**	**586,536,108**

The financial model contains an additional set of calculations, as show in Table 11. These calculations pertain to depreciation, taxes and other costs not relevant to the economic analysis. The financial model does not show borrowing for non-MCC projects. However, the financial management rate of return contains both a borrowing rate and a minimum or hurdle rate for investments by NEA in the transmission network. These measures indicate whether and to what extent NEA's operational and financial performance will allow it to borrow further from both MLA and other sources of financing.

Table 11: Financial Model Additional Calculations

Tax & Depreciation						
	Depreciation on new assets					
	Pre-tax Income					
	Income tax					
	Net Income					
	Free Cash Flow	0	0	0	0	0

1.3.3 Presentation of Results of the Economic and Financial Models

Each package sheet contains is a summary table that shows the economic or financial results for that package. These present value calculations are created using standard Excel functions. The individual package summaries for the economic model are shown in Table 12 and for the financial model in Table 13 for representative packages. Actual numbers in these tables will depend on the parameters, scenarios, and additional data that may apply to each package.

Baseline Case Results

Table 12: Economic Model Individual Package Results Summary (USD)

Present Value Measures	EIRR	19.64%
	PV Net Benefits	1,083,574,164
	PV Total Benefits	6,585,532,548
	PV Total Costs	5,501,958,384
	PV MCC Costs	398,990,591
	PV NEA Costs	5,102,967,793
	B/C Ratio	1.197
	Annualized B/C % (average annual return above discount rate/cost of money)	0.72%

Table 13: Financial Model Individual Package Results Summary (USD)

Present Value Measures	FIRR	19.29%
	PV Net Income	1,766,129,230
	PV Total Income	6,958,266,652
	PV Total Costs	5,521,748,657
	PV MCC Costs	391,171,853
	PV NEA Costs	5,130,576,803
	B/C Ratio	1.260
	Annualized B/C % (average annual return above discount rate/cost of money)	0.46%
	PV Free Cash Flow	$870,316,267
	Financial Management Rate of Return	15.23%
	EBITDA	1,436,517,995

The reason that the amounts for the present value measures for total costs are much larger than the MCC investment costs has to do with the very large energy differentials occasioned by the MCC projects, which must be purchased by NEA. These large volumes of energy, even if only a few U.S. cents per kWh, enlarge quite rapidly when multiplied by hundreds of millions of units annually.

The summary sheet of the model, the one that contains the main parameter and scenario menus, also contains a summary of results for each package and for all the MCC investments, as shown in Table 14.

Table 14. Results Summary for Economic Model (Baseline Assumptions & Conditions)[12]

Key Project Findings by Package: Generation & Demand = Base Case; Electricity Tariffs = Marginal Tariffs						
Package	EIRR	PVNB ($ US)	B/C	PV MCC Costs	PVB	PVB/PV MCC
BC+NR1	#NUM!	(2,558,901,606)	0.269	380,225,407	940,790,301	2.47
BC+NR1+XB1	19.64%	1,083,574,164	1.197	398,990,591	6,585,532,548	16.51
BC+NR1+XB1+T2'+T3	25.96%	1,948,586,931	1.326	470,149,325	7,923,113,608	16.85
BC+NR3	#NUM!	(2,898,032,679)	0.088	17,072,762	278,016,649	16.28
BC+NR4	#NUM!	(2,911,757,455)	0.080	4,781,252	252,201,398	52.75
BC+T8	#NUM!	(730,741,126)	0.827	37,625,908	3,491,320,089	92.79
MCC	40.03%	4,061,482,638	1.577	529,629,246	11,102,597,910	20.96
MCC-XB1	#NUM!	(1,916,532,321)	0.577	510,864,062	2,612,828,160	5.11

Note: Table title bar automatically accesses key scenario and parameter choices. "#NUM!" appears when Excel cannot calculate an EIRR, as when, for example, there are no positive benefit years, or the cash flow line crosses the 0 axis more than once.

The last column, present value of benefits divided by present value of MCC investment, is a measure of the "leverage" of each MCC dollar. The number must be positive and higher is generally better.

Sensitivity to Changes in Assumptions and Parameters

Sensitivity cases for the Counterfactual and ALL MCC packages show that if the MCC investments are able to catalyze an otherwise sluggish generation sector (*Counterfactual* Gx = low, *ALL MCC* Gx = High), then the EIRR will rise by 16 percentage points, to more than 53%. For the other packages, testing the sensitivity is accomplished by varying price and performance assumptions around the Baseline conditions.

As Table 15 shows, a combination of attractive export prices, based on Indian LNG generation costs, NEA efficiency improvements, and cost control in new generation can raise the positive results for the three generally feasible packages. In addition, the T8 package is very sensitive to export prices and can be feasible if export prices to India rise substantially. None of the other packages is close to economically feasible, even with highly optimistic assumptions.

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[12] It was noted by reviewers that a high power factor, 0.99, was used for the PSS/E simulations, perhaps overstating benefits. A test of a lower power factor, 0.85, than the one in the original WSP PSS/E simulations was used to calculate revised technical and economic benefits for 2030 for the ALL MCC Package Base Case. Since the lines are not at full capacity, even in 2030, there is almost no net change in EIRR calculations.

A similar exercise, generating a pessimistic scenario, shows that only the *NR1+XB1+T2'+T3* package remains feasible with lower export prices and lower electricity valuation, including load shedding (see Table 16). The *All MCC* package does not remain feasible under such highly unfavorable conditions. Annual net benefits are turn positive only after 2030 for the *All MCC* package. The excess of costs over benefits remains substantial between 2023 and 2029. The assumption of a successful Gx program in the Counterfactual reduces the differential in throughput between the Without Project Case and the various With Project Cases, thereby obviating some MCC program benefits.[13]

Returning the Counterfactual to the Baseline Case, but maintaining the other pessimistic assumptions on valuation, then the relatively higher role of exports, combined with higher prices for these exports and reduced value for load shedding causes the EIRRs to fall. The *NR1+XB1+T2'+T3* package falls from almost 26% in the Baseline Case to an EIRR of 13.64%. *The NR1+XB1* package falls from marginal in the pessimistic case (EIRR=7.88%) to infeasible (EIRR=3.15%).

The Counterfactual Gx scenario is almost as important as electricity valuation. If the Gx Counterfactual scenario is high and import prices remain high, but electricity WTP returns to the Baseline Case valuation level then the *NR1+XB1* drops to 9.73%, almost feasible, and the *NR1+XB1+T2'+T3* package rises, with EIRR=19.85%.

Table 15. Optimistic Scenario

Key Project Findings by Package: Generation & Demand = Base Case; Electricity Tariffs = Marginal Tariffs

Package	**EIRR**	**PVNB ($ US)**	**B/C**	**PV MCC Costs**	**PVB**	**PVB/PV MCC**
BC+NR1	#NUM!	(3,088,647,960)	0.152	380,225,407	555,334,588	1.46
BC+NR1+XB1	20.89%	1,478,874,241	1.268	398,990,591	6,999,550,288	17.54
BC+NR1+XB1+T2'+T3	32.68%	3,292,136,746	1.561	470,149,325	9,155,589,525	19.47
BC+NR3	#NUM!	(3,854,301,086)	-0.158	17,072,762	-524,600,178	-30.73
BC+NR4	#NUM!	(3,845,941,443)	-0.159	4,781,252	-527,807,084	-110.39
BC+T8	34.85%	297,093,253	1.071	37,625,908	4,464,733,119	118.66
MCC	55.24%	7,474,191,143	2.113	529,629,246	14,186,673,782	26.79
MCC-XB1	#NUM!	(1,775,859,162)	0.607	510,864,062	2,738,179,875	5.36

Note: Table title bar automatically accesses key scenario and parameter choices.
Other parameter changes in this scenario include higher valuation of load shedding, export prices based on the marginal energy cost of LNG for India, moderate NEA performance improvements (loss reduction.

"#NUM!" appears when Excel cannot calculate an EIRR, as when, for example, there are no positive benefit years, or the cash flow line crosses the 0 axis more than once.

13 The generation forecast in With and Without Project Cases is same. However, there are high Gx and low GX cases in PSS/E as well.

Table 16: Pessimistic Scenario

Key Project Findings by Package: Generation & Demand = High Counterfactual Gx; Electricity Tariffs = Low						
Package	**EIRR**	**PVNB ($ US)**	**B/C**	**PV MCC Costs**	**PVB**	**PVB/PV MCC**
BC+NR1	#NUM!	(2,562,275,363)	0.311	380,225,407	1,155,640,120	3.04
BC+NR1+XB1	7.88%	(181,916,358)	0.971	398,990,591	6,078,971,899	15.24
BC+NR1+XB1+T2'+T3	17.70%	748,531,210	1.113	470,149,325	7,388,370,878	15.71
BC+NR3	#NUM!	(2,659,689,316)	0.224	17,072,762	767,311,660	44.94
BC+NR4	#NUM!	(2,649,589,832)	0.224	4,781,252	766,365,514	160.29
BC+T8	#NUM!	(538,799,488)	0.880	37,625,908	3,933,073,242	104.53
MCC	-2.49%	(840,969,891)	0.846	529,629,246	4,604,174,973	8.69
MCC-XB1	#NUM!	(1,736,206,747)	0.637	510,864,062	3,047,701,997	5.97

Note: Table title bar automatically accesses key scenario and parameter choices.
Other parameter changes in this scenario include lower valuation of load shedding, export prices at current levels, import prices based on the marginal cost of LNG for India, no NEA performance improvements (loss reduction.

"#NUM!" appears when Excel cannot calculate an EIRR, as when, for example, there are no positive benefit years, or the cash flow line crosses the 0 axis more than once.

1.3.4 Further Support for MCC Economic Analysis

Tetra Tech has engaged an economist in Nepal to collect or compile other data required, to support MCC's own economic analysis efforts. Activities and outputs by the Tetra Tech economic support team include:

- Data to support baseline conditions
- Generation plant completion timelines, and possible delays
- Types of electricity users (commercial, industrial, residential)
- Income strata and location of customers
- Estimating the difference between a Nepal "business as usual" and a "best practices" scenarios
- Providing details on evolving policy and institutional issues, including trade with India.

The annexes to this report provide additional data and analysis related to this support role. In addition, the Tetra Tech Task 4 lead will provide documentation and instructions on use of the two project models as part of the final deliverable of this task order.

1.3.5 Linkages to Other Tasks

The activities in Task 4 will be related closely to almost all of the other Tasks in the effort, as shown in Table 17.

Table 17. Task 4 Linkages to Other Tasks

Task	Description	Input or Output to/from Task 4	How Task 4 Uses Output from/Contributes to Other Tasks
1	Technical	Input	Use Task 1 output for cost estimates and technical benefit estimations, provides scenario direction for PSS®E activities
2	Environmental and Social	Input	Provides estimates of cost for environmental mitigation and social costs
3	Resettlement	Input	Provides estimates of costs for resettlement
5	Sustainability	Output	Task 4 identifies various risks with respect to sustainability, and mitigation activities for specific risks, role of NEA management, tariffs, and trade arrangements with India
6	Monitoring & Evaluation	Output	Task 4 should assist the M&E Task with respect to key measures of project performance – technical benefits, economic valuation of benefits, tariff indicators, and generation scenario indicators

The three input tasks are well understood and the Task 4 team will work with the engineering team especially closely to obtain and refine the measures of costs and technical benefits. Coordination with the environmental and resettlement tasks should be relatively straightforward. However, it is possible that some of the mitigation efforts and costs may affect either generation or transmission project costs and effectiveness.

1.4 Financial Modeling and Analysis

As noted at the start of this task description, Tetra Tech is required to perform a financial analysis of NEA's incorporation of the MCC projects to determine the level of tariffs and other reform activities required to sustain these operations in the long term. This means that NEA must reduce losses to a level more consistent with international best practices. Further, sustainability means that NEA must charge tariffs that cover the full cost of generating, purchasing, transmitting, and distributing electricity. The financial analysis is quite distinct from the economic analysis in approach and intent. However, the financial assessment will use the same cost and performance databases as the economic assessment efforts. The scenarios used will be identical to those in the economic analysis and technical benefits analyses.

1.4.1 Financial Model

The financial model uses the same Excel structure as the economic model, with the same set of worksheets.

- Parameters and summary of results
- Revenue and cost calculations for each package
- Project Benefits from PSS®E output
- Project Costs
- Generation, Demand and Supply worksheets – not now used

In addition to the present value methods used in the economic model, the financial model adds depreciation, system upgrade required investments, taxes, required return for NEA investments, and WACC. This allows the model to calculate rates of return and present values for:

- EBITDA (earnings before interest, taxes, depreciation, and amortization)
- Pre-tax Income
- Taxes and depreciation
- Debt, if any
- Capex
- Cost of capital
- System upgrades
- Financial Internal Rate of Return
- Financial management Internal Rate of Return (FMRR or MIRR), and
- Free Cash Flow for each package.

1.4.2 Data Inputs

Data for the financial model use the same costing model (Tasks 1, 2 and 3) as is used for the economic analysis. Where appropriate, any taxes, excises, or other government charges for equipment or services will be added to the project cost as part of the contingency parameter. The WACC calculation is based on NEA's inventory of loans.

1.4.3 Technical Benefits of Additional Transmission Capacity

These estimates will be identical with regard to changes in load flow. If the NEA implements a specific transmission tariff, the model can perform its calculations using unbundled pricing. At present, the proposed charges for transmission and distribution services are part of the overall tariff structure that this Task is designed to assess.

1.4.4 Pricing of Transmission Services

The financial model contains specific provisions for pricing transmission and generation. Distribution will be considered as a pass-through in the financial model.

1.4.5 Project Scenarios

In addition to the technical benefit scenarios discussed in the previous section, the financial analysis will contain explicit entries for the following management, pricing, and policy choices:

Reform activities – changes in the relative efficiency of implementation and operations (generally given as a percentage of fully successful implementation).

Generation scenarios – Not currently used but in future provide values for purchases/sales of electricity with GX segment, independent power producers, India.

Tariff scenarios

- Level of tariff
- Adjustment and achievement of cost coverage
- Export and import tariffs
- Possible separate transmission (wheeling) tariffs

Maintenance scenarios – best practice and Nepal "business as usual."

1.4.6 Findings and Results

The output of the financial model (see Table 18) will consist of the typical array of financial and technical measures of merit for the project. The key financial analysis results will include:

- Annual Revenue
- Annual O&M Costs
- Annual EBITDA
- Pre-Tax Income
- After-Tax Free Cash Flow[14]
- Project and NEA Unlevered FIRR (financial internal rate of return)
- Modified IRR (MIRR) or Financial Management Rate of Return
- Project Unlevered Pre-tax Net Present Value (NPV)
- After-Tax FIRR
- After-tax NPV.

The financial model will help the MCC to determine the pricing, borrowing, and operational conditions under which Nepal's electricity sector can be sustained financially on a longer-term basis. This means that the financial model will need to include activities that are not part of the MCC project, but for which the NEA will need to borrow and/or finance from its own cash flows. The FMRR shows the returns on the after-tax free

[14] Jack Welch, the legendary GE CEO, was a strong believer in free cash flow and required operating divisions of GE to return cash dividends to headquarters.

cash flow that NEA can expect given the WACC, the performance of the MCC investments, the tariff system and import/export prices contained in each scenario. For the Baseline conditions the financial results are consistent with the economic results, though more conservative in the case of the *NR1+XB1* package.

The earnings before interest, taxes, depreciation, and amortization (EBITDA) provide some picture of how the enterprise performs as an ongoing entity. If EBITDA is positive, then the enterprise can pay its operating expenses. These results indicate that the three economically feasible packages show positive PV EBITDA as well. At least one other, T8 is close to feasible

Table 18. Results for All Packages for Baseline Assumptions

Key Project Findings by Package: Generation & Demand = Base Case; Electricity Tariffs = Marginal Tariffs						
Package	**FIRR (FCF)**	**PV Net Income ($ US)**	**B/C**	**PV EBITDA**	**FMRR**	**PV FCF**
BC+NR1	#NUM!	(2,781,394,168)	0.371	(2,226,197,639)	-100.00%	(2,226,197,639)
BC+NR1+XB1	17.34%	1,474,115,403	1.202	1,167,226,989	14.32%	670,866,894
BC+NR1+XB1+T2'+T3	23.52%	2,529,827,701	1.334	2,079,235,216	17.00%	1,336,990,938
BC+NR3	#NUM!	(3,720,031,208)	0.203	(2,559,541,004)	-100.00%	(2,559,541,004)
BC+NR4	#NUM!	(3,755,306,861)	0.196	(2,568,508,519)	-100.00%	(2,568,508,519)
BC+T8	#NUM!	(524,915,190)	0.906	(398,744,062)	-100.00%	(398,744,062)
MCC	34.81%	4,789,118,884	1.574	4,186,334,223	19.83%	2,817,604,254
MCC-XB1	#NUM!	(1,715,898,068)	0.649	(1,615,904,089)	-100.00%	(1,615,904,089)

Note: Table title bar automatically accesses key scenario and parameter choices.
If EBITDA PV is negative then it is equivalent to the PV of free cash flow, of which there is none in such cases, since taxes and depreciation do not enter such calculations.
The PV Net Income measure is not equivalent to PVNB in economic analysis. Rather, it represents the present value of the net after tax income before depreciation addback.

"#NUM!" appears when Excel cannot calculate an EIRR, as when, for example, there are no positive benefit years, or the cash flow line crosses the 0 axis more than once.

1.4.7 Sensitivity to Changes in Parameters and Assumptions

As with the economic analysis, the financial results are sensitive to changes in NEA performance, prices for electricity, and costs of supply. Table 19 and Table 20 show how the financial results vary with NEA losses, tariffs, and other parameters.

Table 19: Optimistic Scenario

Key Project Findings by Package: Generation & Demand = High Gx; Electricity Tariffs = Marginal Tariffs						
Package	**FIRR (FCF)**	**PV Net Income ($ US)**	**B/C**	**PV EBITDA**	**FMRR**	**PV FCF**
BC+NR1	#NUM!	(2,807,084,072)	0.398	(2,243,744,189)	-100.00%	(2,243,744,189)
BC+NR1+XB1	23.35%	2,661,403,721	1.414	2,314,053,740	16.82%	1,481,800,790
BC+NR1+XB1+T2'+T3	33.26%	4,653,339,884	1.693	4,117,302,668	20.32%	2,787,378,331
BC+NR3	#NUM!	(4,275,019,575)	0.120	(2,938,605,526)	-100.00%	(2,938,605,526)
BC+NR4	#NUM!	(4,271,724,465)	0.120	(2,921,228,691)	-100.00%	(2,921,228,691)
BC+T8	67.42%	1,274,283,560	1.285	1,194,323,080	25.46%	830,132,894
MCC	49.94%	8,996,055,932	2.211	8,262,071,257	23.02%	5,690,998,863
MCC-XB1	#NUM!	(815,610,796)	0.790	(973,506,089)	-0.11%	(1,000,995,768)

Note: Table title bar automatically accesses key scenario and parameter choices.

"#NUM!" appears when Excel cannot calculate an EIRR, as when, for example, there are no positive benefit years, or the cash flow line crosses the 0 axis more than once.

The Optimistic scenario shows much higher FIRR results and substantial increases in free cash flow for the packages with positive FMRRs. The positive EBITDA means that NEA would be able to finance a greater share of its own expansion and ongoing system improvements. The *NR1+XB1* package, positive under Baseline conditions, becomes a bit more attractive with higher prices and greater supplies.[15]

With lower export prices, higher import prices, and a failure to reform the NEA tariff structure, only the *NR1+XB1+T2'+T3* package remains positive in terms of free cash flow. The *NR1+XB1* package cash flow turns slightly negative and *ALL MCC* is negative, with positive EBITDA in some years.

Table 20: Pessimistic Scenario

Key Project Findings by Package: Generation & Demand = Base Case; Electricity Tariffs = Low						
Package	**FIRR (FCF)**	**PV Net Income ($ US)**	**B/C**	**PV EBITDA**	**FMRR**	**PV FCF**
BC+NR1	#NUM!	(2,499,982,983)	0.430	(2,033,990,013)	-100.00%	(2,033,990,013)
BC+NR1+XB1	7.33%	196,930,694	1.004	24,133,673	9.04%	(201,467,447)
BC+NR1+XB1+T2'+T3	14.34%	1,088,464,138	1.107	713,965,490	12.94%	352,520,230
BC+NR3	#NUM!	(3,935,312,217)	0.172	(2,706,580,830)	-100.00%	(2,706,580,830)
BC+NR4	#NUM!	(4,010,596,152)	0.157	(2,742,874,540)	-100.00%	(2,742,874,540)
BC+T8	#NUM!	(1,897,100,214)	0.691	(1,335,964,896)	-100.00%	(1,335,964,896)

[15] The T8 package can be feasible, EIRR=59.8%, if it is the only way to increase exports to India and prices received are high.

Table 20: Pessimistic Scenario

Key Project Findings by Package: Generation & Demand = Base Case; Electricity Tariffs = Low						
Package	**FIRR (FCF)**	**PV Net Income ($ US)**	**B/C**	**PV EBITDA**	**FMRR**	**PV FCF**
MCC	-8.93%	(556,024,008)	0.851	(816,651,611)	-0.75%	(833,200,263)
MCC-XB1	#NUM!	(2,882,984,415)	0.483	(2,413,039,768)	-100.00%	(2,413,039,768)

Note: Table title bar automatically accesses key scenario and parameter choices.

"#NUM!" appears when Excel cannot calculate an EIRR, as when, for example, there are no positive benefit years, or the cash flow line crosses the 0 axis more than once.

1.4.8 Linkages to Other Tasks

This element is identical to the table of economic analysis linkages.

1.5 Results, Conclusions, and Recommendations

The findings and results of the economic and financial analyses provide some key indicators of MCC investment performance and how these proposed projects may fit into the country's overall electricity supply enhancement programs. The economic and financial results generally mirror each other with regard to the key factors influencing project assessments. These are:

- Domestic market integration is vital; most benefits come from greater supply to Nepali users, only one export-priority line, T8, is feasible under *some* conditions
- Prices matter – prices/valuations for new supply and load shedding relief are the most important factors in project performance
- NEA reform is vital – loss reduction, maintaining cost recovering tariffs, and negotiating good export transactions with India are critical to project outcomes; indeed, if Nepal can negotiate trading arrangements that allocate credit for supplying firm capacity in India to Nepal, and can avoid annual renewals that will expose the country increasingly to fuel price risk, the longer term arrangements, similar to those now under preparation by the U.S., may be highly beneficial;
- Some benefits of MCC's proposed projects may be attributable to others if the MCC projects are delayed or not built at all. If a generation expansion program can proceed *without* MCC's network lines, by using slack capacity in projects to be funded by World Bank, ADB, and others, and increase exports and domestic supplies, then returns for the MCC investments will be low
- Cash flow is critical – financial analysis shows that projects with large free cash flow under the Baseline conditions are quite resistant to pessimistic events in pricing, exports, and generation costs.

1.6 Way Forward

The two models should be modified as appropriate and their data updated so that each can play a continuing role in the monitoring and evaluation activities.[16] The financial model will be useful to assess ongoing NEA reforms and performance improvements. The model will also be useful to assess the adequacy of tariff reform in general and unbundling of tariffs in particular. A particular strength of the current financial model is its ability to quickly and accurately assess the impacts of prices on company performance, especially relevant when tariff reform is likely to remain both controversial and subject to MLA and MCC project conditionalities.

The financial model is a partial model. It does not provide a high level of detail on assets and liabilities for NEA overall. There is no inventory of NEA debt and the entry into service of new generation is not modeled in detail. However, the results of this model, when compared with more detailed NEA enterprise models, indicate a good degree of accuracy in the areas of the company that are treated in detail – namely, new investments in transmission, reductions in load shedding, and export and import of electricity. It would be useful for NEA if some of the parameter and scenario menus could be translated to the more detailed enterprise financial models.

The MCC economic model is likely to supersede the current Tetra Tech model. However, some of the features of the current approach can be useful in the MCC model. The project benefit sheet and its transfer of data to package sheets is critical to a straightforward implementation of changes in project specifications, a normal occurrence for MCC's power sector activities. The multi-attribute scenario menus allow the user to combine a series of assumptions about performance and pricing into a plausible set of circumstances, rather than simply dialing one parameter or another up and down.

Finally, both models point to what might be feasible with one or more of the packages in terms of modifications. For example, the T8 results show that trade oriented investments do not necessarily pay for Nepal if they are not integrated with domestic supply enhancements. However, a small increase in the T8 package's contribution of load shedding relief makes that project quite feasible. This could happen if the East-West line were upgraded. Other variations can also be tried out in the economic model to determine whether and to what extent certain technical approaches are worth trying, before a lot of money is spent on engineering and environmental studies.

[16] An approach to update and extend the two models was discussed with MCC on 2017.10.02, and agreement was reached on this particular matter.

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