Thailand: Mae Moh Flue Gas Desulphurisation Units

Ex post evaluation report

OECD sector	23063 – Coal-fired power plants	
BMZ project ID	1995 65 342	
Project executing agency	Electricity Generating Authority of Thailand (EGAT)	
Consultant	Steag AG	
Year of ex post evaluation	**2006**	
	Project appraisal (planned)	**Ex post evaluation (actual)**
Start of implementation	June 1996	June 1996
Period of implementation	43 months	55 months
Investment costs	EUR 96.5 million	EUR 94.8 million
Counterpart contribution	EUR 33.6 million	EUR 47.1 million
Financing, of which Financial Cooperation (FC) funds	EUR 62.9 million	EUR 47.7 million
Other institutions/donors involved	Not applicable	Not applicable
Performance rating	2	
• Significance/relevance	2	
• Effectiveness	2	
• Efficiency	2	

Brief description, overall objective and project objectives with indicators

The environmental protection project "Mae Moh Flue Gas Desulphurisation Plants" consists of upgrading the four existing lignite-fired 150 MW blocks 4-7 at the Mae Moh power plant by adding two turnkey flue gas desulphurisation units (FGDs), building a new chimney, installing new components for the joint use of all FGDs and providing consulting services. The project objective is to reduce emissions at the power plant that are harmful to the environment, thus reducing emissions for people, flora and fauna in the vicinity of Mae Moh to a level that is in keeping with the environmental protection legislation on the removal of health hazards caused by SO_2 emissions and doing away with the need to restrict operations at the power plant. The total cost of this project is EUR 94.8 million. The foreign currency costs of the plant and the engineering services were financed by an FC composite loan of EUR 47.7 million.

The project executing agency was the Electricity Generation Authority of Thailand (EGAT). The state-owned enterprise, which is responsible for electricity generation, transmission (including load distribution) and purchasing from independent generators, was established in May 1969 and had around 24,830 employees at the end of 2005 (1995: 35,200). In July 2005 the enterprise was converted into a public company with an IPO scheduled for October 2006. However, the privatisation process was called to a halt in March 2006 by a decision of the supreme administrative court. The court prohibited the IPO because of procedural irregularities (conflicts of interest and suspected nepotism) and ordered EGAT to be converted back into a state-owned enterprise.

Programme design / major deviations from the original programme planning and their main causes

The project measures financed with FC funds consist of building two turnkey flue gas desulphurisation units for power plant blocks 4/5 and 6/7, installing central flue gas desulphurisation facilities (electrical and control technology, limestone preparation), instructing and training operational staff and providing consulting services. The measures financed with local funds cover building a chimney for the two FDGs and construction and installation work.

Minor design adjustments and improvements proved necessary in the course of the project. After the modifications had been carried out and an adipic acid system added to the facilities, the systems functioned perfectly. Overall, the design and project concept proved to be appropriate.

As a result of the measures at blocks 4-7, the Mae Moh power plant has now been fitted fully with FDGs for a total electrical output of 2,400 MW. The three oldest blocks (225 MW), which do not have an FDG, were shut down in 1999, have not been used as cold reserves since 2003 and are scheduled for removal by 2009. It is no longer necessary to apply emission-related load restrictions at the plant, particularly in the winter months. The project can be expected to mean that if regular maintenance and repairs are carried out, the power plant blocks fitted with FDGs will be operative for a further 20 years.

Key results of the impact analysis and performance rating

The project objective was to achieve a distinct reduction in the SO_2 emissions of the power plant blocks 4-7 so that the sulphur dioxide contamination affecting people, animals and plants in the vicinity of the power plant is at an environmentally acceptable level, making it unnecessary to impose emission-related operational restrictions at the power plant. The overall objective was to ensure that the Mae Moh power plant makes a positive contribution to the development of the region and of the country as a whole. The project target group primarily comprises the people living within a radius of 5-10 km from the power plant (approximately 30,000 people), which is where the pollution caused by the power plant is greatest. In addition, the people living in northern Thailand would indirectly benefit from the reduction in the acid rain caused by sulphur and nitrogen dioxide.

The indicator for the achievement of the project objective requires at least 95% of the SO_2 to be eliminated from the flue gas in blocks 4-7. The achievement of the overall object is indicated by the fact that no emission-related operational restrictions are necessary at the blocks.

The project objective indicator was clearly met. Since the FDGs were put into operation, the average annual desulphurisation at blocks 4-7 is more than 95%. From 2003 onwards the degree of desulphurisation even exceeded 97%. In terms of the overall objective indicator, the project was also successful as there have been no emission-related restrictions in the power plant operation since 2001. The average annual time availability of blocks 4-7 was 87.3% and their capacity utilisation was almost 86%. The power plant could be un sustainably at base load without polluting the environment with inacceptable sulphur dioxide emissions.

With regard to the overall objective, it should be noted that the definition chosen for the project appraisal report ignores the environmental aspects of the project. As this is an environmental protection project, it would be appropriate from today's perspective to formulate the overall objective in such a way that emphasises the contribution made by the power plant to achieving an environmentally friendly and economically efficient energy supply in the region and the country. That would have shown that the project is geared to the elimination of environmentally harmful effects of electricity generation and energy supply and that that the intention was to achieve environmental sustainability in an economically cost-effective manner.

The project has made a substantial contribution to reducing the pollution caused by the Mae Moh power plant. It took account of the priorities of German development cooperation in Thailand at the time. In addition, the project is in a field of action which is also given priority in the BMZ's new Asia concept (environmental and resource protection) and is in line with the environmental objectives of the Thai government.

The microeconomic analysis of the project shows that the additional costs associated with flue gas desulphurisation makes it more expensive to generate electricity in blocks 4-7 but the level of additional expenditure is acceptable and affordable. The calculations take account of the investment costs due, estimate the current FDG operational costs (July 200) including expenditure on limestone,

water and adipic acid, refer to the development of net electricity generation from 2000 to 2005, continue the expected volume of electricity generated from 2006 until 2019 and allocates the cost of flue gas desulphurisation to additional electricity consumption (3%) as evaluated at market prices. With these assumptions and using a discount rate of 6%, the dynamic desulphurisation costs are EUR 3.64 per net MWh (at 2006 prices). This includes EUR 0,08 per MWh for the addition of adipic acid and EUR 1.80 per MWh for proprietary use of the FDGs. Excluding these two items, the desulphurisation costs were EUR 1.76 per MWh, which corresponds roughly to the microeconomic costs of EUR 1.50 MWh estimated at project appraisal (at 1995 prices).

The dynamic microeconomic costs of SO_2 avoidance for blocks 4-7 are therefore EUR 65.30 MWh. The calculation is based on the assumption that the lignite burned has an average sulphur content of 2.7%, the FDG-based SO_2 elimination is 97% and SO_2 emissions without FDG would be around 57.5 kg/MWh. The estimated SO_2 avoidance costs are comparatively low. They are below the costs that were determined for similar FC-financed projects in the People's Republic of China, for example. The figure is at the lower end of the prices at which SO_2 certificates have previously been traded in the USA (from USD 70 per tonne in 1996 to USD 1,550 per tonne towards the end of 2005).

Even including FDGs, thanks to cheap lignite, the cost of generating electricity at the Mae Moh power plant is still well below the cost of producing electricity at the other thermal power plants run by EGAT. According to information provided by EGAT, the microeconomic short-term marginal costs of the electricity generated at Mae Moh (excluding interest rate expenditure and depreciation of fixed assets) are currently around EUR 10 per MWh (480 THB/MWh). Of this amount, approximately EUR 1.54 per MWh is accounted for by the cost of operating the FDGs. If the FDG investment costs are added, the electricity generating cost is EUR 12.11 MWh (excluding interest and power plant depreciation). However, if low-sulphur fuels such as light oil or natural gas are used, the fuel costs alone are far higher. If, for example, light fuel oil with a calorific value of 37 MJ per litre and a 1% sulphur content is burned and the fuel oil purchased at the average wholesale price in 2005 of THB 11.5 per litre (EUR 0.24 per litre), even at an efficiency rate of 42% specific fuel costs of EUR 55 per MWh would be expected. The wet desulphurisation units for the Mae Moh lignite-fired power plant are therefore a solution which is not only efficient from an environmental perspective but is also the most favourable by comparison with alternatives.

The macroeconomic advantage of the project consists mainly in reducing health risks for the people living in the vicinity of Mae Moh, preventing damage to plants and animals and securing a low-cost, environmentally friendly supply of electricity. As already determined at project appraisal, a detailed inventory and monetary evaluation of the positive impact on the environment can only be achieved with a disproportionately high input of time and effort. In the meantime, however, there are studies which endeavour at least to provide an approximate quantification of the health risks deterred by flue gas desulphurisation in the project area. In accordance with these calculations, for every 300 MW in power plant output an FDG in Mae Moh would each year avoid 16 deaths, 12 medical treatments for respiratory disorders and nearly 354,000 person/days lost owing to respiratory complaints.

The fact that the project could achieve a positive impact on the environment with comparatively low SO_2 avoidance costs is indicative of its macroeconomic profitability. The wet desulphurisation solution is cost-effective in macroeconomic terms as alternative measures such as changing over to low-sulphur fuels would place a greater burden on the economy than desulphurising the lignite gases.

The project was geared towards protecting the environment and natural resources. The main effects are in the area of environmentally and economically efficient electricity generation. Reducing environmental pollution was the most important aspect of the project implementation. Sulphur dioxide was eliminated from the flue gases in blocks 4-7 in accordance with the objective. Operation of the Mae Moh power plant and its FDGs is currently meeting all environmental protection requirements and regular measurements are being taken to check compliance.

At the project appraisal and the final review no project risks worth mentioning were discerned. From today's perspective, there are also few risks for the long-term success of the project and its sustainable use. Some deficiencies in the design and operation of the FDGs, which were provisionally graded as medium risk, have since been rectified. The plants are being operated professionally, run without breakdowns and produce the expected desulphurisation.

In a summarised evaluation of the above-mentioned aspects we rate the overall developmental effectiveness of the programme as follows:

Effectiveness:

The project objective was to achieve a distinct reduction in the SO_2 emissions of the power plant blocks 4-7 so that the sulphur dioxide contamination affecting people, animals and plants in the vicinity of the power plant would fall to an environmentally acceptable level, making it unnecessary to impose emission-related operational restrictions at the power plant. The project objective of achieving a clear reduction in the SO_2 emissions of power plant blocks 4-7 was achieved satisfactorily. With more than 97% desulphurisation, the plants exceeded the project objective achievement indicator (95%). SO_2 pollution of the area around the Mae Moh power plant has declined significantly and is now well below the legal ceiling. Overall, we classify the project's effectiveness as satisfactory (sub-rating 2).

Relevance/significance

The overall objective was to ensure that the Mae Moh power plant makes a positive contribution to the development of the region and of the country as a whole. However, this definition, which was selected at the time of the project appraisal, takes no account of the environmental aspects of the project. As this is an environmental protection project, it would be appropriate from today's perspective to formulate the overall objective in such a way that emphasises the contribution made by the power plant to an environmentally friendly and economically efficient energy supply in the region and the country. That would have shown that the project is geared to the elimination of environmentally harmful effects of electricity generation and energy supply and that environmental sustainability was to be achieved in an economically cost-effective manner. Measured in terms of its indicator, the overall objective of the project was achieved. Owing to the successful reduction in the environmental damage caused by sulphur dioxide and other pollutants, the statutory environmental provisions were observed with the result that no emission-related operational restrictions were imposed on the power plant. The operational data show that the power plant has been run constantly at base load. The average annual capacity utilisation of blocks 4-7 was therefore almost 86%. The overall objective formulated at the project appraisal to the effect that the project was to make a positive contribution to the development of the region and the country was thus met. As environmental protection determined the project implementation, it would have been appropriate, however, to tie the overall objective to the contribution made by the project to environmentally and economically efficient energy supply. With regard to these two issues, the project was also successful. Environmental damage caused by the Mae Moh power plant was reduced cost-efficiently, which meant that the power plant could be better utilised without causing any major reduction in its competitveness. A positive assessment can also be given to the fact that the Thai electricity business is efficient despite some functional defects. Overall, we classify the project's developmental relevance and significance as satisfactory (sub-rating 2).

Efficiency

The project provided an effective and efficient solution for reducing SO_2 emissions and pollution, for which there was no cheaper alternative. We therefore consider the allocation efficiency to be good. The costs of the environmental protection measures are kept within acceptable limits and are microeconomically affordable. The SO_2 avoidance costs for blocks 4-7 amount to EUR 65.30 per MWh. We judge the production efficiency as satisfactory. Even if the project benefits are difficult to define in monetary terms, it can be assumed that its macroeconomic advantages are high, especially because of the positive impact on health. The advantages are strengthened by the fact that the SO_2 avoidance costs associated with the project are relatively low. Overall, we assess the project efficiency as satisfactory (sub-rating 2).

In weighing up the impacts and risks, we assess the overall developmental efficacy of the project as satisfactory (rating 2).

General conclusions and recommendations

Investment projects in the electricity sector can have a sustainable developmental impact if they are carried out in a sectoral environment in which the sector performance is satisfactory (operational evaluation criteria as the benchmark).

Assessment criteria

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 developmental efficacy
Rating 6:	The project is a total failure.

Performance evaluation criteria

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:

- Have the **project objectives** been achieved to a sufficient degree (project **effectiveness**)?
- Does the programme generate sufficient significant **developmental effects** (project **relevance and significance** measured in terms of the achievement of the overall developmental 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 appropriate** with a view to achieving the objectives and how can the programme's microeconomic and macroeconomic impact be measured (**efficiency** of the programme design)?
- To the extent that undesired **(side) effects** occur, can these be tolerated?

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