China, PR : Turbine Modernisation Programme

Ex post evaluation

OECD sector	23030 - Energy generation	
BMZ project ID	1996 65 255	
Project-executing agency	Huadian Power Corp. and Guodian Corp.(formerly State Power Corp.)	
Consultant	Ingenieurunternehmen für Kraftwerks-, Energie- und Umwelttechnik, Vetschau	
Year of ex post evaluation	**2005**	
	Project appraisal (planned)	**Ex post evaluation (actual)**
Start of implementation	03/1996	04/2000
Period of implementation	50 months	32 months
Investment costs	EUR 136.10 million	EUR 45.20 million
Counterpart contribution	EUR 418.20 million	EUR 348.80 million
Financing, of which Financial Cooperation (FC) funds	EUR 92.00 million of which FC: EUR 31.13 million	EUR 38.09 million of which FC: EUR 12.89 million
Other institutions/donors involved	not applicable	not applicable
Performance rating	2	
• Significance / relevance	2	
• Effectiveness	2	
• Efficiency	1	

Brief description, overall objectives and project objectives with indicators

The turbine modernisation programme (TB-Programme) is one project from a sequence of projects for the **modernisation of six existing coal-fired power plants in China that are all located near city centres.** The common overall objective of the six projects is to improve the supply of electricity and district heat and to contribute towards reducing ambient air pollution as preconditions for the environmentally sound growth of industry and trade in the project regions. The turbine modernisation programme **for the conversion of Russian-designed 200/210 MW turbines (conversion of low-pressure turbines) and the procurement of vehicles fully equipped to measure emissions in order to optimise the combustion in coal-fired power plants was implemented in the project region in northern China including** the big cities of Mudanjiang and Shuangyashan and the SO_2 control areas in the greater Beijing and Qingdao areas.

Under the turbine modernisation programme FC funds were extended to replace turbine components in 20-year old coal-fired power stations with the aim of reducing coal consumption to approximately 360 g/kWh. In order to be able to use the entire working capability of the steam in the low pressure component of 13 Russian-built turbines of the 200 MW class this component were replaced by a more efficient German component with large end-blades and the entire turbine group was equipped with modern control technology. The overall objective is to contribute to improving the energy supply in China and to reducing the environmental pollution caused in power generation. The project objective

is to increase the capacity of the power plant units, to reduce the specific coal consumption and to improve operation and management.

The achievement of the objectives was to be measured on the basis of the modernisation measures actually implemented: In the event that measures were implemented only on the low pressure turbine component the overall objective and the project objective were considered as achieved if the maximum continuous output per block was increased by approximately 9 MW and the specific coal consumption reduced to around 10 g/KWh.

Under the turbine modernisation programme the efficient low pressure components with large end-blades that have been well proven in Europe were used in order to ensure a better utilisation of the working capability of the steam in the 13 Russian-built turbines of the 200 MW class. In this way the capacity of the turbines was increased by around 9 MW and the specific coal consumption was reduced by approximately 11 g/kWh (+/- 10%). With the quantity of coal thus saved the units can increase their power generation by 2.8 to 3.2 %.

The additional programme package of measures covering the provision of measuring vehicles had a broad-scale effect and helped to improve the combustion efficiency and the specific NOx and CO emissions. The retrofitting of older 200 MW bocks with flue-gas desulphurisation plants, which is successively required in the SO_2 control areas, reduces the net capacity and the net efficiency. This has caused power plant operators throughout the country to combine the retrofitting with flue-gas desulphurisation plants and the measures of the exchange of low pressure turbine as conducted under the turbine modernisation programme (in this way the SO_2 is separated while the specific net consumption of coal of the power plant is maintained). Thus, with hindsight the environmental objective of the turbine modernisation programme was given more weight and the generally good contribution of the Programme to achieving the overall objective was improved further. The objectives of the turbine modernisation programme were largely achieved.

Programme Design / Major Deviations from the original Programme Planning and their main Causes

China's high economic growth has concentrated on the metropolitan areas, leading to rapidly rising electricity demand for which supply was inadequately being responded to (core problem No. 1) by technically outdated power plant technology (core problem No. 2), with high coal consumption per kWh causing severe air pollution. In the early 1990s, however, it was possible to significantly increase the energy offer with a high level of reliability and very low grid losses using existing infrastructure and the capacities of the surrounding 220/110 kV grid, allowing the supply gap to be closed fast and in a particularly cost-efficient way.

The project, which is designed as an open programme, was implemented largely as planned. The selection criteria for including measures in the programme were a minimum rate of return and a maximum amortisation period. This ensures a high efficiency. In deviation from the original project planning 14 additional measuring vehicles were procured in order to measure the coal consumption in the power plants in ten provinces and to optimise the operation of steam generaters and combustion facilities.

The total costs of the turbine modernisation programme amounted to EUR 45.20 million, EUR 38.09 million of which was foreign exchange costs. Foreign currency costs of EUR 6.4 million were produced for the procurement of 14 measuring vehicles. The average costs for the modernisation of one power plant unit was EUR 2.985 million, which is comparatively cheap for a 9 MW increase in capacity.

Key results of the impact analysis and performance rating

The programme objectives were achieved, the newly created capacities were used to a higher than expected degree and the power plant technology installed to enable lower specific coal consumption was also utilised in other modernisation projects. The power plant sites were secured for the long term and modernised to accommodate future demands.

The more efficient low pressure components installed under the turbine modernisation programme in 13 turbine units enable an increase in power generation without increasing environmental pollution. Due to the procurement of 14 measuring vehicles it is now possible to implement a mobile diagnosis

service for coal-fired power plants. In the SO_2 control areas older 200 MW units are successively retrofitted with flue-gas desulphurisation plants. The combination of flue-gas desulphurisation plants (FGDs) with the turbine modernisation programme is ideal in order to compensate for efficiency losses caused be the installation of FGDs. This combination is used on a broad scale. Overall, the effectiveness of the Turbine Modernisation Programme is satisfactory (sub-rating 2).

The result of the cost-benefit analysis of the modernisation projects is positive because several favourable factors coincided (further utilisation of existing plant components, no additional grid losses; historic design flaws of older components were eliminated; increased capacity with generally lower emissions; investments in efficiency improvements proved to be reasonable as coal prices increased in real terms). Net investment costs per kW net capacity and a good capacity utilisation and availability lead to low specific costs of electricity supply in the load centre even amid rising coal prices and increasing demands on pollution control (production efficiency). In the turbine modernisation programme both the production efficiency and the allocation efficiency are far above the average (internal rate of return of 25%). Overall, the efficiency of the turbine modernisation programme is good (sub-rating 1).

Using modern power plant technology, the project addressed three cause-and-effect chains at the right time that are important for China's development: reduction of power supply shortages along with very low grid losses, reduction of specific coal consumption to preserve natural resources, and reduction of environmental damage in densely populated areas. The indicators for the overall objective are being met. The technology, which is established in Europe but in several efficiency aspects new to China, had a model character for the further practical utilisation for modernising this segment of low pressure turbine efficiency within the sector. Since the year 2000 the power plant technology provided through the FC projects has gradually become the Chinese standard for power plant technology. Given China's environmental problems, technology for reducing coal consumption continues to be highly relevant. Therefore, we assess the significance / relevance of the turbine modernisation project as satisfactory overall (sub-rating: 2).

On the basis of the above key criteria we rate the project as having high developmental efficacy (overall rating 2).

General Conclusions and Recommendations

The successful modernisation of the low-pressure components of condensing turbines combined with a reduced captive power demand of the FGDs increase the efficiency of power generation. **These efficiency aspects of electricity generation therefore should be given particular attention in comparable modernisation projects.**

Legend

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

Criteria for the Evaluation of Project Success

The evaluation of the "developmental effectiveness" 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.