Turkey: Flue Gas Desulphurisation Plants in Orhaneli (I) and Yatağan (II)

Ex post evaluation

OECD sector	23020/Power generation/non-renewable sources	
BMZ project ID	**I** 1993 65 289 - Orhaneli **II** 1995 65 334 - Yatağan	
Project executing agency	Elektrik Üretim A.Ş. (EÜAŞ), formerly Türkiye Elektrik Üretim-Iletim A.S. (TEAS)	
Consultant	ELTEM-TEK/Steag enotec GmbH	
Year of ex-post evaluation report	**2009 (sample 2008)**	
	Project appraisal (planned)	**Ex-post evaluation (actual)**
Start of implementation	**I** Q 4 1993 **II** Q 2 1995	**I** Q 3 1994 **II** Q 3 1997
Period of implementation	**I** 39 months **II** 40 months	**I** 45 months **II** 126 months
Investment costs	**I** EUR 74.0 million **II** EUR 85.8 million	**I** EUR 50.0 million **II** EUR 88.2 million
Counterpart contribution	**I** EUR 38.2 million **II** EUR 21.2 million	**I** EUR 19.2 million **II** EUR 31.9 million
Financing, of which Financial Cooperation (FC) funds	**I** FC/D: EUR 20.5 million F: EUR 15.3 million EUR 35.8 million Combined finance **II** FC/D: EUR 31.2 million F: EUR 16.9 million EUR 48.1 million Combined finance	**I** FC/D: EUR 15.5 million F: EUR 15.3 million EUR 30.8 million Combined finance **II** FC/D: EUR 22.9 million F: EUR 16.9 million EUR 39.8 million Combined finance
Other institutions/donors involved	**I** Project executing agency **II** Project executing agency; Canada	**I** Project executing agency **II** Project executing agency; Canada
Performance rating	**I: 3** **II: 4**	
• Relevance	**I: 2** **II: 2**	
• Effectiveness	**I: 3** **II: 3**	
• Efficiency	**I: 4** **II: 5**	
• Overarching developmental impacts	**I: 3** **II: 3**	
• Sustainability	**I: 3** **II: 3**	

Brief description, overall objective and project objectives with indicators

The projects comprised the erection of turnkey flue gas desulphurisation plants (FGDs) including ancillary structures for the 1 x 210 MW power station in Orhaneli and the 3 x 210 MW power station in Yatağan. As part of the projects, the operatives were trained and inducted in the technology, operation and maintenance of the

desulphurisation plants and consultancy services were financed. A complementary training measure was also carried out, during which a Turkish delegation of executive and environmental protection personnel was informed about the flue gas desulphurisation technology applied in Germany.
The objective of both projects was a drastic reduction of SO_2 concentration in flue gas from the power stations to below the emission limits stipulated by law.
The overall objective of the project in Orhaneli was the reduction of air pollution from the power station to protect the surrounding forest in order to sustain its ecological function and economic use. The direct target group was the population living around the power station whose main source of livelihood was agroforestry. Indirect beneficiaries were the electricity users. The overall objective of the project appraised later in Yatağan was to reduce air pollution caused by the power station to safeguard the health of the population, protect the remaining and afforested forestland and revive agricultural production.
The indicator for objective achievement in both projects was a SO_2 concentration of less than 1,000 mg/m3 (at 6% O_2) in the flue gas of the respective power stations.

Project design/major deviations from original planning and main causes

The measures in both projects comprised the delivery, assembly and commissioning of respectively one and three flue gas desulphurisation plants using limestone wet wash processes including ancillary plants for water supply and gypsum transport and the training and induction of operating and maintenance personnel.
The project executing agency was the state Turkish power producer EÜAS (formerly TEAS or TEK). EÜAS and its predecessor institutions are long-standing project partners of German Financial Cooperation.
The Orhaneli FGD was commissioned in 1998 after a construction period of 44 months, 16 months later than planned. The implementation period of the project in Yatağan lasted 126 months as compared with the planned time of 40 months due to delays in project implementation, unreliable test operation of the FGDs and prolonged downtimes as a result of legal disputes.

Key results of impact analysis and performance rating

The indicator of an annual average of less than 1,000 mg SO_2 concentration per m^3 of flue gas was met in the Orhaneli plant according to operator records, although the power station ran for long periods without the FGD, as became evident from the power station data. Due to the delays in the construction of the FGDs in Yatağan, the indicator was met there only after final commissioning in March 2008. Before, the power station had in part been operating without FGDs andthe emission limits were temporarily exceeded by a large margin. Altogether then, the overall and project objective in the two plants have only been achieved to a limited extent only. Due to failures in measurement equipment, long-term indicator verification was not possible.
Based on past power generation data and the assumption of full-load operation to 2017, the FGD in the power station in Orhaneli would raise the commercial costs of net power generation by an estimated 0.63 cents/kWh, with operation and maintenance costs accounting for 0.15 ct/kWh. At project appraisal, a cost increase was forecast for the FGDs at the Yatağan power station of 0.44 cents per kWh, which was far exceeded, but this cannot be quantified more precisely due the short operating period so far.
The main benefits of the FGDs are reducing health hazards for the population near the power station, regaining the previous level of agricultural yields, enabling reforestation of the deforested areas and protecting the vegetation from future SO_2 damage. Moreover, by installing the FGDs, investments in the power stations and coalmines can be put to further productive use. The projects thus make a contribution to ensuring a cleaner power supply in Turkey with the beneficial effects entailed for economic development and job creation.

The results chain postulated at project appraisal remains valid. Environmental awareness in Turkey has risen considerably in the last few years and compliance with recognised environmental standards is accorded high policy priority, partly with a view to the accession negotiations with the EU. The projects were therefore effectively aligned with sectoral policy in the partner country. The German Federal Government also continues to attach high priority to environmental protection in electricity generation as part of development cooperation. Power demand continues to rise in Turkey. The installation of filter plants enables continued use to be made of available generating capacity and protects the population and the environment from the harmful effects. The relevance of both projects thus remains high (Subrating 2).

The projects' objective consisted in the drastic reduction of SO_2 concentration in flue gas from the power stations to below the statutory emission limits. The FDGs are generally capable of effectively desulphurising the flue gas at both power station sites. This benefits the population and the flora and fauna around the project power stations. The requisite SO_2 separation rate of 95% has not been consistently reached, though, and there have been frequent shutdowns of the FGDs, because the flue gases of the power stations did not correspond with the specifications of the FGDs or technical defects arose in the FDGs themselves, particularly at Yatağan (Effectiveness for both projects: Subrating 3).

As to efficiency, the two projects must be assessed differently. In **Orhaneli, the FGD** was built with no great time lag**.** One problem, however, is that plant utilisation falls well short of expectations and the power station was operated for lengthy periods without the FGD. The investment in the FGD was therefore not put to full economic use (Efficiency: Subrating 4). In Yatağan, the FGDs were not used for several years due to disputes in the course of constructing the facilities and the damage incurred. The power station has in part been operated without desulphurisation, so that the investments in the FGDs have not been put to effective use. Moreover, the dysfunctional FGDs repeatedly impaired the operation of the power station with considerable earnings losses for the project executing agency (Efficiency: **Subrating** 5).

Altogether, the overall objective of reducing air pollution and protecting the population and the surrounding forest was achieved after completion of the FGDs at both power station sites, despite some deficiencies, although in the case Yatağan the delayed completion of the facilities caused an unacceptable level of air pollution over several years and worsened the resultant harmful effects. Despite the partial adverse experience in the construction of the FGDs in Yatağan, the plants can be expected to have had a positive capacity-building impact on the Turkish energy sector. In conjunction with a third project (FGD Cayirhan) financed from German FC, the two plants in Yatağan and Orhaneli were the first FGDs ever to be installed in Turkey. The experience gained was applied in retrofitting other FGDs so that a large part of Turkish brown-coal power station capacity is now equipped with FGDs. (Overarching developmental impacts for both projects: Subrating 3).

Although long-standing operational experience with the FGD in **Orhaneli has revealed** substantial technical problems**,** the operator has credibly demonstrated that it has identified the causes of the problems and is working successfully to eliminate them. No completely trouble-free operation can presumably be expected in future either, but sustainability is graded as sufficient (Subrating 3). Due to the multiple problems and the resulting operation downtimes in the FGDs in Yatağan, project sustainability has been unsatisfactory till now. Considering the high priority the executing agency now attaches to the FGDs, the Yatağan plant can be expected to remain in long-term future use with the attendant benefits (Sustainability for Yatağan: Subrating 3).

With special consideration given to the efficiency criterion and an otherwise even weighting of the other factors, overall project **performance in Orhaneli merits a sufficient rating (Rating 3).** Despite discernible positive effects, the results in the Yatağan project, particularly the low efficiency and the downtime years of the plants, are insufficient, so that it is accorded a Rating of 4.

Information on performance rating is available in the document, Ex Post Evaluation Criteria and Rating System for German Bilateral FC (14 September 2006).

General conclusions

When retrofitting filter plants, it is very important to account for the actual technical specifications of the power stations. In the present two cases, large technical problems arose in the filter plants, as the flue gases in the power stations did not correspond to the assumed rates. In similar projects, more attention should therefore be paid to the interaction between the existing power station and the new installed filter plant.

Notes on the methods used to evaluate project success (project rating)

Projects are evaluated on a six-point scale, the criteria being relevance, effectiveness (outcome), "overarching developmental impact" and efficiency. The ratings are also used to arrive at a final assessment of a project's overall developmental efficacy. The scale is as follows:

1	Very good rating that clearly exceeds expectations
2	Good rating fully in line with expectations and without any significant shortcomings
3	Satisfactory rating – project falls short of expectations but the positive results dominate
4	Unsatisfactory rating – significantly below expectations, with negative results dominating despite discernible positive results
5	Clearly inadequate rating – despite some positive partial results the negative results clearly dominate
6	The project has no positive results or the situation has actually deteriorated

A rating of 1 to 3 is a positive assessment and indicates a successful project while a rating of 4 to 6 is a negative assessment and indicates a project which has no sufficiently positive results.

Sustainability is evaluated according to the following four-point scale:

Sustainability level 1 (very good sustainability)

The developmental efficacy of the project (positive to date) is very likely to continue undiminished or even increase.

Sustainability level 2 (good sustainability)

The developmental efficacy of the project (positive to date) is very likely to decline only minimally but remain positive overall. (This is what can normally be expected.)

Sustainability level 3 (satisfactory sustainability)

The developmental efficacy of the project (positive to date) is very likely to decline significantly but remain positive overall. This rating is also assigned if the sustainability of a project is considered inadequate up to the time of the ex post evaluation but is very likely to evolve positively so that the project will ultimately achieve positive developmental efficacy.

Sustainability level 4 (inadequate sustainability)

The developmental efficacy of the project is inadequate up to the time of the ex post evaluation and an improvement is very unlikely. This rating is also assigned if the sustainability that has been positively evaluated to date is very likely to deteriorate severely and no longer meet the level 3 criteria.

The overall rating on the six-point scale is compiled from a weighting of all five individual criteria as appropriate to the project in question. A rating of 1 to 3 indicates a “successful” project while a rating of 4 to 6 indicates an “unsuccessful” project. In using (with a project-specific weighting) the five key factors to form an overall rating, it should be noted that a project can generally only be considered developmentally “successful” if the achievement of the project objective (“effectiveness”), the impact on the overall objective (“overarching developmental impact”) and the sustainability are considered at least “satisfactory” (rating 3).