China/PR : Yang Liu Qing Power Plant

Ex-post evaluation

OECD sector	23063 – Coal-fired power plants	
BMZ project IDs	1989 65 550	
Project-executing agency	Huaneng Power Co. (formerly State Power Corp.)	
Consultant	Consortium Steag-Fichtner	
Year of ex-post evaluation	**2005**	
	Project appraisal (planned)	**Ex-post evaluation (actual)**
Start of implementation	10/1990	05/1994
Period of implementation	48 months	68 months
Investment costs	EUR 552.30 million	EUR 480.61 million
Counterpart contribution	EUR 418.20 million	EUR 348.80 million
Financing, of which Financial Cooperation (FC) funds	EUR 134.10 million of which FC: EUR 67.54 million	EUR 130.81 million of which FC: EUR 64.34 million
Other institutions/donors involved	n.a.	n.a.
Performance rating	1	
• Significance / relevance	1	
• Effectiveness	1	
• Efficiency	2	

Brief description, overall objectives and project objectives with indicators

The Yang Liu Qing (YLQ) Power Plant is one project from a sequence of projects for the **modernisation of six existing coal-fired power plants located near city centres in China.** 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.

Two 330 MW power plant blocks with a coal consumption of 330 grams per kWh were erected in accordance with European standards for YLQ and equipped for supplying district heat to substitute small coal-fired heating boilers. The FC project component comprised two 1020 t/h boilers with firing and power plant control technology to meet stringent efficiency and environmental criteria (with control technology for faster load changes, granulated slag as building additive in the construction industry, feed-water treatment with reversal osmosis, and low emission of pollutants). The objective of the project YLQ is to contribute to improving the supply of electricity and district heat in Tianjin and to reduce the emissions released by the power plant and a previous great number of individual heat

generators. Attainment of objectives was measured by the following indicators taking into account subsequent adjustments:

Indicators to measure the achievement of the overall objective

-- reduction of specific coal consumption per kWh and related specific pollutant emissions (consumption without FGD-Plant 308 g/kWh and with FGD-Plant 330 g/kWh);

-- high energy efficiency in connection with SO_2 emissions of less than 1,500 mg/Nm3 (without FGD-Plant)

-- compliance with Chinese ambient air pollution limits for dust and SO_2 (daily average of 150 micrograms/Nm3);

-- increase in electricity sales as forecast (7.5% p.a.)

Indicators relating to the project objective

-- electricity and district heat generation with FGD-Plant (3,280 GWh/a net);
-- dust emissions below 100 mg/Nm3;

In the overall context, YLQ has made a greater than expected contribution to achieving the overall objectives in terms of meeting electricity demand, energy efficiency and emissions reduction. The project objective of providing the city of Tianjin with an improved and cleaner power supply in the medium-load range (target: 3,280, actual: 4,094 GWh/a net) has been achieved. The target definition indirectly implied low specific coal consumption, suitability for load fluxuations, proximity to the loan centre and compliance with ambient air pollution limits. The project has achieved this too, additionally using the efficiency advantages of combined heat and power generation during the heating period. The low coal consumption (with FGD 322.5 g/kWh net electricity equivalent) is exemplary for large thermal power plants in metropolitan areas. Following completion of the final expansion to 4x330 MW, which began in 2004, all units of YLQ will be fitted with a FGD. This will further reduce to 70 mg/Nm3 the SO_2 emissions which were already reduced to 500 - 800 mg/Nm3 without FGD.

Project design / major deviations from the original project 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.

In Tianjin the two 330 MW power plant blocks with 330 g/kWh coal consumption were erected on schedule in accordance with established European practice and equipped with district heating technology to substitute small coal-fired heating boilers. Contrary to the initial planning, the project was later dovetailed with the "Expansion of District Heating in Tianjin", which was later begun, with a new design as a thermal power plant for 580 MW during the heating period and 660 MW outside the heating period (previously only 2x300 MW electricity generation). The project conception for the extension included subsequent fitting of a FGD right from the start, as environmental requirements were taken into account at the time of project appraisal. The plans already provided for further stages leading up to the final expansion of the site. The final expansion measures are being implemented since 2004 and are to be completed by 2010. YLQ is being fitted with two further identical blocks while the existing and new blocks are being fitted with FGD's.

For the first expansion stage of YLQ the total cost of EUR 480.6 million was 13% lower than at the time of project appraisal while the installed capacity was 10% higher. Foreign currency costs were EUR 130.81 million for the power plant equipment and EUR 0.80 million for consulting services for project design and the technical specifications of the boilers. Even considering the costs and captive power requirements of the subsequent FGD retrofitting, the specific investment cost of EUR 928 per kW net capacity at 2005 prices are rated low.

Key results of the impact analysis and performance rating

The project 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 site was secured for the long term and modernised to accommodate future demands. Sulphur dioxide emissions were reduced and, in accordance with the project conception, FGD's will be retrofitted for further sulphur dioxide emissions reduction.

In terms of its effective thermal power supply to a megacity, YLQ is ready for the future (high block capacity of 330 MW, high net efficiency, fitted with FGD, located on the outskirts of the city, heat energy from four units fed into a large district heating network). The original project objectives were overachieved in several aspects: 20% higher electricity generation in the summer, high substitution of coal-fired heating furnaces by district heat from the power plant, additional sulphur dioxide ambient air pollution reduction, both before and after FGD. Overall, YLQ has good effectiveness (sub-rating 1).

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, efficient coal consumption per electricity and heat unit generated (YLQ 322.5 kg/MWh with FGD), good capacity utilisation and availability lead to low specific costs of electricity and district heat supply in the load centre even amid rising coal prices and increasing demands on pollution control (production efficiency). The internal rate of return (allocation efficiency) of 8% to 10% is good in comparison with the many Chinese power plant projects (600 MW blocks) and has been an argument for adding two identical units to YLQ. Overall, YLQ has satisfactory efficiency (sub-rating 2).

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 power and heat generation 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 cogeneration technology. Given China's environmental problems, technology for reducing coal consumption continues to be highly relevant. The large power producers regard YLQ as exemplary in many technical respects of a cogeneration plant. Considering the local sulphur dioxide pollution and the global carbon dioxide problems as well as the good multiplier effects (broad effectiveness), YLQ has high overall developmental relevance and significance (sub-rating 1).

On the basis of the above key criteria we rate the project as having high developmental efficacy (overall rating 1).

Conclusions and recommendations

The successful modernisation of the thermal power plants in the megacities of Tianjin (YLQ), Shanghai and Beijing is the result of a disproportionately high increase in power generation, the clearly higher heat cycle efficiency in the high-pressure and low pressure components of modern condensing turbines than that of the old equipment, reduced captive power demand of the FGD's and, in the case of YLQ, also of the superheating in the steam 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 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 Evaluating 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.