Pakistan: Muzaffargarh Transformer Station

Ex-post evaluation

OECD sector	23040 – Distribution from power source to end user; transmission lines	
BMZ Project number	1996 65 860	
Project executing agency	NTDC – National Transmission and Dispatch Company	
Consultant	National Engineering Services Pakistan (PVT) Ltd. (NESPAK)	
Year of ex-post evaluation	**2006**	
	Project appraisal (planned)	**Ex-post evaluation (actual)**
Start of implementation	1/1997	5/1997
Period of implementation	16 months	22 months
Investment costs	EUR 39.9 million	EUR 34.7 million
Counterpart contribution	EUR 11.1 million	EUR 7.9 million
Finance, of which FC funds	EUR 28.8 million	EUR 26.8 million
Other institutions/donors involved	Not applicable	Not applicable
Performance rating	2	
• Significance/Relevance	2	
• Effectiveness	2	
• Efficiency	3	

Brief Description, Overall Objective and Project Objectives with Indicators

The project consisted of stepping up the capacity of the existing 220-kV power station transformer at Muzaffargarh to 500 kV. A conditionality attached to project finance was the reduction of the Muzaffargarh power station's sulphur dioxide emissions to a maximum of 235 t/day.

The project objective was the secure feed-in of electricity generated by the Muzaffargarh and AES Lalpir power stations to the nationwide 500 kV integrated grid. The overall objective was to contribute to the macroeconomically efficient supply of ecologically viable electric energy and output. The main target group were productive power consumers.

The indicator for overall objective achievement required 70% nominal power (600 MVA) utilisation by the 220/500-kV step-up transformer after operation start. The indicators for the project objective were: (i) retention of tariffs with an average cost recovery quota of 80% of long-term marginal costs; (ii) above average increase in tariffs for private households and agriculture; (iii) maximum consumer electricity consumption at 40% of electricity sales; (iv) reduction of transmission and distribution losses to under 20%; (v) no transmission losses from the Muzaffargarh and AES Lalpir power stations; (vi) maximum sulphur dioxide emission from the Muzaffargarh power station of 235 t/day.

Project Design/Major Deviations from Original Planning and Main Causes

The project executing agency was the National Transmission and Dispatch Company (NTDC), which was founded in 1998 as a legally independent joint-stock company in the course of deglomerating WAPDA and took over the tangible assets and liabilities of WAPDA's power transmission business on 1 March 1999. At the same time, about 10,000 personnel transferred from WAPDA to NTDC

(workforce in 2005 about 9,000). As of January 2003, NTDC holds an operating licence issued by the regulatory authority which permits it to function as a transmission grid operator (including load management), sole purchaser (of electric energy transmitted to the distributor corporations) and as the operator of a planned wholesale electricity market. The prices at which the NTDC buys current from the producers and sells it to the distributors are set together with the grid fees by the regulatory authority in tariff approval procedures as of 2004. The project was carried out with no substantial divergences from the original plan.

The project location is directly adjacent to the Muzaffargarh thermal power station near the small town of Muzaffargarh, some 50 km north of the city of Multan in Punjab Province. The project consisted of enlarging the existing 220-kV switchgear of the Muzaffargarh transformer station with a 500 kV switchgear, including all the requisite ancillary facilities, to be able to feed electric energy from the Muzaffargarh power station (1,350 MW) directly via the transformer station into the 500-kV Pakistani integrated grid. The existing 220-kV switchgear was connected via two 220-kV two-core cables with basically adequate transmission capacity to the 500/220-kV Multan transformer station 45 km away but when only one of the four electrical circuits failed due to a transmission fault the entire Muzaffaragarh power station had to be taken offline, which occurred relatively frequently. At project appraisal, a 362-MW steam power station financed by the U.S. company AES was also installed in Lalpir about 18 km from the project site and connected to the existing 220-kV switchgear in Muzaffargarh with a 220-kV two-core cable. The transmission capability of the four 220-kV electrical circuits leading to Multan from Muzaffargarh would not, however, have sufficed to feed in the additional capacity of the AES Lalpir power station that went online in 1997. Upgrading the Muzaffargarh transformer station to 500 kV also removed this bottleneck. The site selected for the transformer station was large enough to be able to extend the 500-kV switchgear to triple capacity if need be.

The project comprised the following individual components:

- Erection of a 500/220-kV transformer bank with a capacity of 600 MVA, made up of three interconnected single-phase 200-MVA autotransformers and an additional autotransformer
- Installation of four single-phase 500-kV inductors with 37 MVAr each, including one spare inductor
- Construction of a 500-kV outdoor substation using the American power switch method with two 500-kV diameters, one looped into the 500-kV Guddu-Multan line and connected to the 500-kV transformer bank and the other connected to the 500-kV inductors to compensate reactive power in the grid at the 500-kV Guddu cable exit
- Addition to the existing 220-kV outdoor substation at the Muzaffargarh power station of a control panel for connection of the 500/220-kV transformer bank
- Delivery and installation of all other facilities required for a functional system, including a switchgear building with control room, station power supply and communications facilities
- Delivery of spare parts, tools and testing equipment
- Training measures and consultancy services from the Pakistani consultant NESPAK
- Monitoring of air-borne emissions from the Muzaffargarh power station and specification of immission thresholds by IUCN Pakistan
- Construction of a pollution measurement station on the premises of the Muzaffargarh power station

As a result of the project measures, the project executing agency now has an upgraded transformer station at its disposal in Muzaffargarh to feed electric energy via the transformer bank at a capacity of 600 MVA from the 1,350-MW Muzaffargarh power station and the 362-MW AES Lalpir power station directly into the 500-kV integrated grid. On failure of an overhead cable attached to the 220-kV switchgear, the integrated grid now has sufficient reserves to be able to run the two power stations without disruption and capacity shortfalls. The transformer station also functions to transmit electric energy from the AES Pak Gen thermal power station (365 MW) started up in 1998 and the Kot Addu power station meanwhile sold to private investors (1,342 MW). It raises grid stability and prevents grid losses. In confirmation of the project executing agency's assessment, the quality of the installations can rate as good. The appropriate, matched up layout, which is well adjusted to local conditions, has so far assured secure operations. The importance of the Muzaffargarh transformer station for the

Pakistani integrated grid is also underlined by the NTDC's now ongoing project for the additional construction of a second 500/220-kV transformer bank and the erection of an additional 500-kV cable for connection to the Gatti transformer station.

There were difficulties in complying with the environmental protection regulations. The environmental organization IUCN Pakistan entrusted with measuring emissions and air pollution was not taken under contract until November 1999. Altogether, the IUCN prepared 13 quarterly reports covering the period from July 1999 to December 2002. Considerable delays also occurred in erecting the requisite pollution measurement station on the premises of the Muzaffargarh power station. The procurement contract negotiated with Lahmayer International was not signed until December 2000. Whereas on final assessment, measurements were expected to start in mid-2001, problems with the software and hardware delayed station startup up until January 2003. As a result, the IUCN Pakistan investigations could not access the data from the pollution measurement station as planned. The station is nevertheless a useful measure to be able to monitor pollution in future as well.

The total costs of the project amounted to EUR 35.1 million. Of this, about EUR 26.8 million was financed with an FC mixed financial loan. The project executing agency WAPDA/NTDC bore the national costs amounting to PKR 451.5 million (EUR 8.3 million).

Main Results of Impact Analysis and Performance Assessment

In the project region itself, the project has successfully contributed to solving the core problem identified on appraisal. The upgrading of the Muzaffargarh transformer station to 500 kV enables the secure transmission of the electricity generated from the now fully extended Muzaffargarh and AES Lalpir thermal power stations into the nationwide 500-kV integrated grid. It has improved the load flow, increased grid stability and reduced grid losses.

The overall objective indicator has been fully met: Since startup, the step-up transformer has averaged a capacity utilisation of more than 70%. Maximum utilisation even rose steadily from 106% (2001) to 112% (2005) of nominal power so that the scheduled extension of the transformer station with a second 220/500-kV step-up transformer is already underway.

As to the project objective indicators the picture is as follows: Although there are no current calculations on the long-term macroeconomic marginal costs of power supply to verify the cost-recovery criterion, the business cost recovery quota for WAPDA has tended to deteriorate since project appraisal and tariff income now only covers just about 90% of expenditure only. There has, however, been an above-average increase in tariffs for private households and agriculture so that the second project objective has been met. In electricity for consumption, the 40% threshold had already been exceeded at project appraisal: At that time, the share of power for consumption measured in terms of private household end use amounted to 46%. Even if we assume as in the project appraisal report that 10% of the electricity consumption by private households serves productive purposes, consumer current amounted to more than 40%. On the other hand, private households accounted for 43.5% of electricity sales in the last financial year 2004-05, and for only as much as 39.15% after deduction of the assumed productive portion of 10%. In addition, private households have only made up 37.4% of growth in total consumption since project appraisal. The consumer electricity criterion can therefore rate as having been met.

Whereas neither WAPDA nor its successor organisations quite managed to reduce grid losses to below the indicator figure of 20% (project objective indicator iv), project objective indicator (v) for power failures was met: In the Muzaffargarh and AES Lalpir power stations there were no malfunctions due to the transmission grid. As for the sulphur dioxide criterion (vi), the tests carried out by IUCN from July 1999 to December 2002 verified that the SO_2 emission of the Muzaffargarh power station only exceeded the maximum figure of 235 tons of SO_2/day in the January and December months and stayed otherwise well under this, largely even keeping below the World Bank benchmark of 185 t/day (The statutory Pakistani standard provides for a maximum of 500 t/day.). For the subsequent period, only monthly daily mean values are available for SO_2 emissions. These figures also show that the ceiling of 235 t/day in the January months was not adhered to, but in the other months daily mean emissions usually remained well under the indicator value. A factor that needs to be taken into account here is that the specific SO_2 emissions (kg/MWh) are smaller the more natural gas is combusted as fuel in mixed operation with petroleum but the availability of natural gas for power stations is subject to government-set quotas that favour gas supply to consumers outside the power

sector, particularly in the winter months. Strictly speaking, the sulphur dioxide criterion was breached since the SO_2 emissions from the Muzaffargarh power station exceeded the indicator value on individual winter days but altogether environmental pollution from the Muzaffargarh power station has declined considerably since project implementation. We therefore gauge the indicator to be sufficiently met. At project appraisal, the planned Muzaffargarh transformer station with its task of securely transmitting generated power was seen as an integral component of the neighbouring Muzaffargarh power station. In this connection, we consider the required limitation of sulphur dioxide emissions from the Muzaffargarh power station to a maximum of 235 t/day as appropriate and sensible. However, linking a conditionality for a FC project in the transmission sector (executing institution: NTDC) with the generating sector (executing institution: NPGCL) due to the deglomeration of the Pakistani power sector (generation, transmission, distribution) was not very helpful to discussions on compliance during project implementation.

At appraisal, no detailed business study was conducted as the project was not seen as a delimited undertaking but as a joint investment as part of the nationwide Pakistani power system. Nevertheless, the project appraisal report assumed that the project would prevent transmission losses and raise revenue for WAPDA as a result. Load flow calculations carried out on final assessment by the NTDC found that the grid losses would under normal conditions currently amount to 30 MW without upgrading the Muzaffargarh transformer station to 500 kV. If one of the 220-kV electrical circuits between Muzaffargarh and Multan failed the transmission losses would even increase to 48.6 MW. In the view of the NTDC, the only gain, however, is the additional peak load which can be transmitted by the upgraded transformer station. Following the latest decision of the regulatory authority, the NTDC receives a monthly grid use fee of 100.15 PKR/kW (instead of the previous 73.40 PKR/kW). On the conservative assumption that the integrated grid absorbs an additional 300 MW thanks to the upgraded transformer station, the project would yield a return of 11.5% for the NTDC, approximately equivalent to the return on equity accounted for by the regulatory authority at the last tariff decision. From a microeconomic standpoint, we assess the project as favourable.

The Muzaffagarh transformer station is part of the plan for the cost-efficient expansion of the power sector. The macroeconomic benefit primarily consists in preventing transmission losses and adding transmission capacity. For the sake of simplification, an additional kWh delivered to the distributor corporations can be valuated as the price at which they obtain electricity. The purchase price presently amounts to 3.4 PKR/kWh. This professed willingness to pay is at least the lowest limit of its (unknown) actual willingness to pay. From this we can also infer the approximate willingness to pay for additional transmission capacity, i.e. the amount distributors will pay for being able to obtain an additional kWh via the transmission grid. The conservative estimate amounts to 0.38 PKR/kWh. Accounting for 30 MW saved on grid losses, an additional transmission capacity of 300 MW and a load factor of 56%, this monetary appraisal comes to an annual macroeconomic gain of EUR 12.3 million. The macroeconomic rate of return of the project would thus amount to 40%. In macroeconomic terms, we judge the project to be very favourable.

The direct employment effects of the project are confined to the short-term assignment of local construction workers. It has made an indirect contribution to securing jobs in industry and agriculture that would have been endangered by a larger power supply bottleneck due to a transmission capacity shortfall. It is not possible to quantify the income and employment effects of the projects at reasonable cost. The project was geared to achieving a general developmental impact.

The project itself has had no adverse environmental impacts. The plot of unused land claimed for the switchgear measures about 13 hectares and can be classified as insignificant. The usual protective precautions (accident prevention, oil collection basins) have been taken. By virtue of the environmental protection requirements for the Muzaffargarh power station stipulated in the loan and project agreement, a secondary objective of the project was geared to environmental protection and resource conservation. The environmental provisions were met.

From today's standpoint, the risks for the sustainable technical success of the project are quite small. The upgraded transformer station is in very good condition and is fully utilised; the technical and financial conditions for sustainable operation are also favourable.

There are certain risks attached to the environmental specifications: The SO_2 emissions from the Muzaffargarh power station have recorded a distinct downward trend in recent years but it is not impossible that bottlenecks in gas supply may force the operator to use more fuel oil again with a far higher sulphur content.

Taking all the above impacts and risks of the project together, we arrive at the following assessment of its developmental efficacy:

Effectiveness

The project objective was the secure feed-in of power generated by the Muzaffargarh and AES Lalpir power stations to the nationwide 500 kV integrated grid. The indicators for the project objective were: (i) retention of tariffs with an average cost recovery quota of 80% of long-term marginal costs; (ii) above average increase in tariffs for private households and agriculture; (iii) consumer electricity portion not exceeding 40% of electricity sales; (iv) reduction of transmission and distribution losses to under 20%; (v) no transmission losses from the Muzaffargarh and AES Lalpir power stations; (vi) maximum sulphur dioxide emission from the Muzaffargarh power station of 235 t/day. Measured against the indicators, the project objective of the secure transmission of current generated in the Muzaffargarh and AES Lalpir power stations was met to a satisfactory degree. The main indicator for measuring project objective achievement was no. v: No transmission failures occurred in the Muzaffargarh and AES Lalpir power stations. As to project objective indicators pertaining to the sectoral environment of the FC project: Tariffs for private households were raised above average (indicator ii). The portion of consumer current in electricity sales fell to below 40% (indicator iii). Microeconomic cost recovery has tended to decline slightly, but still remains at just about 90% (indicator i). In our assessment, the above three indicators have been met in satisfactory measure. The indicator for the grid loss criterion (< 20%) was not met in sufficient measure (indicator iv). The SO_2 emissions from the Muzaffargarh power station (indicator vi) have been declining over the last 5 years and have remained below the critical figure of 235 t/day, with a few exceptions. The environmental impact indicator has been met to a satisfactory degree in our assessment. We assess the effectiveness of the project as satisfactory altogether (Subrating 2).

Significance/Relevance

The overall project objective of contributing to the macroeconomically efficient supply of ecologically viable electric energy has clearly been attained. While the indicator for overall objective achievement required a capacity utilization of the transformer station amounting to at least 70%, maximum utilisation of the step-up transformer already exceeded nominal power in the first year of operation. The increased load and the planned construction of new power stations in the project region now even necessitate enlarging the transformer with a second transformer bank. At minimum cost, the project has contributed to expanding the power supply system and has proved to be highly advantageous in both microeconomic and macroeconomic terms. The cutback in emissions from the Muzaffargarh power station has considerably reduced environmental pollution in the project region. Another positive aspect is the reorganisation of the power sector now underway and the work of the regulatory authority. The relatively high grid losses, however, still impair the macroeconomic efficiency of power supply, particularly at distribution level. Altogether, we rate the relevance/significance of the project as satisfactory (Subrating: 2).

Efficiency

The project was technically necessary and there was no option under the general plan to expand the power sector at minimum cost. We therefore judge the allocative efficiency to be satisfactory. The project was implemented at reasonable cost. It encountered various implementation problems after the call to tender, however, so that the upgraded transformer station could not be completed until March 2000 instead of the beginning of 1998 as planned. For this reason, transmission bottlenecks occurred over two years impairing the transmission of electric energy from the AES Lalpir power station that went online in 1997. In our estimation, the production efficiency was sufficient. Altogether, we assess the efficiency of the project as sufficient (Subrating 3).

Weighing up the above subcriteria, we assess the developmental efficacy of the project as satisfactory overall (**Rating 2**).

General Conclusions

For conditionalities to be effective (e.g. environmental conditionalities), compliance should lie within the scope of the project executing agency or should largely fall under its influence. Furthermore, for conditionalities that have substantial cost implications alternative avenues to achieve objectives should also be considered with a view to cost efficiency and sustainability (e.g. fuel switch vs. flue gas desulphurisation).

Legend

Developmentally successful: Ratings 1 to 3	
Rating 1	**Very high or high degree of developmental efficacy**
Rating 2	**Satisfactory developmental efficacy**
Rating 3	**Overall sufficient degree of developmental efficacy**
Developmental failures: Ratings 4 to 6	
Rating 4	**Overall slightly insufficient degree of developmental efficacy**
Rating 5	**Clearly insufficient degree of developmental efficacy**
Rating 6	**The project is a total failure**

Criteria for the Evaluation of Project Success

The evaluation of the "developmental efficacy" of a project and its classification during the ex-post evaluation into one of the various levels of success described in more detail below concentrate on the following fundamental questions:

- Are the **project objectives** reached to a sufficient degree (aspect of project **effectiveness**)?
- Does the project generate sufficient **significant developmental effects** (project **relevance** and **significance** measured by the achievement of the overall development-policy objective defined beforehand and its effects in political, institutional, socio-economic and socio-cultural as well as ecological terms)?
- Are the **funds/expenses** that were and are being employed/incurred to reach the objectives **appropriate** and how can the project's microeconomic and macroeconomic impact be measured (aspect of **efficiency** of the project conception)?
- To the extent that undesired **(side) effects** occur, are these tolerable?

We do not treat **sustainability**, a key aspect to consider for project evaluation, as a separate category of evaluation but instead as a cross-cutting element of all four fundamental questions on project success. A project is sustainable if the project-executing agency and/or the target group are able to continue to use the project facilities that have been built for a period of time that is, overall, adequate in economic terms, or to carry on with the project activities on their own and generate positive results after the financial, organisational and/or technical support has come to an end.