Financing Rural Energy Projects in China: Lessons for Nigeria

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Abstract

In this paper, we conduct a financial analysis of a typically viable and unviable World Bank supported hydroelectric projects in China and draw inferences for Nigeria by conducting similar analysis with a classic Nigerian economic and financial environments. The analysis of the hypothetical cash-flow shows that while a similar project is feasible and viable in Nigeria, there is need for a price regime that can adjust annual price increase to offset the impact of inflation as the project appears very sensitive to inflation rates. Several other pros and cons of the Chinese projects were highlighted as lessons other developing countries like Nigeria.

Keywords: Financing, Cash flow, China, Developing countries, Energy, Hydroelectric, Inflation, Nigeria

1. Introduction

Without new policy interventions, IEA (2010) points out that about one billion people will still lack accessto electricity by the year 2030 andthe challenges pose by available financing options are as great as the problem of energy access itself. While the rate of rural electrification and indeed access has increased globally in recent times, the number of people without access to energy worldwide has not declined significantly in absolute term. This implies that supply is rising faster than demand and is not unconnected with financial, technical and skilled human resource constraints

The economic and infrastructural disparities between the rural and urban communities of most developing countries, coupled with the responsibilities and policy objectives of their governments to provide basic societal needs and infrastructure, ensure social equity and eradicate poverty, have been the major drivers of rural energy projects. However, due to high capital requirements and long gestation periods of energy projects, it is imperative for governments to embark on a sustainable plan of action to ensure financial security in carrying out such projects. Therefore, there is need for market reforms, incentives, and favourable business environment to stir competition in the private sector, as well as effective government regulation to bring about efficient implementation

The contributions of electrification especially in rural areas to both human and economic development are well documented in the literature (see World Bank 2008 and NRECA 2002). Aside the direct connection with poverty suppression (Gunaratne 2002a), there are several other associated socio – economic benefits (ESMAP 2002; Yang and Yu 2004). However, despite these economic and social benefits, there is a considerable degree of contention about the financial viability of rural electrification. There are little or no market enticements for typical profit maximising private businesses to venture into rural energy financing and this has indeed spur quite a number of studies on how developing countries can attract private players into rural energy projects particularly through privatisation and commercialisation and other government's legislation (see Reiche et al. 2000; Haanyika 2006 and ARE (Note1) 2009).However, available evidence indicates that little attention have been paid to how developing countries can draw comparative experience from other developing countries by showcasing how, why and what

characterises (un)successful projects. We intend to fill this gap.

China presents a good example of a developing country that has successfully embarked on rural electrification and energy projects over the last few decades and achieved a great feat of 99% electrification rate (IEA 2009). Therefore, the purpose of this research is to find out how China's rural energy projects were financed, if such projects achieved financial viability and how? How the source of finance affected the projects? How funding was sustained? And what various instruments were used to guarantee the success of the projects?

The methodology applied here involves looking at specific projects (both successful and failed) and performing some financial analysis to see why they succeeded or failed financially, then carrying out a comparative analysis with Nigeria's case to see the feasibility and viability of adopting such projects in Nigeria.

This rest of the paper is organized as follows: following this introduction is section 2, which discusses issues relating to financing rural energy projects in china, while section 3 analyses the methodology employed and presents the data. The results are discussed; lessons drawn and recommendations are made in section 4 while section 5 concludes the paper.

2. Financing Rural Energy Projects in China

China basically has about four financing channels for rural energy projects which include Commercial banks and non-bank financial institutions; International funding; Government finance; and Public stock markets.

Although, the commercial banks are seen to be largely involved in providing private sector lending to the Chinese public, they have not been very active in providing finance to rural energy projects. The reason for this is the high risk and low profit margins that may be associated to these energy loans. With a developed rural banking infrastructure, the links between these banks and the rural energy renewable sector in supporting some of these rural projects is still weak.

TheInternational Funding arrangement involves bilateral and multilateral organisations financing some rural energy renewable projects. Among these organisations are The World Bank, The African Development Bank, The European Union Institutions, just to mention a few. It is important to note that before funding is given, these projects would usually meet some certain guidelines and standards from the financier, and must be appealing to the financier. Among the numerous international funded rural energy renewable projects in China are the solar Village Project, Clean energy research project, Wind Power Project in China's Hubei.

Government Finance represents the most common form of financing rural renewable energy projects in China. The Government of China through the China's State Development and Planning Commission in 2001 launched the Song Dian Dao Xiang programme which was purely a rural based renewable electrification project, with the whole of objective of electrifying different townships in China. This project provided electricity to over 1000 villages in nine different townships with over a million people gaining access. This was made possible with the provision of $240 million by the government to subsidise the cost of the equipment. This project has been tagged one of the largest renewable energy rural electrification project to have deployed modern renewable energy technology in providing electricity to a rural populace.

Lastly, the stock exchanges in China are beginning to open up to renewable energies. This is because about over 23 renewable energy companies have been listed on the floor of both stock exchanges. As discussed earlier, the Chinese stock exchanges as we have seen have the potentials of bringing the necessary support to rural renewable energy projects.

Aside these institutions, China use an array of financial instruments to execute rural energy projects. A financial instrument is a contract between two parties which give rise to a financial resource (asset) to one party and simultaneously an obligation (a liability) to the other party. In executing rural renewable energy projects in China the following financial Instruments are available:

- Low Interest and Long term loans: The Chinese government have over the years provided specific low interest loans for rural energy development For example, Loans granted for the execution of large and medium biogas projects, wind and solar projects by the government all have interest rates which is almost half the interest rates obtainable on similar projects at a commercial rate.
- The establishment of Joint ventures: The setting up of Zhonghang (Boading) Huiteng wind power Equipment Company limited in China by a United States Company Tang Energy Group limited is a good example of a joint venture. This company has therefore been a leading manufacturer of blades for wind turbine generators. Many Chinese wind farms have benefitted from the sale of this machinery.

- Private Equity/Venture Capital: Funding from both private equity and venture capital are really on the increase in China. Haung (2008) said in 2006, there was a private equity investment of about $100million used for the expansion of wind technologies production, while about $403 million came from venture capital financing. These venture capital investments were all channelled into wind, solar and biomass development.
- Grants: Some renewable energy project in China is offered cash grants for each system installed upon the provision of the certification of installation. A good example is the payment of a cash grant of $100 to a solar home system dealer.
- Asset Financing: Wind projects are very popular for asset financing in China and China is said to be the 3rd largest location for asset financing after the United States and Spain.
- Subsidies: The provision of subsidies by the Chinese central and local government has actually aided the research and development of technologies for the promotion of renewable energies in the rural areas.
- Value Added Tax Reduction: To encourage the production of renewable energies in China, the government has decided to lower the VAT on renewable energy equipment rather than charge the normal 17% commercial VAT rate. The VAT charged are as follows: biogas-3%, wind power- 8.5%, and small hydro-3% (Haung, 2008)

3. Financial Appraisal of Energy Projects in China

3.1 Ertan I Hydroelectric Project

China's demand for electricity grew rapidly due to industrialisation and better living standards. Shortages of electricity in Sichuan province, location of the Ertan I Hydroelectric Project, were a major hindrance to economic development and improving standards of living. China has abundant supply of coals but to meet power shortages from thermal power plants alone would increase pollution drastically. The power generated by the Ertan I Hydroelectric Project not only reduced the power shortages but also was better than coal-fired thermal power plants in terms of pollution and impact on the environment.

The basic objectives of the project were to alleviate power shortages in the Sichuan province; assist in transferring modern power technology to China (Ertan I, 1997); assist in analysing environmental impacts of hydroelectric projects; and to aid institutional development of the Ertan Hydroelectric Development Corporation- the owner of the power project.

The project met its objective of reducing power shortages in Sichuan by adding a clean-energy capacity of 3,300 MW. The project was also successful in transferring technology for dam and power station construction through participation of international experts, training programs for local people and project studies (Ertan I, 1997). The project's success in analysing the environmental impact of hydroelectric projects was achieved through monitoring meteorological, sedimentation and water quality aspects of the projects and the outcome was satisfactory. Finally, the institutional development aspect of the Ertan Hydroelectric Development Corporation was also largely met as it was established as a commercially independent power producer with a Board of Directors to monitor and implement corporate governance. This gives the company more independence and allows it to function with less political interference.

3.1.1 Financing the Project

Six 550 MW generating units were installed. The number of people to be resettled increased significantly from the initial estimate of around 30,000 to over 45,000 thereby increasing the resettlement budget by over 255% (Ertan I, 1997).

The actual costs were $941.9 million in foreign costs and Yuan 10,653.9 million in local costs, equivalent to a total of $2,282.4 million (Ertan I, 1997). This was 21 percent higher in USD and 60 percent higher in Yuan than the estimated price (Ertan I, 1997). The main reasons for higher actual costs were the higher than anticipated inflation rates and devaluation of Yuan (Ertan I, 1997). Also, higher resettlement costs contributed to the massive increase in local costs.

$780.0 million (25.4% of the total actual cost of $3,068 million) was financed by loan from the World Bank (Ertan I, 1997). The World Bank also gave guarantees for $150 million which helped in raising finance from international financial institutions at lower cost (Ertan I, 1997). The World Bank loan and loan guarantees gave more credibility to the project as foreign institutional lenders were assured of completion of the project and repayment of loans.

The Government of China and Sichuan provinces gave loans of $803 million each (Ertan I, 1997). These loans comprised 52% of total costs. Total equity was $478 million - 15.6% of the total cost (Ertan I, 1997).

3.1.2 Financial Appraisal

The total project life is 37 years including 7 years for the construction work. The project was started in 1991 and is expected to last till 2027. Appendix I shows the cash flows of the project over its expected lifetime. Payback period method calculates the time required to recover initial cost from operating cash flows (Brigham and Houston, 2007, p. 373). The cumulative cash flows turn positive in 2002, 12^{th} year of the project. Payback period = 11 + (-Cumulative cash flow till 11^{th} year / Net cash flows in the 12^{th} year) = 11 + (5,433.3 / 5,438.0) = 12 years.

This is lower than the project life and hence the project is viable under the payback period method. However, the payback period method has flaws. It does not take into account the time value of money which is a major hindrance when evaluating projects similar to Ertan I that have very long project life. This drawback is overcome in the net present value method which discounts future cash flows by a discount rate that appropriately reflects the risks of the investment. The cost of capital was 12% (Ertan I, 1997). Discounting the net cash flows of the project gives a net present value of Yuan 5,845 million. The project assumes USD: Yuan conversion rate of 8.3. This conversion rate gives a NPV of $704 million. This shows that the project is financially viable.

The IRR of the project is 16.09%. This is significantly higher than the cost of capital and hence the project is financially viable. Adding economic benefits of positive environment impact will further increase the NPV and IRR of the project.

3.2 Ertan II Hydroelectric Project

Sichuan province in China faced massive power shortages in the last quarter of the twentieth century (Ertan II, 2002). Ertan II hydroelectric power plant was commissioned to eradicate power shortages in Sichuan. This green-energy plant will save about 6.3 million tons of coal annually (Ertan II, 2002). There would be further economic benefits in terms of irrigation and controlling floods.

The project objectives were designed to increase the supply and competition in the power sector in an environmentally friendly manner. Apart from alleviating power shortages in the Sichuan province and developing the Ertan Hydroelectric Development Company as a commercially viable company, it is designed to increasing competition in the power supply market and explores new financing strategies for power development in China.

The project fully met its objective of eliminating power shortages in Sichuan. It added a clean-energy capacity of 3,300 MW with an annual energy output of 17 TWh (Ertan II, 2002). However, the objective of a commercially and financially sound venture was only partially met because of lower sales and prices. This has restricted company's ability to raise finances for future investments.

The elimination of power shortages increased competition and resulted in the closure of inefficient power plants. However, a fully developed market could not be achieved due to government's interference. The fourth objective of establishing new financing mechanisms was achieved as a number of sources including offshore lending and Chinese commercial banks and investment companies were used in financing the project. Overall, objectives were satisfactorily met.

3.2.1 Financing of the Project

Dam and powerhouse were completed and commissioned ahead of schedule. Six 550 MW generating units were installed (Ertan II, 2002). This is a major achievement considering most big industrial projects are delayed. The number of people to be resettled increased significantly and the Government of China had to increase resettlement budget.

The estimated cost was $2,200 million equivalent, of which $930 million were in foreign costs and $1,270 million in local costs (Ertan II, 2002). The actual costs were $2,601 million, an increase of over 18% from the estimated cost. The actual costs were made of $984.2 million in foreign costs and $1,616.8 million in local costs (Ertan II, 2002). This excludes interest of $928.9 million during the construction phase (Ertan II, 2002). The interest increased disproportionately as the increase in the construction costs was funded by a higher proportion of debt.

$779.85 million (30% of the actual cost) was financed by loan from the World Bank (Ertan II, 2002). The World Bank also gave guarantees for $150 million to the international financial institutions. The State Development Bank of China financed 31% of the actual cost (Ertan II, 2002). Commercial banks financed 31% and share of equity was 8% (Ertan II, 2002). The funding gap between planned and actual was sustained by the State Development Bank which gave additional loan than planned to meet the shortage in the funding.

3.2.2 Financial Appraisal

The total project life is 57 years including 7 years for construction works. The project was started in 1991 and is expected to last till 2047. Appendix II shows the cash flows of the project over its expected lifetime. From 2004 onwards, sales increase by the annual rate of inflation of 2%. The net cash flows are calculated after subtracting capital investment, operating cost, sales and incomes taxes from revenues.

The cumulative cash flows turn positive in 2009, 19th year of the project. Payback period = 18 + (-Cumulative cash flow till 18th year / Net cash flows in the 19th year) = 18 + (2,442.9 / 2,479) = 18.98 years. This is lower than the project life and hence the project is viable under the payback period method. The cost of capital was 10 percent (Ertan II, 2002, p. 11). Discounting the net cash flows of the projects gives a net present value of Yuan -4,581 million. The project assumes a USD to Yuan conversion rate of 8.28. This conversion rate gives a NPV of -$553 million. This shows that the project is financially unviable.

The IRR of the project is 7.56%. This is significantly lower than the cost of capital and hence the project is financially unviable. With 34.1 fen/kWh price agreed by the government from 2006, the IRR would be 9.2%. Though this is still lower than the cost of capital, it is much closer to the cost of capital. This shows the key role played by governments in power purchase and prices.

The rate of return will increase by 2 percent if environmental effects are added which will increase returns over the cost of capital (Ertan II, 2002). However, it is difficult to quantify and measure environmental benefits.

3.3 Analysis of Hypothetical Hydroelectric Project in Nigeria

It is proposed to construct a 1,100 MW – one-third of the Ertan II capacity - hydroelectric power plant in Nigeria. The costs of the proposed plant will be one-third of the Ertan II adjusted for the inflation since 1997. The local prices in Nigeria, according to IMF – International Financial Statistics, 2009 increased by 331% since 1998 and if we assume a 3% annual inflation in the developed countries, the foreign costs since 1998 increased by 46.8%.

Appendix III shows the inflation increases applied to the respective local and foreign costs to Ertan II. It shows the overall costs increased by 224% since 1998. This is applied to each year's cost in case of Nigeria. The cost is then divided by one-third to reflect the smaller size of the proposed plant in Nigeria.Appendix IV shows the cash flows of the proposed project. It assumes that the number of people to be resettled in Nigeria will be similar to those in the Ertan project. Any changes in the number of people resettled will have a significant impact on the total costs as resettlement costs are a major proportion of total costs.

Future annual inflation is estimated at 11.0% based on the average of the past five years. It is also closer to the average of the 1998-2010 annual inflation rates. Energy price is Nigerian Naira 8.50 kW/h in 2010 (Akinbajo, I. 2010). The operating & maintenance costs are of same proportion as in Ertan II. The sales tax and income tax are 5% and 30% respectively (Nigerian tax rates). A Chinese Yuan: Nigerian Naira conversion rate of 22.69 was applied (Yahoo Finance, 2010).

The discount rate used for projects in China in mid 1990s was 10%. The interest rates have since come down significantly due to the global credit crunch. So the current discount rate should be lower now in China. However, the risks of implementing a project in Nigeria are different from those in China. In addition to the risks associated with a large scale project, Nigeria has additional risks that were either absent or very low in China. Nigeria ranks among the top countries in terms of corruption and World Bank had noted that the funds may not be used in a transparent and accountable way (Fadama, 2008). The World Bank has also noted the lack of expertise and accountability in implementing large size projects and rates this as a substantial risk (Fadama, 2008). The accountability is also reflected in poor quality of audit reports submitted in previous World Bank projects. The higher corruption and implementation risk in Nigeria will be reflected in the higher discount rate as compared to those prevalent in China now. Sambo et al. (2006) had assumed a discount rate of 10% for non-nuclear power projects in Nigeria. The same rate will be assumed for discounting the proposed hydroelectric project in Nigeria.

The project has a positive NPV of Nigerian Naira of 624,482 million. This is a positive NPV and shows Nigeria should go ahead with the project.

4. Results and Analysis

The main reason behind the non-viability of the Ertan II project was the significant jump in the initial investment. The costs increased due to higher than anticipated increase in the inflation in China which significantly increased the local costs. The higher inflation in costs was not reflected in the higher price of power sold as power price agreement was entered before completion of the project. Also, the sales price in a year should reflect inflation in that year to

recoup higher operating costs. Removing inflation from future sale prices would reduce the Ertan II's IRR by approximately 1% (Ertan II, 2002). Increasing electricity prices by a high inflation of 11% has resulted in the positive NPV of the project in Nigeria.

Shareholders injected less than 50% of their commitment in Ertan II (Ertan II, 2002). Paid-in capital accounted for only 8% of the total cost as against a target of 18.5% (Ertan II, 2002). The increase in costs was funded by increase in debt only. This significantly increased the proportion of debt in the overall capital structure and hence disproportionately increased the interest costs during construction even higher. This increased the overall costs and made the project unviable. If similar situation were to happen in Nigeria, the chances of turning the positive NPV project into a negative NPV project will increase.

Appendix V shows the sensitivity analysis. The project in Nigeria is more sensitive to changes in the inflation rate and hence a minimum annual price hike should be agreed to guarantee a positive NPV.

4.1 Lessons, Policy Implications and Recommendations

From the foregoing, we can observe that there is a host of ambivalences in financing rural energy projects in China, which are attributable to a couple of factors. This sub-section x-rays those factors to draw lessons for Nigeria.

Firstly, results from our cash flow analysis shows that inflation could have a strong influence on rural energy projects, as higher than anticipated inflation during the construction phase of a project can turn a positive NPV project into a negative NPV project. Hence, it is very important to negotiate power sale prices in a way that will fully reflect the inflation during the construction phase, so as to be able to cushion its effect in constructing the project.

Secondly, given the large scale nature of energy projects, long gestation period and capital intensiveness, it is vital to limit cost and time delays because of lower returns on the utility projects, since large scale projects are prone to suffer cost and time overruns. Nigeria will have to take extra steps to manage the project in a transparent way to limit cost increases. Costs also increase due to resettlement as often the number of people to be resettled come out much higher than the initial estimate. Nigeria should plan properly to limit increase in the resettlement costs.

Thirdly, financial viability of the project is likely to be affected by funding. Shareholders injected less than 50% of their commitment in Ertan II project, which increased the interest and overall costs. Any proposed project in Nigeria should structure the funding agreement in such a way that the share of equity remains stable even if costs increase.

Also, from this study, we observe that China was able to make tremendous progress in its rural electrification stride due to a combination of factors/forces, which includes; the political will and resolve of government, financial aid, subsidies, and incentives for investors, all of which allowed the rural electrification projects in China to succeed. Thus, in replicating the Chinese approach to rural electrification in Nigeria, the right dose and mix of a combination of the aforementioned factors, needs to be harmonized and adopted to enhance rural electrification in Nigeria.

In addition to a well decentralization approach of the Chinese experience of rural energy projects, it is observed that the Central Government of China went into a host of partnerships with the various provinces and local communities, private energy companies, state owned donor agencies such as Bank of China and international donor agencies such as the World Bank, Which gave impetus and sped up the rural electrification programmes of China. However, it should be noted that the Chinese Government embarked on such partnerships on a least cost basis, under a strict and well-coordinated process that was transparent and accountable to all parties involved, which built trust and allowed the projects to succeed.

Thus, Nigeria which was ranked the 134th most corrupt country in the world (Note 2) will, in order to attract investments into the energy sector need to curb this corruption perception by building strong anti-corruption institutions/ government and allowing for the tenets of due process, rule of law, transparency and accountability to reign, so as to be able to build confidence/trust of foreign private investors and international donor agencies.

However, it is also worthy of note that the success story of China’s rural electrification programmes would not be complete without the improvements in the economic lives of the rural communities, which was brought about by liberalisation of agriculture and the economy to allow private participation and enterprise. This led to an increased income earning power for the rural communities, and attracted more private investments in the energy sector as investments became viable in the rural communities. At the moment, the rural communities in Nigeria are not attractive for private investments in energy infrastructure as the current energy prices obtainable are still heavily subsidized by government making investments unviable. Thus, government needs to create the enabling environment to allow economic activities thrive, which would increase the earning powers of the rural folks, thereby allowing investments to flow in.

On the other hand, the accelerated rural electrification drive of China presented a number of challenges and predicaments as seen in multiple tariff regimes at different tiers of government, duplicity of responsibilities by various energy agencies, unclear pricing policy, low power consumption in rural areas, inadequate funding and high maintenance costs, use of unsuitable materials, vague mechanisms for calculating subsidies and uncertainty about the reliability of technologies used. More so, issues relating to operation and maintenance of systems in the long-term, monopoly of supply system in the counties and convoluted administrative structure also constituted obstacles to rural electrification in China.

5. Conclusion

This study sheds more light on how the central government of China with sheer political will and doggedness, used a pragmatic approach of decentralizing the decision-making apparatus of government and liberalizing economic activities in rural areas amongst others to bring about increased investments in energy infrastructural projects thereby, increasing access to energy services in the rural communities.

Results from the analysis of a hypothetical hydro-electric project in Nigeria after requisite adjustments to suite the Nigerian economic environment, shows that a similar hydro-electric project such as the World Bank assisted one in China is viable in Nigeria. However, the sensitivity analysis carried out in the study shows that the project is more sensitive to inflation. Thus, a provision for a slight price increase should be allowed annually to offset the impact of inflation and allow for viability of energy projects.

Finally, it is worthy of mention that the cash-flow methodology employed in this study attempted to provide answers to the aforementioned research questions, which the study did to a large extent in spite of the dearth of data and information from the People's Republic of China. It is suggested that future works in this area especially those involving hydro-electric projects should strive to incorporate the impact of seasonal variations in output due to water level changes in the analysis, as well as changes in costs due to delays, revenue variations due to tariff control by the state, and consider using probabilistic analysis to make the NPV stochastic rather than deterministic.

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Notes

Note 1. Alliance for Rural Electrification

Note 2. Transparency International Corruption Index 2010

Appendices

Appendix I. Ertan I hydroelectric project

Year	Investment	Revenue	Operating & Maintenance cost	Net cashflow	Cumulative net cashflow	Discounted cashflow
1991	1,128.3	0.0	0.0	-1,128.3	-1,128.3	-1,007.4
1992	3,194.0	0.0	0.0	-3,194.0	-4,322.3	-2,546.2
1993	1,472.9	0.0	0.0	-1,472.9	-5,795.1	-1,048.4
1994	1,510.3	0.0	0.0	-1,510.3	-7,305.5	-959.8
1995	1,786.4	0.0	0.0	-1,786.4	-9,091.9	-1,013.7
1996	3,791.5	0.0	0.0	-3,791.5	-12,883.4	-1,920.9
1997	4,486.3	0.0	0.0	-4,486.3	-17,369.7	-2,029.4
1998	1,472.6	419.3	188.4	-1,241.7	-18,611.4	-501.5
1999	523.8	3,511.2	193.7	2,793.7	-15,817.7	1,007.4
2000	128.6	5,345.6	195.0	5,022.1	-10,795.7	1,617.0
2001	0.0	5,557.3	195.0	5,362.4	-5,433.3	1,541.5
2002	0.0	5,632.9	195.0	5,438.0	4.6	1,395.8
2003	0.0	5,563.9	195.0	5,369.0	5,373.6	1,230.4
2004	0.0	5,560.0	195.0	5,365.1	10,738.7	1,097.8
2005	0.0	5,624.9	195.0	5,430.0	16,168.6	992.0
2006	0.0	5,596.8	195.0	5,401.9	21,570.5	881.2
2007	0.0	5,785.9	195.0	5,591.0	27,161.4	814.3
2008	0.0	5,800.1	195.0	5,605.2	32,766.6	728.9
2009	0.0	5,643.6	195.0	5,448.7	38,215.2	632.6
2010	0.0	6,145.9	195.0	5,951.0	44,166.2	616.9
2011	0.0	6,145.9	195.0	5,951.0	50,117.1	550.8
2012	0.0	6,145.9	195.0	5,951.0	56,068.1	491.8
2013	0.0	6,145.9	195.0	5,951.0	62,019.0	439.1
2014	0.0	6,145.9	195.0	5,951.0	67,970.0	392.1
2015	0.0	6,145.9	195.0	5,951.0	73,920.9	350.1
2016	0.0	6,145.9	195.0	5,951.0	79,871.9	312.5
2017	0.0	6,145.9	195.0	5,951.0	85,822.8	279.1
2018	3.6	6,145.9	195.0	5,947.4	91,770.2	249.0
2019	79.6	6,145.9	195.0	5,871.4	97,641.5	219.5
2020	58.5	6,145.9	195.0	5,892.5	103,534.0	196.7
2021	321.3	6,145.9	195.0	5,629.7	109,163.6	167.8
2022	1,331.2	6,145.9	195.0	4,619.8	113,783.4	122.9
2023	455.7	6,145.9	195.0	5,495.3	119,278.6	130.6
2024	503.8	6,145.9	195.0	5,447.2	124,725.8	115.5
2025	193.1	6,145.9	195.0	5,757.9	130,483.6	109.1
2026	0.0	6,145.9	195.0	5,951.0	136,434.6	100.6
2027	0.0	6,145.9	195.0	5,951.0	142,385.5	89.9
	22,441.5	170,667.7	5,840.7	142,385.5	1,732,601.3	5,845.6

(Source: Ertan I, 1997, p. 31)

Appendix II. Ertan I hydroelectric project

Year	Investment	Revenue	Operating cost	Sales tax	Income tax	Cashflow after tax	Cumulative cashflow after tax	Discounted cashflow after tax
1991	2,655.5	0.0	0.0	0.0	0.0	-2,655.5	-2,655.5	-2,414.1
1992	1,889.5	0.0	0.0	0.0	0.0	-1,889.5	-4,545.0	-1,561.6
1993	1,840.2	0.0	0.0	0.0	0.0	-1,840.2	-6,385.2	-1,382.6
1994	1,723.7	0.0	0.0	0.0	0.0	-1,723.7	-8,108.9	-1,177.3
1995	2,145.3	0.0	0.0	0.0	0.0	-2,145.3	-10,254.2	-1,332.1
1996	3,751.6	0.0	0.0	0.0	0.0	-3,751.6	-14,005.8	-2,117.7
1997	5,527.9	0.0	0.0	0.0	0.0	-5,527.9	-19,533.7	-2,836.7
1998	2,337.8	118.6	19.9	2.8	0.0	-2,241.9	-21,775.6	-1,045.9
1999	1,482.0	775.0	79.9	18.4	0.0	-805.3	-22,580.9	-341.5
2000	969.7	1,469.7	129.7	35.0	0.0	335.3	-22,245.6	129.3
2001	0.0	2,300.7	250.0	54.8	0.0	1,995.9	-20,249.7	699.6
2002	0.0	2,745.3	243.2	65.4	0.0	2,436.7	-17,813.0	776.4
2003	0.0	2,800.2	248.1	66.7	0.0	2,485.4	-15,327.6	719.9
2004	0.0	2,856.2	253.0	68.0	0.0	2,535.2	-12,792.4	667.6
2005	0.0	2,913.3	258.1	69.4	0.0	2,585.8	-10,206.5	619.0
2006	0.0	2,971.6	263.3	70.8	0.0	2,637.6	-7,569.0	574.0
2007	0.0	3,031.0	268.5	72.2	38.7	2,651.6	-4,917.3	524.6
2008	0.0	3,091.6	273.9	73.6	269.7	2,474.4	-2,442.9	445.0
2009	0.0	3,153.5	279.4	75.1	320.0	2,479.0	36.1	405.3
2010	0.0	3,216.5	285.0	76.6	380.2	2,474.8	2,510.9	367.9
2011	0.0	3,280.9	290.7	78.1	447.9	2,464.2	4,975.1	333.0
2012	0.0	3,346.5	296.5	79.7	494.8	2,475.5	7,450.6	304.1
2013	0.0	3,413.4	302.4	81.3	540.8	2,488.9	9,939.5	278.0
2014	0.0	3,481.7	308.5	82.9	587.4	2,502.9	12,442.5	254.1
2015	0.0	3,551.3	314.6	84.6	634.8	2,517.3	14,959.8	232.3
2016	0.0	3,622.4	320.9	86.3	686.8	2,528.4	17,488.2	212.1
2017	0.0	3,694.8	327.3	88.0	730.7	2,548.8	20,037.0	194.4
2018	3.6	3,768.7	333.9	89.7	772.2	2,569.3	22,606.2	178.2
2019	79.6	3,844.1	340.6	91.5	810.3	2,522.1	25,128.3	159.0
2020	58.5	3,921.0	347.4	93.4	845.8	2,575.9	27,704.2	147.6
2021	321.3	3,999.4	354.3	95.2	879.2	2,349.3	30,053.5	122.4
2022	1,331.2	4,079.4	361.4	97.1	904.5	1,385.1	31,438.6	65.6
2023	455.7	4,160.9	368.6	99.1	930.3	2,307.2	33,745.9	99.3
2024	503.8	4,244.2	376.0	101.1	956.6	2,306.7	36,052.6	90.3
2025	193.1	4,329.1	383.5	103.1	983.4	2,665.9	38,718.5	94.9
2026	0.0	4,415.6	391.2	105.2	1,010.8	2,908.5	41,627.0	94.1
2027	0.0	4,503.9	399.0	107.3	1,379.0	2,618.7	44,245.7	77.0
2028	0.0	4,594.0	407.0	109.4	1,407.4	2,670.2	46,915.9	71.4
2029	0.0	4,685.9	415.1	111.6	1,436.5	2,722.7	49,638.6	66.2
2030	0.0	4,779.6	423.4	113.8	1,466.1	2,776.3	52,414.8	61.3
2031	0.0	4,875.2	431.9	116.1	1,496.4	2,830.8	55,245.6	56.9
2032	0.0	4,972.7	440.5	118.4	1,527.2	2,886.6	58,132.2	52.7
2033	0.0	5,072.2	449.4	120.8	1,558.6	2,943.4	61,075.6	48.9
2034	0.0	5,173.6	458.3	123.2	1,590.7	3,001.4	64,077.0	45.3
2035	0.0	5,277.1	467.5	125.7	1,623.4	3,060.5	67,137.5	42.0
2036	0.0	5,382.6	476.9	128.2	1,656.8	3,120.8	70,258.3	38.9
2037	0.0	5,490.3	486.4	130.7	1,690.8	3,182.3	73,440.6	36.1
2038	0.0	5,600.1	496.1	133.4	1,725.6	3,245.0	76,685.6	33.4
2039	0.0	5,712.1	506.1	136.0	1,761.0	3,309.0	79,994.6	31.0
2040	0.0	5,826.3	516.2	138.8	1,797.1	3,374.3	83,368.9	28.7
2041	0.0	5,942.9	526.5	141.5	1,833.9	3,440.9	86,809.9	26.6
2042	0.0	6,061.7	537.0	144.4	1,871.5	3,508.8	90,318.7	24.7
2043	0.0	6,183.0	547.8	147.2	1,909.9	3,578.0	93,896.7	22.9
2044	0.0	6,306.6	558.7	150.2	1,949.0	3,648.7	97,545.4	21.2
2045	0.0	6,432.7	569.9	153.2	1,988.8	3,720.9	101,266.3	19.7
2046	0.0	6,561.4	581.3	156.3	2,029.5	3,794.4	105,060.6	18.2
2047	0.0	6,692.6	592.9	159.4	2,071.0	3,869.3	108,930.0	16.9
	27,270.0	208,723.3	18,557.7	4,970.5	48,995.1	108,930.0	1,719,963.9	-4,581.1

(Source: Ertan II, 2002, p. 36)

Appendix III. 1998 to 2010 inflation data

	Costs, $ m	Weight of costs	Inflation multiplier	Cost adjustment
Foreign	984.2	37.8%	1.469	0.556
Local	1616.8	62.2%	4.319	2.685
	2601			3.241

(Source: International Monetary Fund, Annual IFS series (Nigeria) July 2009).

Appendix IV. Hypothetical hydroelectric project in Nigeria

Year	Investment	Electricity price NGN/kWh	Revenue	Operating cost	Sales tax	Income tax	Cashflow after tax	Cumulative cashflow after tax	Discounted cashflow after tax
2011	65,087		0	0	0	0	-65,087	-65,087	-59,170
2012	46,312		0	0	0	0	-46,312	-111,400	-38,275
2013	45,104		0	0	0	0	-45,104	-156,504	-33,887
2014	42,248		0	0	0	0	-42,248	-198,752	-28,856
2015	52,582		0	0	0	0	-52,582	-251,334	-32,649
2016	91,953		0	0	0	0	-91,953	-343,287	-51,905
2017	135,491		0	0	0	0	-135,491	-478,778	-69,528
2018	57,300	8.5	1,527	135	76	395	-56,379	-535,157	-26,301
2019	36,324	9.4	11,079	980	554	2,863	-29,643	-564,800	-12,572
2020	23,768	10.5	23,321	2,064	1,166	6,027	-9,704	-574,504	-3,741
2021	0	11.6	40,523	3,586	2,026	10,473	24,438	-550,067	8,565
2022	0	12.9	53,673	4,750	2,684	13,872	32,368	-517,699	10,313
2023	0	14.3	60,769	5,378	3,038	15,706	36,646	-481,053	10,615
2024	0	15.9	68,802	6,089	3,440	17,782	41,491	-439,561	10,926
2025	0	17.6	77,898	6,894	3,895	20,133	46,976	-392,585	11,246
2026	0	19.6	88,196	7,805	4,410	22,794	53,187	-339,399	11,575
2027	0	21.7	99,855	8,837	4,993	25,808	60,218	-279,181	11,914
2028	0	24.1	113,056	10,005	5,653	29,219	68,179	-211,002	12,263
2029	0	26.8	128,002	11,328	6,400	33,082	77,192	-133,810	12,621
2030	0	29.7	144,924	12,826	7,246	37,456	87,397	-46,414	12,991
2031	0	33.0	164,083	14,521	8,204	42,407	98,950	52,537	13,371
2032	0	36.6	185,775	16,441	9,289	48,014	112,032	164,568	13,763
2033	0	40.7	210,334	18,615	10,517	54,361	126,842	291,410	14,166
2034	0	45.1	238,141	21,075	11,907	61,547	143,611	435,021	14,580
2035	0	50.1	269,623	23,862	13,481	69,684	162,596	597,617	15,007
2036	0	55.6	305,267	27,016	15,263	78,896	184,091	781,708	15,446
2037	0	61.7	345,623	30,588	17,281	89,326	208,428	990,137	15,898
2038	88	68.5	391,315	34,631	19,566	101,135	235,894	1,226,031	16,358
2039	1,951	76.1	443,047	39,210	22,152	114,505	265,228	1,491,259	16,720
2040	1,434	84.4	501,617	44,393	25,081	129,643	301,066	1,792,325	17,254

Year	Investment	Electricity price NGN/kWh	Revenue	Operating cost	Sales tax	Income tax	Cashflow after tax	Cumulative cashflow after tax	Discounted cashflow after tax
2041	7,875	93.7	567,931	50,262	28,397	146,782	334,616	2,126,941	17,433
2042	32,628	104.0	643,012	56,907	32,151	166,186	355,140	2,482,081	16,820
2043	11,169	115.5	728,018	64,430	36,401	188,156	427,862	2,909,943	18,422
2044	12,348	128.2	824,262	72,947	41,213	213,030	484,723	3,394,665	18,973
2045	4,733	142.3	933,229	82,591	46,661	241,193	558,051	3,952,716	19,858
2046	0	157.9	1,056,602	93,509	52,830	273,079	637,184	4,589,900	20,612
2047	0	175.3	1,196,285	105,871	59,814	309,180	721,419	5,311,319	21,216
2048	0	194.6	1,354,434	119,867	67,722	350,053	816,791	6,128,111	21,837
2049	0	216.0	1,533,490	135,714	76,674	396,330	924,771	7,052,882	22,476
2050	0	239.7	1,736,217	153,655	86,811	448,725	1,047,026	8,099,907	23,134
2051	0	266.1	1,965,745	173,968	98,287	508,047	1,185,442	9,285,350	23,811
2052	0	295.4	2,225,616	196,967	111,281	575,211	1,342,158	10,627,508	24,508
2053	0	327.9	2,519,843	223,006	125,992	651,253	1,519,591	12,147,099	25,226
2054	0	364.0	2,852,966	252,487	142,648	737,349	1,720,481	13,867,580	25,964
2055	0	404.0	3,230,128	285,866	161,506	834,827	1,947,929	15,815,509	26,724
2056	0	448.4	3,657,151	323,658	182,858	945,191	2,205,445	18,020,954	27,506
2057	0	497.8	4,140,626	366,445	207,031	1,070,145	2,497,005	20,517,958	28,312
2058	0	552.5	4,688,017	414,890	234,401	1,211,618	2,827,109	23,345,067	29,140
2059	0	613.3	5,307,773	469,738	265,389	1,371,794	3,200,853	26,545,920	29,993
2060	0	680.7	6,009,461	531,837	300,473	1,553,145	3,624,005	30,169,925	30,871
2061	0	755.6	6,803,912	602,146	340,196	1,758,471	4,103,099	34,273,024	31,775
2062	0	838.7	7,703,389	681,750	385,169	1,990,941	4,645,528	38,918,553	32,705
2063	0	931.0	8,721,777	771,877	436,089	2,254,143	5,259,667	44,178,220	33,662
2064	0	1,033.4	9,874,795	873,919	493,740	2,552,141	5,954,995	50,133,215	34,648
2065	0	1,147.1	11,180,243	989,452	559,012	2,889,534	6,742,246	56,875,461	35,662
2066	0	1,273.3	12,658,272	1,120,257	632,914	3,271,530	7,633,571	64,509,032	36,706
2067	0	1,413.3	14,331,695	1,268,355	716,585	3,704,027	8,642,729	73,151,761	37,781
	668,397		122,411,339	10,833,403	6,120,567	31,637,210	73,151,761	589,582,840	624,482

Appendix V. Sensitivity analysis

Cost overrun	-10%	0%	10%	20%	30%	40%	50%
NPV	661,369	624,482	587,595	550,708	513,821	476,934	440,047

Inflation	2%	4%	6%	8%	10%	12%	14%
NPV	-192,469	-136,090	-41,685	123,607	424,253	988,000	2,069,565

Note: NPV here is expressed in Millions of Nigerian Naira