People's Republic of China Wind Park Programme I and II

Ex post evaluation

OECD sector	23068 / Wind power	
BMZ project ID	I: 1995 66 753 II: 1997 65 256	
Programme executing agency	I: Hainan Dongfang Windpark; Zhejiang Wind Power Development Company. II: Guandong Wind Power Company Ltd; Shandong Changdao Wind Power Company Ltd.	
Consultant	I, II: Deutsche Energie-Consult Ingenieur-gesellschaft mbH (DECON) II: Lahmeyer International GmbH	
Year of ex post evaluation	**2005**	
	Project appraisal (planned)	**Ex post evaluation (actual)**
Start of implementation	I: Q4 1995 II: Q3 1997	Q4 1995 II: Q3 1997
Period of implementation	I: 16 months II: 24 months	I: 40 months II: 37 months
Investment costs	I: EUR16.8 million II: EUR 22.7 million	I: EUR18.4 million II: EUR 18.3 million
Counterpart contribution	I: EUR 5.0 million II: EUR 10.4 million	I: EUR 6.9 million II: EUR 6.4 million
Financing, of which Financial Cooperation (FC) funds	I: EUR 5.9 million FC/loan EUR 5.9 Mio Market funds/loan II: EUR 6.1 million FC/loan EUR 6.1 million MM/D	I: EUR 5.8 million FC/loan EUR 5.8 million Market funds/loan II: EUR 5.9 million FC/loan EUR 5.9 million Market funds/loan
Other institutions/donors involved	None	None
Performance rating	3	
• Significance / relevance	2	
• Effectiveness	3	
• Efficiency	4	

Brief description, overall objective and programme objectives with indicators

The Wind Park I and Wind Park II projects cover the establishment of four separate wind parks in four different provinces in the People's Republic of China for the purpose of generating electricity, connecting the wind parks to the relevant power grid and feeding electricity into those grids (Wind Park I: Hainan and Zhejiang; Wind Park II: Guandong and Shandong) (programme

objective). The projects are intended to exploit sources of renewable energy and to help to improve the energy supply without producing environmentally harmful emissions. Wind turbines with a capacity of 36 MW were erected.

A separate quantification of the achievement of the overall objectives was not carried out during the project appraisal as the volume of CO_2 not produced (compared with the alternative of generating power at thermal power plants) by operating the wind parks can be calculated clearly from the volume of electricity produced. These figures are taken as indicators of the extent to which the programme objective has been met. When the final inspection was carried out in 2001 these indicators were corrected upwards as, owing to favourable tender results, more capacity was installed than originally planned. The programme objective indicators are as follows:

Location	**Target figures at project appraisal** *(Annual production in GWh from 2nd year of operation)*	**Corrected indicator (according to BMZ evaluation)** *(annual production in GWh from 2nd year of operation)*	**Actual figures at ex post evaluation** (*Annual* production *in GWh from 2nd year of operation*)
Wind Park I (Hainan)	12 GWh	14.40 GWh	9.95 GWh.
Wind Park I (Zhejiang)	10 GWh	18.00 GWh	14.88 GWh.
Wind Park II (Shandong)	11 GWh	11.88 GWh	9.68 GWh.
Wind Park II (Guangdong)	25 GWh	33.00 GWh	19.80 GWh.

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

The four wind parks being financed under FC are all on China's south-east coast or on off-shore islands, i.e. close to China's economically most dynamic development regions. The wind conditions in these coastal regions and in other inland areas make them particularly suitable for generating electricity from wind power.

The projects cover the setting up four wind parks including infrastructure measures and connecting them to the local grids. As a result of favourable tender results and the use of fairly large wind turbines (600 KW units) it was possible, with the available funds, to install a total of 36 MW instead of the 26 MW planned during the project appraisal. From the current perspective, the wind park design can be described as appropriate with regard to the design of the individual wind turbines and to the breakdown of delivery into imported equipment and a local part covering land connection, foundation laying and grid connection.

Four regional operating companies were founded to run each of the four plants. On the basis of the training courses organised by the manufacturers and the additional expertise gained during the guarantee period, the programme executing agencies are in a position to carry out operation and maintenance independently and in accordance with the manufacturers' operational specifications.

Key results of the impact analysis and performance rating

Until the mid-1990s the commercial use of wind power was largely unknown in China and no technical expertise was available. The various FC projects in this sector (together with smaller preceding projects carried out by the Federal Ministry of Education and Research (BMBF)) made a major contribution to wind power in China being perceived today as a highly promising source of environmentally sound energy which is observed with interest by national operating companies and international enterprises.

In economic terms, wind power in China is still not a profitable source of energy and, from the perspective of business management, is only attractive to operators because of subsidised input tariffs. However, the establishment of a national industry for the production of wind turbines,

which has already begun, is likely to lead to a distinct decrease in investment costs and to make using this technology a more economically viable prospect. The Chinese government is supporting this development by putting the erection and operation of larger wind parks out to tender in such a way that the contract is awarded to the enterprise which offers the most favourable input tariff.

The wind power capacity in China increased from some 30 MW at the time of the project appraisal (mainly very small and experimental decentralised plants) to just under 600 MW in 2003. Of this amount, 36 MW is accounted for by the two FC projects, which were the first to introduce industrial exploitation in China in the form of large-volume wind parks. The share of wind power capacities in the total Chinese generation capacities is, at 0.12%, still very low at present. Although wind power will cover only a limited portion of China's growing energy needs, it will also make a growing contribution to environmentally sound electricity generation in China in the future.

Operational experience at the individual wind parks has varied in the first years from virtually problem-free operation at the Zhejiang plant to extensive serial damage, particularly to the axle gear systems, at all other plants, which led to the contractually agreed availability not always being met. However, extensive replacement work, in part with better designed parts, and repairs by the manufacturers under the terms of the guarantee finally resulted in good to satisfactory availability levels for the wind turbines.

The annual operating costs for the plants in Wind Park Programmes I and II that have been incurred since the end of the guarantee period are below 1% per annum of the investment amount. This is a comparatively low figure. It is explained partly by the fact that the plants are still in a new condition just after expiry of the guarantee period and by the low Chinese wages. Spare parts will be purchased from the manufacturers as required. Based on experience, the annual operating costs are likely to increase over the years as more extensive maintenance and repair work becomes necessary; on average they will probably be around 2.0% of the investment amount.

The dynamic generation costs which were updated during the ex post evaluation were EUR 0.08 per kWh for Wind Park I and EUR 0.07 per kWh for Wind Park II (in each case based on 2004 prices). The dynamic generation costs are slightly higher than estimated during the project appraisal. The increase is due primarily to the fact that less energy is generated than expected during the project appraisal (see below).

The actual input tariffs are EUR 0.11 per kWh for Wind Park I and EUR 0.07 per kWh for Wind Park II. They thus cover the aforementioned updated dynamic generation costs. On the basis of this income situation, the internal interest rate method results in rate of returns of 10% for Wind Park I and 7% for Wind Park II, which is rated satisfactory overall.

The bodies running the wind parks are maintaining and operating the plants professionally and appropriately. There are only limited risks (wind regime, input tariffs) to sustained operation of the four wind parks and the operators have little or no influence on them. All in all, the projects are sustainable from a microeconomic perspective.

The macroeconomic justification for using wind power (in view of the far higher generation costs per kWh compared with thermal alternatives) is primarily that the production of harmful greenhouse gases is prevented. For the macroeconomic assessment of the projects, the focus was therefore on the cost of avoiding CO_2 production. In accordance with today's requirements, the incremental prevention costs should not exceed a ceiling of USD 10 per tonne of CO_2 emissions. The relevant calculations made in the ex post evaluation show that for Wind Park I the incremental costs are USD 31.9 per tonne and for Wind Park II USD 21.4 per tonne. This is clearly in excess of the ceiling and indicates that the projects can currently not be considered as efficient solutions for the CO_2 problem in China.

The achievement of the overall and project objectives of Wind Park Programmes I and II can be summarised as follows:

- **Achievement of project objective:** The amount of electricity actually generated is clearly below the adjusted target values at all four locations. The average deviations are -30%. (Hainan: -31%, Zhejiang: -17%, Shandong: -19%, Guandong: -40%). The following reasons contributed to varying degrees to the loss of output:

- Over-estimation of the wind potential by the provision of unreliable measurements in the run-up to the feasibility studies;
- The observation period included a lengthy period of unusually weak winds;
- Reduced generation possibilities as a result of technical defects (e.g. axle gear system, especially during the guarantee period) or the transmission network being (particularly at Shangdong)
- At the Hainan wind park, the location was changed by the executing agency to one with less wind potential (but lower costs) and at the location in Guandong, there was a less than optimal "micrositing" of the individual wind turbines.

- **Achievement of the overall objective:** With the electricity generated at the four wind parks, at the relevant thermal power plants – in this case, the comparatively modern black coal-fired power plants in the coastal area – the corresponding volume of fuels, i.e. black coal, is reduced and hence CO_2 emission as well. Given a specific emission of 1,164 tonnes CO_2/GWh, production of the following average annual amounts is avoided:
  - Wind Park I 29,342 t CO_2
  - Wind Park II 35,630 t CO_2

With regard to the sectoral problem situation – strongly increasing demand for energy, large dependence on fossil fuels, growing environmental problems, China's significance for the global climate – the two projects can, be justified.

The projects did not aim specifically at supporting gender equality and gender-specific impacts did not occur. Equally, the programme did not aim at achieving a participatory development or good governance. There were no clear employment effects directly attributable to the programme.

The programme locations are isolated or at a sufficient distance from the nearby settlements. There were absolutely no complaints from people living nearby. A side route of the north-south of the route taken by migratory birds, which follows the coastline, passes by the Changdao archipelago. Migratory birds have also been seen resting on the island on which the wind park has been built, without any collision victims being reported to date. The other three wind park locations are not on bird migration routes. From today's perspective, the projects have made an overall contribution to improving the environmental conditions.

The different aspects of developmental effectiveness can be assessed as follows:

- **Relevance/significance:** Given China's environmental problems, the projects are still very relevant. They will make a long-term (small) contribution to environmentally sound energy supply in China (overall objective). It is more important that the FC-funded pilot projects produced a sustained interest in the industrial use of wind power and in this respect also had structural effects. Wind power continues to play a very minor, but growing, role in China. The installed wind power capacity in China has increased by a factor of 20 since the project appraisal and has expanded more and more dynamically thanks to an increase in commercial interest. We evaluate the overall significance/relevance of the project as satisfactory (Partial evaluation: rating 2).
- **Effectiveness:** The windparks are being maintained appropriately, which leads us to assume that operation will be sustained. The programme achievement indicators were on average 30% below target at the four wind parks, which is why we evaluate the effectiveness only as sufficient (Partial evaluation: rating 3).
- **Efficiency:** The specific investment costs per installed MW (production efficiency) were favourable and from a microeconomic point of view operation even covers all costs thanks to subsidised input tariffs (which appear to be secured for the future too). Generating power from the funded wind power plants is, however, seven to nine times more expensive than generating electricity from thermal power plants. However, in economic terms wind power plants are not justified in terms of energy production but in terms of the prevention of CO_2 emissions (fuel saver operation). Nonetheless, the CO_2 prevention costs (allocation efficiency) in these cases are, at USD 26.1-32.5 per tonne well above the ceiling of USD 10 per tonne so far used to assess similar projects. On the European spot market, CO_2 pollution rights are currently trading at prices above EUR 20 per tonne. However, in this

case the prevention costs are very high, meaning that we evaluate the efficiency of the programme as slightly insufficient (Partial evaluation: rating 4).

Taking the aforementioned partial criteria into account, particularly the successful introduction of industrial wind parks in China and the dynamic market development since then, and given that the economic costs that were still far too high in the projects that were subject to ex post evaluation are now falling dramatically because wind turbines can now be produced more cheaply in China (new plants are below the current spot market prices and are approaching the USD 10 per tonne mark), we evaluate the overall developmental effectiveness of the programme as just sufficient (**Overall evaluation: rating 3**).

General conclusions

The following conclusions can be drawn for the project as a whole as regards future wind power projects:

- Feasibility studies for wind power plants should be based on standardised wind measurements at the actual location of the programme over at least one year to enable a sufficiently sound basis for assessing the wind power potential to be obtained.
- The remaining uncertainty with regard to fluctuations in the wind regime lasting several years should be taken into account in wind power projects in the profitability analysis as scenarios/sensitivity calculations.
- The projects confirm previous experiences from other programmes, i.e. that wind potential calculations often overestimate the actual volume of energy that can be generated. The assumptions made in such calculations should therefore be appraised critically in every case and, as appropriate, adjusted on the basis of conservative approaches.

Keys

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 under 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 project generate sufficient **significant developmental effects** (project **relevance** and **significance** measured in terms of the achievement of the previously defined overall development policy objective 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 (**efficiency** of the project concept)?
- 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 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 independently and generate positive results after the financial, organisational and/or technical support has come to an end.