

Annex 2

Economic Benefit Assessment of Financing Package 2

1 Assumptions and Conditions for Benefit-Cost Assessment

In this pre-feasibility study, benefit-cost analyses are carried out by comparing the economic benefits and costs in two cases, one “with project” and the other “without project.” Costs and benefits are estimated for each project group (1 to 5) of Financing Package 2 and analyses are also carried out respectively. The economic internal rate of return (EIRR) is used as the evaluation index, and the economic net present value (ENPV) and benefit-cost ratio (B/C) are also presented for reference.

Table 1 Indexes Used in Benefit-Cost Assessment

Index	Outline
EIRR	The discount rate by which the aggregate present values of economic benefits and costs are discounted to be equal
ENPV	Aggregate present values (which are discounted at given discount rate) of the yearly differences between economic benefits and costs
B/C	The aggregate present values (which are discounted at given discount rate) of economic benefits divided by the aggregate present values of economic costs.

1.1 Assumptions and Conditions for Estimation of Economic Benefits

In general, benefits of transmission expansion projects are represented by (i) increased electricity distribution, (ii) improved reliability, (iii) stabilized

system voltage and (iv) reduced system losses. To simplify the estimation, only direct and quantifiable benefits generated by the project are counted in this study.

The national electrification rate of Nigeria remains at only around 25%, and even in the already electrified areas, power supplies are absolutely short to cover the demands. Presently, families and manufacturers in the areas without access to electricity depend on the self-generation from diesel and petrol generators to gain the electric power. However, self-generation is much more costly than the electricity supply from the grid. By the implementation of the project, Nigerians are able to enjoy more electricity with lower cost.

These gaps between the price of self-generation and grid electricity are assumed as the economic benefit in "with project" case in this study. And at the same time, the projects, especially transmission lines, will occupy the lands which could be used for other purposes if the projects are not carried out. The economic values of those occupied lands are taken as the economic benefit of "without project" case. The economic benefit of "without case" will be deducted from the economic benefit of "with case" as same as the various costs of the projects. The assumptions of benefits in the "with case" and "without case" will be described in the following sections.

1.2 Economic Benefit of "With Case"

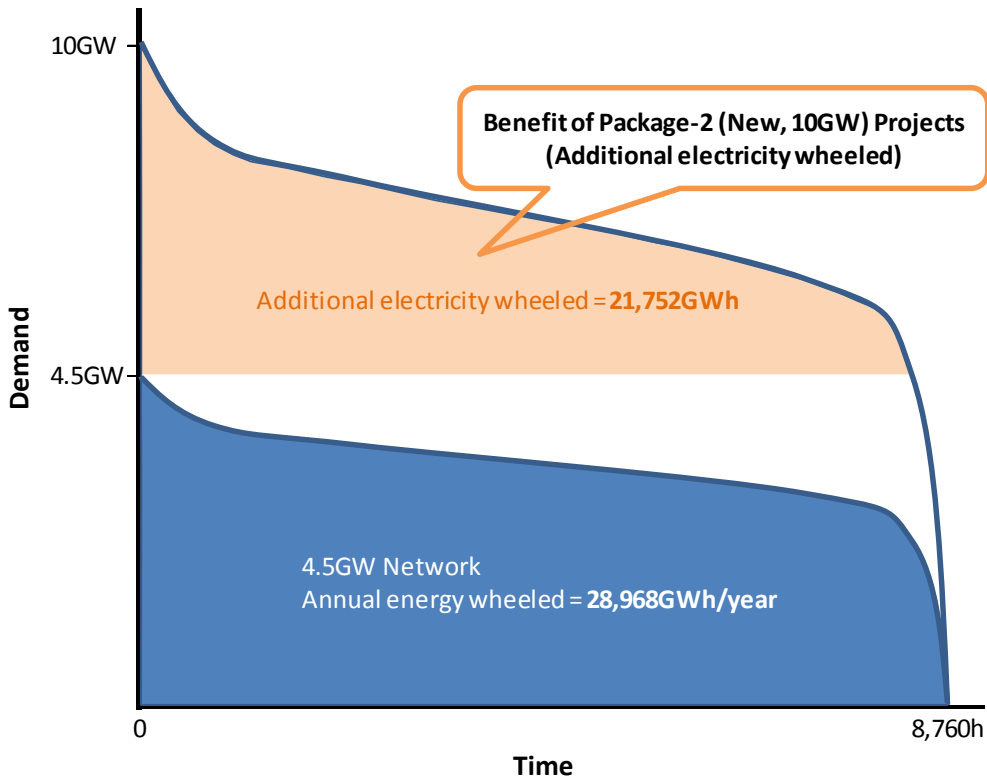
1.2.1 Estimation of Increased Annual Electricity

Increased amount of electricity by the projects is estimated under the following assumptions.

- Amount of wheeled electricity increased by the projects are estimated from the differences of 10 GW transmission capacity model (project package 2) and 4.5 GW transmission capacity model (current condition).
- Electricity demands in each project area of Group 1-5 are high enough to absorb whole increased volume of electricity generated by the projects from the 1st year of the operation (2019).
- Load factor is 70%.

Following figure shows the concept of increased amount of wheeled electricity by the projects.

Figure 1 Load Duration Curve of Nigerian Power System



Increased annual electricity wheeled in each Group is as follows.

Table 2 Increased Annual Electricity by Project Groups (GWh/year)

Group	Areas	Increased annual electricity
Group-1	Kainji-Birnin Kebbi-Gusau	5,253
Group-2	Lagos	9,510
Group-3	Jos-Gombe-Damaturu	2,256
Group-4	Awka-Ugwuaji-Jos	3,104
Group-5	Benin-Katampe	1,629
Total		21,752

1.2.2 Electricity Tariff

The Nigerian electricity industry is comprised of following three sectors: power generation companies, transmission company and distribution

companies. In evaluation of economic benefit, only the charges on the customers should be considered, therefore the charges of distribution companies were focused in the calculation. There are 11 distribution companies operating in each region, which are Abuja, Benin, Eko, Enugu, Ibadan, Ikeja, Jos, Kaduna, Kano, Port Harcourt and Yola. Distribution companies corresponding to each transmission project group are as follows.

Table 3 Corresponding Distribution Companies of Project Groups

Group	Distribution Company
Group-1	Kaduna, Kano
Group-2	Eko, Ibadan, Ikeja
Group-3	Jos, Yola
Group-4	Benin, Enugu
Group-5	Abuja, Benin

MYTO II was referred to calculate the tariffs of each distribution company, though it only settles the tariffs for up to 2016. The future tariffs from 2017 to 2046 were estimated under the assumption that the tariff rises annually by the average increasing rate of the tariffs from 2012 to 2016. Tariffs of distribution companies are varied by 14 categories of customer types. Future electricity consumption and customer populations by each category are estimated by the current values obtained from the final report of "National Load Demand Study (2009)" conducted by the Power Holding Company of Nigeria (PHCN).

1.2.3 Self-Generation Cost

The fuels such as diesel and petrol to operate the generators are to be the cost for the self-generation. N60/kWh which is indicated in the "Roadmap for Power Sector Reform (2010)" prepared by Nigerian Government was adopted in this study.

1.3 Economic Benefit of “Without Case”

1.3.1 Occupied Areas for Projects

At least 50m width of lands along the transmission lines should be seized for the exclusive use of the projects. Areas to be occupied with planned transmission lines in each project group are roughly estimated as presented in the following table.

Table 4 Estimated Occupied Areas (ha)

Group	Estimated Occupied Areas
Group-1	6,575
Group-2	4,240
Group-3	1,995
Group-4	5,630
Group-5	3,125

1.3.2 Economic Values of Lands

Economic values of lands are estimated based on the most likely purpose of land use in “without case”. Since as much as 70% of population engage in agriculture in Nigeria, the agricultural use is the most likely purpose for the lands. In this study, economic values of lands were evaluated based on the domestic market price of maize, which is the most prevailing cultivated crop in Nigeria. As for the yield of maize, cereal yield data of World Bank was alternatively used in this study. Assumption basis are as follows.

Table 5 Assumption Basis of Land Economic Value

Group	Estimated Occupied Areas
Domestic Market Price of Maize ¹⁾	92,593 NGN/1000kg
Cereal Yield (2012) ²⁾	1,363kg/ha

Source: 1) West-African Market Information Network¹ 2) World Bank

¹ <http://www.resimao.org/html>

2 Assumptions and Conditions for Estimation of Economic Costs

2.1 Initial Investment Cost

Initial investment costs of each group are as follows.

Table 6 Estimated Initial Investment Cost of Project

Group	Initial Investment Cost (million USD)
Group-1	438
Group-2	548
Group-3	246
Group-4	618
Group-5	385
Total	2,235

To conduct the cost-benefit analysis, project costs should be converted into economic values with consideration of the existence of shadow rates such as minimum wages of unskilled labour. In this study, 0.95 was adopted as the standard conversion factor into the economic cost according to the final report of "WAPP North Core 330 kV Project" conducted by PHCN in 2007.

2.2 O&M Cost

O&M cost was settled as 1% of the initial investment cost for the transmission lines and 1.5% for the substations according to the report of "WAPP North Core 330 kV Project".

3 Benefit-Cost Analysis Results

3.1 General Assumptions

General assumptions of the analysis are presented as follows.

Table 7 General Assumptions for Economic Analysis

Element	Value
Analysis Period	2017–2046 (30 years)
Construction Period	2014–2016 (3 years) Initial investment costs were allocated 70% for the 1 st year of construction, 20% for the 2 nd year, 10% for the 3 rd year.
Residual Value	10% of construction cost
Discount rate to evaluate ENPV and B/C	12% (settled with reference to the monetary policy rate of FGN and previous studies carried by TCN)
Exchange Rate	1 USD = 158.228 NGN

3.2 Benefit Cost Results

Results of benefit-cost assessment are presented in the following table.

Table 8 Results of Benefit-Cost Assessment

Group	EIRR	ENPV (million USD)	B/C	ENPV/C
Group-1	23.94%	637	2.35	1.35
Group-2	37.92%	2293	5.07	4.07
Group-3	20.92%	261	2.03	1.03
Group-4	16.36%	299	1.47	0.47
Group-5	17.60%	245	1.62	0.62

Group 2 scores the highest EIRR of 37.92% and one of the reasons of it is because the project areas of Group 2 are located in Lagos and its surrounding areas, which are most densely populated areas in this country, therefore potential demands and expected increased electricity compared to the project costs are relatively high. Overall, EIRR of all groups are higher than the provided discount rate of 12%. It means that the economic benefits overtake

the opportunity costs of the capital. Hence, all project groups can be assessed as economically valid judged from the results of benefit-cost analyses.

3.3 Sensitivity Analysis Results

Table 9 presents the results of sensitive analyses which were carried out by re-assessment of EIRRs under the assumptions of $\pm 10\%$, $\pm 20\%$ of initial investment cost and benefit respectively. Results are as follows.

Table 9 Results of Sensitivity Analysis of Benefit-Cost Assessment

Group	Project Cost				Benefit			
	-20%	-10%	+10%	+20%	-20%	-10%	+10%	+20%
Group-1	27.83%	25.72%	22.41%	21.08%	20.25%	22.14%	25.66%	27.31%
Group-2	43.50%	40.48%	35.72%	33.81%	32.82%	35.44%	40.29%	42.56%
Group-3	24.39%	22.51%	19.56%	18.39%	17.73%	19.37%	22.41%	23.84%
Group-4	19.17%	17.64%	15.25%	14.28%	13.71%	15.07%	17.58%	18.76%
Group-5	20.59%	18.96%	16.42%	15.40%	14.82%	16.25%	18.89%	20.13%

Even in the sensitive analyses, evaluated EIRRs are all exceeding 12% and indicating the validity of the projects from the economic viewpoint. EIRRs of Group 1 and 2 secure 20% at lowest and it can be said these project groups are robust enough from the economic aspect. EIRRs of Group 4 and 5 mark the lower values: 13.71% of Group 4 and 14.82% of Group 5, the values just above the discount rate 12%. Both are resulted from the analyses with -20% benefits. In implementation of Group 4 and 5, the economic benefit as well as costs should be re-assessed carefully.