# ECONOMIC ANALYSIS

1. The project has several core and noncore subprojects, including rehabilitation and reinforcement of substations and transmission lines for Hanoi Power Corporation (EVN HANOI) and Ho Chi Minh City Power Corporation (EVN HCMC). Similar to the financial analysis, the economic analysis is conducted for six core subproject groups[1] and follows the same approach except that costs and benefits are defined and valued in economic terms.

2. **Demand and supply analysis.** From 2005 to 2012, Viet Nam's gross domestic product grew at an average rate of 6.3% per annum, reaching $1,755 per capita in 2012, and electricity consumption increased at a compound annual growth rate of 12.6%, reaching 120.3 terawatt-hours (TWh) in 2012. Between 2007 and 2012, annual sales growth ranged from a low of 10.3% to a high of 13.9%. The seventh power development plan (PDP7)[2] anticipates average annual growth in electricity demand of 10% from 2012 to 2020, reaching 330 TWh in 2020 and potentially 700 TWh in 2030. The installed generation capacity in 2012 was 26.5 gigawatt (GW) and is planned to increase to 75 GW by 2020. The transmission assets as of 2012 comprise (i) transformer substation capacities of 16.050 megavolt-amperes (MVA) at 500 kV, 27,901 MVA (220 kV), and 32,976 MVA (110 kV); and (ii) 31,176 kilometers (km) of transmission lines—4,670 km (500 kV), 11,449 km (220 kV), and 15,057 km (110 kV). The PDP7 targets the development by 2020 of more than 40,000 MVA of 500 kV substation capacity and 70,000 MVA of 220 kV substation capacity, as well as over 9,000 km of 500 kV transmission lines and about 15,000 km of 220 kV transmission lines.

3. **Approach.** The proposed project is in line with the country's overall grid development plan and designed to (i) ensure that the increase in network capacity is commensurate with the expansion of generation capacity, and (ii) reduce system losses and increase the reliability and quality of the power network. Following ADB's Guidelines for the Economic Analysis of Projects,[3] the economic costs and benefits accrued from the project are compared with a "without- project" scenario during the assumed project life of 20 years. It is believed that the current grid system has reached its maximum capacity and struggles to meet growing electricity demand despite ongoing and planned generation capacity expansion. The with-project case therefore assumes that the increase in grid capacity delivered by the project will be converted into more supply of grid power. The without-project case assumes that there will be no investments in the grid network and growing demand will instead be met by diesel-powered self-generation. For the purposes of calculating economic costs and benefits, the subprojects have been grouped into those that represent rehabilitation of existing substations (Son Tay, Tran Hung Dao, and Phuong Liet), those that represent reinforcements to the existing transmission and distribution network (District 8 and Tham Luong), and one that is used to meet new loads (Noi Bai).

4. **Economic cost.** A system approach is taken to capture all the economic costs related to the with-project case. These include (i) project capital, and operation and maintenance (O&M) costs, which are adjusted to reflect the economic resource cost; and (ii) additional capital and

[1] There are eight core subprojects, but for the purpose of economic analysis, related components are combined into (i) Son Tay 110 kV substation rehabilitation; (ii) Tran Hung Dao 110 kV substation rehabilitation; (iii) Phuong Liet 110 kV substation rehabilitation; (iv) new Noi Bai 110 kV substation; (v) District 8 220 kV substation, transmission line and underground cable reinforcement; and (vi) Tham Luong 110 kV substation, transmission line, and underground cable reinforcement.

[2] Government of Viet Nam. 2011. *Prime Minister Decision 1208/QD-TTg on Approval of National Power Development Plan between 2010 and 2020, with Orientation towards 2030.* Ha Noi.

[3] ADB. 1997. *Guidelines for the Economic Analysis of Projects*. Manila

O&M costs required to expand generation capacity, and medium-voltage (MV) and low-voltage (LV) networks. In calculating those economic costs, transfer payments (taxes and duties) and price contingencies are excluded. In addition, the domestic price numeraire is chosen and a shadow exchange rate factor (SERF) of 1.1[4] is used to convert all traded costs and benefits to domestic prices. Equipment and material procurement will be done through international competitive bidding and national competitive bidding. These costs are considered to represent traded goods and are therefore multiplied by the SERF. For labor costs, a shadow wage rate factor of 0.9 is applied for unskilled labor because of its supply surplus. For skilled labor, a shadow wage rate factor of 1.0 is applied because it is believed to be sufficiently competitive for wages to reflect marginal productivity.

5. Resource costs are calculated as the sum of generation, transmission, and MV and LV network costs. The generation cost is calculated to include both capital investment and O&M costs for a combined-cycle gas turbine because it represents the marginal generator[5] in Viet Nam. The resulting resource cost for generation is ¢7.23 per kilowatt-hour (kWh). An allowance of ¢0.24/kWh is added to this, which represents the estimated long-run marginal cost of transmission.[6] Transmission losses of 2.5% are assumed to give a total estimated resource cost of bulk power supply entering the project-supported power networks. In total, the resource cost for generation and transmission is estimated at ¢7.66/kWh.

6. An allowance for MV and LV network costs that are needed to deliver the additional supply to customers is added to the subproject costs. The capital costs of MV and LV network investment are estimated using a ratio of $1.00 in substation investment to $0.90 in matching capital expenditure at these voltage levels—the ratio applied for equivalent subprojects in the analysis conducted for the World Bank's Distribution Efficiency Project.[7] Those costs are assumed to be incurred evenly from the substation commissioning date up to 2020, except for Noi Bai substation, where the capital cost of the MV network is assumed to be incurred once, in 2015, because Noi Bai airport is expected to start its operation in 2015. The O&M costs of MV and LV network investments are assumed to be 2% of capital expenditures. The exception is the District 8 substation and associated transmission lines and cables under EVN HCMC, where the subproject is at a voltage of 220 kV (as opposed to the 110 kV voltage of other subprojects) and, therefore, the lower voltage investment costs considered include 110 kV as well as MV and LV infrastructure. The cost ratios used are adjusted accordingly. For the District 8 subproject, an average cost in $/kW has been estimated from other subprojects and applied to this subproject. This average cost equals $0.062/kW.

7. **Economic benefit.** The quantified economic benefits arising from the with-project case are calculated as incremental benefits. For this, changes in the energy balance of each substation are identified. Increased supply is valued at the willingness to pay,[8] which is estimated at ¢9.46/kWh by using the average total supply resource costs of two power corporations as proxy for the long-run marginal cost. In addition to incremental benefits, there will be benefits when diesel generation is replaced by an increase in grid-power supply, which

[4] Approximated using the assumed average taxes and duties on imports of 10%.
[5] The marginal generator is the generator with the highest variable (energy) cost required to meet demand in any particular time period.
[6] Economic Consulting Associates and Vernstrom Associates. 2006. *EVN Bulk Power, Distribution Margin, Retail Consumer Tariff Design and Development of an Independent Creditors Model – Final Report*. Unpublished.
[7] World Bank. 2012. *Project Appraisal Document on the Distribution Efficiency Project.* Washington, DC.
[8] The retail tariff adjusted for taxes (for deduction) and subsidies (for addition) can be used as willingness to pay. But in Viet Nam, it is difficult to break down the retail tariff by taxes and subsidies because it involves cross-subsidies between different customer groups.

will result in carbon savings thanks to reduced greenhouse gas emissions. While incremental benefits are mainly calculated and presented as a core project benefit, the benefits from carbon savings are captured as part of the sensitivity analysis.

8. **Energy balance.** The energy balance is calculated for each subproject showing the with-project and without-project scenarios and, therefore, the incremental changes that can be attributed to the project and which are used in the calculation of its costs and benefits. Table 1 shows the common assumptions made in calculating each substation's energy balance.[9]

**Table 1: Energy Balance Assumptions**

| Item | | Value | Notes |
|---|---|---|---|
| **Losses** | | | |
| From exit from NPT system to entry into S/S | | 1.0% | |
| S/S losses | | 0.3% | |
| From exit from S/S to final customer | EVN HANOI | 6.9% | 2012 average loss, less above |
| | EVN HCMC | 4.2% | losses |
| **Power factor** | | | |
| Power factor | | 0.98 | |
| Normal rating | | 1.0 | |
| Overload rating | | 1.2 | |
| **Electricity supply** | | | |
| Maximum equivalent hours operating at full load | | 5,500 | |
| Sales growth (per annum) | EVN HANOI | 12.8% | 2012–2020 average projected |
| | EVN HCMC | 10.0% | growth |

EVN HANOI = Hanoi Power Corporation, EVN HCMC = Ho Chi Minh City Power Corporation, NPT = National Power Transmission Corporation, S/S = substation.
Source: Asian Development Bank estimates.

9. In the case of rehabilitation, the substations are assumed to be able to operate up to the equivalent of 4,121 hours at peak load annually (representing operation at 100% capacity during peak hours and 50% capacity during normal hours). Electricity supplied through the substations is assumed to grow from currently constrained levels to these new maximum levels at the average sales growth rate applicable to the respective power corporation. For the new Noi Bai subproject, electricity supplied through the substation is assumed to immediately reach maximum capacity (equivalent to 5,500 hours annually operating at peak load). Reinforcement subprojects are assumed to contribute to meeting overall demand growth in the area served by the respective power corporation. To capture this, the average "contribution" of each MVA of added transformer capacity (at each voltage level) to the ability to meet demand is calculated based on investment plans and demand projections up to 2020. The maximum demand served by the reinforcement subproject is then calculated as equal to the installed transformer capacity under the subproject multiplied by this contribution coefficient. Demand served is assumed to ramp up to meet this maximum demand by 2020. Table 2 illustrates the calculation of the contribution coefficient.

10. **Economic internal rate of return.** Following the above approach, all the economic costs and benefits for the six core subproject groups are calculated over a project life of 20 years. Based on this, their combined economic internal rate of return (EIRR) is calculated as 16.5% (Table 3). The rate is above the minimum rate of 12% deemed acceptable by the Asian Development Bank, which means the proposed project is economically viable.

[9] These have been drawn from a review of the assumptions made by the consultants retained by the power corporations in their economic and financial analyses for the proposed subprojects and the separate analysis conducted for the World Bank's Distribution Efficiency Project (footnote 7).

**Table 2: Calculation of Contribution Coefficient for Reinforcement Subprojects**

| EVN HCMC | | | | | | |
|---|---|---|---|---|---|---|
| | **Sales** | **Transformer additions (cumulative)** | | | **Average Energy** | |
| | | **220 kV** | **110 kV** | | **220 kV** | **110 kV** |
| | GWh | MVA | MVA | | GWh/MVA | |
| 2010 | 15,409 | | | | | |
| 2015 | 26,755 | 2,500 | 3,566 | 2010-2015 | 4.5 | 3.2 |
| 2020 | 42,931 | 6,250 | 7,944 | 2016-2020 | 4.3 | 3.7 |
| | | | | 2010-2020 | 4.4 | 3.5 |

| | **Capacity** MVA | **Contribution coefficient** GWh/MVA | **Sales enabled** GWh pa |
|---|---|---|---|
| District 8 | 250 | 4.4 | 1,101 |
| Tham Luong | 126 | 3.5 | 437 |

EVN HCMC = Ho Chi Minh City Power Corporation, GWh = gigawatt-hour, kV = kilovolt, MVA = megavolt-ampere, pa = per annum.
Source: Asian Development Bank estimates.

**Table 3: Economic Cost and Benefit Stream**

| $ million | **Investment Costs** | **Operating Costs** | **Incremental Benefits** | **Net Benefits** |
|---|---|---|---|---|
| 2014 | (5.14) | 0.00 | 0.00 | (5.14) |
| 2015 | (94.86) | (0.40) | 4.57 | (90.69) |
| 2016 | (6.13) | (2.12) | 9.39 | 1.13 |
| 2017 | (6.13) | (2.25) | 14.33 | 5.96 |
| 2018 | (6.13) | (2.37) | 19.42 | 10.93 |
| 2019 | (6.13) | (2.49) | 24.40 | 15.78 |
| 2020 | (6.13) | (2.61) | 29.33 | 20.58 |
| 2021 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2022 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2023 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2024 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2025 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2026 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2027 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2028 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2029 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2030 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2031 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2032 | 0.00 | (2.61) | 29.85 | 27.24 |
| 2033 | 0.00 | (2.61) | 29.85 | 27.24 |
| **EIRR** | | | | **16.5%** |

( ) = negative, EIRR = Economic Internal Rate of Return.

11. The estimated EIRR for each individual core subproject is shown in Table 4. All are over 12%, which means that each subproject is also economically viable by itself.

**Table 4: Economic Internal Rate of Return by Subproject Group**

| Sub-Project Group | EIRR |
|---|---|
| **Hanoi Power Corporation** | |
| Son Tay 110 kV substation rehabilitation | 24.0% |
| Tran Hung Dao 110 kV substation rehabilitation | 35.9% |
| Phuong Liet 110 kV substation rehabilitation | 13.5% |
| New Noi Bai 110 kV substation | 23.9% |
| **Ho Chi Minh City Power Corporation** | |
| District 8 220 kV substation + transmission line + underground cable | 12.2% |
| Tham Luong 110 kV substation + transmission line + underground cable | 18.8% |
| **Total** | **16.5%** |

EIRR = economic internal rate of return, kV = kilovolt.
Source: Asian Development Bank estimates.

12. **Sensitivity analysis.** A sensitivity analysis is carried out to investigate the robustness of the economic viability of the project under changes in key variables and assumptions: (i) increase of 10% in investment costs, (ii) slowdown in annual demand growth by one-third, and (iii) inclusion of the benefits of carbon savings.[10] Table 5 shows the estimated EIRR under these sensitivities. The combined subprojects would have an EIRR above 12%, and all individual subproject groups would have an EIRR of 10% or above. Overall, the economic viability of the subprojects appears reasonably robust to changes in key assumptions.

**Table 5: Economic Sensitivity Analysis**

| | | | Economic Internal Rate of Return | | | |
|---|---|---|---|---|---|---|
| | **Sub-Project Group** | **Base case** | **Sensitivity 1** Investment costs increased by 10% | **Sensitivity 2** Demand growth reduced by one-third | **Sensitivity 3** Carbon-saving benefits are added | **Combined** |
| **Hanoi Power Corporation** | | | | | | |
| 1 | Son Tay 110 kV S/S rehabilitation | 24.0% | 21.6% | 20.5% | 26.8% | 20.7% |
| 2 | Tran Hung Dao 110 kV S/S rehabilitation | 35.9% | 33.1% | 28.9% | 39.1% | 29.1% |
| 3 | Phuong Liet 110 kV S/S rehabilitation | 13.5% | 11.9% | 10.6% | 15.4% | 10.7% |
| 4 | New Noi Bai 110 kV S/S | 23.9% | 20.9% | 23.9% | 26.3% | 23.1% |
| **Ho Chi Minh City Power Corporation** | | | | | | |
| 1 | District 8 220 kV S/S + T/L + U/C | 12.2% | 10.7% | 10.0% | 14.0% | 10.1% |
| 2 | Tham Luong 110 kV S/S + T/L + U/C | 18.8% | 16.9% | 15.4% | 21.1% | 15.5% |
| **TOTAL** | | **16.5%** | **14.6%** | **14.1%** | **18.5%** | **14.1%** |

kV = kilovolt, S/S = substation, T/L = transmission line, U/C = underground cable.
Source: Asian Development Bank estimates.

[10] For the carbon-saving benefits, the difference in emission factors between grid-supplied electricity and diesel generation is used. The grid emission factor is estimated at 0.624 kilogram (kg) of carbon dioxide-equivalent ($kgCO_2e$)/kWh. To this, savings from avoided transmission losses (of 2.5%) are added to obtain a final emission factor for grid-supplied electricity of 0.640 $kgCO_2e$/kWh. The emission factor of diesel generation is estimated at 0.764 $kgCO_2e$/kWh. The savings from replacing diesel generation with grid electricity are 0.124 $kgCO_2e$/kWh, which is valued at a carbon price of $10 per ton of carbon dioxide-equivalent ($tCO_2e$) at entry into the distribution network.