Environmental Protection and Compensation Costs for the Yali Hydropower Plant in Vietnam

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EXECUTIVE SUMMARY

The Yali Hydropower Plant (YHPP) is located on the Sesan River in the West Highlands of Vietnam's Central region. It has an installed capacity of 720 MW and an energy output of 3,600 GWh per annum. Construction of the plant began in 1993 and was completed in 2000. Inundation of the reservoir led to the flooding of 1,933 ha agriculture-based land and the relocation of 1,149 households living in 26 villages.

In published environmental and financial studies of YHPP, the original financial analysis ignored a wide range of environmental costs in determining the most important indices of financial viability namely, its net present value and electricity price. As a result, the full cost of hydropower generation scheme is understated. Thus the calculated price charged for electricity generated by the plant did not cover the full cost of electricity production, and the estimated net present value of the plant did not reflect its real value.

The purpose of this study is to estimate the monetary value of the main environmental protection and compensation costs of YHPP and to incorporate them into the financial viability indices of the plant, namely its net present value and electricity price.

The study was carried out through the following steps:

Analyze environmental data from published environmental impact assessments of YHPP and undertake additional on-site surveys where necessary.

Estimate the costs of preventing and mitigating environmental impacts and those of compensation for the relocation and resettlement of residents affected by the plant.

Incorporate these costs into the main indices of financial viability of the plant, namely its net present value and electricity price.

Recommend polices that would apply the principles of full-cost pricing and user pays for environmental costs in pricing the electricity generated by YHPP. This should ensure sufficient revenue to cover all costs of electricity generation, including environmental protection and compensation costs.

The central assumption of the study is that the ecosystem and its inhabitants should be restored to the state of environment and health that they enjoyed before the dam was constructed. The present study has not attempted a cost-benefit analysis of any of the

mitigation measures to see whether or not the benefits the people and ecosystems would receive are large enough to justify the cost of mitigation.

It was found that if the electricity price is kept at its original level of 5.2 US cents/kWh to cover direct costs only, the net present value of the plant would be reduced to about 27% by incorporating environmental costs. Alternatively, the electricity price would have to be increased to 5.68 US cents/kWh in order to cover the full costs of YHPP and to maintain the original net present value.

The main policy recommendations are:

Government regulations should require that the financial analysis and appraisal of all future electricity sources include the full cost of these schemes, including not only direct costs but also environmental costs related to preventing or mitigating the environmental impact caused by them.

The electricity pricing policy applied to all future electric power sources should be based on the principles of full cost pricing and user pays for environmental costs caused by them. This should be applied to all fuels and energy sources, not only hydro-electricity. Among other things, this will encourage electricity consumers to implement energy saving measures and to eradicate the current subsidized electricity pricing mechanism of the electricity sector.

An appropriate financial mechanism should be established to allocate the revenue from full cost electricity pricing to a fund to cover the environmental protection and compensation costs.

1.0 INTRODUCTION

1.1 Background and Rationale of the Study

The Yali Hydropower Plant (YHPP) ranks second among the electricity sources of Vietnamese unified national electricity system. This is because of its great electricity potential, high financial viability and favorable plant location for cheap electricity in supplying the central and southern part of Vietnam and for ensuring the stability of running the whole electricity network of the country.

The YHPP is located on Sesan River in the western highland of Central Vietnam where the Thuong ethnic minority tribes live. These tribes have low incomes and special customs and habits. The plant has an installed capacity of 720 MW and an electricity generation of 3,600 GWh per annum. This is about 10 % of the total electricity production forecasts for the country in the year 2010 (Institute of Energy 1998). The plant construction began in the year 1993 and was completed in April 2002 with an earth fill dam of 12,457,000 m^3 embankment volume and a reservoir of 64.8 km^2 surface and 1,037 Mm^3 gross capacities. This caused the inundation of 26 villages, the relocation of 1,149 households (with 5,384 inhabitants) and the loss of about 6,000 ha of agriculture and forestry-based land.

The project area is sited in the western highlands of Central Vietnam at altitudes of 350 m to 1,700 m. The hydropower plant is constructed just at Yali Falls on the Sesan River. After completing the dam embankment, the Yali Falls with their scenic splendors were destroyed.

The dam is earth fill, with a crest elevation of 520 m, upstream slope of 1:5 and downstream slope of 1:2. The spillway has an overflow crest elevation of 500m. Its peak outflow discharge at 1,000 years probable flood is 10,500 m^3/sec and maximum reservoir water level is 527.2 m. The catchment area is 7,445 km^2 .The average annual rainfall is 2,200 mm per annum and runoff is 8,515 million m^3 per annum. The total construction cost was USD 614.78 million. The plant lifespan of YHPP is forecasted to be 48 years (1993 - 2040).

In order to meet plant-related environmental concerns, the environmental impacts of the plant was fully assessed qualitatively and partially estimated quantitatively in previous environmental studies by the Mekong Secretariat and Ministry of Energy. However, these studies ignored a wide range of environmental protection and compensation costs. Because these were not incorporated into the direct costs of the plant, the full cost of hydropower production was understated.

This study provides a comprehensive assessment of the main environmental protection and compensation costs of YHPP and incorporates them into its net present value (NPV) and electricity price (p).

This study did not attempt a cost-benefit analysis of any of the mitigation measures to see whether it is of benefit to the people and whether the ecosystems are large enough to justify the costs of these measures. Our assumption is simply that the ecosystems should be returned to an approximation of its pre-dam state. Failing that, compensation should be provided to the people who are directly affected.

1.2 Objectives

1. To identify and value the environmental costs of YHPP.

To determine the full cost of YHPP by incorporating environmental costs into the direct costs of its hydropower production.

To apply the principles of full cost electricity pricing and electricity user pays for YHPP environmental costs and to estimate the financial effects of applying these principles on YHPP's net present value and electricity price.

To recommend policies and to apply these principles to electricity generation in Vietnam.

1.3 Methodology

Information was first collected from published sources about the physical impacts of YHPP (Mekong Secretariat and Ministry of Energy 1992; PIDC 1 1994; Francisco and Glover 1999). In particular, it drew on the impact assessments in the original Environmental and Financial Studies by the Mekong Secretariat and the Vietnamese Ministry of Energy.

This was supplemented by on-site surveys in a few cases. Twelve impacts were assessed: meteorology, hydrology, water supply, erosion and sedimentation, land-use, forestry, watershed management, fauna, water quality and aquatic life, induced seismicity, public health, compensation and resettlement. Monetary values for each were estimated using procedures described in 2.0. Valuation of Environmental Protection and Compensation Costs

We then incorporated the monetized environmental costs into the direct costs of hydropower production of the plant in order to determine its full cost

$C_{ft} = C_{dt} + C_{et}$

in which:

C_{ft} Full cost in year t of the plant

C_{dt} Direct cost in year t of the plant that consists of investment cost and operation – management - amortization cost

C_{et} Environmental cost in year t of the plant that consists of its environmental protection and compensation cost

The C_{dt} of YHPP was calculated in the original financial study for the plant, while the C_{et} was valued by this study, considering the twelve environmental factors as follows:

$$C_{et} = \sum_{k=1}^{12} C_{ekt}$$

in which:

C_{ekt} Environmental cost related to the environmental factor k in year t

We then determined the net present value (NPV) of the plant using two assumptions: with and without incorporating the environmental costs into the direct costs of the plant on condition that its direct cost-based price p is kept at the original level of 5.2 US cents/kWh (this electricity price is formally defined by electricity authorities for YHPP).

- Without incorporated YHPP environmental costs:

$$NPV_d = \sum_{t=1}^{N} (pQ - C_{dt})(1+i)^{-t};$$

- With incorporated YHPP environmental costs:

$$NPV_f = \sum_{t=1}^{N} (pQ - C_{dt} - C_{et})(1+i)^{-t};$$

in which:

p Direct cost - based electricity price

Q Annual electricity quantity generated by the plant

N Plant life of 48 years (1993 - 2040)

i Standardized discount rates for the Vietnamese electricity sector (8%;10%; 12%)

We also explored a scenario in which the NPV was kept at its original value, while the electricity price was increased to a level that would allow incorporation of environmental costs. The full cost-based electricity price p' is determined by solving the following equation:

$$\sum_{t=1}^{N} (pQ - C_{dt})(1+i)^{-t} = \sum_{t=1}^{N} (p'Q - C_{dt} - C_{et})(1+i)^{-t}$$

Finally, we drew from this analysis some recommendations for full-cost electricity pricing for YHPP and for Vietnam in general.

2.0 VALUATION OF ENVIRONMENTAL PROTECTION AND COMPENSATION COSTS

2.1 Meteorology

There is a negligible impact on the climate of the catchment area through the increase in local humidity. The only mitigation measure required is monitoring equipment valued at USD 2,000 and disbursed entirely in 1993.

2.2 Hydrology

No significant adverse environmental effects are identified and no mitigation measures are required. However, existing monitoring stations need to be expanded and supplemented with new stations to improve flood warning and water level recording. This equipment would cost USD 350,455 disbursed over five years from 1993 to 1997, (i.e. USD 350,445 = 5 × USD 71,091).

2.3 Water Supply

There is no significant harmful effect on water supplies either for domestic consumption or for agriculture in the catchments, so no mitigation measures are required.

However, the future growth of demand for irrigation water in the catchments will reduce runoff, and thus the YHPP's energy generation will be reduced by about 2% per annum. This effect is assessed through estimating the foregone revenue caused by the reduction of electricity generation:

5.2 US cents /kWh × 2% × 2,726 GWh/year = USD 2,862,546/year.

This environmental cost is allocated over the period from 2001 (when all of four electricity generation units of the plant are functioning) to 2040, the last year of the plant's lifespan.

2.4 Erosion and Sedimentation

Estimated reservoir sedimentation is about 2.0 million m^3/year, half of which can be expected to penetrate deep into the reservoir's dead storage. This can lead to the reduction in lifespan storage of the reservoir of about 1% per year. Delta formation and flooding of Kontum town by an additional backwater effect could also occur. None of these three effects would have drastic consequences. Some reservoir bank erosion could occur at its west bank and near the dam. Mitigation of erosion and sedimentation can be accomplished through the measures described in Section 2.7, such as protecting the reservoir's shoreline by a forest belt and limiting agricultural activities and habitation.

In this section, we include a cost of USD 1,000/year as the cost of monitoring these measures.

2.5 Land Use

Due to the construction of YHPP, a change in land use in the reservoir area occurred. The total area permanently and seasonally flooded by the reservoir is 6,400 ha, of which 1,700 ha of permanently flooded area and 4,700 ha of seasonally flooded area have considerable potential for agricultural production and forestry. This total flooded area of 6,400 ha comprises 1,200 ha of agricultural land, 700 ha of forestry land, 3,600 ha of uncultivated land and 900 ha of other land.

The loss of agricultural production value by flooding is estimated at USD 166,273 per annum. This loss is allocated annually from 2001 to 2040. The cost of a study on the irrigation potential of a semi-impounded area is estimated at about USD 7,688. The cost of realizing a pilot scheme on soil conservation and sedentarization of agriculture is estimated at USD 90,000.

The cost of monitoring the land use status is estimated at USD 655 per annum.

The total costs of the above USD 7,688 and USD 90,000 is as allocated for the period from 1993 to 2000, i.e. the land-use related annual environmental cost, is $\left(\frac{7{,}688 + 90{,}000}{8} + 655\right) = 12{,}866$ USD/year.

In addition, two costs possibly attributed to land use change have been assessed elsewhere. Compensation for the loss of home-gardens flooded by reservoir is estimated in the discussion in Section 2.12 (Compensation and Resettlement) as a component of the total compensation for the relocated population. Compensation for forestry land flooded by reservoir is estimated and discussed in Section 2.7 (Watershed Management).

2.6 Forestry

During the construction phase of the plant, after completing the dam embankment in the project area, a forestry area of 3,944 ha was lost due to the reservoir's flooding. This flooded forest area includes 114 ha of high value forests, 161 ha of medium value bamboo forests and 3,669 ha of degraded mixed forests.

After building the powerhouse, access roads, and quarry sites etc., in the downstream area, 150 ha of high value forests were destroyed. The following losses are significant:

Loss of annual timber extraction from the flooded high and medium value forest area of 425 ha (114 ha + 161 ha + 150 ha = 425 ha) (Bann 1998)

Loss of annual timber extraction from the flooded degraded forest area of 3,669 ha (Bann 1998)

Loss of local households' income from exploitation of non-timber forest products of flooded forest areas.

Costs of forming protection forests by replanting degraded forests and protection against fire and illegal logging. These forestry-related activities were from an independent program for forestry development in western highlands' areas in order to compensate for the forest areas flooded by the YHPP reservoir.

The forestry - related environmental costs are estimated on the basis of the following data:

The annual timber extraction figure per hectare of rich and medium forest in Gia Lai and Kontum provinces is estimated at 54.63 m^3/ha/year (Mekong Secretariat and Ministry of Energy 1992 Vol. II).

The annual timber extraction figure per hectare of degraded (poor) forests in Gia Lai and Kontum provinces is estimated at 8-12 m^3/ha/year. These are estimated from interviews with senior forestry specialists of Gia Lai and Kontum provinces.

The average annual income from exploiting non-timber forest products by local households is estimated at USD 155/household/year. These are estimated from household surveys in similar parts of Vietnam (Mekong Secretariat and Ministry of Energy 1992; Francisco and Glover 1999).

The costs of the program of afforestation, reforestation, re-planting and forest protection are estimated by the environmental management and monitoring plan for YHPP project (Mekong Secretariat and Ministry of Energy 1992 Vol. IV).

The average unit sale price of timber in Gia Lai and Kontum provinces is USD 17.05 /m^3 (Mekong Secretariat and Ministry of Energy 1992 Vol. V: (Annex 7 – Table 7-4)

Estimated monetary values for the area in question are as follows:

1. Loss of annual timber extraction from flooded forest area of 425 ha:
(114 ha + 161 ha + 150 ha = 425 ha). USD 396,115/year

2. Loss of annual timber extraction from flooded degraded forest areas of 3,669 ha:
USD 618,255/year

3. Loss of local households' income from exploiting non-timber forest products:
USD 98,739/year

4. Costs of the forestry development program in areas located near YHPP in order to compensate for the forest areas flooded by the reservoir of the plant:

a. During eight years (1993-2000) of construction phase: USD 177,024 /year

b. During the first 10 years (2001-2010) of operation phase: USD 339,909 /year

2.7 Watershed Management

Watershed management requires a set of measures for the development and reform of forestry and agriculture as well as the environmental protection and monitoring within the YHPP project area. These costs would be realized during the construction phase (1993-2000) and the first 10 years of YHPP operation phase (2001- 2010) (Mekong Secretariat and Ministry of Energy 1992 Vol. IV). These estimated costs are as follows:

a. During the construction phase (1993-2000): USD 45,455/8year
or USD 5,688/year.

b. During the operation phase (2001-2010): USD 84,500/10 year
or USD 8,450/year.

c. Additional replanting (1993-1997): USD 1,111/year.

2.8 Fauna

The protection of indigenous fauna within the YHPP catchment area is considered as an important part of the watershed management. For the project area, it is necessary to create and preserve the reservoir shoreline wetland vegetation (i.e. the semi - impounded vegetation belt) for protecting the reservoir's shore, which are shelters for indigenous fauna.

The total fauna protection-related cost is estimated at USD 300,000, allocated principally for the construction phase of 8 years from 1993 to 2000 (USD 37,500 per annum).

2.9 Water Quality, Aquatic Life and Fisheries

Due to the small storage and short retention time of the Sesan River water within the YHPP reservoir, there is little danger of oxygen depletion and negligible negative effects on the quality of out-flowing water. At the same time, the change from running river water with low nutrient content to stagnant reservoir water may slightly increase the number of fish species and other fauna.

Environmental costs are preventive expenditures for monitoring and managing the water quality through additional instruments to analyze its temperature, pH, oxygen content etc. and for developing new fishing systems after reservoir filling. This sum in 2001 is allocated as listed below:

a)	Additional instruments for analyzing water quality	USD 3,000
b)	Development of new reservoir fishing infrastructure	USD 7,600
	Total:	USD10,600

2.10 Reservoir-induced Seismicity

The environmental costs relating to reservoir-induced seismicity are the preventive expenditures for investigating and monitoring the reservoir-induced seismic hazards at the dam site. The costs of an up to date micro-seismic network recommended for YHPP are estimated at USD 64,890 disbursed over 5 years (1993-1997), i.e. USD 12,978 per annum.

2.11 Public Health and Water-borne Diseases

In general, due to the change from running river water to stagnant reservoir water and the considerable resettlement by forming the YHPP reservoir, there is the possibility of mass development of disease vectors and the increasing exposure of the local population to these vectors. These can lead to diseases like malaria, diarrhea, dysentery and intestinal parasitic diseases.

Preventive and curative health care for affected local population consist of the following items:

1.	Building of four new village health stations	USD 24,000
2.	Renovation of eight existing health centers	USD 77,334
	Total public health - related new investment costs	USD 101,334

This cost is disbursed during the YHPP construction phase from 1993 to 2000, i.e. the public health - related annual new investment cost is USD 12,677/year.

3.	Running of 12 preventive medicine programs	USD 1,982,667/year

4. Realizing the popular health education program USD 662,800/year

Total operation and management costs of these programs USD 2,645,467/year

This total operation and management costs is allocated for the first 10 years of the YHPP operation phase, i.e. from 2001 to 2010.

(References for Section 2.1 to 2.11: Mekong Secretariat and Ministry of Energy 1992; Vol. II, IV and V).

2.12 Compensation and Resettlement

The total relocated population consists of 1,149 households with 5,384 inhabitants living in 846 houses in 26 villages, amongst which are 10 fully flooded villages and 16 partially flooded ones. The public infrastructures affected by YHPP reservoir are: 6.8 km of provincial road; 25.6 km of rural road; four small bridges; five culverts; 6.8 km of telephone lines and several houses, schools, crèches, health care stations, shops and offices of people's committees. The agricultural area affected by reservoir flooding is 1,933 ha. These are planted with rice, auxiliary crops and perennial trees.

There are two alternatives for the estimation of compensation and resettlement- related costs:

Alternative 1. This is purely based on the compensation cost only, which is defined according to the Decree No. 90/CP of the Government. The relocated households and local authorities of flooded communes could use these compensation payments to build themselves new housing in the resettlement area. Using this alternative, the compensation and resettlement - related costs consist of the following items:

A.	Resettlement expenditures used to compensate for property losses only	USD 16,132,243
B.	Clearing of trees in reservoir bed	USD 992,734
C.	Cost of afforestation	USD 445,332
	Total (A + B + C)	USD 17,570,309

Alternative 2. This adds the costs of building infrastructure in the new resettlement areas:

Resettlement expenditures not only to compensate for property losses but also for building new complete resettlement areas USD 26,373,339

B.	Clearing of trees in reservoir bed	USD 992,734
C.	Cost of afforestation	USD 445,332
	Total (A + B + C)	USD 27,811,405

Alternative 2 has been selected as the preferred one although its costs are greater because resettlement would be more thorough. (It would include construction of infrastructure like the irrigation, and allow compensation for disruption and loss of intangible assets.)

The compensation and resettlement-related costs of USD 27,811,405 are assumed to be allocated for the period from 1993 to 1997 (USD 5,562,281 per annum).

(References for Section 2.12: PIDC 1 1994; People's Committee of Kontum Province 1994).

2.13 Other Effects

In addition, four other effects were investigated. They were found to be of negligible magnitude. These are vegetation, groundwater, mineral and radioactive deposits, and archeological/recreational sites.

2.14 Results

The major environmental costs of Yali Hydropower Plant are summarized and discounted with standardized discount rates of 8%, 10% and 12% for the whole plant lifespan from 1993 to 2040. These values are presented in Table 3 below and analyzed in section 3.0 (Net Present Value and Electricity Price With and Without Environmental Costs).

Table 1. Environmental Costs of Yali Hydropower Plant

No.	*Environmental Factor*	*Standardized Discount Rate*					
		8%		*10%*		*12%*	
		Discounted Environ-mental Cost USD	*Percentage in total*	*Discounted Environ-mental Cost USD*	*Percentage in total*	*Discounted Environ-mental Cost USD*	*Percentage in total*
1	Meteorology	1,852	-	1,818	-	1,786	-
2	Hydrology	283,846	0.3	269,491	0.5	256,267	0.5
3	Water Supply	16,705,411	22.7	11,829,276	19.9	8,633,456	17.4
4	Erosion and Sedimentation	6,422	-	4,562	-	3,330	-
5	Land Use	1,145,151	1.6	827,177	1.5	617,524	1.3
6	Forestry	15,814,862	21.5	12,933,116	21.8	10,889,128	22.1
7	Watershed Management	64,085	-.	55,276	-	48,200	-
8	Fauna	215,499	0.3	200,060	0.4	186,287	0.4
9	Water Quality	5,303	-.	4,495	-	3,822	-.
10	Reservoir-induced Seismicity	51,817	-	49,197	-	46,783	-
11	Public Health	17,116,222	23.3	12,136,208	20.4	8,871,073	17.9
12	Compensation and Resettlement	22,208,617	30.3	21,085,461	35.5	20,050,807	40.4
	Total	73,619,087	100.0	59,396,137	100.0	49,608,465	100.0

The largest single item is compensation and resettlement, which accounts for about one-third of environmental costs. Effects on forestry, water supply and public health are also significant, each accounting for about one-fifth of the costs. Together, these account for over 97% of YHPP's environmental costs.

3.0 NET PRESENT VALUE AND ELECTRICITY PRICE WITH AND WITHOUT ENVIRONMENTAL COSTS

The NPV and the electricity price (p) are the two most important financial criteria that are used for estimating the financial viability of electric power plants in Vietnam. For YHPP, these criteria are considerably influenced by incorporating the environmental costs into the direct costs of the plant to determine its full costs.

In this section, the NPV and p are calculated on the basis of formulae presented in Section 1 for the following cases:

Original case: without incorporating the YHPP environmental costs into the costs of the plant; its electricity price is kept at the original level p of 5.2 US cents /kWh.

This is the original case of the YHPP original financial appraisal with its direct cost - based net present value NPV_d and electricity price p (See formulae presented in Section 1.3).

2. Case 1: with incorporating the YHPP environmental costs into the direct costs of the plant but maintaining the electricity price at the original level p of 5.2 US cents/kWh. In this case, the YHPP's net present value and thus its financial viability is decreased.

3. Case 2: with incorporating the YHPP environmental costs into the direct costs of the plant while increasing the electricity price of the plant so that its net present value, that is, its financial viability is kept unchanged at the original level of NPV_d (See formulae presented in Section 1.3).

Table 2. Effects of Incorporating Environmental Costs on YHPP's Net Present Value and Electricity Price

Case	*Original*	*1*	*2*
Assumptions of calculations	- Without incorporated YHPP environmental costs. - Direct cost - based electricity price (original) of 5.2 US cents/kWh. - Original net present value (NPV_d).	- With incorporated YHPP environmental costs; - Direct cost - based electricity price (original) of 5.2 US cents/kWh. - Decreased net present value (NPV_f).	- With incorporated YHPP environmental costs; - Full cost – based electricity price (increased) - Original net present value (NPV_d).
NPV (USD)	NPV_d = 219,520,140	NPV_f = 160,124,000	NPV_d = 219,520,140
p (US cents/kWh)	p = 5.20	p = 5.20	p' = 5.68

Note: Using the standardized discount rate of 10%. See Appendix 2.

In the YHPP's original financial appraisal, the environmental costs of the plant were not considered or incorporated into its costs. This means that the net present value NPV_d = USD 219,520,140 and the electricity price p = 5.2 US cents/kWh mentioned in this financial appraisal are only the direct cost - based ones.

If environmental costs of the plant are incorporated while its electricity price is kept unchanged at the original value of p = 5.2 US cents/ kWh, the net present value is decreased to NPV_f = USD 160,124,000.

If the net present value of the plant is maintained at NPV_d = USD 219,520,140 while its environmental costs are incorporated, the electricity price needs to be increased to p' = 5.68 US cents.

4.0 POLICY RECOMMENDATIONS

In the past, the government of Vietnam had heavily subsidized electricity production. In recent years, it has declared its intention to eliminate these subsidies partially because of the burden they imposed on the treasury. It is also believed that subsidizing electricity consumption encourages excessive use and thus increases the environmental damages that result from power generation.

As a result of this policy change, electricity prices were increased three times between 1986 and 2000 until they reached the current level. For YHPP, this is 5.2 US cents/kWh. In spite of these increases, subsidization still occurs.

This study recommends that electricity pricing should be revised, not only to eliminate direct government subsidies, but also to incorporate the environmental costs of electricity production. Current pricing policies do not achieve this. Environmental costs may not be explicitly recognized, but they are still paid. They come in the form of damages to health and ecosystems, or relocation of affected people, and are most often paid by vulnerable groups and future generations.

Incorporating these costs in the price of electricity would have several advantages. These are:

a. It would make environmental costs more visible, and thus more pressure will be exerted to minimize them.

b. It would implement the widely accepted principle of “polluter pays”, making it possible to assign the payment of environmental costs to the activities that generate these costs.

c. If applied to all forms of power generation, it would provide appropriate incentives for the generation of environmentally-friendly energy sources.

d. It would provide incentives to reduce energy consumption through demand-side measures, such as reducing transmission losses, adopting energy saving technologies, shifting to less-energy intensive industries, and so on.

e. It would provide revenue with which the environmental mitigation and compensation activities associated with power generation could actually be undertaken.

This study therefore recommends that full-cost electricity pricing – incorporating environmental costs – be applied to all forms of energy generation in Vietnam. Studies would be required for each energy source in order to assess their environmental costs. One such study has already been done for coal-fired electricity in Vietnam (Song and Hanh 2001) and similar studies exist for coal-fired electricity in other countries (Zhang and Duan 1999). Such studies generally show that full-cost pricing would result in modest increases and would be affordable to all but the most energy-intensive and energy-wasting activities.

In the case of YHPP, the price increase recommended is from 5.2 to 5.68 US cents/kWh – a 10% increase. This is not an exorbitant amount. Furthermore, it should be emphasized that these costs are already being paid through losses of forest benefits, damages to public health, disruption to the lives of people relocated because of dam construction and so on. Full cost electricity production simply reallocates these costs according to the „polluter pays' principle. In doing so, it makes the costs visible and creates incentives to reduce them.

We therefore make the following specific recommendations:

a. full-cost pricing should be applied to all forms of electricity generation in Vietnam;

b. revenue from the additional changes for environmental costs should be put into a fund that would be used to pay for the prevention, mitigation and compensation costs accordingly;

c. in the case of Yali Hydropower Plant, the electricity price should be increased from 5.2 to 5.68 US cents/kWh.

We believe these policy changes would help put Vietnam's power sector on a path that is economically and environmentally sustainable.

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APPENDICES

Appendix 1. YHPP Environmental Costs by Years and by Environmental Factors

No.	Hydro-logy	Water Supply	Land Use	Forestry	Water shed Mana-gement	Fauna	Reser-voir-induced Seismi-city	Public Health	Resettle-ment & Compen-sation	Total Environ-mental Costs
1	2	3	4	5	6	7	8	9	10	11
1993	71,091	–	12,866	1,290,133	5,821	37,500	12,978	12,667	5,562,286	7,006,217
1994	71,091	–	12,866	1,290,133	5,821	37,500	12,978	12,667	5,562,286	7,006,217
1995	71,091	–	12,866	1,290,133	5,821	37,500	12,978	12,667	5,562,286	7,006,217
1996	71,091	–	12,866	1,290,133	5,821	37,500	12,978	12,667	5,562,286	7,006,217
1997	71,091	–	12,866	1,290,133	5,821	37,500	12,978	12,667	5,562,286	7,006,217
1998	–	–	12,866	1,290,133	5,821	37,500	–	12,667	–	1,358,751
1999	–	–	12,866	1,290,133	5,821	37,500	–	12,667	–	1,358,751
2000	–	–	12,866	1,290,133	5,821	37,500	–	12,667	–	1,358,751
2001	–	2,593,000	166,273	1,452,318	8,450	–	–	2,645,467	–	6,865,508
2002	–	2,593,000	166,273	1,452,318	8,450	–	–	2,645,467	–	6,865,508
2003	–	2,593,000	166,273	1,452,318	8,450	–	–	2,645,467	–	6,865,508
2004	–	2,593,000	166,273	1,452,318	8,450	–	–	2,645,467	–	6,865,508
2005	–	2,593,000	166,273	1,452,318	8,450	–	–	2,645,467	–	6,865,508
2006	–	2,593,000	166,273	1,452,318	8,450	–	–	2,645,467	–	6,865,508
2007	–	2,593,000	166,273	1,452,318	8,450	–	–	2,645,467	–	6,865,508
2008	–	2,593,000	166,273	1,452,318	8,450	–	–	2,645,467	–	6,865,508
2009	–	2,593,000	166,273	1,452,318	8,450	–	–	2,645,467	–	6,865,508
2010	–	2,593,000	166,273	1,452,318	8,450	–	–	2,645,467	–	6,865,508
2011	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2012	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2013	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2014	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2015	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2016	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2017	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2018	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2019	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2020	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2021	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2022	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2023	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849

Appendix 1. (Continued)

1	2	3	4	5	6	7	8	9	10	11
2024	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2025	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2026	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2027	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2028	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2029	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2030	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2031	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2032	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2033	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2034	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2035	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2036	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2037	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2038	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2039	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849
2040	–	2,593,000	166,273	1,113,109	–	–	–	2,645,467	–	6,517,849

Note*:* The YHPP environmental costs by environmental factors of meteorology, erosion and sedimentation, vegetation, water quality and aquatic life, ground water and mineral radioactive deposits are not considered in Appendix 2 because of their negligible values.

APPENDIX 2.

Net Present Value (NPV) for Two Assumptions: With and Without Incorporating the Environmental Costs of the Plant into Its Direct Costs

(i.e. the Direct Cost - based NPV_d and Full Cost - based NPV_f at original formal electricity price of 5.2 US cents/kWh).

Input Data of Appendix 2

Energy sale per annum:	2,728.4 GWh
Electricity price formally determined by the electricity sector:	5.2 US cents/kWh
Revenue obtained by electricity sale per annum:	USD 141,876,000
Total investment capital cost:	USD 614,775,000
O & M Costs in percentage of the initial investment capital cost:	0.8%
Common standardized discount rate:	10%

Calculation Table of Appendix 2

Cost - Revenue Balancing for Two Assumptions: With and Without Incorporating the YHPP Environmental Costs into Its Direct Costs.

Unit: USD per annum.

Year	*YHPP Direct Cost*			*YHPP Environ-mental Cost (See App. 2)*	*YHPP Full Cost (6)=(4)+(5)*	*YHPP revenue by Energy Sale*	*Cost-Revenue Balancing*	
	Investment Cost	*O & M Cost*	*Total Direct Cost (4)=(2)+(3)*				*Direct Cost - based (8)=(7)-(4)*	*Full Cost - based (9)=(7)-(6)*
1	2	3	4	5	6	7	8	9
1993	28,026,000	–	28,026,000	7,006,217	35,032,217	–	-28,026,000	-35,032,217
1994	57,962,000	–	57,962,000	7,006,217	64,968,217	–	-57,962,000	-64,968,217
1995	120,495,000	–	120,495,000	7,006,217	127,501,220	–	-120,495,000	-127,301,220
1996	99,803,000	–	99,803,000	7,006,217	106,809,220	–	-99,803,000	-106,809,220
1997	113,408,000	–	113,408,000	7,006,217	120,414,220	–	-113,408,000	-120,414,220
1998	88,317,000	–	88,317,000	1,358,751	89,675,751	–	-88,317,000	-89,675,751
1999	67,071,000	–	67,071,000	1,358,751	68,429,751	–	-67,071,000	-68,429,751
2000	39,694,00	–	39,694,00	1,358,751	41,052,751	–	-39,694,00	-41,052,751
2001	–	4,918,000	4,918,000	6,865,508	11,783,508	141,876,000	136,958,000	130,092,490
2002	–	4,918,000	4,918,000	6,865,508	11,783,508	141,876,000	136,958,000	130,092,490
2003	–	4,918,000	4,918,000	6,865,508	11,783,508	141,876,000	136,958,000	130,092,490
2004	–	4,918,000	4,918,000	6,865,508	11,783,508	141,876,000	136,958,000	130,092,490
2005	–	4,918,000	4,918,000	6,865,508	11,783,508	141,876,000	136,958,000	130,092,490
2006	–	4,918,000	4,918,000	6,865,508	11,783,508	141,876,000	136,958,000	130,092,490

2007	–	4,918,000	4,918,000	6,865,508	11,783,508	141,876,000	136,958,000	130,092,490
2008	–	4,918,000	4,918,000	6,865,508	11,783,508	141,876,000	136,958,000	130,092,490
2009	–	4,918,000	4,918,000	6,865,508	11,783,508	141,876,000	136,958,000	130,092,490
2010	–	4,918,000	4,918,000	6,865,508	11,783,508	141,876,000	136,958,000	130,092,490
2011	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2012	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2013	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2014	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2015	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2016	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2017	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2018	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2019	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2020	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2021	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2022	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2023	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2024	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2025	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2026	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2027	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2028	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2029	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2030	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2031	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2032	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2033	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2034	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2035	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2036	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2037	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2038	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2039	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
2040	–	4,918,000	4,918,000	6,517,849	11,435,849	141,876,000	136,958,000	130,440,150
NPV	NPV_d = Direct cost - based Net present value = $\sum_{t=1}^{48}(pQ - C_{dt})(1+i)^{-t}$ NPV_f = Full cost - based Net present value = $\sum_{t=1}^{48}(pQ - C_{dt} - C_{et})(1+i)^{-t}$ (See formulas presented in the paragraph 1.3)						NPV_d 219,520,140 USD per annum	NPV_f 160,124,000 USD per annum