**Public Establishment of Electricity for Generation and Transmission (PEEGT)**

# Environmental Impact Assessment Report

# for

# EXTENSION OF DEIR ALI

# 700 MW Combined Cycle Power Plant

# Environmental Impact Assessment Report of 700 MW EXTENSION OF DEIR ALI Combined Cycle Power Plant Project

# SECTION A

# EXECUTIVE SUMMARY

# SECTION A: EXECUTIVE SUMMARY

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# 1. INTRODUCTION

As an important basis for developing the industrial sector and infrastructure, and ultimately increasing the quality of life of people in Syria, the Syrian government has set the expansion of the power generation sector as a high priority.

Syria's power sector has achieved a fairly high growth rate thus far. The totally installed capacity of the power generation system has increased from 4'128 MW at the end of 2000 to 7000 MW at the end of 2007. The average growth rate during this period was about 7 % per annum. In future the electricity demand is projected to rise by 6-5 % per year until 2010. The Government plans to increase capacity by 5500 MW from 2006 to 2010. To achieve this goal, the Public Establishment for Electricity Generation and Transmission (PEEGT) issued a request for proposal at the end of 2005 to develop a combined cycle power plant nearby the village DEIR ALI some 35 km south of Damascus.

The EXTENSION OF DEIR ALI Combined Cycle Power Plant Project will have an electrical power output of around 700 MW and its design operating life of the plant is 30 years.

The project with a financial volume of some 650 million EURO of which about 300 EURO will be financed by the European Investment Bank (EIB) and the remain by some Arab funds, will make a big contribution in achieving the abovementioned goal.

The main objective of this Environmental Impact Assessment Report is to analyse the environmental situation and the issues resulting from establishing the EXTENSION OF DEIR ALI Combined Cycle Power Plant. This EIA report will consider environmental issues occurring during construction and operation phase. Another important aim is to provide additional information and data if required for the project execution.

# 2. BACKGROUND OF THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT

## 2.1. LEGAL AND TECHNICAL BACKGROUND

The following legal documents were used as a basis for the preparation of this EIA report:

- International finance corporation - Procedure for Environmental and Social Review of Projects 1998
- Guidelines of European Community
- World Bank Guidelines for new thermal power plants 1998
- Syrian guidelines for air quality and emissions

The main technical documents which have been used for the preparation of this EIA report are the following:

- Enquiry specification of EXTENSION OF DEIR ALI Combined Cycle Power Plant
- Technical and Commercial Proposal of the successful EPC-Contractor

## 2.2. ENVIRONMENTAL REQUIREMENTS

Considering the World Bank (WB) and European Community (EC) Standards and Regulations for construction of the power plants, the applicable environmental requirements for EXTENSION OF DEIR ALI Power Project are summarised in Table A 1. The table consists of the requirements on stack emissions, ambient air quality, wastewater discharge, cooling water discharge and noise.

**Remark:** The legal base for this project is the World Bank and European Community standards. The Syrian standards, where available, are not the crucial factor and are only provided as additional information and for comparison reasons.

**Table A 1: Main Environmental Requirements for EXTENSION OF DEIR ALI Power Project**

| Items | Dimension | Syrian Standards | EC Guidelines | WB Guidelines |
|---|---|---|---|---|
| **Emission** | | | | |
| $NO_2$ | mg/Nm$^3$ | 300 | 120 | 125 (gas)/ 165 (oil) |
| | t/day | - | - | - |
| $SO_2$ | mg/Nm$^3$ | 1000 | - | 2000 |
| | t/day | - | - | 120 (for 700 MW) |
| TSP | mg/Nm$^3$ | 50 | - | 50 |
| CO | mg/Nm$^3$ | 250 | - | - |
| **Ambient Air Quality** | | | | |
| $NO_2$ | | | | |
| - 1 h Average | mg/Nm$^3$ | 0.4 | 0.2 | - |
| - 24 h Average | mg/Nm$^3$ | 0.15 | - | 0.15 |
| - Annual Average | mg/Nm$^3$ | - | 0.03 | 0.10 |
| $SO_2$ | | | | |
| - 1 h Average | mg/Nm$^3$ | - | 0.35 | - |
| - 24 h Average | mg/Nm$^3$ | 0.125 | 0.125 | 0.15 |
| - Annual Average | mg/Nm$^3$ | 0.05 | 0.02 | 0.08 |
| TSP | | | | |
| - 1 h Average | mg/Nm$^3$ | - | - | - |
| - 24 h Average | mg/Nm$^3$ | 0.12 | - | 0.23 |
| - Annual Average | mg/Nm$^3$ | - | - | 0.08 |
| $PM_{10}$ | | | | |
| - 1 h Average | mg/Nm$^3$ | - | - | - |
| - 24 h Average | mg/Nm$^3$ | 0.12 | 0.05 | 0.15 |
| - Annual Average | mg/Nm$^3$ | - | 0.02 | 0.05 |
| **Wastewater Discharge** | | | | |
| Temperature increase | °C | Not defined | Not defined | ≤ 3 |
| pH | - | “ | “ | 6-9 |
| TSS | mg/l | “ | “ | 50 |
| Oil and Grease | mg/l | “ | “ | 10 |
| Residual Chlorine | mg/l | “ | “ | 0.2 |
| **Noise (Industrial Areas)** | | | | |
| Day Time (7 h – 22 h) | dB(A) | Not defined- | Not defined | 70 |
| Night Time (22 h – 7 h) | dB(A) | “ | “ | 70 |
| **Noise (Residential Areas)** | | | | |
| Day Time (7 h – 22 h) | dB(A) | “ | “ | 55 |
| Night Time (22 h – 7 h) | dB(A) | “ | “ | 45 |

# 3. PROJECT DESCRIPTION

The plant site is located in the south-western part of Syria, about 35 km south of Damascus. DEIR ALI village is with its 2000 inhabitants and a distance of 2 km to the site the closest settlement beside a hamlet called Zogbor.

The plant site can be reached by highway and road which are in good condition. The transport and delivery of the plants facilities will therefore not pose a problem. The other required infrastructures like gas- and water-pipelines need to be constructed by the EPC-Contractor. The water will come from the Al-Sharaa and baiiat wells 25 km far away while the gas will be delivered from the same pipline feeding the existing power plant.

The EXTENSION OF DEIR ALI Power Plant will be similar to the existing plant and mainly consist of 2 gas turbine-generator units, 2 heat recovery steam generators and one steam turbine-generator set. Further is needed for operation the dry cooling tower, water storage tanks and the switchyard will be extended. This will located in the existing power plant. The main design and operational data of this plant are summarised in Table A 2 and a drawing of the plant layout with view from south-east can be found in Figure A 1.

**Table A 2: The Main Design and Operational Data of the EXTENSION OF DEIR ALI Power Plant**

| | Dimension | Data |
|---|---|---|
| Plant location | - | EXTENSION OF DEIR ALI Plant Site |
| Annual operational time<br>Annual average plant load factor<br>Annual equivalent full load operation | h/a<br>%<br>h/a | 8’000<br>90<br>7885 |
| Plant thermal efficiency<br>Net heat rate<br>Net power generation capacity<br>Annual net power generation | %<br>kcal/kWh<br>MW<br>GWh | 55.3<br>1555<br>700<br>5500 |
| **Plant concept:**<br>- Technology<br>- No. of gas turbines<br>- No. of steam turbines<br>- No. of heat recovery systems<br>- No. of stacks (main and by-pass) | <br>-<br>-<br>-<br>-<br>- | <br>Combined cycle system<br>2<br>1<br>2<br>4 |
| **Type of fuel**<br>- Main fuel | - | Natural gas from Palmyra gas field throw the existing pipeline |

| | Dimension | Data |
|---|---|---|
| - Emergency fuel | - | Distillate oil max. 30 hours per year. |
| **Emissions** | | |
| $NO_x$ | | |
| - Natural gas | $mg/Nm^3$ // ppmv | 51 // 25 |
| - Distillate oil (max. 30 hours/year) | $mg/Nm^3$ // ppmv | 150 // 75 |
| $SO_2$ (dist. oil; max. 30 hours/year) | $mg/Nm^3$ // ppmv | 374 // 132 |
| CO (gas / oil) assumed | ppmv | 24 // 24 |
| **Noise level** | | |
| - Plant Complex boundary | dB(A) | 60 |
| - Equipment (1 m distance) | dB(A) | 90 |

# 4. BASELINE DATA

The EXTENSION OF DEIR ALI plant site is located in the South-Western part of Syria about 60 km from the political border to Lebanon and 90 km from Jordan. The distance to Syria's capital Damascus is 35 km which is inhabited by about 3000.000 people today. The closest villages are DEIR ALI, the most populated centre, with around 2000 inhabitants and the small settlement Zogbor with about 400 people.

The topography around the plant area is plain upland with an average altitude of 680 m a.s.l. (EXTENSION OF DEIR ALI Plant site is 671.6 m a.s.l.) and a slight decrease in height to the south, what causes the general rain water run from north to south. Wind blow is coming mainly from north-west and by this, the two hills (782 m and 705.5 m a.s.l.) north of the site will not form an obstacle for air emission dispersion.

Due to its proximity to Lebanon, where the African, Arabian and the European plate meets, the DEIR ALI region is also affected by seismic activities. The SAC (Seismic Analysis Code) for this area is 4 while on the UBC (Uniform Building Code) scale it is 3. The ground acceleration while shaking is designated 0.1 g. The UBC is ranging from 0 (no risk of ground shaking) to 4 (10% chance of severe shaking in 50 years). The main baseline data can be found in the following Table A 3.

**Table A 3: Main Baseline Data of EXTENSION OF DEIR ALI Area**

| **Climate** | |
|---|---|
| Average temperature | Hottest month (July and August): Average temp. approx 27 °C<br>Coldest month (December and January): Average temp. approx 7 °C |
| Average pressure | Summer: between 932 and 937 mbar<br>Winter: between 937 and 942 mbar |
| Average humidity | Summer: between 47 and 53 %<br>Winter: between 50 and 74 % |
| Average rainfall | Period April to September: 0 to 5.3 mm per month<br>Period October to March: 6.5 to 27 mm per month |
| Average wind velocity | Wind direction north west:<br>Summer from 3.5 to 5.6 m/s with peaks up to 20 m/s<br>Winter from 2.9 to 4.1 m/s with peaks up to 23 m/s |
| **Hydrology** | |
| Surface water | No surface water available |
| Ground water | On EXTENSION OF DEIR ALI plant site sufficient only for plant construction<br>For operation water source is Al-Sharaa area 25 km away from site |

| | |
|---|---|
| **Ambient air quality** | |
| Estimated highway traffic exhaust (t/a) | $SO_2$: 12.3<br>$NO_x$: 84.5<br>CO: 57.2<br>VOC: 12.7<br>PTS: 19.9 |
| Pollutant concentration | No information was found concerning pollution concentration in the surrounding of EXTENSION OF DEIR ALI |
| **Noise pollution** | |
| Noise pollution monitoring | No information was found concerning noise pollution in Syria |

The construction of EXTENSION OF DEIR ALI Combined Cycle Power Plant will have positive long-term benefits on the DEIR ALI region, providing direct and indirect employment opportunities for the local populace. It is predicted that during the construction phase of EXTENSION OF DEIR ALI CCPP it will be provided employment opportunities for up to 1000 construction workers, and once the plant enters commercial operation it will provide high quality long-term employment for approximately 60 persons.

# 5. PROJECT IMPACTS AND MITIGATION MEASURES

## 5.1. INTRODUCTION

The Project, including the construction and operation of the EXTENSION OF DEIR ALI Power Plant will play a very important role in the development of the Syrian Energy Sector, particularly in the Southern part of Syria. It will create a great opportunity for urbanisation, proper change in land-use and overall socio-economic development in the Southern part of Syria.

Beside significant beneficial impacts, and despite the use of a modern combined cycle technology and the use of natural gas as primary fuel, the project may cause minor negative effects on the environment. But the design and approach of the implementation are intended to minimise such negative effects as much as possible.

## 5.2. CONSTRUCTION PHASE

Table A 4 summarises the main impacts of the EXTENSION OF DEIR ALI Power Project during the construction phase of EXTENSION OF DEIR ALI CCPP. In addition, the table contains a short assessment of each individual impact and the applied mitigation measures.

As an overall assessment, it can be stated that there are no serious impacts during the construction period.

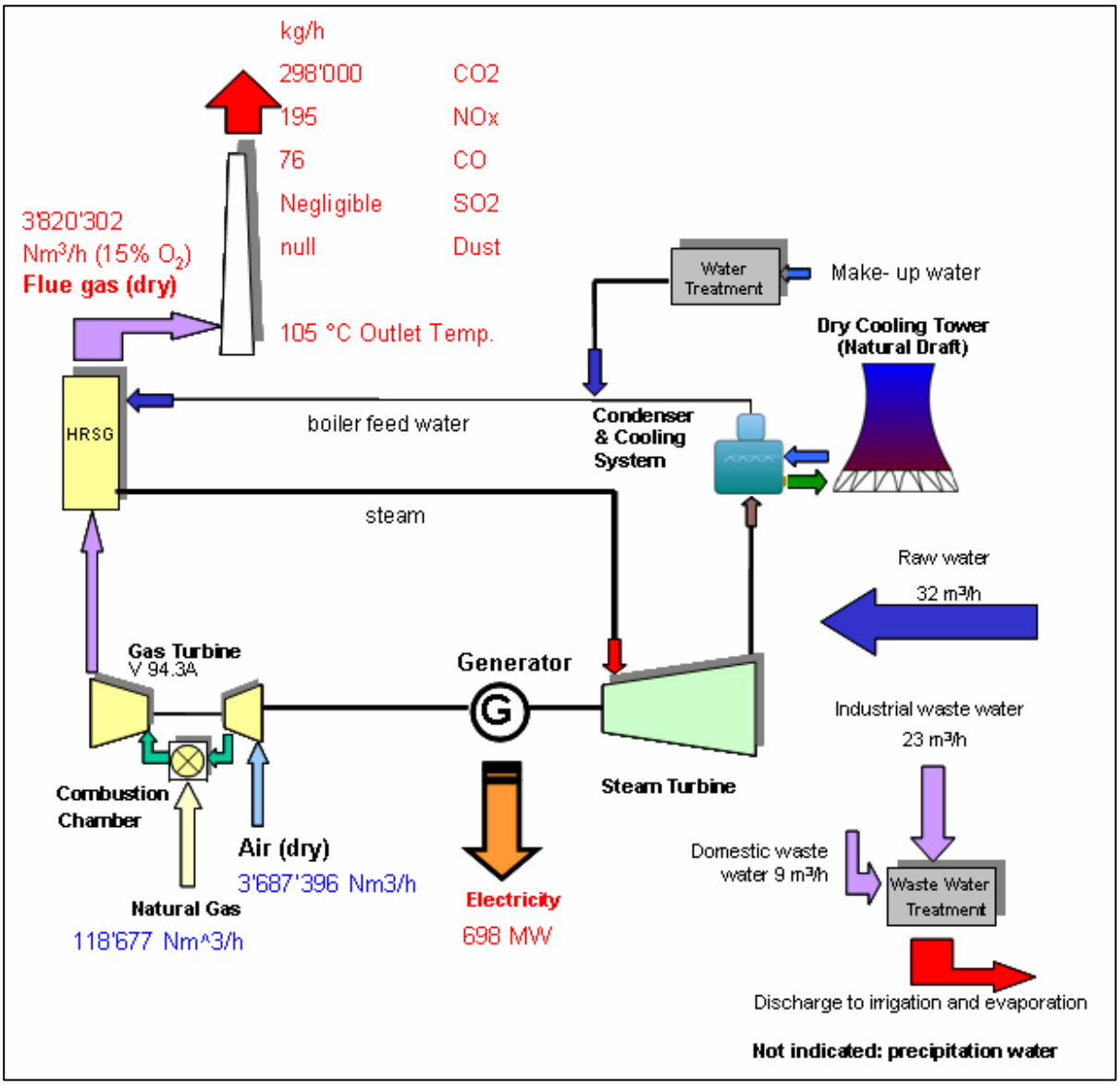
**Table A 4: The main Project Impacts and Mitigation Measures during Construction Phase**

| No. | Impact | Possible Effects | Assessment / Mitigation Measures |
|---|---|---|---|
| 1 | Land used | Space requirement | Approx. 10 ha of total 65 ha PEEGT owned land is required |
| 2 | Traffic / Transportation | Increase in traffic volume | Temporarily effects. Transport of all plant equipment by road. Keep the traffic slow for safety and cover trucks transporting dust such as soil |
| 3 | Construction labour and activities | Increase in air pollution, noise and waste quantity | Temporarily effects. Establishing a wind sealed fence around the site. Avoiding of noisy activities during the night. Wastewater and solid waste disposal according to the local regulations |
| 4 | Socio-economic | Employment aspects | Positive effects on temporary employment for local workers |

## 5.3. OPERATION PHASE

A schematic diagram and balance of the EXTENSION OF DEIR ALI Power Plant is shown in Figure A 2. For reasons of simplicity only one line of combustion chamber – gas turbine – HRSG – stack is drawn. Two gas turbine lines with HRSGs and one steam turbine will be installed. The data in the figure stand for 2 GT + 1 ST at full load.

**Figure A 1: Schematic Diagram and Balance of EXTENSION OF DEIR ALI Power Plant**



During operation phase of the EXTENSION OF DEIR ALI Power Plant the following impacts on the ambient media air, soil and ground water are possible to be controlled by the power plants operating modes:

- Flue gas emissions into the atmosphere (e. g. $NO_x$, $SO_2$, CO)
- Noise within the plant boundary
- Solid waste disposal
- Ambient air quality
- Waste water discharge
- Sanitary water discharge
- Noise outside of the Plant boundary

As an overall assessment the following can be stated:

- Due to the selected technology (combined cycle) and fuel (natural gas) the environmental impact of the plant will be minimized to an acceptable level (see Figure A 8).

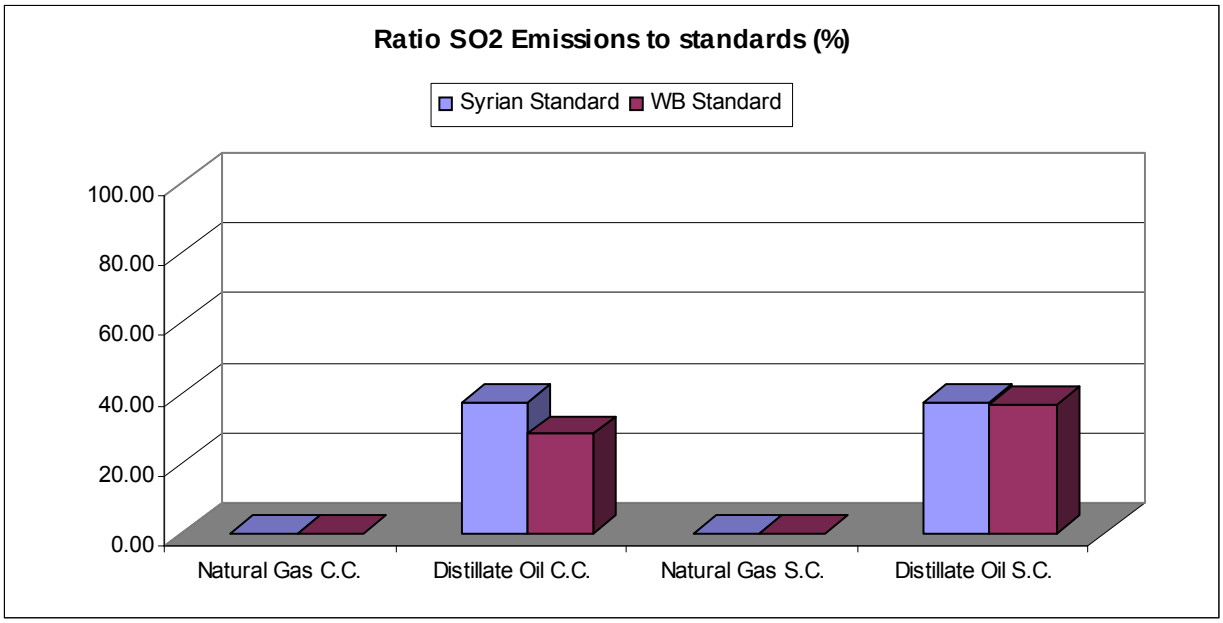
- The project fulfils the Syrian Standard, WB and EC Regulations in all normal operation modes. In particular, the pollutant emissions of the plant when firing natural gas will be very low in comparison to the relevant Standards and Regulations (see Figures A 3 and A 4).
- When applying the EC Guidelines for NOx (120 mg/$Nm^3$) emissions for oil-firing, the guarantee value of the EPC Contractor (150 mg/$Nm^3$) is exceeding this value. But since the distillate oil is considered as emergency fuel only, the operation in that mode is restricted to a maximum of 30 hours per year. Continuously, the plant can be operated for a few hours only as in all the poer plant in Syria. Considering these aspects the possible slight increase of NOx emissions in case of distillate oil operation can be assessed as acceptable and nil.
- The socio-economic benefits of the project for the development of local region as well as for the Syria is very high

A summary of all important impacts during operation phase and the applied mitigation measures are given in the following Table A 5:

**Table A 5: The Main Project Impacts and Mitigation Measures during Operation Phase**

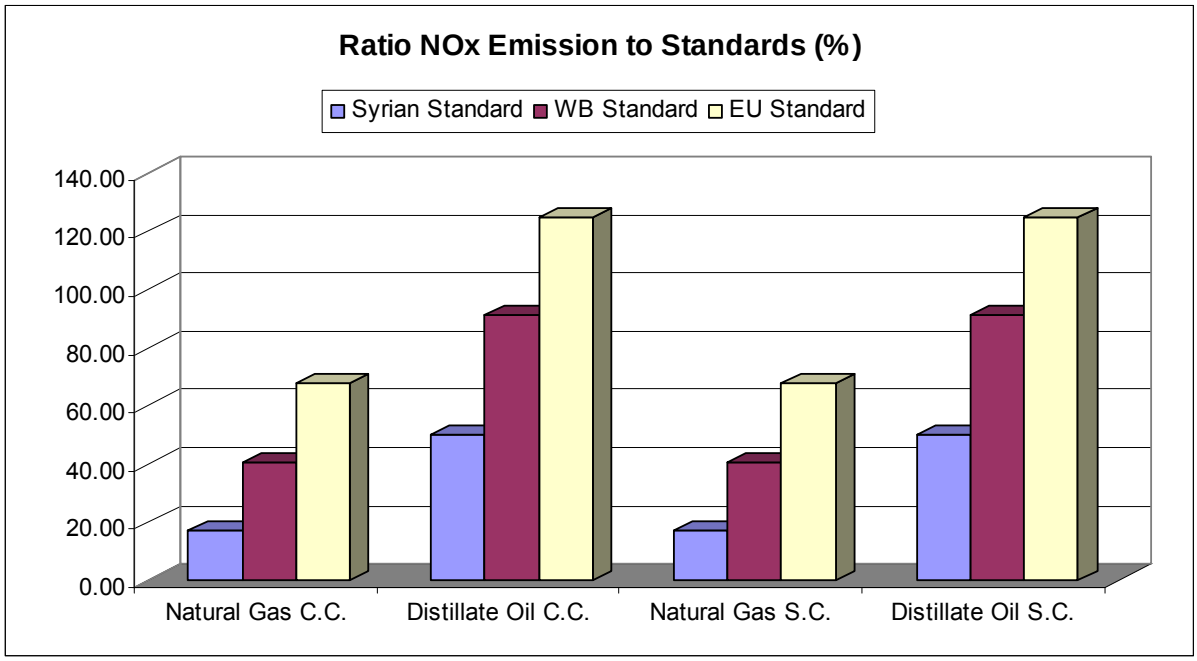
| No | Impact | Possible Effects | Assessment / Mitigation Measures |
|---|---|---|---|
| **1** | Climate | Greenhouse effect | Minimising of specific $CO_2$ emissions by high plant efficiency and natural gas as fuel (427 kg/MWh) |
| **2** | Emissions | $NO_x$ and $SO_2$ pollutions | Limitation of $NO_x$ emission by applying a modern combustion technology (gas 51 / oil 150 mg/Nm$^3$) Limitation of $SO_2$ by using of oil for max. 30 hours/year |
| **3** | Ambient air quality | Increasing of pollutant concentration | Impact minimised because Combined Cycle technology with gas as main fuel (relatively low emissions). Stack height supports good dispersion |
| **4** | Noise | Plant surrounding | Applying noise protection measures in order to meet the required standard |
| **5** | Fresh water demand | Water availability | Fresh water demand of 30 to 55 m$^3$/h will be supplied via pipeline from Al-Sharaa wells. This fresh water demand has no material impact for the current users of this water source. Because of the considered dry cooling tower system no additional cooling water is required |
| **6** | Wastewater discharge | Soil and ground water pollution | Applying of wastewater treatment in order to meet the required standards |
| **7** | Solid waste disposal | Pollution of soil and ground water | The solid waste will be disposed by an authorised local disposal company according to local regulations |
| **8** | Socio-economic | Country and future development | The impact of the project on the local and Syrian socio-economic development can be assessed as very high |

**Figure A 2: $SO_2$ Emissions in % of the Relevant Standards**




Comments: Distillate oil will only be used as emergency fuel max. 30 hours per year

**Figure A 3: NOx Emissions in % of the Relevant Standards**




Comments: Distillate oil will only be used as emergency fuel max. 30 hours per year

# 6. PROJECT ALTERNATIVES

In order to assess the selected technology of the EXTENSION OF DEIR ALI Project regarding the environmental impacts, the following two power generation alternatives (with and without flue gas desulphurisation) have been investigated:

- Generation of 700 MW by a fuel oil-fired conventional power plant.
- Generation of 700 MW by a coal-fired conventional power plant

The results of this investigation show that the negative environmental impacts of these alternatives are much higher than of the EXTENSION OF DEIR ALI plant concept:

- Higher $CO_2$ emission
- Higher $NO_X$ emission
- Higher $SO_2$ emission
- Higher Noise level
- Additional consumables for flue gas cleaning
- Additional residues to be treated and to be disposed
- Higher disposal problems (ash, gypsum, etc.)
- Higher risks of oil spill and fire
- Higher space requirement and land used
- Higher running cost
- Higher plant capital cost
- Higher employees No,

Figures A 5 and A 6 show the comparison between EXTENSION OF DEIR ALI main emissions and the considered alternatives.

Considering all the above gained results, it can be assessed that the plant concept of EXTENSION OF DEIR ALI is the most suitable technology selection for the generation of 700 MW power at the EXTENSION OF DEIR ALI plant site. This plant concept is based on modern combined cycle technology with high thermal efficiency and relatively low environmental impact.

**Figure A 4: Comparison of $CO_2$ Emissions of the Alternatives**

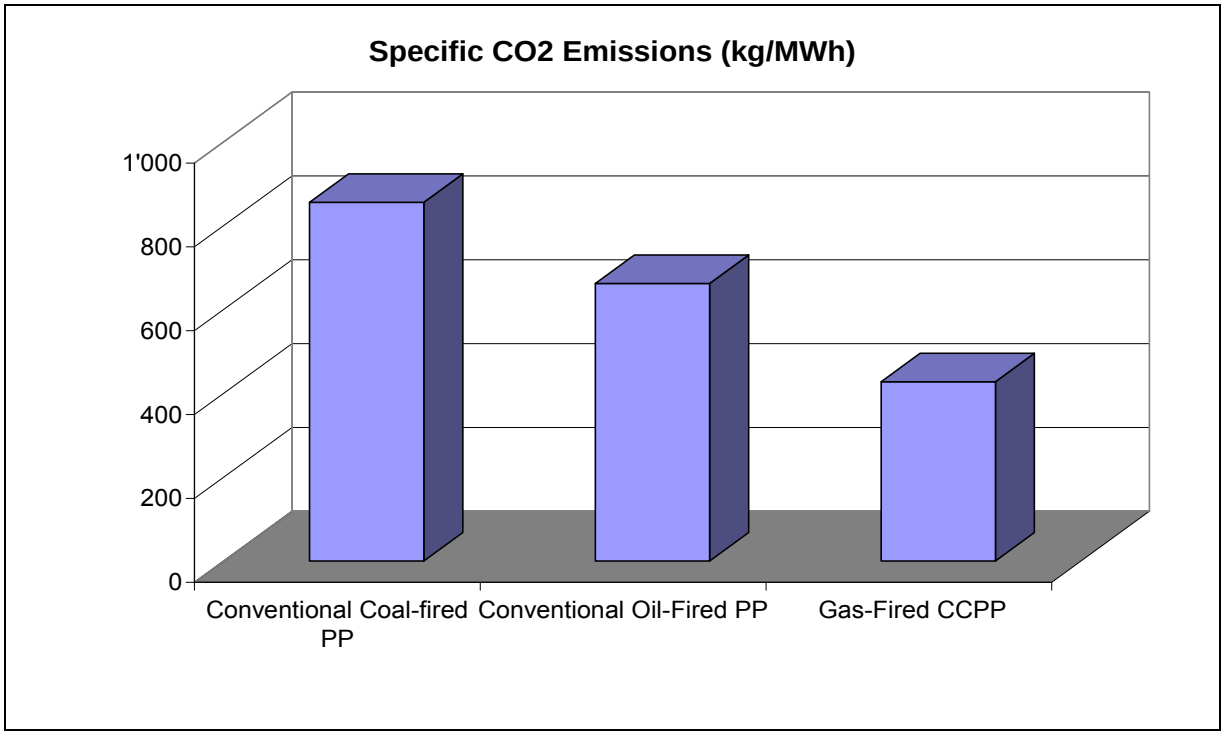
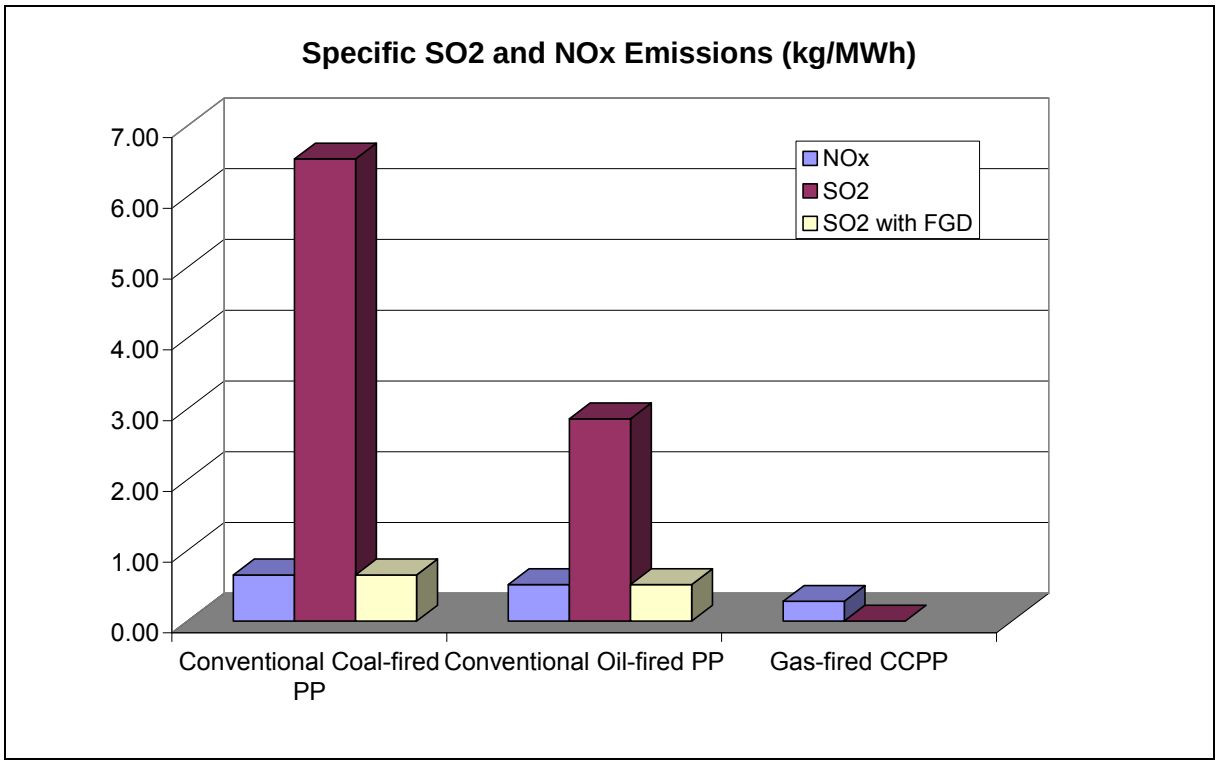



**Figure A 5: Comparison of NOx and $SO_2$ Mass Flows of Alternatives with and without considering FGD for Coal- and Oil fired Power Plants**



# 7. ENVIRONMENTAL MANAGEMENT AND MONITORING

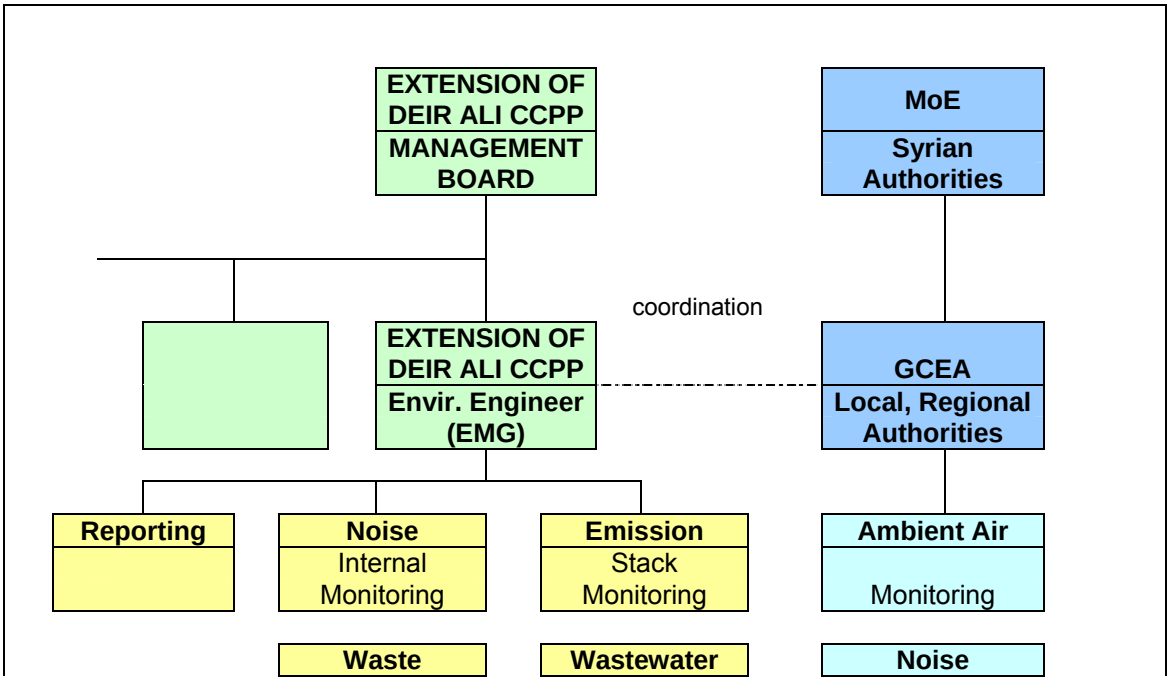
In order to properly assess environmental impacts of the EXTENSION OF DEIR ALI Combined Cycle Power Plant as well as evaluate effectiveness of mitigation measures applied for abatement of environmental pollution a program of monitoring and oversight of the project will be implemented.

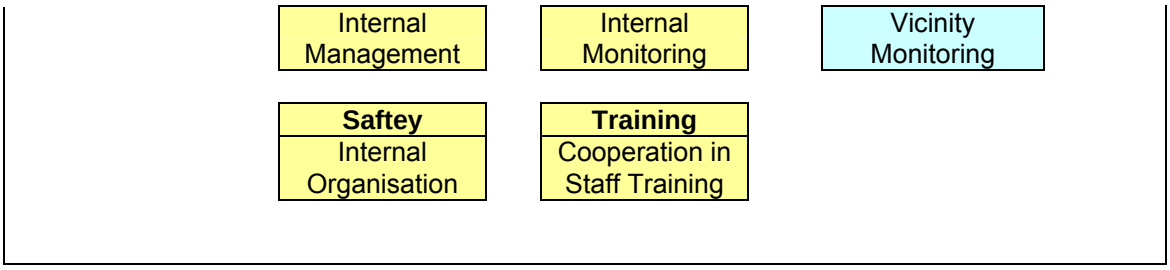
Figure A 7 shows a recommendation for the organisation of the environmental management and monitoring of the EXTENSION OF DEIR ALI Power Plant which will be similer to the existing power Plant and it will be combined after the execution .

The DEIR ALI CCPP Management Board which will be the same for both the existing and the extension shall be responsible for the internal environmental management and monitoring of the plant. For this purpose, the board shall appoint an Environmental Engineer as head of an environmental management group (EMG) who shall be responsible for the execution of environmental related issues of EXTENSION OF DEIR ALI plant in conjunction with DEIR ALI plant.

The organisation of the environmental management in the EXTENSION OF DEIR ALI CCPP shall be set up early in order to commence working already during construction phase.

**Figure A 6: Organisation of Environmental Management for EXTENSION OF DEIR ALI Power Plant**






# 8. CONCLUSIONS

Considering all investigation results, the EXTENSION OF DEIR ALI Power Project can be assessed as follows:

- The project will help to meet the rapid growth in electricity demand in southern Syria and Damascus
- The project will strengthen the regional power supply system, stimulate industrial development and improve the living standards of local residents
- The project will create add ional employment for many workers during the construction and operation phase, and numerous indirect jobs in the supporting local services and supply industry.
- The selected technology of the project “combined cycle principle” is currently representing the most technically and environmentally appropriate power generation system
- The design, construction and operation of the plant will consider and meet the relevant national and international standards and regulations
- The project will use natural gas as fuel (distillate oil max. 30 hours/year) which is, environmentally, the most suitable fossil fuel for power generation
- The project will use most of the existing background
- The project will use the same Gas pipeline
- The project will use the same D O tank

- The project will use the building
- The project will use the same substation
- Some system will be extended
- The same administrative staff will be the existing one
- The same operation and maintenance staff will be the existing one
- The same Vehicle facilities will be the existing one
- Considering the importance of this power project for Syria, the environmental impacts of the plant are in an acceptable range. The main impacts can be assessed as slight to intermediate (see Figure A 8).

**Figure A 7: Summarising Assessment of Environmental Impacts**

| Impact | slight | | inter-mediate | | high | | Remark |
|---|---|---|---|---|---|---|---|
| **Impacts During Construction Phase** | | | | | | | only temporary |
| Land clearing | | | | | | | no population on site |
| Air pollution | ■ | ■ | | | | | mainly dust |
| Water pollution | ■ | ■ | | | | | sanitary water |
| Noise | ■ | ■ | ■ | | | | construction equipment |
| Land used | ■ | | | | | | |
| **Impacts During Operation Phase** | | | | | | | |
| Particulate emission | | | | | | | negligible |
| CO emission | ■ | | | | | | |
| SO2 emission | ■ | | | | | | |
| NOx emission | ■ | ■ | | | | | |
| Impact on ambient air | ■ | ■ | | | | | |
| Noise | ■ | | | | | | |
| Impact on water (by wastewater discharge) | | | | | | | negligible |
| Impact on climate (CO2) | ■ | ■ | | | | | |
| Impact on Flora & Fauna | | | | | | | negligible |
| | | | | | | | |

# Environmental Impact Assessment Report of 700 MW EXTENSION OF DEIR ALI Combined Cycle Power Plant Project

# SECTION B

# PROJECT BACKGROUND, POLICY, LEGAL AND ADMISTRATIVE FRAMEWORKS

# SECTION B: PROJECT BACKGROUND, POLICY, LEGAL AND ADMISTRATIVE FRAMEWORKS

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# 1. POLICY AND PROJECT BACKGROUND

## 1.1. POWER DEVELOPMENT POLICY

To increase the quality of Syrian people's living standard and to keep up with worldwide industrial growth the government should pay special attention on the improvement of the power generation sector. By 1978 a national grid linked nearly all of the country's generating units and most of the larger towns; distribution was extended to rural areas only in the west around the major cities Damascus and Aleppo. According to government statistics, 40 percent of the population remained without electricity in 1980. However, by 1985 almost all of the urban population had received electricity. Rural electrification projects, a top priority of the Ministry of Electricity in the seventies, had also achieved widespread success. The government planned extending electricity to all villages with over 100 inhabitants by 1990. This power expansion process associated with organisational problems, lack of spare parts for power plants, technical impediments and declining water levels in Lake Assad was leading to an electricity crisis around 1985.

Syrian official statistics and Ministry of Electricity data projected that consumption, growing at an annual rate of 20 to 22 percent in the middle of the eighties, would outstrip production until the middle of the nineties. Syria could meet the increasing demand for electricity only by producing additional 300 to 400 MW a year. However, Syria's Ministry of Electricity had problems to cover the increasing power demand by the power plants implemented until 1990. Electricity shortages, blackouts, power cuts, and rationing remained a prominent feature of Syrian life in the late 1980s, frustrating industrial development and impeding economic growth. The situation improved at the end of the nineties when even a part of the produced electric energy could be exported.

At the beginning of 2007 the totally installed Syrian electric generating capacity amounted to about 6250 MW. In future the electricity demand is projected to rise by 6 % per year through 2010. The Government plans to increase capacity by 5500 MW from 2007 to 2011. Almost 13000 MW should be installed until 2020. The demand of Syria's power is supposed to increase in the next years almost constant with an average annual growth rate of estimated 5.6 % as shown in Table B 1. The data of the past years (marked with a star) in the table are actually determined data.

**Table B 1: Power and Electric Energy Demand Forecast until 2020**

| Year | Electric Energy demand Forecast (GWh) | Estimated Annual Growth Rate (%) | Peak load Forecast (MW) | Estimated Annual Growth Rate (%) |
|---|---|---|---|---|
| 2000 | 25217 | | 4128 | |
| 2001 | 26712 | 5.93 | 4565 | 10.59 |
| 2002 | 28013 | 4.87 | 4791 | 4.95 |
| 2003 | 29533 | 5.43 | 5081 | 6.05 |
| 2004 | 31700 | 7.34 | 5460 | 7.46 |
| 2005 | 33919 | 7.00 | 5842 | 7.00 |
| 2006 | 36225 | 6.80 | 6239 | 6.80 |
| 2007 | 38616 | 6.60 | 6651 | 6.60 |
| 2008 | 41088 | 6.40 | 7077 | 6.41 |
| 2009 | 43635 | 6.20 | 7516 | 6.20 |
| 2010 | 46253 | 6.00 | 7967 | 6.00 |
| 2011 | 48936 | 5.80 | 8429 | 5.80 |
| 2012 | 51677 | 5.60 | 8901 | 5.60 |
| 2013 | 54467 | 5.40 | 9382 | 5.40 |
| 2014 | 57299 | 5.20 | 9870 | 5.20 |
| 2015 | 60164 | 5.00 | 10364 | 5.01 |
| 2016 | 63052 | 4.80 | 10861 | 4.80 |
| 2017 | 65953 | 4.60 | 11361 | 4.60 |
| 2018 | 68854 | 4.40 | 11861 | 4.40 |
| 2019 | 71746 | 4.20 | 12359 | 4.20 |
| 2020 | 74616 | 4.00 | 12853 | 4.00 |

The electric energy consumption of Syria is still low compared to other adjacent countries as can be seen from Table B 2. The total electricity consumption 2001 was 21.63 million MWh which conforms to a consumption per capita of 1230 kWh. Iran e.g. had 2001 an annual consumption of 115.9 million MWh or a per capita consumption of 1698 kWh while the United Arab Emirates had 2001 a consumption of 35.1 billion kWh corresponding to a per capita consumption of 14126 kWh.

**Table B 2: Comparison of Power Generation, Power Consumption and GDP of Syria with some other Neighbouring and International Countries for 2001**

| Country | GDP [Billion USD] | Electricity production total [Billion kWh] | GDP per capita [USD] | Electricity production per capita [kWh] | Electricity consumption per capita [kWh] |
|---|---|---|---|---|---|
| **Syria** | 57.6 | 26.7 | 3275.41 | 1517.05 | 1229.98 |
| **United Arab Emirates** | 48.9 | 37.7 | 19679.50 | 15188.23 | 14125.78 |
| **Kuwait** | 31.4 | 31.5 | 14382.81 | 14424.03 | 13416.32 |
| **Bahrain** | 10.1 | 6.3 | 15137.02 | 9377.46 | 8721.02 |
| **Saudi Arabia** | 235.6 | 122.4 | 9697.93 | 5038.31 | 4684.31 |

| Country | GDP [Billion USD] | Electricity production total [Billion kWh] | GDP per capita [USD] | Electricity production per capita [kWh] | Electricity consumption per capita [kWh] |
|---|---|---|---|---|---|
| **Lebanon** | 18.6 | 6.728 | 4989.66 | 1804.86 | 1995.86 |
| **Iran** | 374.6 | 124.6 | 5486.32 | 1824.87 | 1697.45 |
| **Turkey** | 455.3 | 116.6 | 6684.82 | 1711.94 | 1653.22 |
| **Jordan** | 19.4 | 7.091 | 3552.94 | 1298.65 | 1256.34 |
| **Yemen** | 15.6 | 3.01 | 806.20 | 155.55 | 144.70 |
| **Germany** | 2’062.2 | 544.8 | 25027.20 | 6611.78 | 6150.61 |
| **Japan** | 3’394.4 | 1’037 | 26682.49 | 8151.58 | 7579.32 |
| **USA** | 9’612.7 | 3’719 | 33108.13 | 12809.00 | 12406.03 |

There are two different types of power plants in Syria. The major part of electricity generation is done by thermal power plants 48.56% Steam units , 25.60% Combine cycle,7.42% Gas turbine , while the remaining 18.42 % is generated by hydro power plants located mainly in the north of Syria e.g. Euphrates-dam (see Table B 3). Due to the fact that Turkey is using the Euphrates River also for electric energy production, the amount of exploitable water decreased so that the Syrian hydroelectric plants can only be run significantly below their nominal capacity.

**Table B 3: Types of Power Generation Plants and their Installed Capacity in Syria in 2007**

| Type of Power plants | Percentage Contingent | Installed Capacity |
|---|---|---|
| Thermal Power | 81.58 | 34026 GW |
| Hydro Power | 18.42 | 3520 GW |

Natural gas fired power plants provide around 33 % of the electricity generated by thermal power plants in 2007.

## 1.2. PROJECT BACKGROUND

In 2006 PEEGT (Public Establishment of Electricity for Generation and Transmission) announced the need for design, manufacture, supply, transport, insurance, testing and execution of a 700 MW Combined Cycle Power Plant on turn-key basis in EXtension of DEIR ALI region (35 km South of Damascus) with in the site of Deir Ali power plant. The design operating life time of the plant will be 30 years. Financing of this project will be done by the EIB (European Investment Bank) and the Arab Fund for Economic and Social Development.

Power output from the plant will help to meet the rapid growth in electricity demand in Damascus and other areas.

The main objectives of this power plant project can be summarised as follows:

- To strengthen the regional power supply system, upgrade the general physical infrastructure, stimulate industrial development and improve the living standard of local residents.

- To efficiently use the indigenous natural gas from the Palmyra resource area.

- To create long term, stable, high quality direct employment for approximately 1’000 skilled and unskilled workers during the construction phase, and numerous indirect jobs in the supporting local services and supply industry.

- To transfer the best available technology, and management technique and expertise, through the installation of an advanced technological power plant using power equipment and technology, and the implementation of long-term advanced level multidisciplinary skill training.

# 2. LEGAL FRAMEWORK

## 2.1. SYRIAN ENVIRONMENTAL LEGISLATION

In the Syrian Arab Republic, issues related to environmental pollution are handed to the Ministry of State for Environment. Partially, environmental policies are also distributed among different governmental ministries and sub organisations. The Ministry of State for Environment, founded in 1991, enacted several environmental protection laws until now for a better use of natural resources and preventing and reducing pollution.

Some examples of environmental laws and regulations adopted by the Syrian government are given below:

- **Law on Environmental Protection and Development of March 1994**
  This Law is composed of 10 sections and 46 articles. Some of them are listed below: definitions and terms (sec. I); environmental media protection: water protection, water standards and criteria suitable for various uses, air pollution monitoring, allowed limits of noise and vibration, land classification (industrial, agricultural, pastoral, for afforestation and for housing), classification of pollutants, protection of plants and animals, creation of nature reserves, environmental impact assessment of industries (art. 2); pesticides use control (art. 3); prohibition to smoke in public places and in means of transport (art. 10); refuse treatment (art. 12) (sec. II); licences and environmental impact assessment (sec. III); disasters (sec. IV); liability and compensation for damages (sec. V); legal and administrative procedures (sec. VI), etc.

- **Water protection**
  In the civil code of 1949 also the property of land waters is arranged. The principle in this code is that the ownership of land includes what is above and below the surface. A spring or a groundwater reservoir would also be owned by the landowner.
  There are individual laws including the water ownership and use
  - Order law No. 79 of 16 March 1960 making drilling of wells subject to a prior authorisation issued by the interested administrative agency
  - With finishing of the Tabaqah Dam, law No. 3 organizing dam operation was passed in February 1972

## 2.2. SYRIA'S INTERNATIONAL ENVIRONMENTAL AGREEMENTS

In the last 30 years Syria signed several covenants regarding environmental issues. Some of them are listed below.

### 2.2.1. Major International Environmental Accords

**General Environmental Concerns**

- Convention on Environmental Impact Assessment in a Transboundary Context, Espoo, 1991: This convention stipulates the obligations of parties to assess the environmental impact of certain activities at an early stage of planning. It also lays down the general obligation of States to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries.

**Accords Regarding Atmosphere**

- Annex 16, vol. II (Environmental Protection: Aircraft Engine Emissions) to the 1044 Chicago Convention on International Civil Aviation, Montreal, 1981
- United Nations Framework Convention on Climate Change (UNFCCC), New York, 1996

### 2.2.2. Major Conventions Regarding Living Resources

**Nature Conservation and Terrestrial Living Resources**

- Convention on Biological Diversity (CBD), Nairobi, 1992
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Washington, D.C., 1973

## 2.3. OBJECTIVES OF THIS EIA REPORT

The main objective of this Environmental Impact Assessment Report is to analyse the environmental situation and the issues resulting from establishing a combined cycle power plant near DEIR ALI village in Syria. The lender requires an EIA report and defines its structure which in this case needs to meet the requirements of the International finance

corporation from December 1998. It covers and evaluates all environmental aspects occurring during the realisation of this power plant project. This EIA report will consider environmental issues occurring during construction and operation phase. Another important aim is to provide additional information and data if required for the project execution.

## 2.4. LEGAL BACKGROUND OF THE PROJECT

This EIA report is based on the following legal documents:

- International finance corporation - Procedure for Environmental and Social Review of Projects 1998
- World Bank Guidelines for new thermal power plants 1998
- Directive 2001/80/EC of the European parliament and of the council of 23 October 2001 on the limitation of emissions of certain pollutants into the air form large combustion plants
- Directive 1999/30/EC of European parliament and of the council of 22 April 1999 relating limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air
- Syrian guidelines for air quality and emissions

## 2.5. TECHNICAL BACKGROUND OF THE PROJECT

The technical documents have been used for the preparation of this EIA report are the following:

- Enquiry specification of EXtension of DEIR ALI Combined Cycle Power Plant
- Technical and Commercial Proposal of the successful Contractor

# 3. ADMINISTRATIVE FRAMEWORK

## 3.1. PROJECT TEAM

This report in hand has been prepared by a team of experts of the PEEGT based on Deir Ali EIA report.

## 3.2. APPLIED METHODOLOGY

### 3.2.1. Assessment Methods

Assessment of the possible impacts of the EXtension of DEIR ALI Power Plant Project on the environment was based on the following methods:

**Judgement**

Based on the proposal of the successful EPC-Contractor submitted for project implementation, international literature and experience, judgement was used for the preliminary assessment of the impacts of the project on the environment.

**Classification of Potential Impacts**

In this study the evaluation of the potential impacts is based on experience with similar projects and on the environmental conditions present in the site surrounding area. The anticipated negative environmental impacts are classified into 4 categories “High”, “Intermediate”, “Slight”, and “Negligible”.

- A **high** impact can destroy an element of the environment or create a strong environmental modification. Such an impact can greatly affect an environmental component if it is impossible to adopt adequate mitigation measures.

- A **intermediate** impact may partially reduce a value or use of an environmental component and have an affect on a limited portion of the population

- A **slight** impact may slightly reduce the value or use of an environmental component and slightly affect a small group of the population

- Some activities of the project may not create evident negative impacts on the environment. In such cases, the assessment will not be detailed but some commentaries will be given. This type of impacts is identified as **negligible.**

# 4. ENVIRONMENTAL REQUIREMENTS

In the following, Syrian and international guidelines and laws with reference to the project are described.

**Remark:** The legal base for this project is the World Bank and European Community Guidelines. The Syrian standards, where available, are not the crucial factor and are only provided as additional information and for comparison reasons.

## 4.1. EMISSION STANDARDS AND WARRANTIES

For the assessment of the impact of the flue gas emission from the EXtension of DEIR ALI power plant the following standards will be considered:

- Present Syrian Air Emission Standards
- Directive of the European Community 2001/80/EC for large Combustion Plants
- The World Bank Emission Guideline for thermal power plants from 1998

In Table B 4 the Syrian, EC and World Bank emission standards are summarised. The Syrian guideline gives a range in the limit values, where the lower values are the general threshold, valid for general emitters while the higher value is valid for specific industries which are e.g. handling this kind of materials. In case of the EXtension of DEIR ALI Power Plant Project the lowest value of the parameters was applied in this report.

**Table B 4: Emission Standards of Syria, EC and World Bank Guidelines (for CCPP)**

| | **Load (t/day)** | **Concentration in Flue gas (mg/Nm$^3$)** | | | |
|---|---|---|---|---|---|
| | **$SO_2$** | **$SO_2$** | **$NO_x$ (as $NO_2$)** | **CO** | **TSP[1)]** |
| **Syrian Standard** | - | 1000 | 300 | 250 | 50 |
| **EC Guideline** | - | - | Gaseous fuels: < 75<br><br>Liquid fuels: < 120 | - | - |
| **World Bank Guideline** | 0.2 tons per MWe and day up 500 MWe<br><br>plus 0.1 tons per MWe and day for each additional MWe over 500 MWe | < 2000 | Gaseous fuels: < 125<br><br>Liquid fuels: < 165 | - | For all fuels: 50 mg/Nm$^3$ |

1) TSP: Total Suspended Particulate

**Emission Guarantees by EPC-Contractor**

The EPC-Contractor is to guarantee values for $NO_x$ which cannot be calculated by a combustion calculation. These values are listed in Table B 5 for each operation mode.

**Table B 5: Guaranteed Emission Values by EPC-Contractor**

| | Unit | Guaranteed $NO_x$ values |
|---|---|---|
| **Natural gas firing** | ppmv | 25 |
| **Distillate fuel oil firing** | ppmv | 75 |

## 4.2. AMBIENT AIR QUALITY STANDARDS

For the assessment of the ambient air quality of the EXtension of DEIR ALI project the WB and EC Guideline can be considered. The relevant air quality requirements of these Guidelines are shown in Table B 6. The relevant values of the Syrian guideline for ambient air quality and the corresponding measure time are shown in Table B 7. In case of $SO_2$, TSP and $PM_{10}$ the Syrian guideline is stricter than the World Bank requirements which are applied for the EXtension of DEIR ALI Power Project. The $NO_x$ value is the same for a 24 hour measurement.

**Table B 6: Ambient Air Quality Standards of World Bank and European Community**

| Parameter | 1 h average (mg/Nm3) | | 24 hrs average (mg/Nm$^3$) | | Annual average (mg/Nm$^3$) | |
|---|---|---|---|---|---|---|
| | WB | EC | WB | EC | WB | EC |
| $SO_2$ | - | 0.35 | 0.15 | 0.125 | 0.08 | 0.02 |
| NOx as $NO_2$ | - | 0.20 | 0.15 | - | 0.10 | 0.04 |
| TSP | - | - | 0.23 | - | 0.08 | - |
| $PM_{10}$ | - | - | 0.15 | 0.05 | 0.05 | 0.02 |

**Table B 7: Relevant Syrian Air Quality Standards**

| Parameter | Measure Time | mg/Nm$^3$ |
|---|---|---|
| $SO_2$ | 24 h<br>1 year | 0.125<br>0.05 |
| $NO_x$ as $NO_2$ | 1 h<br>24 h | 0.4<br>0.15 |
| TSP | 24 h | 0.12 |
| $PM_{10}$ | 24 h | 0.07 |

| Parameter | Measure Time | mg/Nm$^3$ |
|---|---|---|
| **CO** | 15 min<br>30 min<br>1 h<br>8 h | 100<br>60<br>30<br>10 |

## 4.3. WATER QUALITY STANDARDS

Table B 8 shows the World Bank Guideline for Effluents from Thermal Power Plants taken from the guideline for new thermal power plants 1998. There exists no relevant Guideline for EC regarding the waste water effluent.

**Table B 8: World Bank Guideline for Effluents from Thermal Power Plants**

| Parameter | Maximum Value (mg/l); (pH without unit) |
|---|---|
| pH | 6 - 9 |
| TSS | 50 |
| Oil and grease | 10 |
| Total residual chlorine | 0.2 |
| Chromium (total) | 0.5 |
| Copper | 0.5 |
| Iron | 1.0 |
| Zinc | 1.0 |
| Temperature increase at the edge of the mixing zone | less than or equal 3°C |

## 4.4. NOISE STANDARDS

### 4.4.1. Outside plant area

Noise abatement measures should achieve either the levels shown in Table B 9 or a maximum increase in background levels of 3 dB (A). Measurements are to be taken at noise receptors located outside the project property boundary. There exists no relevant Guideline for EC regarding the noise emissions.

**Table B 9: World Bank Noise Guideline**

| Receptor | Maximum allowable log equivalent (hourly measurements), in dB (A) | |
|---|---|---|
| | Day (7.00 – 22.00) | Night (22.00 – 7.00) |
| **Residential, institutional, educational** | 55 | 45 |

| | | |
|---|---|---|
| **Industrial commercial** | 70 | 70 |

### 4.4.2. Inside plant area

Inside the plant the ISO 1996 and ISO DP 6190.2/87 recommendations are guaranteed by the EPC-Contractor. According to these standards 90 dB (A) shall not be exceeded at a horizontal distance of 1 m to the noise emitter and 1.2 m above ground in any operation mode of the plant.

### 4.4.3. At plant boundary

The EPC-Contractor guarantees that noise radiated from the plant will not exceed 60 dB (A) at the site boundary with the plant running in any mode when measured at 15 minutes intervals. The measurement position shall be made at a height of 1.2 m above ground.

With this requirement the World Bank Immission standards for industrial zones shown in Table B 9 are achieved easily.

# Environmental Impact Assessment Report
# of 700 MW EXTENSION OF DEIR ALI
# Combined Cycle Power Plant Project

# SECTION C

# PROJECT DESCRIPTION

# SECTION C: PROJECT DESCRIPTION

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# 1. INTRODUCTION

The implementation of the EXTENSION OF DEIR ALI CCPP is a very important project for the national energy provider PEEGT (Public Establishment of Electricity for Generation and Transmission) which was created due to reorganisation measures within the Ministry of Electricity in July 1994. The Ministry was split into two divisions. The PEEGT is, as the name indicates, responsible for the power generation and for the transmission of electric power. The second department, the GEDEEE (General Establishment for Distribution and Exploitation of Electrical Energy) is answering for distribution, exploitation and demand side. This new organisational structure improves the handling of this wide range field, from first stage of exploitation over power generation and transmission to efficient use of fuel energy and electricity by the end-user.

Due to the growing energy demand of the country, new power plants are necessary to ensure a reliable energy supply for industry, households, public utilities etc. The 700 MW EXTENSION OF DEIR ALI CCPP will make an important contribution to this in the South Western part of Syria.

# 2. PROJECT LOCATION AND PLANT LAYOUT

## 2.1. PROJECT LOCATION

The plant site is located in the south-western part of Syria, about 35 km south of Damascus, about 60 km from the political borders to Lebanon and about 90 km from Jordan. The location of the plant site is in the Municipality of DEIR ALI village pertaining to the province of "Damascus Countryside". 2 km northwest to the site DEIR ALI village is located with around 2000 inhabitants. It is also the most populated centre in the surrounding area. The hamlet Zogbor is the closest settlement with a population figure of 400 persons and a distance of 1 km to the site.

The altitude of the plateau at the plant site is 671.6 m above sea level. The surrounding area is relatively flat, except two elevations. The first hill is located 1 km northeast and its highest point reaches 782 m while the second is about 200 m in the north with 705.5 m height. These elevations will not form an obstacle for air emission dispersion, because most of the time wind blows from northwest.

Due to the fact that surface water trickles away fast in the rainy season from November to April it can not be used as a reliable water source. As the ground water reservoir is also scarce on plant site, but sufficient for the construction phase, the main water supply will be done by wells located in Mesmieh ,Zahnan and Baiat and PEEGT start to dig anther wells to cover the need of the extension . The raw water will be pumped up to the site via a 25 km long pipeline, what will be built by the Contractor. The difference of level is 65 m over the total pipeline length.

The approval for this site was granted by PEEGT due to the following reasons:

- Existing infrastructure, the already established systems of streets and electric power lines do not require further investments and soil usage
- Interconnection with the national electricity network due to the already existing substation and a close proximity to Damascus, the largest power consumption centre in Syria
- There is no relevant hindrance for air emission dispersion
- No resettlement of people living on or close to site area needs to be done
- The important public utilities like hospitals, schools or markets are already available in the nearby village DEIR ALI

- The availability of the extisting site of Dair ALI Combine cycle site which has the following :
  1. The gas pipeline
  2. The existing D O tanks
  3. The existing Building ( administration , ware house, worker housing,…)
  4. The existing site
  5. The existing fence
  6. The existing operation and maintenance staff
  7. The existing administration stuff
  8. The existing grid
  9. The existing substation
  10. The existing facilities such as ( Vehicles, fire truck ,mobile crane ….)
  11. The existing road network

## 2.2. TRAFFIC SYSTEM

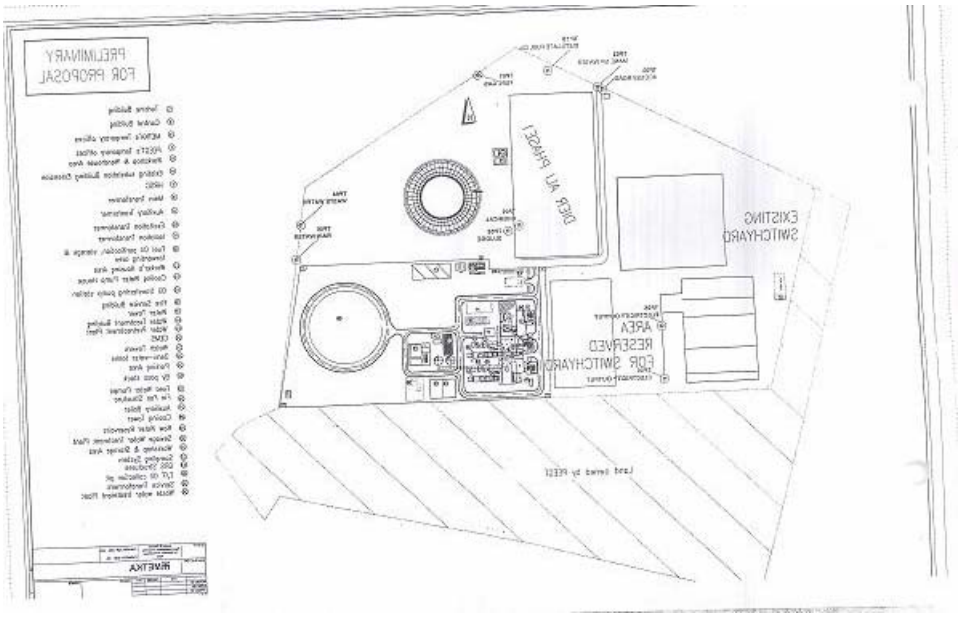
To cover the distance between the plant site and Damascus city three different types of roads have to be used. While the highway needs to be taken for about 28 km, two well paved main roads in good condition cover the remaining 7 km to the plant site. The huge amount of traffic occurring during plant construction will be run mainly on the described way. The delivery of the general supply with all accessories during construction and operation phase will also be transported by this way. A road extension due to the heavy and big loads carried during plant construction will not be necessary. Beside air- and the way mentioned before, there is no other option to reach the location in the desert.

## 2.3. PLANT LAYOUT

The EXTENSION OF DEIR ALI Combined Cycle Power Plant will be installed next to an already existing Dair ali power plant which is very similar to the new one. The plant can be divided in four principal areas. The power block, the high voltage switchyard, water treatment facilities will be constructed on the project site. The existing 400 kV substation connected already to the national transmission grid will be extended to be connected into the plants' switchyard. The power generation block mainly consists of two gas turbines, two Heat Recovery Steam Generators and one steam turbine with all their auxiliaries. Natural gas will be supplied by a the existing pipeline. The general plant layout is shown in Figure C 1.

The water for plant operation must first be treated and then be stored for different usage like drinking, cooling, steam production etc. Before discharging the sewage water it needs to be treated and cleaned. and can be used for irrigation The detailed description of the procedures can be found in this Section, “chapter 3.3.”. A detailed description of the main plant components can be found in “Chapter 3.” later in this Section

**Figure C 1: Plant Layout of EXTENSION OF DEIR ALI CCPP**




## 2.4. MAIN CONSTRUCTION ISSUES

### 2.4.1. Site preparation

The project area is all land what will be required for the construction and operation of the project. The area used by the EXTENSION OF DEIR ALI power plant project including the existing power plant and the substation. Site preparation for the installation of the extension power units will be restricted to this area. The land owned by PEEGT provides, for extension, enough space for the Combined Cycle Power Plant with a capacity of 700 MW.

### 2.4.2. Statics

Even if neither wind speeds in this area throughout the year (see “Section D, Chapter 2.4.5.”) nor the seismic parameters (described in “Section D, Chapter 2.3.”) are reaching critical values, the construction needs to achieve a high security and reliability. The design of e.g. the plant’s stacks is done to resist wind speeds up to 35 m/s and a basic pressure of 75 kg/m$^2$.

### 2.4.3. Man Power Requirement

Some labour force for both, the construction and the operation phase can be found in the existing power plant and in the surrounding villages and Damascus. Adequate accommodation will be set up by the contractor for labour force coming from farther and PEEGT will arrange the accommodation for their staff in the existing worker housing. The necessary amount of workers during the construction period is estimated to be between approx. 200 and 1000, depending on construction activities. 160 – 200 people will be employed as staff for plant operation in 3 shifts. but no administration staff is necessary for the extension. It will be located 1 km away from plant site. Numerous indirect jobs e.g. in the supply industry will also be created mainly in Damascus and in the surrounding villages.

# 3. PLANT CONCEPT

In the following the main concepts and data of the EXTENSION OF DEIR ALI Power Project will be presented.

## 3.1. PLANT PROCESS

3.1.1 Existing deir Ali power plant:

The plant consists of two power generation cycles. The first cycle is represented by the gas turbines. Air is compressed and passed on into the combustion chambers with a reciprocating compressor. Here fuel mixed with air is burned to produce a hot high pressure gas which is expanded through a turbine. The turbine drives both the compressor and an electrical generator to produce electricity.

The second cycle is a steam cycle. The exhaust gas from the gas turbine is still hot (over 500 °C) and is passed on into a Heat Recovery Steam Generator (HRSG) where the heat energy of the flue gas is used to generate steam at high pressure. This steam is used to drive a steam turbine which powers a further electrical generator.

The plant has two gas turbines, two Heat Recovery Steam Generators and one steam turbine (2:2:1 concept). They operate together as a single integrated module.

3.1.1 Extension of Deir Ali power plant:

A simplified process flow diagram of EXTENSION OF DEIR ALI Power Plant is shown in Figure C 2. The plant consists of two power generation cycles. The first cycle is represented by the gas turbines. Air is compressed and passed on into the combustion chambers with a reciprocating compressor. Here fuel mixed with air is burned to produce a hot high pressure gas which is expanded through a turbine. The turbine drives both the compressor and an electrical generator to produce electricity.

The second cycle is a steam cycle. The exhaust gas from the gas turbine is still hot (over 500 °C) and is passed on into a Heat Recovery Steam Generator (HRSG) where the heat energy of the flue gas is used to generate steam at high pressure. This steam is used to drive a steam turbine which powers a further electrical generator.

The plant has two gas turbines, two Heat Recovery Steam Generators and one steam turbine (2:2:1 concept). They operate together as a single integrated module.

With all necessary buildings such as administration building , fire fighting building ,ware house building , water treatments plants ,gate house , fence ….

## 3.2. FUEL SUPPLY

The combustion turbines which are used in EXTENSION OF DEIR ALI CCPP are based on a dual-fuel concept, firing either natural gas or distillate oil.

### 3.2.1. Natural Gas

Two options for the natural gas supply of EXTENSION OF DEIR ALI CCPP:

- From the existing gas net work ( Syrian gas )
- From the Egyptian gas ( which start to feed Dair Ali site )
- Mixture of the two sources

The analysis of the used gas is listed below:

**Table C 1: Main Data of the Natural Gas used in EXTENSION OF DEIR ALI CCPP**

A-Gas Analysis

The Gas is Mixture of the Following Gases :

| Gas | Omar gas Mol % | Conoco gas Mol % | Arak gas Mol % | AL Jbossa gas Mol % | Egyptian gas Mol % |
|---|---|---|---|---|---|
| N2 | 0.66 | 3.468 | 3.782 | 2.69 | 0.01 |
| CO2 | 10.14 | 5.274 | 0.92 | 0 | 0.55 |
| C1 | 73.58 | 77.729 | 92.964 | 89.22 | 92.24 |
| C2 | 10.14 | 8.39 | 1.701 | 5.51 | 4.09 |
| C3 | 4.94 | 3.675 | 0.249 | 1.96 | 1.87 |
| I-C4 | 0.22 | 0.595 | 0.061 | 0.25 | 0.41 |
| n-C4 | 0.32 | 0.449 | 0.062 | 0.19 | 0.43 |
| I-C5 | 0 | 0.06 | 0.039 | 0.05 | 0.15 |
| n-C5 | 0 | 0.01 | 0.029 | 0.07 | 0.15 |

| | | | | | |
|---|---|---|---|---|---|
| C6+ | 0 | 0.35 | 0.121 | 0.06 | 0.1 |
| | 100% | 100% | 100% | 100% | 100% |
| H2S | <30 ppm | <30 ppm | <30 ppm | <30 ppm | 10 ppm |

Guaranteed Gas Specifications

| **Component** | **Max./Min.** | **Specification Limit** |
|---|---|---|
| H2S Content | Maximum | 10 ppm (by Volume) |
| Total Sulfur Content | Maximum | 150 mg /SCM |
| Mercapten Sulfur | Maximum | 40 mg/SCM |
| Carbon Dioxide | Maximum | 15 mol % |
| Water Dew point | Maximum | 0 C at 70 bara. |
| Hydrocarbon Dew Point | Maximum | +5 C at 70 bara. |
| Gross Heating Value | Minimum | 950 BTU/SCF |
| | Maximum | 1180 BTU/SCF |
| Individual Trace Metal | Maximum | 2 ppm (by Weight) |
| Mercury | Maximum | 40 micrograms/SCM |
| Specific Gravity | Minimum | 0.5 |
| | Maximum | 0.7 |

**Note :** Natural Gas Commercially contain of sand , dust , gums and liquids

### 3.2.2. Distillate Fuel Oil

Distillate fuel oil is considered only as a fuel for emergency situations e.g. in case the gas supply has to be disconnected. The total yearly operation time with distillate oil as fuel is restricted to 30 hours per year .The distillate oil will be stored in two existing tanks with a capacity each of 15000 $m^3$. The distillate oil will be delivered by road tankers from the refineries at Banias and Homs. The analytical characteristics of the used distillate oil are listed in Table C 2:

**Table C 2: Main Data of the Emergency Fuel Distillate Oil**

| Fuel parameter | Value | Unit |
|---|---|---|
| (Lower) calorific value | 42,654 | kJ/kg |
| Specific gravity (15°C ;60F)D1298/67 | 0.82 to 0.86 | g/ml |
| Flash point (D93/66) | 60 | °C |
| Viscosity at 37.8 °C (100F) D44165 | 2.5 to 4.5 | $mm^2/s$ |
| Distillation range (D86/67) | | |
| Up to 280°C | 50 | Vol-% |
| Up to 350°C | 85 | Vol-% |
| Pour point (D97/66) | -12 | °C |
| Conradson carbon residue (D189/88) | 0.1 | Wt-% |
| Water and sediments (D2709168) | 0.05 | Wt-% |
| Ash (D 482/63) | 0.01 | Wt-% |
| Total Sulphur (D 1266/70) | 0.7 | Wt-% |
| Anilin point (D611/64) | 65 | °C |
| Diesel index (IP 21/53) | 53-65 | |
| Cu test (3 h at 50°C) (D130168) | No. 3 | |
| Acids and alkalis (D664/58) | Nil | |

## 3.3. WATER SUPPLY AND TREATMENT

During construction phase of the project, PEEGT will supply the contractor with necessary water at the site boundary. The analytical characteristics and data of the water from the plant site which is used during plant construction are listed in Table C 3.

PEEGT will supply raw water for plant operation and services from the 25 km far away Mesmieh, Zahnan and Baiat wells, where sufficient water can be found. and PEEGT will supply the contractor with necessary water at the site boundary

Raw water tanks, which will be installed for plant operation, will have enough volume to allow a one week plant operation without refilling. In total there are 2 X 5000 m3 raw water tanks and one is located at Al-Sharaa 1000 $m^3$. The potable water for the plant is stored in a water tower while the housing areas' roof tanks are supplied by one water tower with a capacity of 50 $m^3$ each. The estimated demand is 150 l/Person and day.

**Table C 3: Main Data of Plant Site Groundwater**

| Item | Unit | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 |
|---|---|---|---|---|---|---|
| The hardness (in spring season) | mg eqv/l | 207 | 290 | 285 | 145 | 220 |
| Total Dissolved Solids (TDS) | g/l | 0.47 | 0.25 | 0.52 | 0.49 | 0.46 |
| Conductivity | mS/cm | 0.96 | 0.52 | 1.05 | 1 | 0.93 |
| pH | | 8.7 | 8.4 | 8.6 | 8.6 | 8.6 |
| Na | mg eqv/l | 140 | 65 | 150 | 140 | 150 |
| K | mg eqv/l | 3.5 | 6.5 | 3.5 | 3.5 | 3 |
| Mg | mg eqv/l | 82.5 | 55 | 90 | 100 | 80 |
| Fe | mg/l | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 |
| Cu | mg/l | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.05 |
| Al | mg/l | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.5 |
| $SiO_2$ | mg/l | 25.67 | 21.39 | 23.53 | 23.53 | 27.81 |
| Cl | mg/l | 163.5 | 70.9 | 154 | 166.6 | 157 |
| SO4 | mg/l | 124 | 51 | 150 | 149 | 131 |
| $NO_3$ | mg/l | 27.35 | 44.9 | 30.29 | 31.4 | 20.93 |
| Residual dry salts | g/l | 0.641 | 0.332 | 0.633 | 0.713 | 0.597 |

For adequate use of the delivered raw water, several steps of treatment need to be executed to achieve the needed quality:

- **Raw water pre-treatment**
  After receiving filtrated water, achieved by two coagulation reactors and filtration systems, it is stored in a 2 X 1000 $m^3$ tank. Pre-treated water will also be used for fire-protection purposes.

- **Production of Drinking Water**
  By chlorination and activated carbon filtration, the raw water can be upgraded and served as drinking water. This will be channelled into tank. To avoid pump systems in the distribution lines, the tanks will be installed at a height of 25 m above ground level.

- **Demineralisation**
  Demineralised water is also stored in two water tanks with 1000 $m^3$ each and then made available for the two boilers. Reverse Osmosis Units and ion, cation and mixed bed exchangers are used for demineralisation.

## 3.4. GAS TURBINE SYSTEM

The main data of the EXTENSION OF DEIR ALI CCPP GT's are summarised as follows:

| | |
|---|---|
| Type: | Siemens V 94.3A |
| Manufacturer | Ansaldo |
| Number: | 2 |
| Capacity: | 240 MW (gas fired) |
| Fuel consumption at 100% load: | |
| • Natural gas: | 2262.847 Kcal/Kw |
| • Distillate oil (emergency): | 98799.85 kg/h |
| Exhaust system: | Bypass stack, silencer and blanking plate |
| Rotation speed: | 3000 rpm |
| Air compressor + IGV: | 15 stages |
| GT: | 4 stages |
| NOx emission control: | Dry low NOx Hybrid Burner Ring (HBR) |
| NOx emission (for both simple cycle and combined cycle operation mode): | |
| • Natural gas: | 25 ppmv based on dry flue gas and 15 % $O_2$ |
| • Distillate oil: | 75 ppmv based on dry flue gas and 15 % $O_2$ |

## 3.5. STEAM TURBINE

The steam turbine with two casings, combined HP/IP and double flow LP and reheat is designed to operate in combined cycle mode with the gas turbine. The steam turbines' generator will be directly coupled with the steam turbine. It will be a horizontal, three phase, synchronous, hydrogen gas cooled, totally enclosed type machine.

The main data for the steam turbine are shown in the following table:

| | |
|---|---|
| Number: | 1 |
| Capacity: | 221 MW |
| Configuration: | Dual casing |
| Steam inlet conditions: | |
| • HP: | according to EN60045-1 |
| • IP: | according to EN60045-1 |
| • LP: | according to EN60045-1 |
| Rotation speed: | 3000 rpm |
| Exhaust pressure: | 0.156 Bara |

| | |
|---|---|
| Cooling system: | Hydrogen gas cooled |

## 3.6. HEAT RECOVERY SYSTEM

The HRSG is specifically designed to match the operating characteristics of the gas turbine. As a fully integrated part into the combined cycle system, the HRSG includes all required inlet / outlet ductwork, structural supports and accessories. The HRSG is a three-pressure level, reheat, duct-fired, natural circulation type vertical

| | |
|---|---|
| Type: | outdoor, natural circulation, vertical gas flow |
| Number: | 2 |
| Pressure levels: | 3 levels with reheat |
| Steam generation: | about 320 t/h for one HRSG |
| Stack: | |
| • Height main stacks: | 60 m |
| Flue gas inlet temperature (gas fired): | 586 °C |
| Flue gas outlet temperature (gas fired): | 105 °C |

## 3.7. CONDENSER SYSTEM

In the condenser, the steam turbine's exhaust steam is condensed back into water (condensate). Due to water scarcity reasons in the region an indirect dry cooling system will be applied (Heller cooling system) where no additional water is required for the cooling process. The flashed steam from the steam turbine's exit is condensed by an injection system which injects a part of the condensate already chilled in the dry cooling tower. The condensate is cooled down by a heat exchanger system in the dry cooling tower, where natural draft is leading away the heat.

The main data of the Condenser system are shown in the following list:

| | |
|---|---|
| Type: | Dry cooling tower |
| Rated cooling capacity: | 418.64 MW |
| Height of cooling tower: | 125 m |

| | |
|---|---|
| Number of heat exchanger bundles: | 132 |
| Water flow: | 30’000 $m^3$/h |

## 3.8. ELECTRICAL SYSTEM

The electrical facilities include generators, which are directly coupled to each combustion turbine and the steam turbine, generator step-up transformers, the unit auxiliary power system, and an uninterruptible power supply system.

### 3.8.1. Switchyard

Electrical power will be generated at 20 kV and 50 Hz by two gas turbine generators and one steam turbine generator. The existing substation, which will be extended, feeds the combined output of 700 MW via a main unit step-up transformers into the local 400 kV transmission system. The applied standard will be DIN VDE 0101.

### 3.8.2. Auxiliary Electrical system

The auxiliary electrical system of the power plant is designed to provide station power through unit transformers fed from the primary unit bus. The power for the unit auxiliaries is taken from the primary unit bus during normal on-line operation or back-fed from the 400 kV switchyard when the facility is off-line. The proposed auxiliary system voltages are 6.3 kV for main auxiliary electrical cubical and 0.4 kV for the low voltage auxiliaries.

### 3.8.3. Power control system

The control systems will enable remote control and supervision of generating plant operations from the Central Control Room.

### 3.8.4. Power transmission system

The power output will be fed into the already existing transmission lines from the existing substation. The destinations of the electricity produced are:

- 2 x 230 kV towards Kesswass
- 400 kV towards Adra and the north of Syria
- 400 kV towards Damascus

Another 400 kV cable is in service connected to Jordan, whose border is about 90 km south from the plant site.

## 3.9. FIRE PROTECTION SYSTEM

The fire protection system which will be designed in accordance with NFPA (National Fire Protection Association) regulations consists of various elements like a fire fighting ring main, only to be used for fire fighting purpose, a foam and sprinkler system, hoses / branch pipes and fire extinguishers. An alarm system and an adequate alarm plan, which also implies training of personnel, assure a correct performance in case of fire.

Two diesel engine driven pumps, one electrical motor driven pump and one motor driven jockey pump supply the fire water to the fire ring main and take suction from the raw water reservoir. A $CO_2$ flooding system will be provided for gas turbine and auxiliary enclosures such as the generator excitation area.

## 3.10. FLUE GAS SYSTEM

The flue gases from each gas turbine will be discharged to the atmosphere by a 60 m high stack after leading them through a heat recovery boiler (combined cycle operation). The flue gas temperature after the HRSG in the main stack will be about 105 °C while the flue gas temperature in the bypass stack is about 585 °C. Stack (by-pass and main stack) test ports will be installed. The results of the flue gas measurement can be directly monitored in the control room of the plant. The main data of the flue gas systems and flue gas data of EXTENSION OF DEIR ALI CCPP for 100 % plant operation load is shown in the Table C 4.

**Table C 4: The Main Data of the Flue Gas System and Flue Gas Data**

| | Dimension | Natural Gas | Distillate Oil |
|---|---|---|---|
| Stack: | | | |
| - Number | - | 2 | |
| - Height | m | 60 | |
| Flue gas flow (full load) | | | |
| - wet gas flow rate (act.$O_2$, λ=3.1) | $Nm^3/h$ | 3’904’956 | 3’583’896 |
| - dry gas flow rate (15 % $O_2$) | $Nm^3/h$ | 3’820’302 | 3’615’276 |
| Flue gas composition: | | | |
| - $H_2O$ | Vol % | 8.08 | 6.20 |
| - $CO_2$ | Vol % | 3.87 | 4.36 |
| - $N_2$ | Vol % | 74.61 | 75.78 |
| - $O_2$ | Vol % | 13.43 | 13.64 |

| | | | |
|---|---|---|---|
| - $SO_2$ | ppmv | negligible | 132 |
| Flue gas pollutant concentration (According to dry flue gas, 15 % $O_2$):<br>- $NO_x$<br>-$SO_2$<br>- CO<br>- Particulates | <br><br>ppmv<br>mg/Nm$^3$//ppmv<br>mg/Nm$^3$//ppmv<br>mg/Nm$^3$//ppmv | <br><br>25<br>negligible<br>20 // 16<br>negligible | <br><br>75<br>374 // 132<br>30 // 24<br>Negligible |
| Flue gas temperature | °C | 105 | 115 |
| Continuous flue gas measurement (per unit) | | NOx, SOx, CO, $O_2$ | |
| **Comment:** Distillate fuel only used as emergency fuel, maximum operation 30 hours per year | | | |

## 3.9. WASTE WATER TREATMENT

Waste water produced in the extension of the power plant is collected there. The treatment implies the following procedures:

- Chemical treatment for neutralisation
- Biological treatment to extract organic content
- Oil and grease separation to achieve a concentration of 8mg/l
- Clarification basin

After treatment some water is discharged to an irrigation system while the spill-over is piped to an evaporation pond. There water will evaporate into the atmosphere and the remaining sludge will be disposed as described for the solid waste in the following paragraph.

## 3.10. SOLID WASTE DISPOSAL

Because natural gas is the primary fuel there will be no solid wastes (e.g. fly ash) produced in connection with the operation of EXTENSION OF DEIR ALI Power Plant. Some solid waste is created during the maintenance activities, such as air filter elements.

The oily waste collected after oil/water separation as well as the remaining sludge from the evaporation pond and the other municipal wastes will be collected and transported by an external disposal contractor for recycling purposes or special disposal depending on provincial disposal requirements.

# 4. OPERATIONAL CONCEPT

The scheduled total operational time for the power plant is 30 years. The two units of the plant will be operated and controlled automatically from the Central Control Room of the plant. Remote philosophy for start up, shutdown and automatic operation under load will be applied. The annual average plant load will amount to approximately 90 %. About 60 persons will be required for a reliable plant operation. The table C 4 summarises the main operational data of the EXTENSION OF DEIR ALI Power Project.

**Table C 5: The Main Operational Data of EXTENSION OF DEIR ALI Power Plant**

| | Dimension | Natural Gas | Distillate Oil |
|---|---|---|---|
| Annual operational time<br><br>Annual average plant load factor<br>Annual equivalent full load operation | h/a<br><br>%<br>h/a | Max. 8000<br><br>90<br>7885 | Max. 30<br>Only<br>emergency |
| Plant thermal efficiency<br>Net heat rate<br>Net power generation capacity: | %<br>kJ/kWh<br>MW | 55.52<br>6483<br>701 | 53.49<br>6729<br>630 |
| Annual net power generation | GWh | 5500 | |
| Fuel consumption at 100 % load | Kcal/kw<br>t/h | 1554.974 | <br>99 |
| **Emissions:**<br>NOx<br>CO | <br>mg/Nm$^3$//ppmv<br>mg/Nm$^3$//ppmv | <br>25<br>24 | <br>75<br>24 |
| **Noise emission levels:**<br>(guaranteed values by contractor)<br>At plant boundary<br>1 m distance to by-pass<br>1 m distance to air inlet<br>1 m distance to HRSG Blow off<br>1 m distance to gas turbine<br>1 m distance to steam turbine<br>1 m distance to exhaust stack | <br><br>dB(A)<br>dB(A)<br>dB(A)<br>dB(A)<br>dB(A)<br>dB(A)<br>dB(A) | <br><br>60<br>90<br>90<br>90<br>90<br>90<br>90 | |

# Environmental Impact Assessment Report
# of 700 MW EXTENSION OF DEIR ALI
# Combined Cycle Power Plant Project

# SECTION D

# BASELINE DATA

# SECTION D: BASELINE DATA

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# 1. ASSESSMENT OF THE STUDY AREA

The EXTENSION OF DEIR ALI plant site is located in the south-western part of Syria about 60 km from the political border to Lebanon and 90 km from Jordan. The site is belonging to the Municipality of DEIR ALI village which pertains to the province of Damascus Countryside (1.341.000 inhabitants). The distance to Syria's capital Damascus is 35 km which is inhabited by 2.300.000 people today. The closest villages are DEIR ALI, the most populated centre, with around 2000 inhabitants and the small settlement Zogbor with about 400 people.

The highway crossing Damascus countryside in direction north to south is linking the main cities in western Syria from Daara close to the Jordanian border over Damascus and Homs up to Aleppo in the north near Turkey. 7 km need to be covered on the main road from the highway to the plant site.

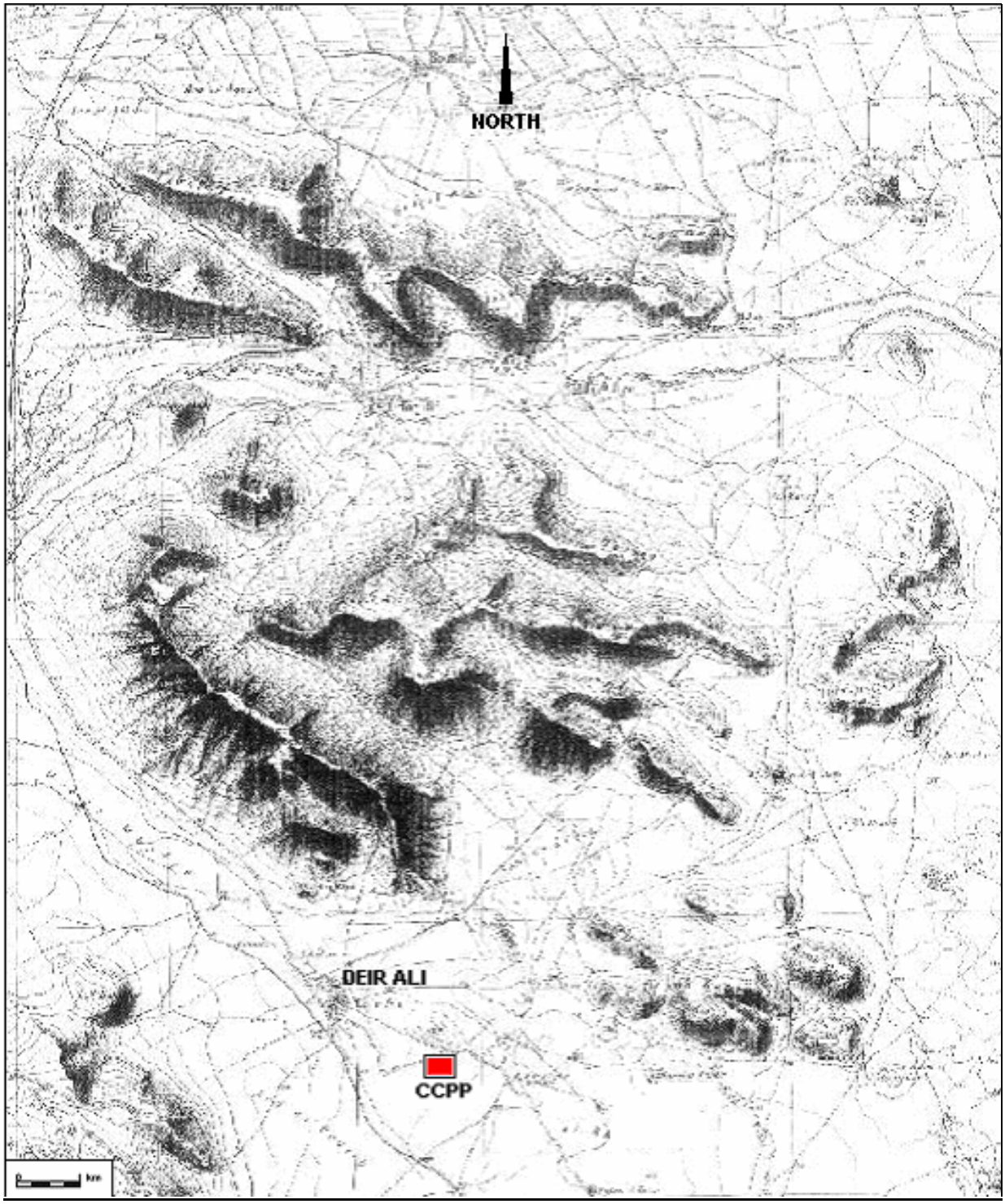
The land owned by PEEGT in the DEIR ALI area contains 67 ha of which 10 ha will be used for the EXTENSION OF DEIR ALI CCPP Project.

# 2. DESCRIPTION OF THE RELEVANT PHYSICAL CONDITIONS

## 2.1. TOPOGRAPHY

The topography around the plant area is plain upland with an average altitude of 680 m a.s.l. and a slight decrease in height to the south. Due to that, the general rain water run is from north to south. The height above sea level of the DEIR ALI Plant site is 671.6 m. Two relatively small elevations can be found north of the site. One is 782 m and the other 705.5 m a.s.l. The distance to the hills' base is about 200 m. The fact that wind blow is coming mainly from North West these elevations will not form an obstacle for air emission dispersion. A map showing the topographical situation can be found in Figure D 1.

**Figure D 1: Topographical Situation in Plant Area**



## 2.2. GEOLOGY

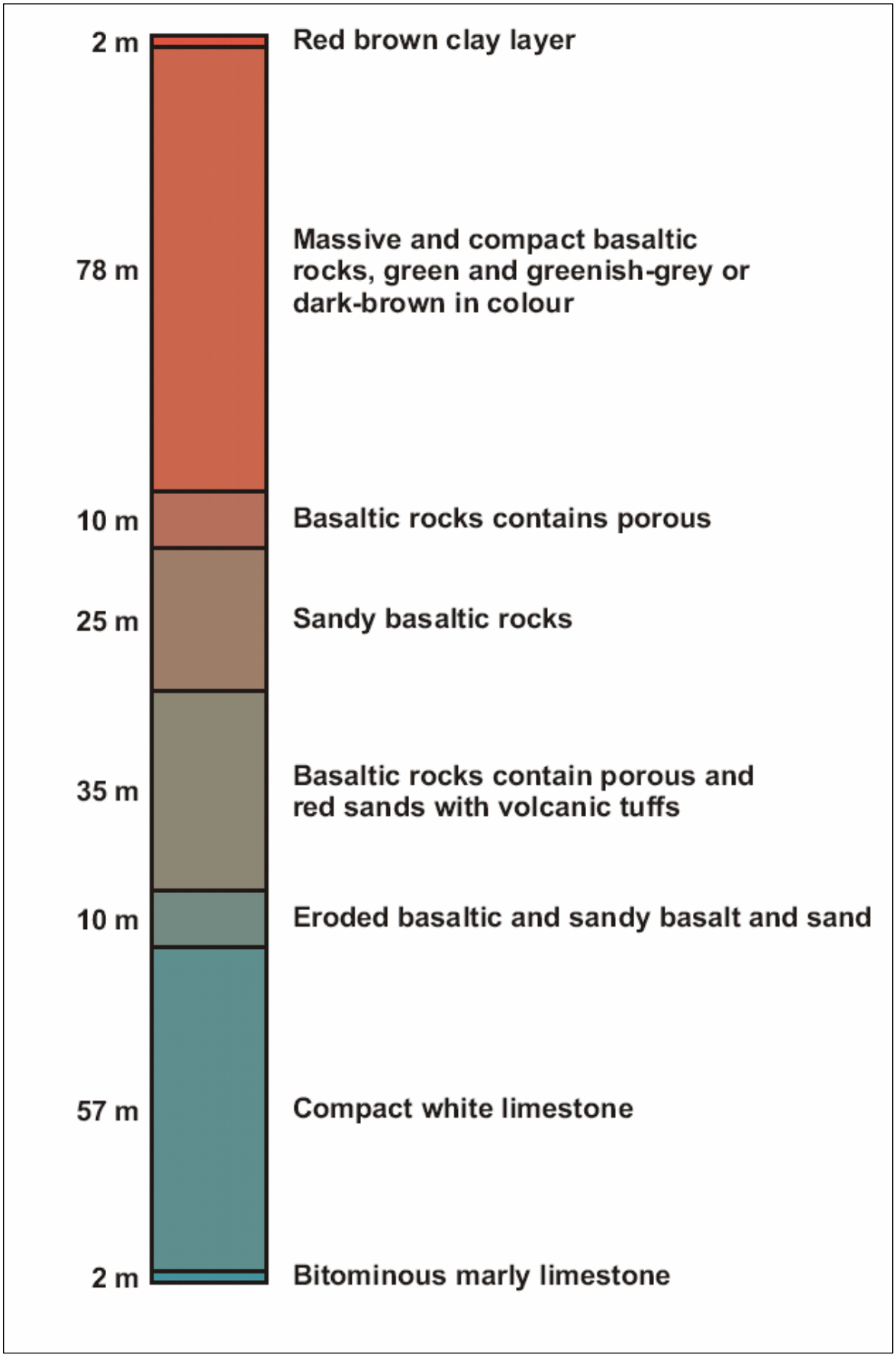
Major land usages in the area of interest are as follows:

- **Residential:** Villages DEIR ALI and Zogbor
- **Industrial:** Ceramic factory close to the highway around 4 km away from plant site
- **Agricultural:** Main agriculture areas are located north east and south of DEIR ALI village, close to some small wells

Basaltic stones with a diameter of 0.5 to 5 cm are covering the site area. Except the elevation in the north, the surface is rather flat. The first 1.5 m - 2 m of the upper soil consist of brown clay, mixed with porous basaltic stones up to 20 % ratio. In summer it's fissured on the surface. Massive and compact basaltic rocks are the main components of the second layer. The general plant foundation could be based on this layer. The unit weight of this rocks ranges from 2.25 g/cm$^3$ to 2.40 g/cm$^3$, depending on porosity.

Data from a sample of the soil from a location approx. five km west of the site show that the depth of this layer is approximately 80 m. In this and the following layer only small amounts of ground water, which will be used for the construction phase are observed. The further composition can be found in Figure D 2.

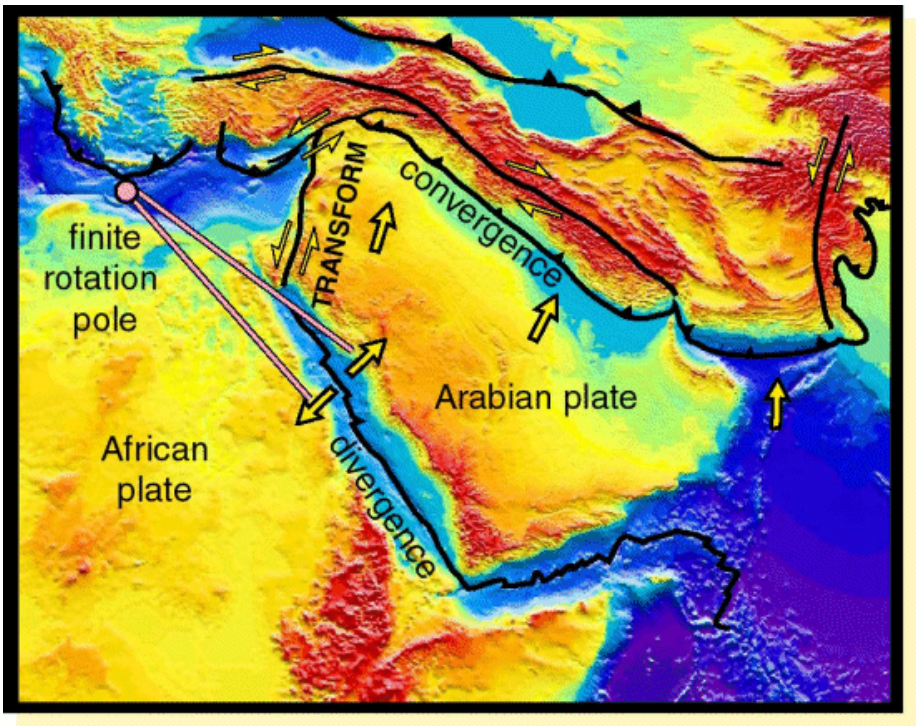
**Figure D 2: Geological Layers 4 km West of Plant Site**



## 2.3. SEISMIC DATA

Syria is located in the northern area of the Arabic plate, which is adjoining to the Eurasian plate in the north with an average speed of 18 ± 2 mm/year. Figure D 3 shows how the Dead Sea Transform relates to other plate boundaries in the region.

**Figure D 3: Seismic Plate Movement in Arabic Region**




On a large scale, divergence in the Red Sea is accommodated by plate convergence in Iraq - Iran (Zagros mountains) as the Arabian plate moves north relative to Africa. Over geological time this relative motion can be described in terms of a counter clockwise rotation (Arabian to African plate) above a pole near Crete. This pole will wander within a geological timescale to the east. Rather strong divergence can be observed in the Red Sea arm Gulf of Aqaba (the transtensive fault segments create basins between the fault segments) while strong convergence in Lebanon enhances transpressive mountain uplift.

Due to its proximity to Lebanon (60 km from the border) the DEIR ALI region is also affected by the movement of these plates. The SAC (Seismic Analysis Code) for this area is 4 while on the UBC (Uniform Building Code) scale it is 3. The ground acceleration while shaking is designated 0.3 g. The UBC is ranging from 0 (no risk of ground shaking) to 4 (10% chance of severe shaking in 50 years).

The earthquakes' intensities are measured on the Mercalli scale which ranges from 1 -12 IL (Intensity Levels). Intensities from 9 – 12 have destructive potentials. Some seismic events have been reported in this area in the last 100 years with epicenter in Lebanon and outside. The most important events concerning the DEIR ALI area in the last century occurred:

- 1951, epicenter near Oronte river sources ( north of Lebanon) IL=7
- 1956, epicenter in Chouf (Lebanon) IL=7 and in Damascus IL=5

The impact of the Intensity Level 7 can be described as follows:
People have difficulty standing. Drivers feel their cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built buildings.

Intensity Level 5 impacts the environment as follows:
Almost everyone feels movement. Sleeping people are awakened. Doors swing open or close. Dishes break. Pictures on the wall move. Small objects move or are turned over. Trees might shake. Liquids might spill out of open containers.

## 2.4. CLIMATE

This paragraph is giving information about the climatic conditions in the site area.

### 2.4.1. Atmospheric Temperature

The temperature in the province of Damascus Countryside is moving within a wide range. In January and December it can drop at night easily below 0°C and in July and August it can reach peaks of 46°C, whereas the average temperature ranges from 6°C in January to 27°C in July and August. With 58°C, the annual span in temperature is wide. The Table D 1 shows the monthly average and absolute temperatures collected at Damascus Airport (610 m above sea level, 35 km east of DEIR ALI) over a record time from 1982-2001 ( Available data which have been given to all bidders ).

**Table D 1: Air Temperature at Damascus Airport (1982 – 2001)**

| | Years | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Average (°C)** | 16.8 | 6.4 | 7.8 | 11 | 16 | 20 | 24 | 27 | 27 | 24 | 19 | 12 | 7.7 |
| **Min. Average (°C)** | 8.1 | 0 | 1.1 | 3.3 | 6.8 | 11 | 14 | 17 | 17 | 14 | 9.1 | 4.1 | 1 |

| | Years | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Max Average (°C)** | 25.6 | 12.8 | 15 | 19 | 25 | 30 | 35 | 37 | 37 | 34 | 28 | 20 | 14.4 |
| **Min. Absolute (°C)** | -12 | -11 | -12 | -7.4 | -7.5 | 0.4 | 4.5 | 9.5 | 8.6 | 3.5 | -0.5 | -9.7 | -10 |
| **Max. Absolute (°C)** | 46 | 22 | 26 | 32 | 38 | 41 | 41 | 46 | 44 | 41 | 37 | 31 | 24.4 |

### 2.4.2. Atmospheric Pressure

The annual atmospheric pressure varying between the seasons of the year is increasing in winter month by 10 mbar up to 941 mbar and is decreasing in summer to 932 mbar. The average over the year is 938 mbar. Table D 2 shows the monthly average atmospheric pressure with its deviation collected at Damascus Airport over a recording period from 1951-1998. ( Available data which have been given to all bidders ).

**Table D 2: Atmospheric Pressure at Damascus Airport (1951 – 1998)**

| | Years | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Air pressure (mbar)** | 938 | 941 | 939 | 937 | 937 | 936 | 934 | 932 | 934 | 939 | 940 | 941 | 942 |
| **Deviation** | | 7.1 | 6.7 | 7.5 | 6.5 | 6.1 | 5.9 | 6.2 | 12.8 | 16.7 | 6.1 | 6.5 | 6.6 |

### 2.4.3. Humidity

Because of a great differentiation in radiation between summer and winter, the difference in humidity between the two seasons is very large. In winter the monthly average of relative humidity varies between 63 % - 74 % and in summer the values are between 47 % and 61 %. The driest month is June while the soggiest month is December (see Table D 3). ( Available data which have been given to all bidders ).

**Table D 3: Monthly Relative Humidity at Damascus Airport (1982 – 2001)**

| | Years | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Average rel. Humidity (%)** | 58 | 74 | 68 | 61 | 53 | 48 | 47 | 49 | 51 | 50 | 55 | 63 | 74 |
| **Min. Humidity (%)** | 2 | 14 | 11 | 2 | 3 | 3 | 3 | 2 | 5 | 4 | 4 | 8 | 12 |
| **Max. Humidity (%)** | 100 | 100 | 100 | 100 | 100 | 100 | 97 | 97 | 97 | 100 | 100 | 100 | 100 |

### 2.4.4. Rainfall

In the Damascus area the highest amount of rain is falling in winter time between November and March. From June until September it is not raining at all or just very few (Table D 4). The small amount of rainfall makes the unavailability of surface water to a serious problem for agriculture in the DEIR ALI area.

**Table D** 4**: Average Rainfall at Damascus Airport** ( Available data which have been given to all bidders ).

| | Years | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Average rainfall (mm)** | 126.4 | 27 | 21 | 19 | 5.3 | 4 | 0.9 | 0 | 0 | 0.4 | 6.5 | 20 | 23 |

### 2.4.5. Wind

At Damascus Airport the average wind speed is varying slightly from an average of 2.9 m/s mainly in winter times to an average of 5.6 m/s in July. The maximum wind speed is almost constant at 20 m/s except a small increase in October and January (see Table D 5). The wind direction is mainly from North West. The fact that the ground surface consists of gravel and dust, wind always carries along dust.

**Table D** 5**: Monthly Average and Maximum Wind Speed at Damascus Airport** ( Available data which have been given to all bidders ).

| | Years | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Average Wind speed (m/s)** | 3.9 | 3.2 | 4 | 4.1 | 4.1 | 4.3 | 4.9 | 5.6 | 4.8 | 3.5 | 2.9 | 2.9 | 2.9 |
| **Max. wind speed (m/s)** | 23 | 22 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 23 | 20 | 20 |

## 2.5. HYDROLOGY

The location of Syria implies a very dry climate except in the coastal region and in the north close to rivers Euphrates and Tigris, where sufficient rain is falling or river water is available for a reliable agriculture. In the eastern and southern part, landscape is either steppe or desert and no river flow is permanent. In these parts the domestic areas are supplied with groundwater from wells and springs. The public water distribution and sewage system is only

extended to the bigger cities with a huge quantity of waste water. A recent study of Syria's water resources found that 95% of urban and 80% of rural population have access to pipe network or well whereas 20% of the rural settlements are supplied by tankers.

On the upland area of Damascus province ground water flow is from north to south due to the decrease in sea level height. The only source of groundwater near the site is 80 m below surface in a field of predominately occurring basaltic porous rocks. This is a small amount that will be sufficient only for plant construction. The analytical characteristics of this ground water can be found in "Section C, Table C 3". For plant operation, water will be used from Al-Mesmieh, Zahnan , Baiat wells 25 km around. It's guaranteed by PEEGT that it will be sufficient for plant operation.

## 2.6. AMBIENT AIR QUALITY

Near the rural location of the power plant site there are not many industrial facilities. The most important polluter is the highway heading from south to north. Because this is the only fast connection to Jordan, the road is quite crowded. A significant sample of highway traffic close to DEIR ALI has been examined in 2002, giving the figures reported in Table D 6. Data referring to hour intervals have been counted, while total amount of vehicles through the day was estimated by the formula:

**[(addition of the number of vehicles of every hour interval/6)*24]**.

**Table D 6: Amount of Vehicles on the Highway near EXTENSION OF DEIR ALI (Result of a Traffic Counting in 2001)**

| Time (hour control) | No. small cars | No. microbuses | No. trucks and buses |
|---|---|---|---|
| **3-4** | 60 | 140 | 120 |
| **9-11** | 140 | 660 | 510 |
| **14-16** | 290 | 474 | 406 |
| **20-21** | 146 | 146 | 160 |
| **Total amount** | 2500 | 5680 | 4780 |

A rough estimation of traffic emissions into the air along the highway sector 1 km north to 1 km south of DEIR ALI, based on the European Emission standard factors (CORINAIR) leads to the values listed in Table D 7.

**Table D 7: Estimated Emissions of the Highway Traffic [t/a]**

| | $SO_x$ | $NO_x$ | CO | VOC[a)] | PTS[b)] |
|---|---|---|---|---|---|
| **Estimated Emissions (t/a)** | 12.3 | 84.5 | 57.2 | 12.7 | 19.9 |

[a)] VOC: Volatile Organic Compounds; [b)] PTS: Persistent Toxic Substances

The emitted amounts of $SO_x$ and $NO_x$ are low compared to the emitted amounts of the EXTENSION OF DEIR ALI CCPP. But the pollution dispersion of the traffics' exhaust is worse than the dispersion of the power plants' exhaust which is using a high stack and is by this leading to a dilution in the surrounding area.

## 2.7. NOISE POLLUTION

Noise monitoring in Syria is not very prevalent yet. Therefore no information was found or provided concerning this topic. In general noise polluted hot spots should be found close to highly frequented traffic routes and industrial areas. For the DEIR ALI area no previous noise measurements are available.

# 3. DESCRIPTION OF RELEVANT BIOLOGICAL CONDITIONS

On the project site the majority of the vegetation will be removed. Hence this study is targeted at the surrounding of the project area, where flora and fauna will be discussed.

## 3.1. FLORA AND FAUNA

Due to the expansion of the desert from east to west, changes in vegetation typologies are in progress. In this area, two different shrub types have been identified:

- Associations of Artemisia (a desert steppe species) and Anabasis syriaca
- Poterium Spinosum (rosas) – is progressively disappearing because it needs more water

According to the University of Damascus, Faculty of Science, Department of Botany, neither particular autochthonous species, both, flora and fauna, nor ecosystems are identified in the area.

# 4. DESCRIPTION OF SOCIO-ECONOMIC CONDITIONS

In this section, Syria's general and the local (DEIR ALI and surrounding) socio-economic conditions are discussed.

## 4.1. OVERALL SITUATION IN SYRIA

### 4.1.1. Political

The political power of Syria lies in the hands of its president, Bashar al Assad. There are elections to the People's Assembly every 4 years. By far the largest group in this assembly is the National Progressive Front, which is lead by the Ba'th Party. Assad holds total control over Syria through being in command of the Ba'th Party. Syria's constitution was introduced in 1973, and describes the country as democratic, popular and socialist. According to the constitution, only a Muslim can be president. The only groups allowed into Syrian politics are the socialists, the communists and the pan-arabists. Following the death of long-time president Hafez al-Assad, and the takeover of his son, there has been some lifting on restrictions in Syria. Some political prisoners have been released from jail, and Assad has taken initiatives to ease control over both economy and information technology. Following the elections of November 30 and December 1 1998 the Ba'th Party got 135 out of 250 seats in the People's Assembly. The other seats were divided between independent candidates (83), the Communist Party (8), Arab Socialist Unionist Party (7), Syrian Arab Socialist Union Party (7), Arab Socialist Party (6) and Socialist Unionist Democratic Party (4).

### 4.1.2. Syria's Economy

The Syrian economy is officially based upon the Socialist ideology defined in 1958, but some fields of economic activities allow private businesses. In November 1995 Syria and many other Middle Eastern and North African countries signed an agreement with the European Union to create a Mediterranean free trade zone by 2010. Syria is by many respects a poor country, and relies heavily on help from rich Arab states. Big industries often have the Syrian state as its owner. Private businesses dominate retail trade, although there are also consumer cooperatives in the larger cities. The Syrian trade union for industrial employees, the General Federation of Workers is a central player in the country's economy. Most other workers are organized in unions, but few play an equally strong role. Syria's oil industry has been developed into becoming the country's most important natural resource. Its production is large enough to allow exports, and the income here is now larger than for any other

commodity. The government has encouraged the search for new oil fields along the Iraqi and Turkish borders. Syria also extracts raw phosphates, asphalt, limestone, basalt and some chrome and manganese. Syrian agriculture produces much of the foodstuffs the country needs. 26% of the land is classified as arable, but large areas lie unused because of lack of water. In most cases irrigation is necessary, as most of the rain falls outside the growing season. The main production beside other is wheat, barley, maize, millet and cotton what is also partially exported.

Syrian industries still include many handmade products. Modern industries play an increasingly important role, but are mainly involved in the production of simple products. The national industries are aided with high tariffs on imported goods.

### 4.1.3. Health

Thanks to consequent health politics in the last decades, Syria improved permanently in health issues. In lower developed countries communicable diseases and under-nutrition are predominating while in industrialized countries more non-communicable diseases followed by poisoning, over-nutrition and psychosocial disorders are found. At the intermediate point of this long-term process, both kinds of hazards may be present. These communities might be afflicted even more because communicable diseases meeting crowded living conditions will result in a worsening of the situation if no adequate vaccination and health care program is provided, which is often not the case in the cities of developing countries.

Syria improved generally in the 1980s. Due to preventive measures and increasing use of vaccinations Malaria declined and it also leaded to a lesser extent tuberculosis. But gastrointestinal and parasitic diseases were endemic, particularly among the rural population. Diphtheria and tetanus also plagued rural communities, and there was a high rate of infectious diseases, heart disease, and cancer in urban areas. As a socialist government, Syria provides virtually free medical care to its citizens and imposed a ceiling on charges by private hospitals.

### 4.1.4. Education

School visit is compulsory for all children between the ages of 6 and 12, free of charge and with free schoolbooks. According to figures of 1996/97 about 91% of all children attended school. Obligatory primary school is followed by 6 years of secondary school, 3 at lower and 3 at upper levels. The education at the secondary levels is divided into general and

vocational curriculums. About 38% of all children in the relevant age attend secondary education. Syria's four universities are located in Damascus, Aleppo, Latakia and Homs. Damascus has also got the Arab Academy offering courses at university level.

### 4.1.5. Religion

Muslims represent an estimated 85% of the Syrian population. More than 65% of the total Syrian population are Sunni Muslims, 11% Alawites, 1- 2% Druze, 1- 2% Isma'ili Shi'is and 1- 4% Twelver Shi'is. About 10% of the Syrians are Christians, divided between several churches: Greek Orthodox, Syrian Orthodox, Armenian Apostolic, Roman Catholic (which is organized between a number of sub-churches: Armenian, Chaldean, Latin, Maronite, Melkite and Syrian), Anglican and Protestant. The largest of these are the Syrian Orthodox and the Roman Catholic. Syria also has a tiny group of Yazidis, who live near the border to Iraq, near the town of Sinjar. There is also a small group of Jews, not counting more than 4'000, of which almost all live in Damascus.

### 4.1.6. Infrastructure

To reach remote destinations e.g. in the desert, Syria has 92 airports. 24 have paved runways with different lengths while the rest is unpaved and has mainly short runways. Damascus and Aleppo are the only international ones.

In 1985 Syria had a road network of some 25000 km. With this the main areas have been linked, but the network required continuous and intensive development. In 1999 there has been already 43.380 km road in total of which 10.020 are paved.
Railroad in Syria has compared to the road a low importance. Until 1999 tracks of 2.740 km length have been built. Some tracks e.g. the one going from Damascus to the south and passing by EXTENSION OF DEIR ALI is not used any more.

To provide a good supply with fossil energy, pipelines are needed to transport the feedstock either to a refinery, a consumer or to a place for further transportation. The only refineries in Syria are located at Banias and Homs. In 2003 the total amount of built pipelines was 2200 km of oil and 2300 km of gas.

### 4.1.7. Tourism

The country receives many tourists coming here not only to explore the country's long history. The number of Arab tourists visiting Syria in the first half of 2004 increased from 523’000 in the first half of 2003 to 890’000. The number of foreign tourists increased from 85’000 to 141’000 in the same period. Total amount of tourists rose from 1’600’000 in the first half last year to 2’600’000 in the same period 2004. This shows the growing importance of this economic sector. Historical sites like Palmyra that narrate the human history, diversity of nature where all the seasons can be found in addition to the good quality and competitive price of the Syrian product such as garments and artefacts, are the main tourist attraction factors.

## 4.2. OVERALL SITUATION IN SITE AREA

In Syrian villages, almost every capable adult works in agriculture. Usually men do farming and all the related works and woman do the housework and taking care of kids. The other necessary facilities like stores are mainly run by retired men or part-time cultivators. In villages where water supply is not reliable the small farmer can be easily ruined by a drought. Only large enterprises are able to compensate a poor harvest. For this reason, the peasant of the interior now depends on financing from the cities in place of receiving advances for crops and equipment formerly supplied by urban absentee landlords.

The villages traditionally were not self-sufficient economic, but were normally depending on the nearest town or city for various services. Due to the increasing public transportation possibilities, the frequency, peasants were visiting cities for e.g. marketing, medical care or entertainment, increased.

### 4.2.1. Economy

The economical factors in the DEIR ALI area mainly consist of agriculture. In the DEIR ALI village the main population are farmers who are cultivating the surrounding areas.

### 4.2.2. Health and education

One public hospital can be found in DEIR ALI village. The proximity to the plant site (2 km) provides a good and reliable health care where also emergencies can be treated without the need of longer travel distances.

For the staffs' children living in the nearby housing area a school is present in DEIR ALI for education. To receive a higher education, it is necessary either to oscillate between DEIR ALI and Damascus or to move to one of the university cities in Syria.

### 4.2.3. Infrastructure around plant site

The local situation of village DEIR ALI turns out being a very good location for a project like a power plant. The relative proximity to Damascus, the cross point of overhead lines of the national grid, the availability of highways and already paved access roads and existence of a substation that will be turned into the plants switchyard, makes this place favourable.

# 5. CHANGES PREDICTED BEFORE PROJECT COMMENCES

The construction of the EXTENSION OF DEIR ALI Combined Cycle Power Plant will have positive long-term benefits on the DEIR ALI region, providing direct/indirect employment opportunities for the local people. Therefore the expected positive benefits far outweigh the short-term negative impacts, which may occur during the construction phase of the project.

It is anticipated that during the construction phase of the project road traffic to/from the site will increase over a short period. This may have a negative impact on the local environment (exhaust fumes, dust, noise, etc.); however as the EXTENSION OF DEIR ALI Power Plant is to be located on the countryside with a sizeable distance to the closest villages there are comparatively few inhabitants living at the road from the highway to the site. These potential negative impacts will pose a negligible risk to the local communities and once the plant enters the operation phase this will no longer apply.

On the positive side is predicted that during the construction phase of EXTENSION OF DEIR ALI Power Plant it will offer short-term employment opportunities for approx. 1000 construction workers, and once the plant enters commercial operation 160 – 200 persons high quality long-term employment will be ensured.

Furthermore the plant should provide the local engineering and service industries with opportunities to develop and expand, which will provide additional indirect employment.

As the Syrian Arab Republic will require 40 – 50 million MWh per year by 2010 this plant is required to assist in achieving this target.

# Environmental Impact Assessment Report
# of 700 MW EXTENSION OF DEIR ALI
# Combined Cycle Power Plant Project

# SECTION E

# ENVIRONMENTAL IMPACTS

# SECTION E: ENVIRONMENTAL IMPACTS

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# 1. INTRODUCTION

The Project, including the construction and operation of a Combine Cycle power plant of 700 MW will play a very important role in the development of the Syrian Energy Sector, particularly in the southern part of Syria. It will promote the policy of industrialisation and modernisation of the government of Syria in the coming decades as well as create a great opportunity for urbanisation, proper change in land-use and overall socio-economic development of Syria's south. In this section of the EIA Report, the impact of the EXTENSION OF DEIR ALI Power Project on the environment will be investigated. All relevant types of emissions and influences are considered in the study. Particularly those, that may have an impact on the physical and biological resources in the vicinity of the project, as well as those that could affect humans and their quality of life.

Beside significant beneficial impacts, and despite the use of a modern, clean technology and the use of natural gas as the primary fuel, the project may have minor negative effects on the environment. But the design, approach and implementation are intended to minimize such negative effects as much as possible.

In the following section the impacts during the construction phase and especially during the long lasting operation phase, as well as socio-economic aspects will be investigated and assessed more in detail.

# 2. IMPACTS DURING THE CONSTRUCTION PHASE

Possible impacts during design and construction phase are:

- Impacts of land clearing on local people
- Impact on land used
- Impacts by traffic and transportation
- Impacts caused by labour concentration
- Impacts by civil works and construction of the power plant.

## 2.1. IMPACTS OF LAND CLEARING ON LOCAL PEOPLE

The EXTENSION OF DEIR ALI Power Project will be installed beside an already existing power plant and its substation. Land clearing is not necessary in this case, because no settlements are on, at or near the site. The existing substation will be connected into the existing switchyard.

## 2.2. LAND USED

The total amount of land owned by PEEGT is 670’000 $m^2$ of which 360’000 $m^2$ are used for the existing and are including the already existing substation and the 250000 $m^2$ for the extension.. The plant will be based on a 80 m thick soil layer of massive and compact basaltic rocks. Further requirements of soil due to infrastructure enlargement or transmission line establishment will not be required. The present road condition is sufficient for the delivery of plant facilities and distillate oil by trucks and road tankers. The transmission lines are already leading from the substation towards their destinations like Damascus, Kesswass, Adra and Jordan.

## 2.3. IMPACTS ON TRAFFIC AND TRANSPORTATION

The EXTENSION OF DEIR ALI Combined Cycle Power Plant site can be reached from Damascus via 28 km on the highway leaving Damascus to the South and additional seven km on a paved road which is suitable to allow heavy load traffic during construction phase and later for distillate fuel oil transportation. The absence of water transport ways pushes all

traffic to the streets. The road system at the plant site needs to be constructed too. Land transportation facilities will need to deliver all the necessary material and equipment which is necessary for civil and plant constructions like gas and steam turbine, HRSG, stones, cement etc.

Due to transportation of construction materials, plant equipment and labour, the traffic volume in the area, especially on the National Highway and the road towards the plant will increase slightly but only for a temporary period during the construction phase. It is expected that the major impact will be on the road, which links the highway to the site. The emission of dust and exhaust gases of cars and trucks will reach an increased level which will be directly attributable to the civil and construction activities.

The increase of traffic may cause a higher probability of traffic accidents. It will be one of main concern of the people living in DEIR ALI to maintain the traffic safety. Possibilities to reduce the impacts from traffic are described under “Section G, chapter 2.2”.

## 2.4. IMPACTS CAUSED BY LABOR CONCENTRATION

The construction phase will constitute the highest levels of activity with up to 1,000 construction workers concentrated onto the project site. Thus the following impacts may be considered:

**Accommodation**

Mainly workers originate from the surrounding area and will be accommodated either in their own houses and in a workers housing area near the site for PEEGT staff. The provided 8200 $m^2$ for workers area consist of canteen, dressing room and other temporary workers facilities like parking space.

**Sanitary waste**

The average daily amount of sanitary waste, produced by a group of 1’000 workers is estimated to reach 30 to 50 $m^3$. The EPC-Contractor is responsible for collecting, treatment and disposal of the sanitary waste.

The sanitary effluent during the construction phase is usually treated by a biological method. The appropriate method is selected depending on flow rate, collection method and condition of land surface. In the case where it is not possible to build a wastewater treatment plant to treat all wastewater from the site the most effective treatment method would be to use a

septic tank system. The function of a septic tank is to settle solid waste, digests in anaerobic process and produces residue with a treatment efficiency of more than 70 - 80 % BOD. This residue needs to be disposed in an appropriate way.

**Domestic solid waste**

With the increase of the construction activities, the amount of the daily domestic solid waste will also increase. Depending on the intensity of the activities, the amount of domestic wastes may reach up to 500 to 1,000 kg, containing 60-70% organic matter and 30-40% others (plastic, papers etc). These wastes will be disposed according to the local regulations by an external authorised disposal company.

**Possible Transmission of Infections Diseases from Workers to Local Population and vice-versa:**

Syria still has a range of endemic infectious diseases, such as typhoid, paratyphoid and amoebic and ancillary dysentery. Communicable diseases like measles and pertussis (whopping cough) have also been reported. In the circumstance of poor sanitary conditions and daily contact between local people and construction workers, infectious diseases cannot be excluded. Effective mitigation and prevention measures shall be taken into consideration.

## 2.5. IMPACTS BY CIVIL WORKS AND CONSTRUCTION OF THE POWER PLANT

During construction phase of EXTENSION OF DEIR ALI Thermal Power Plant and associated civil works, the following impacts are to be expected:

- Temporary increase in air pollution from the construction site, from construction materials utilised on site and from the transportation of construction materials

- Temporary noise and vibration pollution produced by construction equipment

**Impacts on air quality:**

In the construction phase air pollution is predominately produced by dust and exhaust gas from trucks and construction machinery. It is indicated that during site preparation, the following construction equipment will cause adverse impacts on air quality: trucks, compactors, pile drivers, jackhammer and drills, generators, asphalt heating equipment,

concrete processing stations. Because most of this equipment uses gasoline or diesel, they will emit particulate matter, $SO_2$, $NO_X$, VOC and lead into the air.

The major air pollutant during the construction phase will be dust produced by earth works (digging, excavation, filling, levelling), particularly during the dry season. Receptors, which can be affected, are areas surrounding the construction sites, as well as houses and buildings located at a distance of approximately 200 m from the construction site. At this distance in the dry season and at the peak of construction hours, ambient air quality may be degraded. However, at this distance within the construction area there is no residential building, so the impact of air pollution on these types of receptors is not relevant.

**Noise impact:**

The fact that Syria and EC do not have guidelines concerning noise regulation, World Bank guidelines will be applied in order to fulfil the international standard. Due to the absence of industry and settlements near the plant site, the present noise emissions are low. The present substation does comply with international standards and is not exceeding 85 dB (A) at a distance of 1m from the noise producer.

World Bank noise standard for commercial areas:

| | |
|---|---|
| 7 h to 22 h | 70 dB(A) |
| 22 h to 7 h | 70 dB(A) |

World Bank noise standard for residential areas:

| | |
|---|---|
| 7 h to 22 h | 55 dB(A) |
| 22 h to 7 h | 45 dB(A) |

During the construction phase temporary noise emissions may be caused by:

- Construction equipment
- Concrete mixing plant
- Pile driving for construction
- Rock blasting and drilling
- Earth moving activity
- Generators
- Vehicles used for material transport.

For most of the above mentioned construction equipment the noise level in 15 m distance will be in a range of 70 to 90 dB(A). The noise level at further distance can be determined using – 6 dB(A) every time distance is doubled and there is no obstacle. Thus, the maximum level will be 84 dB (A) at 30 m, 78 dB (A) at 60 m, 72 dB (A) at 120 m, 66 dB (A) at 240 m and 60 dB (A) at 440 m. Since the residential areas are located in about 1000 m distance to the construction site, the noise impact will be within an acceptable level.

# 3. IMPACTS DURING THE OPERATION PHASE

The potential environmental impacts of the operation of a thermal power plant are:

- Climate (greenhouse effect)
- Air quality
- Noise
- Water
- Flora and Fauna
- Socio-economic effects

These impacts will be discussed in more detail in the following sub-sections.

Generally, it has to be stated that a combined cycle power plant (CCPP) with natural gas as the primary fuel ranks with the cleanest processes to produce electricity from fossil resources. EXTENSION OF DEIR ALI power plant will use natural gas as the primary fuel. Distillate oil will only be used when natural gas is not available, and restricted to a maximum of 30 days per year with a permanent operation of maximum one week. Also the simple cycle operation mode has to be regarded as an exception. The impacts of these 4 cases, combined cycle gas fired, combined cycle oil fired, simple cycle gas fired and simple cycle oil fired will be examined in this section.

The impacts, which have to be considered during the operational phase of a gas-fired CCPP, are mainly caused by gaseous $NO_X$ emissions. A schematic diagram of CCPP EXTENSION OF DEIR ALI with main balance data is shown in Figure E 1.

Combustion calculations have been performed with the expected compositions of natural gas and distillate oil, and for different operational scenarios. The results of these calculations give detailed data on flue gas volume flows, flue gas composition etc.

In Appendix E 1, the detailed results of the combustion calculations for the combined cycle operation with natural gas and distillate oil are summarised, and a compilation of the emission data is provided. The main results of these calculations are summarised in Table E 1 where means

- Case 1: Combined cycle mode and natural gas fired (Natural Gas CC)
- Case 2: Combined cycle mode and distillate fuel oil fired (Distillate Oil CC)
- Case 3: Simple cycle mode and natural gas fired (Natural Gas SC)
- Case 4: Simple cycle mode and distillate fuel oil fired (Distillate Oil SC)

## Table E 1: Main Results of Combustion Calculation

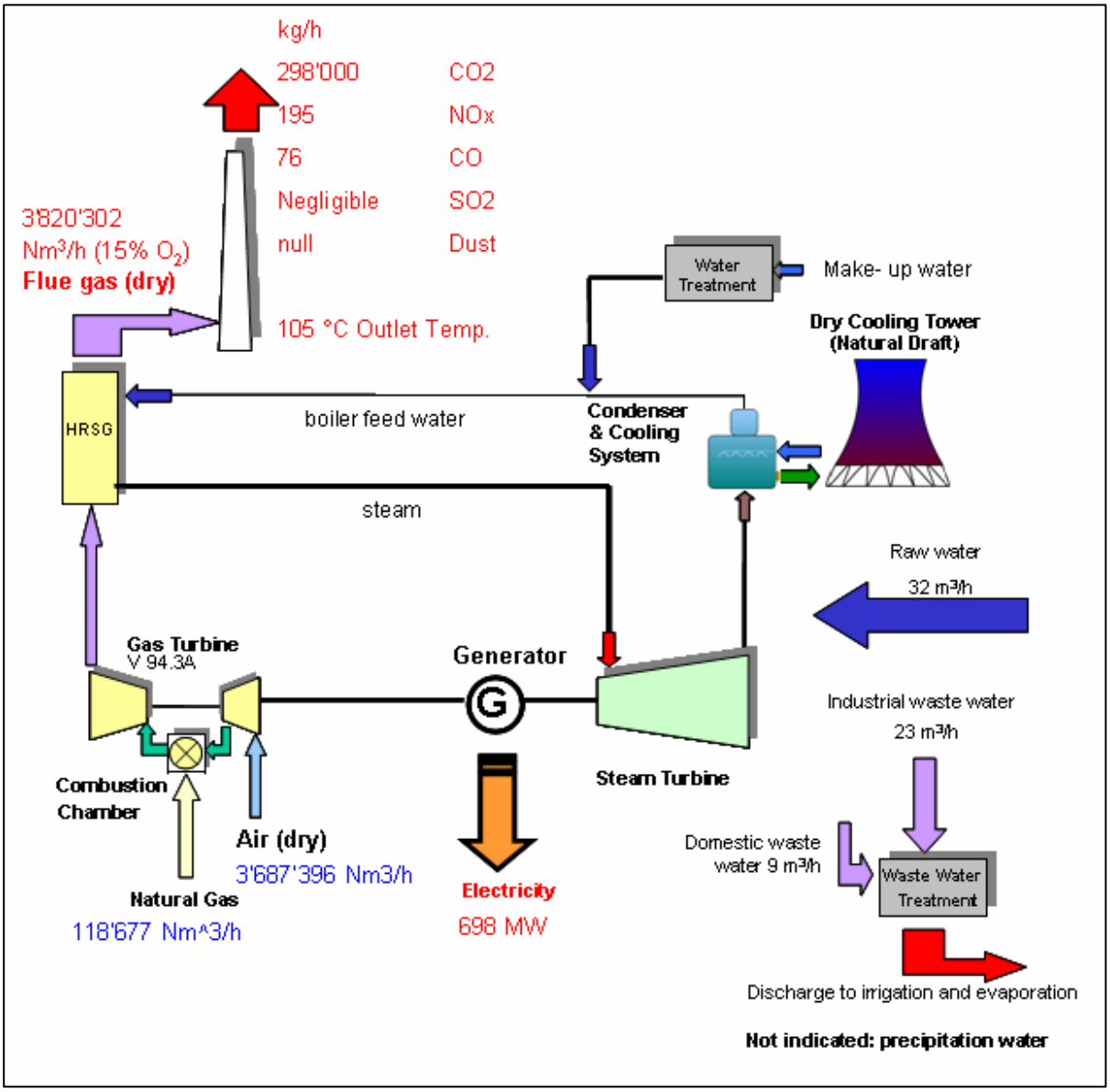
| CASE | 1<br>normal case | 2 | 3 | 4 |
|---|---|---|---|---|
| **PLANT OPERATION DATA** | | | | |
| Fuel | **Gas** | Dist. Oil | Gas | Dist. Oil |
| power MW el. | **700** | 630 | 476 | 435 |
| efficiency % | **55.52** | 53.49 | 37.95 | 37.16 |
| mode | **comb. cycle** | comb. cycle | simple cycle | simple cycle |
| Gas consumption Kcal/kw | **1555** | | 1555 | |
| Dist. Oil consumption kg/h | | 98'800.00 | | 98'800.00 |
| Equival. full load hours per year [1)] | **7'885** | 720 | | |
| Annual power generation GWh/a | **5'500** | | | |
| **EMISSION DATA** | | | | |
| **CO Carbon Monoxide** | | | | |
| mg/Nm3 (dry, 15% O2) | **20** | 30 | 20 | 30 |
| ppmv (dry, 15% O2) | **16** | 24 | 16 | 24 |
| g/s | **21** | 30 | 21 | 30 |
| kg/h | **76** | 108 | 76 | 108 |
| t/day | **1.8** | 2.6 | 1.8 | 2.6 |
| t/a | **602** | 78 | | |
| kg/MWh | **0.11** | 0.17 | 0.16 | 0.25 |
| **CO2 Carbon Dioxide** | | | | |
| kg/Nm3 for Gas kg/kg for D.O. | **2.51** | 3.13 | 2.51 | 3.13 |
| t/h | **298** | 309 | 298 | 309 |
| t/a | **2'348'869** | 222'656 | | |
| kg/MWh | **427** | 494 | 625 | 711 |
| **SO2 Sulfur Dioxide** | | | | |
| mg/Nm3 (dry, 15% O2) | **negligible** | 374 | negligible | 374 |
| ppmv (dry, 15% O2) | | 132 | | 132 |
| g/s | | 376 | | 376 |
| kg/h | | 1'352 | | 1'352 |
| t/day | | 32 | | |
| t/a | | 974 | | |
| kg/MWh | | 2.16 | | 3.11 |
| **NOx (as NO2) Nitrogen Oxides** | | | | |
| mg/Nm3 (dry, 15% O2) | **51** | 150 | 51 | 150 |
| ppmv (dry, 15% O2) | **25** | 73 | 25 | 73 |
| g/s | **54** | 151 | 54 | 151 |
| kg/h | **195** | 542 | 195 | 542 |
| t/day | **5** | 13 | 5 | 13 |
| t/a | **1'536** | 390 | | |
| kg/MWh | **0.28** | 0.87 | 0.41 | 1.25 |
| **Flue Gas Data** | | | | |
| Nm3/h (wet, act. O2 with λ = 3.1) | **3'904'956** | 3'583'896 | 3'904'956 | 3'583'896 |
| Nm3/h (dry, 15% O2) | **3'820'302** | 3'615'276 | 3'820'302 | 3'615'276 |
| Nm3/s (dry, 15% O2) | **1'061** | 1'004 | 1'061 | 1'004 |
| Actual Flowrate m3/s | **1'607** | 1'514 | 3'651 | 3'327 |
| Actual Flowrate m3/h | **5'783'917** | 5'448'804 | 13'143'875 | 11'978'823 |
| Massflow kg/s | **1'502** | 1'379 | 1'502 | 1'379 |

| CASE | 1<br>normal case | 2 | 3 | 4 |
|---|---|---|---|---|
| Temperature at stack exit °C | **105** | 115 [2)] | 586 | 580 [2)] |
| Temperature at stack exit K | **378** | 388 | 859 | 853 |
| Stack height m | **50.00** | 50.00 | 32.00 | 32.00 |
| Number of stacks | **2** | 2 | 2 | 2 |
| FG velocity at stack exit m/s | **29.9** | 28.2 | 30.0 | 27.3 |

1) 90% of 365 x 24 h/a for case 1; case 2 max. 720 h/a
2) Assumed flue gas temperature for oil operation

A schematic diagram and balance of the EXTENSION OF DEIR ALI Power plant is shown in Figure E 1. For reasons of simplicity only one line of combustion chamber – gas turbine – HRSG-stack is drawn. Two gas turbine lines and one steam turbine will be installed. The data in the figure stand for 2 GT + 1 ST at full load.

**Figure E 1: Schematic Diagram and Balance of EXTENSION OF DEIR ALI Power Plant**



## 3.1. IMPACT ON CLIMATE

Each combustion process, burning fossil fuels containing carbon material produces carbon dioxide, $CO_2$ according to the carbon content in the fuel. Carbon dioxide is the major gaseous combustion product. It is not poisonous, but it causes the undesirable greenhouse effect, which will probably lead to an increase in the average temperature and other detrimental disturbances of the global climate. There is no practical way of disposing of large quantities of carbon dioxide other than to release them into the atmosphere. The only measures that can be taken to limit $CO_2$ emissions is to use fuels with low specific $CO_2$ values and to increase the plant efficiency in order to keep the carbon dioxide emission per produced electric energy unit as low as possible.

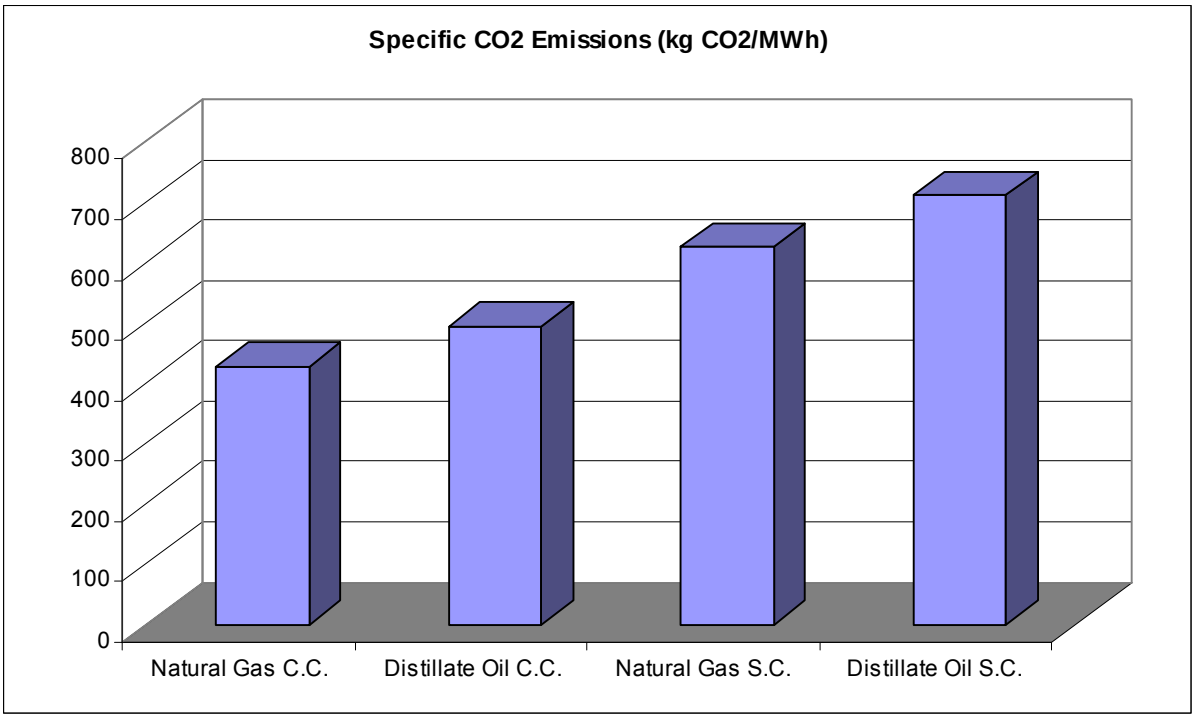
In the proposed project a great deal of effort was taken to select the most efficient thermal plant cycle. At normal operation condition the thermal efficiency of the plant will be about 55 %. The following Table E 2 shows the $CO_2$ emission data of EXTENSION OF DEIR ALI Power Plant for different operation modes.

**Table E 2: Emission data for $CO_2$**

| **CASE**<br>**Fuel** | **1 normal case**<br>**gas** | **2**<br>**Dist. Oil** | **3**<br>**Gas** | **4**<br>**Dist oil** |
|---|---|---|---|---|
| **Power MW el.** | 700 | 630 | 476 | 435 |
| **Efficiency %** | 55.52 | 53.49 | 37.95 | 37.16 |
| **Mode** | Combined Cycle | Combined Cycle | Simple cycle | Simple cycle |
| **Gas consumption Kcal/kw** | 1555 | | 1555 | |
| **Distillate oil consumption kg/h** | | 98’800 | | 98’800 |
| **Equivalent full load hours per year** | 7’885 | 720 | | |
| | | | | |
| | | | | |
| **CO2 Emission** | | | | |
| **kg/Nm3 natural gas** | 2.51 | | 2.51 | |
| **kg/kg distillate oil** | | 3.13 | | 3.13 |
| **t/h** | 298 | 309 | 298 | 309 |
| **t/a** | 2’348’869 | 222’656 | | |
| **kg/MWh** | 427 | 494 | 625 | 711 |

On the following page Figure E 2 shows the specific $CO_2$ emissions of the investigated cases:

**Figure E 2: Specific $CO_2$ Emissions of four Operational Modes (4 cases)**




The lowest specific $CO_2$ emission rate is achieved with the combined cycle operation mode and natural gas as fuel (case 1), which is the normal operation mode of EXTENSION OF DEIR ALI Power Plant. In this case the $CO_2$ emission rate is 297 t/h. With an equivalent of 7885 full load hours per year this is equivalent to:

> Yearly $CO_2$ emissions of EXTENSION OF DEIR ALI CCPP: 2.34 million tons (Combined Cycle, Gas fired).

Syrias total $CO_2$ emissions from consumption and flaring of natural gas in 1999 were around 52.14 million tons. Compared to this amount the EXTENSION OF DEIR ALI Power Plant will have a remarkable fraction of 4.5 percent. This is due the situation that the EXTENSION OF DEIR ALI CCPP will produce almost 12% of the whole electricity generated in Syria. In the global view, Syria is still one of the least $CO_2$ producing countries.

## 3.2. IMPACTS ON THE AIR

The following sections deal with the evaluation of the emissions of EXTENSION OF DEIR ALI project as well as the impacts on the ambient air quality. As a basis for the calculation of

the emission rates combustion calculations were performed as mentioned above (see Appendix E 1). The results of these calculations give the required information on flue gas volume flows and flue gas data as well as on flue gas composition. For $NO_x$ and CO, which cannot be calculated, guaranteed data from the contractor have been used for $NO_x$, while for $CO_2$ an average value has been assumed because no concrete value was given by the contractor.

### 3.2.1. Emissions

In the following section the emission concentrations and emission rates are calculated or estimated on a reliable data basis and compared with the relevant Syrian, WB and EC standards and regulations in order to assess the environmental impact caused by the emission of pollutants with flue gas.

**Remark:** The Syrian Emission Standard is not the crucial factor for this project and is only provided as additional information and for comparison reasons. The legal base for this project are the existing WB and EC guidelines and regulations.

#### 3.2.1.1. NOx–emissions

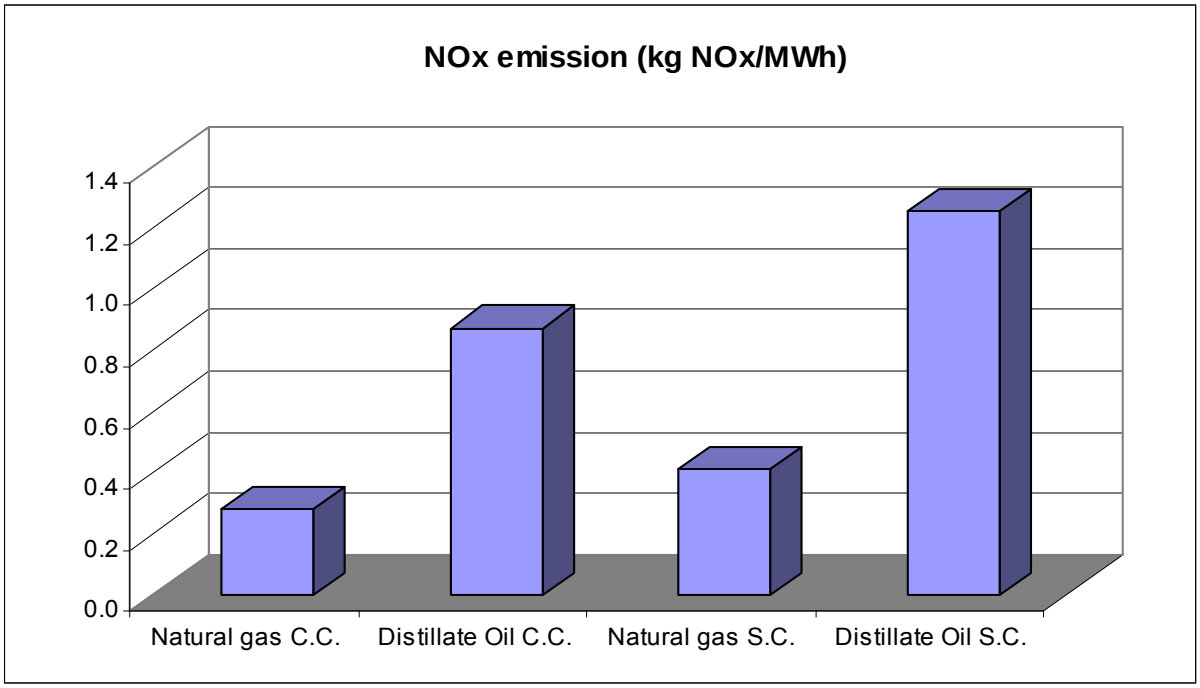
In the EXTENSION OF DEIR ALI Combined Cycle Power Plant Siemens V 94.3A gas turbines will be installed. They are equipped with dry low NOx combustors to achieve low NOx emission levels. The NOx emission concentration is guaranteed to 51 mg/Nm$^3$ (dry, 15% $O_2$) when firing natural gas and to 150 mg/Nm$^3$ (dry, 15% $O_2$) when the plant is operated on distillate oil. The corresponding specific NOx emission factors are 280 g/MWh with gas and 870 g/MWh with distillate oil (Table E 3). The NOx concentration is a guaranteed figure and insofar can be assessed as a maximum value. Figure E 3 clearly shows the advantage of natural gas compared to distillate oil concerning the NOx emissions. The NOx output is lower when firing natural gas even if the plant is run in the natural gas simple cycle operation mode.

**Table E 3: NOx emissions**

| **CASE**<br>**Fuel** | **1 normal case**<br>**Natural gas** | **2**<br>**Dist. oil** | **3**<br>**Natural gas** | **4**<br>**Dist. oil** |
|---|---|---|---|---|
| **Power MW el.** | 700 | 630 | 476 | 435 |
| **Efficiency %** | 55.52 | 53.49 | 37.95 | 37.16 |
| **Mode** | Combined Cycle | Combined Cycle | Simple cycle | Simple cycle |

| CASE<br>Fuel | 1 normal case<br>Natural gas | 2<br>Dist. oil | 3<br>Natural gas | 4<br>Dist. oil |
|---|---|---|---|---|
| **Gas consumption Kcal/Kw** | 1555 | | 1555 | |
| **Distillate oil consumption kg/h** | | 98800 | | 98800 |
| **Equivalent full load hours per year** | 7885 | 720 | | |
| **NOx Emission (as NO2) mg/Nm$^3$ Flue gas (15% O2) dry** | 51 | 150 | 51 | 150 |
| **ppmv** | 25 | 73 | 25 | 73 |
| **kg/h** | 195 | 542 | 195 | 542 |
| **t/a** | 1536 | 390 | | |
| **kg/MWh** | **0.28** | **0.87** | **0.41** | **1.25** |

**Figure E 3: NOx Emission for Different Operational Modes (kg/MWh)**




### 3.2.1.2. CO Emissions

The EPC-Contractor didn't state values for CO-formation during the combustion process. Therefore realistic values for CO emission concentrations have been derived on basis of similar projects and conditions. 20 mg/Nm$^3$ (specific: 0.11 kg/MWh) when firing gas and 30 mg/Nm$^3$ (specific: 0.17 kg/MWh) when firing oil have been used for the emission calculation (see Table E 1). These values are much below the Syrian standard of 250mg/Nm$^3$. WB and EC have no requirements regarding the CO Emissions from combined cycle power plants.

### 3.2.1.3. Dust Emissions

EXTENSION OF DEIR ALI CCPP is a combined cycle power plant with natural gas as primary fuel and a limitation of using distillate oil to max. 30 days a year. If the plant is operated gas fired, particulate emissions are negligible. Even when firing distillate oil the particulate emissions in flue gas will be low (max. 3 mg/Nm$^3$) due to the negligible ash content of the fuel oil (max. 0.01 Wt %).

### 3.2.1.4. $SO_2$ Emissions

Table E 4 summarises the main relevant $SO_2$ emission data of EXTENSION OF DEIR ALI Power Plant. The $SO_2$ emission concentration amounts to 374 mg/Nm$^3$ (dry flue gas at 15% $O_2$) when the plant is operated on distillate fuel oil. The use of this fuel shall be restricted to 30 days per year and as a consequence the maximum expected annual $SO_2$ emission rate is in the range of 0 to 974 t/a. During distillate oil operation, for 1 MWh electricity produced 2.16 kg $SO_2$ will be emitted. The daily emission rate during oil operation amounts to 32.40 t.

For normal operation with natural gas as fuel the $SO_2$ concentration in the flue gas is negligible.

**Table E 4: SO2 Emissions**

| **CASE**<br>**Fuel** | **1 normal case**<br>**Natural gas** | **2**<br>**Dist. oil** | **3**<br>**Natural gas** | **4**<br>**Dist. oil** |
|---|---|---|---|---|
| **Power MW el.** | 698 | 626 | 476 | 435 |
| **Efficiency %** | 55.52 | 53.49 | 37.95 | 37.16 |
| **Mode** | Combined Cycle | Combined Cycle | Simple cycle | Simple cycle |
| **Gas consumption Kcal/kw** | 1555 | | 1555 | |
| **Distillate oil consumption kg/h** | | 98800 | | 98800 |
| **Equivalent full load hours per year** | 7885 | 720 | | |
| | | | | |
| | | | | |
| **$SO_2$ Emission** | | | | |
| **mg/Nm3 Flue gas (15 % O2) dry** | negligible | 374 | negligible | 374 |
| **ppmv** | | 132 | | 132 |
| **kg/h** | | 1352 | | 1352 |
| **t/a** | | 974 | | |
| **kg/MWh** | | 2.16 | | 3.11 |

### 3.2.1.5. Comparison of Emissions with Relevant Standards

In the following, the emission concentrations or emission rates respectively, for the important potential gaseous pollutants $NO_X$ and $SO_2$ are compared with the WB and EC Guidelines (EC defined only NOx) and the Syrian Standard (see Section B, Table B 4) in order to assess the environmental impact caused by the emission of pollutants with the flue gas.

For comparison, the emission standards listed in Table E 5 on the following page have to be considered:

**Table E 5: Emission Standards Considered for Comparison**

| | **$SO_2$-Emission** | **$NO_x$-Emission (mg/Nm$^3$)** |
|---|---|---|
| **Syrian Standard** | 1000 – 3000 mg/Nm$^3$ | 300 – 3000 |
| **EC Directive** | Not defined | 75 for gas<br>120 for oil |
| **World Bank Standard**<br>- **Emission load**<br><br>- **Max. Concentration** | <br>119 t/day (for 697.5MW)<br>112.62 t/day (for 626.2 MW)<br><br>2000 mg/Nm$^3$ | <br><br><br>125 for gas<br>165 for oil |

In the Syrian guideline the upper value is valid for companies which emit bigger amounts of this compound due to their range of products and the associated emissions. The Syrian standard is in terms of emission concentration (mg/Nm$^3$). The applicable WB Guideline for $SO_2$ (EC no requirement for CCPP) is depending on the generating capacity, but with a maximum in terms of concentration. For 697.5 MW the standard comes up to 119.75 t/day $SO_2$ when firing gas. For the distillate oil fired operation mode the generation capacity will be around 626.2 MW. The corresponding WB limit is then 112.62 t/day. In the simple cycle mode the corresponding limit for oil firing is 87 t/day. The concentration in the flue gas is restricted to maximum 2000 mg/Nm$^3$.

Even if the lowest value of the Syrian guidelines is applied as threshold, the concentrations in the flue gas will easily stay within these limits.

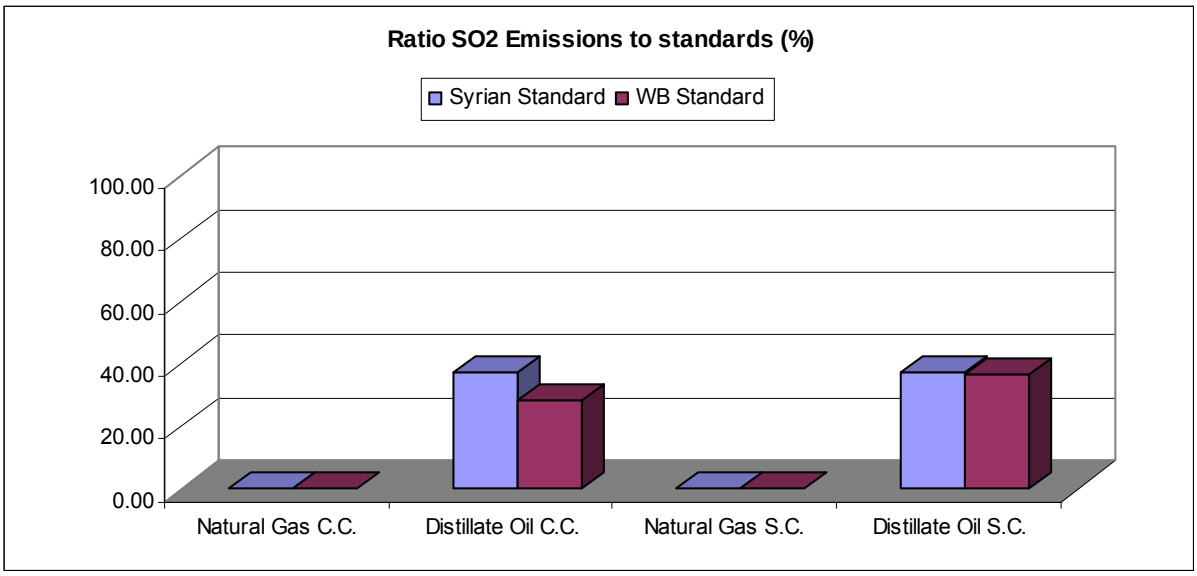
The emission of particulate matter is negligible for EXTENSION OF DEIR ALI CCPP. Beside that, the assumed CO emission values may reach only approx. 12% of the Syrian emission standard (250 mg/Nm3).

As the main emissions are $NO_x$, which is relevant to both gas and oil as fuel, $SO_2$ is relevant only when firing oil. For $NO_x$ different values in terms of concentration apply for both gas and oil. Figure E 4 shows the ratio between $SO_2$ emission of EXTENSION OF DEIR ALI plant and Syrian and World Bank standards.

As can be seen, $SO_2$ emissions will only occur during oil firing (cases 2 and 4) which will be restricted to 30 days per year. Even during these short times whilst using distillate oil the emissions will be within a safe margin and below the values set in the standards.
The $SO_2$ emission during firing distillate oil is 37.4 % of the Syrian emission standard (SES) (1000 mg/Nm$^3$) and 28.41 % of the World Bank (WB) standard. (112.62 t/d) for combined cycle mode (case 2).

During normal operation $SO_2$ emissions will not pose a problem.

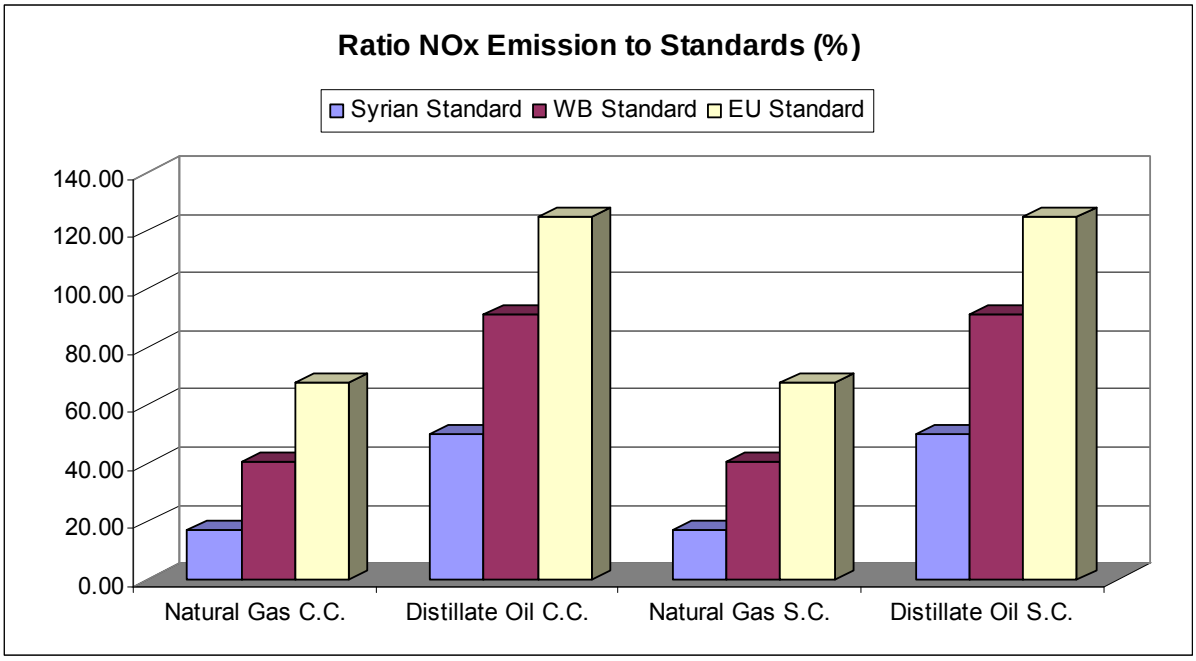
**Figure E 4: $SO_2$ Emissions in % of the Relevant Standards**




The $NO_x$ emissions when firing natural gas correspond to 41% of the WB standard and 17.1% of the SES (Figure E 5). In case of applying the strict EC guideline the value also lies within comfortable margins, reaching 68% of the limit. When firing the distillate oil (only emergency case) 90.7% of the WB standard and almost 50% of the SES is reached. With its 90%, the $NO_x$ value for distillate oil is the most marginal value concerning emissions. But this will occur in maximum 30 days per year (max. 7 days continuously) and just when firing natural gas is not possible. When applying the EC guideline an excess of the maximum

allowed emission value for NOx is recognized. The guaranteed value for NOx when firing distillate oil is with 150 mg/Nm$^3$ slightly above the EC limit of 120 mg/Nm$^3$. The reason for this higher guarantee value is the applied Dry Low NOx system. Technically it would be possible to reduce the NOx emission under the EC limits by injection of water to the combustion system. But in this case high quantities of water would be required (up to 35% of the used amount of fuel) and the plant efficiency will also decrease. Due to general water scarcity at the site and in the region the water injection for further NOx reduction can not be recommended, In addition, the distillate oil is only used as an emergency fuel for a limited operational time as mentioned above. Considering these aspects the impact of possible additional NOx emissions from the distillate oil firing can be assessed as negligible.

**Figure E 5: NOx Emissions in % of the Relevant Standards**




Comment: Distillate oil is only used as emergency fuel for max. 30 days/year and 7 days continuous operation

Summarising it can be stated that:

- Each normal plant operational scenario falls within the margins of the applicable emission standards
- For normal operational with natural gas as fuel the margin for NOx is very comfortable and $SO_2$ emission is negligible.

#### 3.2.1.6. Remarks on Reliability of Emission Data

The calculated emission data are mainly based on fuel composition and combustion calculations. The combustion calculations are particularly accurate and deliver flue gas flow data and composition of flue gas. The $NO_X$ and CO emissions however cannot be calculated. Values for $NO_x$ have been taken from the Contractor's guarantee sheet and can be assessed insofar as being "on the safe side" and in a range, which is the norm for the specified plant. The value for CO is assumed and is an average value of similar power plants implemented nowadays under analogue conditions. With this background and the absence of WB and EC guidelines for CO, this estimation can be assessed as sufficient for this consideration.

Summarising, it can be stated that the above-mentioned emission data are reliable and form a good basis for the environmental assessment.

### 3.2.2. Ambient Air Quality

To assess the impact of EXTENSION OF DEIR ALI CCPP on the ambient air quality the contribution of the plant to the ground level concentrations of pollutant gases shall be estimated. The distribution of the emitted gases is determined mainly by:

- The emitted mass flow (flue gas flow, mass concentration)
- Stack height and flue gas temperature (effective stack height)
- Meteorological conditions, especially wind velocity, direction and distribution (wind-rose)
- Properties of the land surface (flat, mountains).

The pollutant gas $SO_2$ can only be relevant when distillate oil is fired, i.e. for a maximum of 30 days a year. The emissions of dust can be neglected because gas is the primary fuel.
The $NO_X$ emission has to be considered for both gas and oil as fuel. The emission rates for oil are higher but the higher flue gas temperature improves the effective stack height and the dispersion. During the simple cycle operation the flue gas temperature is very high with the consequence of a corresponding high effective stack height and very low ground level values in the area around the site.

Due to the local meteorological and topographical conditions, described in Section D, there is no hindrance for air emission dispersion. The sparsely populated area and the absence of industry indicate that the ambient air quality standards are likely to be reached easily.

To assure this assumption, measurements shall be taken before and during project implementation and during operation phase and being compared with the valid guidelines listed in Table B 6 in Section B.

### 3.2.3. Impacts from Condensation Process

The used dry cooling system for condensation is leading only to a temperature increase in the ambient air and has several environmental advantages compared to a wet cooling system:

- No cooling water consumption → Protection of water resources
- No evaporation of cooling water → Constant absolute humidity of ambient air
- No distribution of contaminants from cooling water into the ambient air

From the environmental point of view the dry cooling system can be considered a positive way condensing steam into water.

## 3.3. NOISE IMPACT

During the operation of the plant, turbines, ventilators, and air compressors may create high noise emissions, impacting on the workers and surrounding residents. If noise exceeds permissible levels, they will have a negative impact on human health. Noise can reduce labour productivity and can lead to worker attention being distracted, which could lead to safety incidents.

The requirements for noise emissions are based on the ISO standards which are described in “Section B, chapter 4.4.2 and 4.4.3”. The necessary measures for the reduction of noise emission and the achievement of the given ISO Standard on the plant site and at the plant boundary have been considered and guaranteed by the EPC-contractor of EXTENSION OF DEIR ALI Power Plant.

Since the residential areas EXTENSION OF DEIR ALI village, Zogbor and the plants’ housing area are relatively far away from the location of EXTENSION OF DEIR ALI Power Plant, the noise generated by the plant will mainly impact the plants’ working areas. The

areas' only frequent noise source, the 4 km far away, east located highway will not play a role in the consideration of noise accumulation. Due to the absence of noise emitters and recipients, it can be stated that noise will not pose a problem during the operation phase. The noise immissions affecting the surrounding shall not exceed the values listed in Table B 9 in Section B. To assure this, a detailed noise level study should be performed at the site boundary.

## 3.4. IMPACTS ON WATER

The impact of EXTENSION OF DEIR ALI Power Plant on water can be divided in the following two aspects:

- Fresh water consumption
- Waste water discharge

### 3.4.1. Fresh Water Consumption

The EXTENSION OF DEIR ALI power plant will consume an average of 32 $m^3$/h fresh water as service water, potable water and demineralised water. The fresh water will be supplied via a water pipeline system from the Mesmieh , Zahnan and Baiat wells. The use of a dry cooling tower instead of an open water cooling circuit where a huge amount of water is needed (for a 700 MW combined cycle power plant approx. 60'000 $m^3$/h), is a very good solution in keeping the water consumption within an expedient level. With this solution the already scarce water resources are protected and can be made available for other users. The relatively small fresh water demand of the EXTENSION OF DEIR ALI Power Plant will not have any material impact on the current users of the Mesmieh , Zahnan , Baiat wells.

Due to the combined cycle technology the cooling capacity demand is more than 50 % lower than for a conventional coal-, oil- or gas fired power plant. The main reason for this is that only about 30 % of the power output is produced by the steam turbine which requires cooling water.

### 3.4.2. Wastewater Discharge

In general a thermal power plant can have an impact on the surface and ground water in the surrounding area. The impact can be caused by the following sources:

- Waste water from various chemical processes, such as demineralised water treatment
- Waste water from washing and cleaning of plant and equipment
- Rainwater
- Sanitary waste water

The fact that in case of EXTENSION OF DEIR ALI CCPP surface water is not available the impact will concentrate on the ground water. The treated wastewater will be provided for irrigation and cultivation in the area and en route trickle away in the soil.

The process wastewater will only rise from the demi-water treatment plant. The demi-water quantity for normal plant operation (e.g. necessary for HRSG blow down) will be about 14 $m^3$/h. The demi wastewater flow rate of this plant will be in a range of 4 to 6 $m^3$/h and will be treated by e.g. neutralisation in order to meet the requirements of the World Bank Discharge Standard (see Section B, Table B 8). The rest of the arising industrial waste water like oil contaminated water will also be treated in adequate wastewater treatment systems like an oil separation pit, coagulation or filtration equipment to achieve the WB standard. The treated wastewater will be monitored (see Section G) and discharged to an irrigation pond. The water, which will not be used for irrigation purposes, will be collected in an evaporation pot.

As natural gas will be used as main fuel (there is no desulphurisation plant and ash storage area which could produce waste water), it can be expected that the concentration of heavy metals in wastewater will be very low (mainly originate from input water).

The rainwater drainage systems design will be based on the data of rainfall over the previous ten years to ensure adequate/rapid drainage. Areas with high potential to be contaminated by oil and grease will have a separate collection system. The drainage system of EXTENSION OF DEIR ALI will also be piped to the irrigation collection pond.

The sanitary effluent of EXTENSION OF DEIR ALI Power plant and the housing area will be collected by a pipe system and routed to the sewage treatment plant, where it will be treated

in an anaerobic process, after settling solids and residues in a primary clarification process. After a final clarification process the treated water will be piped to the irrigation pond from where the water will be led to an irrigation channel. The exceeding water will be piped to an evaporation pond where it will evaporate in the atmosphere. The water discharge will comply with World Bank standards (for EC no general guidelines exist).

The remaining sludge in the evaporation pond will have to be disposed by a qualified and authorised disposal agent.

## 3.5. IMPACTS ON FLORA AND FAUNA

The EXTENSION OF DEIR ALI Project will have negligible impacts on the existing flora and fauna. In this desert steppe area, no autochthonous species which might be affected by the implementation of the project can be found (See “Section D, chapter 3.1”).

## 3.6. VISUAL IMPACT

The landscape in the surrounding of EXTENSION OF DEIR ALI provides just desert and steppe area and therefore no special visual attractions can be found close to the site (Details given in Section D). Therefore the visual impact of the EXTENSION OF DEIR ALI power plant is negligible.

## 3.7. SOCIO-ECONOMICAL IMPACTS

**Direct effect:**

The project will promote industrialisation not only in the EXTENSION OF DEIR ALI area but also in the areas, supplied with the produced energy. It will provide energy for industrial parks and population centres as well as for the Syrian National Power Grid. Consequently, this will promote socio-economic growth in the zone, and indirectly of Syria. With this positive impact, the life of thousands of residents will be improved.

**Population changes:**

Population changes will result from land use modification in EXTENSION OF DEIR ALI area. Agriculture possibilities will increase due to the irrigation system provided by the power plant's treated waste water. Also an increase can be predicted in the industrial sectors such as services and industry.

**Changes in employment opportunity:**

Construction of the plant will provide significant temporary employment for local labourers and construction workers. By this, job opportunities will fairly be increased

Therefore, it may be concluded that the positive impact the project will have on the area is expected to be much higher than any potential losses caused by the negative impacts on local socio-economy and environment.

# 4. RISKS

In connection to the EXTENSION OF DEIR ALI Project, the following environmental risks could be considered:

**Water and soil contamination from oil storage tanks:**
EXTENSION OF DEIR ALI power plant has two tanks with a total capacity of about 27'000 tonnes, sufficient for approximately 10 days full load operation. In order to limit the contamination risks the tanks will be installed in an area surrounded by a bund wall. The total volume that the bund wall can retain will be 110% of the volume of tanks. Therefore this risk is negligible.

**Problems in connection with natural gas supply:**
In case the natural gas will not be available for a long period, the plant could operate with distillate oil. This would increase the emission of pollutions, in particular $SO_2$ emission and consequently impact the quality of ambient air. But this is not possible since operation with oil only for maximum 30 days per year and 1 week continuous is allowed.

**Fire accident:**
In case of a fire accident, the surrounding environment of the EXTENSION OF DEIR ALI could be affected. In order to prevent this accident the fire protection system of EXTENSION OF DEIR ALI plant will be designed, constructed and operated according to the requirements of the NFPA.

It consists of an underground/overhead distribution system extending around all operating areas with a looped configuration to provide multi-directional fire water supply to maintain high reliability. Fire hydrants will be provided along the distribution system at approximately 80 meter intervals. Each hydrant will be provided with an individual curb box valve. Auxiliary equipment and tools will be provided in an equipment hose house located adjacent to each fire hydrant. Portable fire extinguishers will be provided throughout the plant. Also a $CO_2$ fire protection system will be applied for gas turbine enclosures and bearings.

Air foam system will be furnished at the fuel oil storage tank yard. Smoke detectors will be installed for offices and electrical/switchgear rooms. Heat detectors will be installed for workshop building. Rate of heat rise detectors will be installed for lube oil unit, transformer area, $H_2$ generating plant building.

# 5. OVERALL ASSESSMENT OF ENVIRONMENTAL IMPACTS

Based on the results gained in the forgoing chapters, the Figure E 6 has been prepared to show the main environmental impacts of the EXTENSION OF DEIR ALI Project. The impacts are divided into impacts during construction phase and impacts during operation phase. Considering this Figure the environmental impacts of the EXTENSION OF DEIR ALI power plant can be stated as follows:

**Construction phase:**

- The impacts are only temporary
- The impacts can be assessed as slight
- For implementation of such an important project, the impacts can be stated as acceptable

**Operation phase:**

- In general the applied combined cycle technology represents, environmentally, the best available fossil fuel based power generation system
- The considered main fuel, natural gas, is also environmentally representing the best possibility for large scale power generation
- Because of the above mentioned aspects, the overall environmental impacts of the plant can be assessed as slight
- The positive impact of the project on the local and Syrian socio-economical development can be assessed as relatively high

**Figure E 6: Summarizing Assessment of Environmental Impacts**

| Impact | slight | | inter-mediate | | high | | Remark |
|---|---|---|---|---|---|---|---|
| **Impacts During Construction Phase** | | | | | | | only temporary |
| Land clearing | | | | | | | no population on site |
| Air pollution | ■ | ■ | | | | | mainly dust |
| Water pollution | ■ | ■ | | | | | sanitary water |
| Noise | ■ | ■ | ■ | | | | construction equipment |
| Land used | ■ | | | | | | |
| **Impacts During Operation Phase** | | | | | | | |
| Particulate emission | | | | | | | negligible |
| CO emission | ■ | | | | | | |
| SO2 emission | ■ | | | | | | |
| NOx emission | ■ | ■ | | | | | |
| Impact on ambient air | ■ | ■ | | | | | |
| Noise | ■ | | | | | | |
| Impact on water (by wastewater discharge) | | | | | | | negligible |
| Impact on climate (CO2) | ■ | ■ | | | | | |
| Impact on Flora & Fauna | | | | | | | negligible |
| | | | | | | | |

## COMBUSTION CALCULATION FOR SOLID AND LIQUID FUELS

RAIBLE

| | | | | | |
|---|---|---|---|---|---|
| Project: | **700 MW PP** | | | | 700 |
| Combustion calculation for | | | | | 39.0% |
| Fuel: | **Coal** | | | LHV in MJ/kg | **27.61** |
| with following composition | | | | Input MW th. | 1795 |

| | | i. raw | |
|---|---|---|---|
| Carbon | C | 69.80 | mass % |
| Hydrogen | H | 4.10 | mass % |
| Oxygen | O | 4.65 | mass % |
| Nitrogen | N | 1.30 | mass % |
| Sulphur | S | 1.00 | mass % |
| Chlorine | Cl | 0.05 | mass % |
| | | 0.00 | mass % |
| Ash | a | 10.50 | mass % |
| Water | w | 8.60 | mass % |
| | Sum: | 100.00 | |

| | | | | | |
|---|---|---|---|---|---|
| Air ratio: | 1.4 | H2O in air: | 0.013 | O2 in air: | 21% |
| Fuel (kg/h) | 234,000 | | kg/kg dry air | Density dry air: | 1.2933 |

### RESULTS of combustion calculation

| | | Nm³ / kg fuel | kg / kg fuel | Nm³/h |
|---|---|---|---|---|
| Min. demand O2 | | 1.503 | 2.149 | 351,768 |
| Min. demand air | dry | 7.158 | 9.258 | 1,675,087 |
| Act. demand air | dry | 10.022 | 12.962 | 2,345,122 |
| Act. demand air | wet | 10.232 | | 2,394,190 |
| Min. flue gas volume | dry | 6.966 | | 1,630,127 |
| Min. flue gas volume | wet | 7.679 | | 1,796,781 |
| **Actual flue gas volume** | **dry** | **9.830** | | **2,300,162** |
| **Actual flue gas volume** | **wet** | **10.602** | | **2,480,836** |
| spec. CO2-value | | 1.294 | 2.559 | |
| spec. SO2-value | | 0.00683 | 0.02000 | |
| spec. HCl-value | | 0.00032 | 0.00051 | |

| **Flue gas composition** related to wet flue gas | | | **Flue gas composition** related to dry flue gas | | |
|---|---|---|---|---|---|
| H2O | 7.28 | % vol | | | |
| N2 | 74.78 | % vol | N2 | 80.65 | % vol |
| CO2 | 12.20 | % vol | CO2 | 13.16 | % vol |
| O2 | 5.67 | % vol | O2 | 6.12 | % vol |
| SO2 | 644 | ppm | SO2 | 695 | ppm |
| HCl | 30 | ppm | HCl | 32 | ppm |
| SO2 | 1843 | mg / Nm³ | SO2 | 1987 | mg / Nm³ |
| HCl | 49 | mg / Nm³ | HCl | 52 | mg / Nm³ |

**Flue gas volume flow at fuel throughput of**

| | | | | | |
|---|---|---|---|---|---|
| 234,000 | kg / h: | | 2,300,162 | Nm³ / h | dry |
| | | | 2,480,836 | Nm³ / h | wet |
| related to | 6 | % Ref.-O2: | 2,282,177 | Nm³ / h | dry |

# COMBUSTION CALCULATION FOR SOLID AND LIQUID FUELS

RAIBLE

| | | | |
|---|---|---|---|
| Project: | **700 MW PP** | MW el. | 701 |
| Combustion calculation for | | efficiency | 40.0% |
| Fuel: | **Dist. Oil** | LHV in MJ/kg | **42.65** |
| with following composition | | Input MW th. | 1753 |

| | | i. raw | |
|---|---|---|---|
| Carbon | C | 85.40 | mass % |
| Hydrogen | H | 13.70 | mass % |
| Oxygen | O | 0.10 | mass % |
| Nitrogen | N | 0.10 | mass % |
| Sulphur | S | 0.70 | mass % |
| Chlorine | Cl | 0.00 | mass % |
| | | 0.00 | mass % |
| Ash | a | 0.00 | mass % |
| Water | w | 0.00 | mass % |
| | Sum: | 100.00 | |

| | | | | | |
|---|---|---|---|---|---|
| Air ratio: | 1.17 | H2O in air: | 0.013 | O2 in air: | 21% |
| Fuel (kg/h) | 148,000 | | kg/kg dry air | Density dry air: | 1.2933 |

## RESULTS of combustion calculation

| | | Nm³ / kg fuel | kg / kg fuel | Nm³/h |
|---|---|---|---|---|
| Min. demand O2 | | 2.357 | 3.369 | 348,825 |
| Min. demand air | dry | 11.223 | 14.516 | 1,661,069 |
| Act. demand air | dry | 13.131 | 16.983 | 1,943,451 |
| Act. demand air | wet | 13.406 | | 1,984,115 |
| Min. flue gas volume | dry | 10.455 | | 1,547,313 |
| Min. flue gas volume | wet | 12.212 | | 1,807,357 |
| **Actual flue gas volume** | **dry** | **12.363** | | **1,829,695** |
| **Actual flue gas volume** | **wet** | **14.160** | | **2,095,647** |
| spec. CO2-value | | 1.583 | 3.131 | |
| spec. SO2-value | | 0.00478 | 0.01400 | |
| spec. HCl-value | | 0.00000 | 0.00000 | |

| **Flue gas composition** related to wet flue gas | | | **Flue gas composition** related to dry flue gas | | |
|---|---|---|---|---|---|
| H2O | 12.69 | % vol | | | |
| N2 | 73.27 | % vol | N2 | 83.92 | % vol |
| CO2 | 11.18 | % vol | CO2 | 12.80 | % vol |
| O2 | 2.83 | % vol | O2 | 3.24 | % vol |
| SO2 | 338 | ppm | SO2 | 387 | ppm |
| HCl | 0 | ppm | HCl | 0 | ppm |
| SO2 | 966 | mg / Nm³ | SO2 | 1106 | mg / Nm³ |
| HCl | 0 | mg / Nm³ | HCl | 0 | mg / Nm³ |

**Flue gas volume flow at fuel throughput of**

| | | | | | |
|---|---|---|---|---|---|
| 148,000 | kg / h: | | 1,829,695 | Nm³ / h | dry |
| | | | 2,095,647 | Nm³ / h | wet |
| related to | 3 | % Ref.-O2: | 1,805,199 | Nm³ / h | dry |

# COMBUSTION CALCULATION FOR GASEOUS FUELS

| | | | | |
|---|---|---|---|---|
| Project: | **Deir Ali CCPP 700 MW** | | MW el. | 697 |
| Combustion calculation for | | | efficiency | 55.5% |
| Fuel: | **Natural Gas** | | LHV in MJ/Nm³ | **38.08** |
| with following composition | | | Input MW th. (MJ/s) | 1255 |

| | | % vol | | | % vol |
|---|---|---|---|---|---|
| Methan | CH4 | 77.12 | Hydrogen | H2 | |
| Acetylen | C2H2 | | Oxygen | O2 | |
| Ethylen | C2H4 | | Nitrogen | N2 | 0.50 |
| Ethan | C2H6 | 9.08 | Carbon oxide | CO | |
| Propen | C3H6 | | Carbon dioxide | CO2 | 8.69 |
| Propan | C3H8 | 3.86 | | H2S | 0.00 |
| Buten | C4H8 | | | | |
| Butan | C4H10 | 0.62 | | | |
| Pentan | C5H12 | 0.07 | Hexan | C6H14 | 0.060 |
| | Summe: | 100.0 | | | |

| | | | | | |
|---|---|---|---|---|---|
| air ratio: | 3.1 | H2O in air: | 0.013 | O2 in air | 21% |
| Fuel (Nm³/h) | 118,677 | | kg/kg dry air | density dry air: | 1.2933 |

## RESULTS of combustion calculation

| | | Nm³ / Nm³ Gas | kg / Nm³ Gas | Nm³/h |
|---|---|---|---|---|
| Min. demand O2 | | 2.105 | 3.008 | 249,791 |
| Min. demand air | dry | 10.023 | 12.963 | 1,189,483 |
| Act. demand air | dry | 31.071 | 40.185 | 3,687,396 |
| Act. demand air | wet | 31.721 | | 3,764,549 |
| Min. flue gas volume | dry | 9.197 | | 1,091,515 |
| Min. flue gas volume | wet | 11.416 | | 1,354,777 |
| **Actual flue gas volume** | **dry** | **30.245** | | **3,589,428** |
| **Actual flue gas volume** | **wet** | **32.904** | | **3,904,956** |
| spec. CO2-value | | 1.274 | 2.515 | |
| spec. SO2-value | | 0.0000 | 0.0000 | |

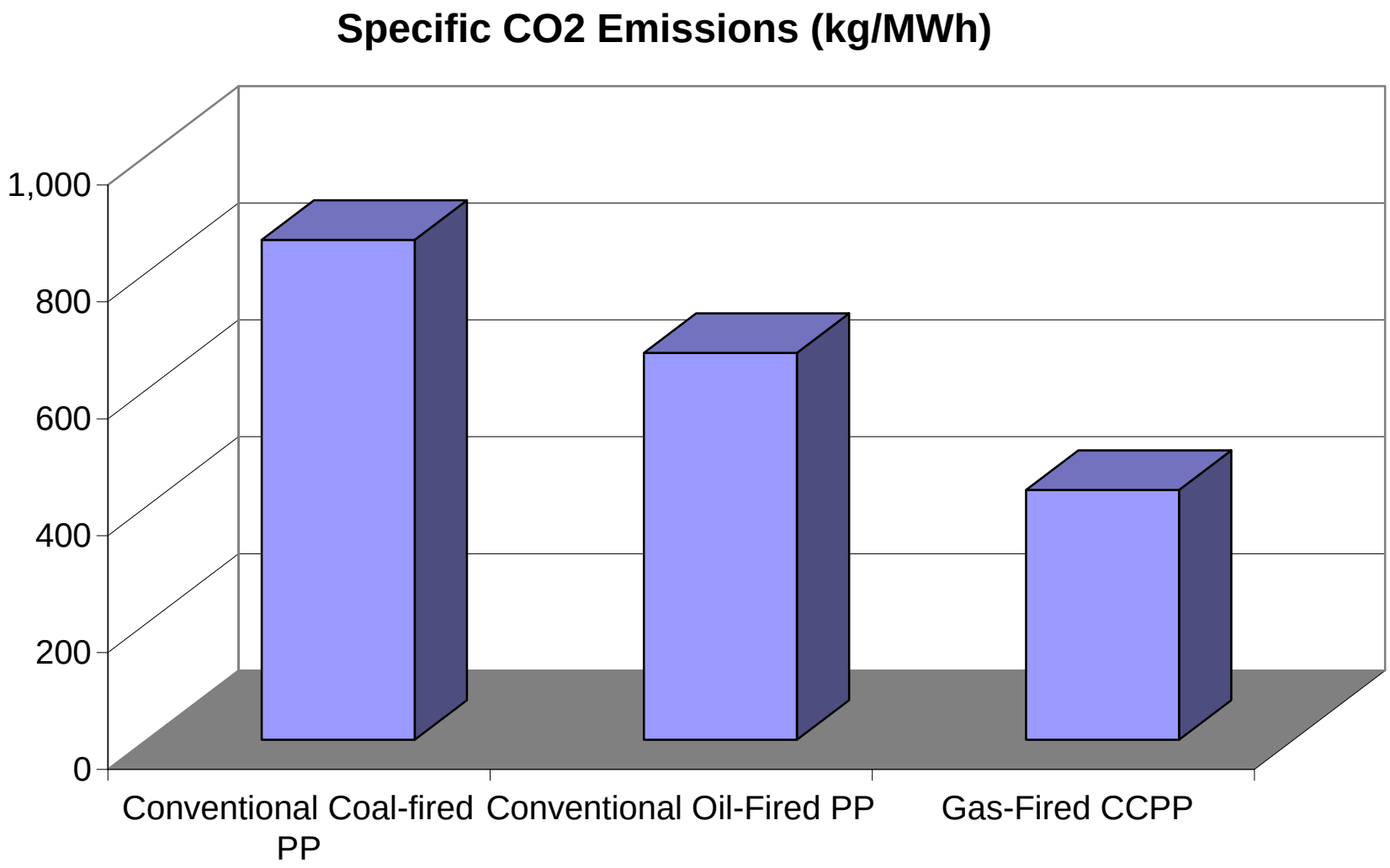
| **Flue gas composition** related to wet flue gas | | | **Flue gas composition** related to dry flue gas | | |
|---|---|---|---|---|---|
| H2O | 8.08 | % vol | | | |
| N2 | 74.61 | % vol | N2 | 81.17 | % vol |
| CO2 | 3.87 | % vol | CO2 | 4.21 | % vol |
| O2 | 13.43 | % vol | O2 | 14.61 | % vol |
| SO2 | 0 | ppm | SO2 | 0 | ppm |
| SO2 | 0.00 | mg / Nm³ | SO2 | 0.00 | mg / Nm³ |

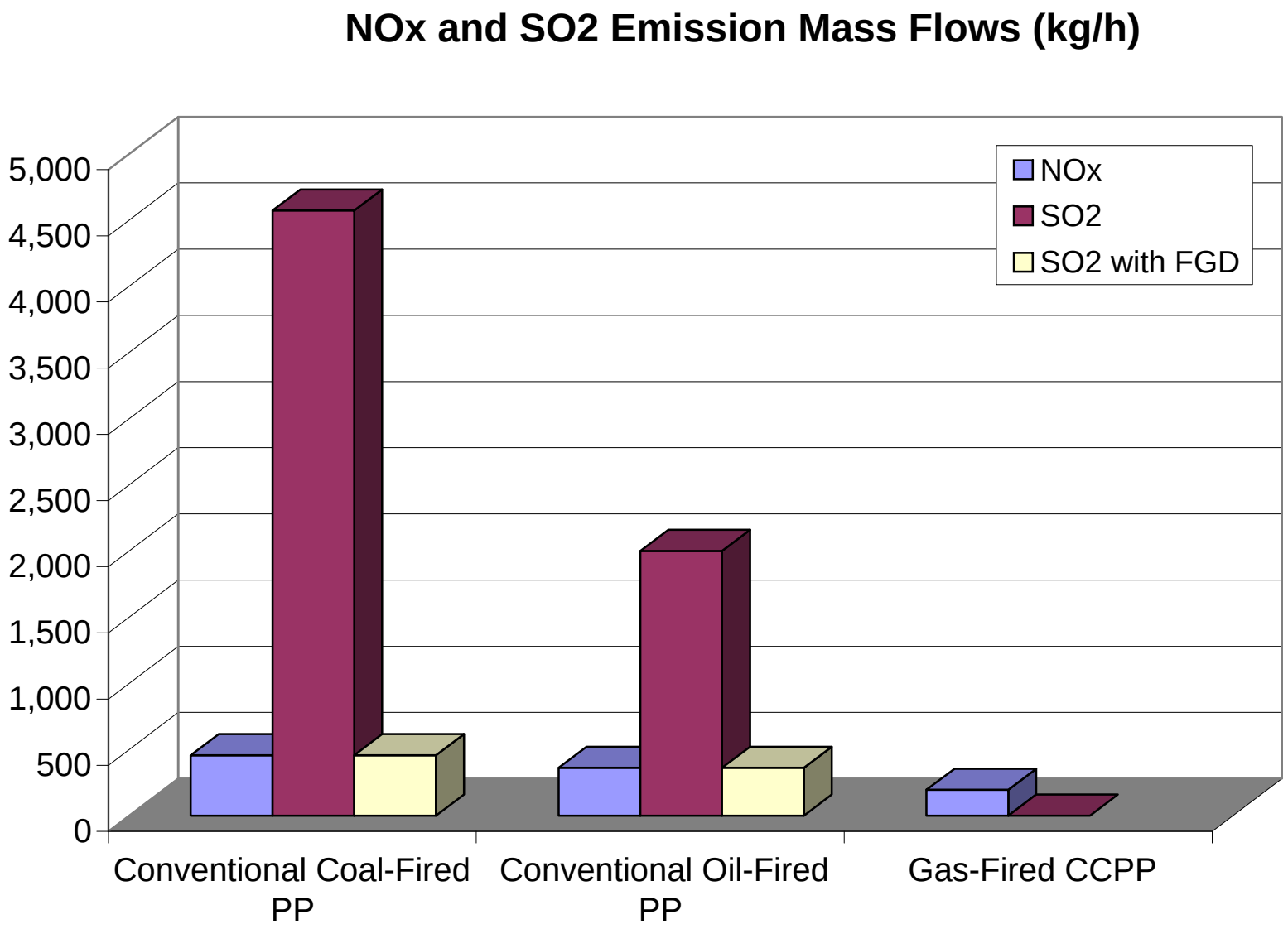
**Flue gas volume flow at fuel throughput of**

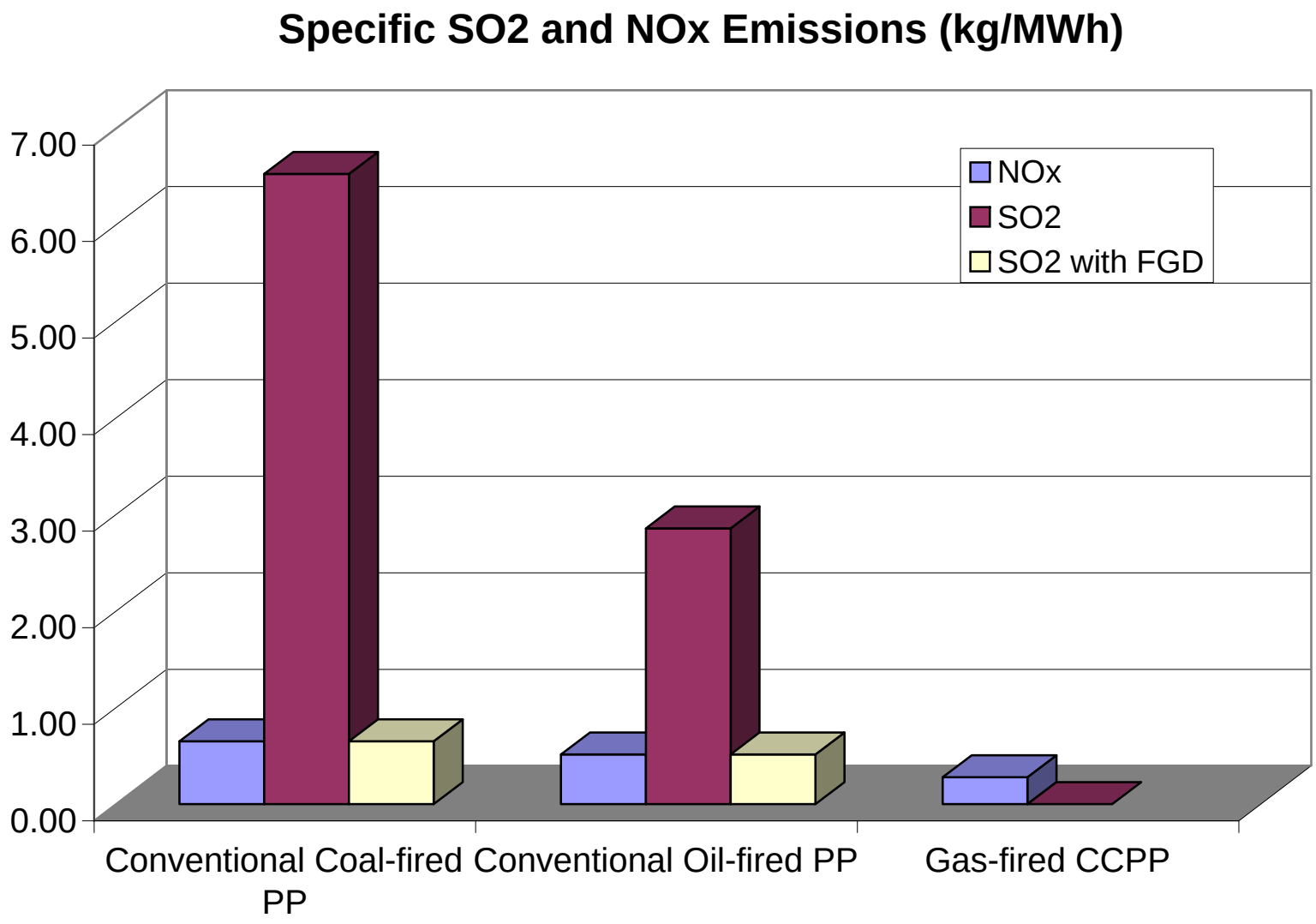
| | | | | | |
|---|---|---|---|---|---|
| 118,677 | Nm³ Gas / h | | 3,589,428 | Nm³ / h | dry |
| | | | 3,904,956 | Nm³ / h | wet |
| ralated to | 15 | % Ref.-O2: | 3,820,302 | Nm³ / h | dry |

| Table F.1: Comparison of different Power Plant Concepts | | | |
|---|---|---|---|
| **Plant Data** | **Conventional Coal-fired PP** | **Conventional Oil-fired PP** | **Gas-fired CCPP** |
| Fuel | Coal [1)] | Oil [2)] | Natural gas [3)] |
| power MW el. | 700 | 700 | 698 |
| efficiency % | 39 | 40 | 55.5 |
| Lower heating value MJ/kg, MJ/Nm3 | 27.6 | 42.7 | 38.1 |
| fuel consumption kg/h, Nm3/h | 234,000 | 148,000 | 118,677 |
| reference O2 % | 6 | 3 | 15 |
| **Flue Gas Data** | | | |
| Nm3/h (dry, ref. O2) | 2,282,177 | 1,805,199 | 3,820,302 |
| NOx mg/Nm3 // ppmv (dry, ref. O2) | 200 // 98 | 200 // 98 | 51 // 25 |
| SO2 mg/Nm3 // ppmv (dry, ref. O2) | 2'000 // 700 | 1'120 // 390 | negligible |
| SO2 mg/Nm3 //ppmv (dry, ref. O2) with FGD | 200 // 70 | 200 // 70 | - |
| CO2 kg/kg fuel, kg/Nm3 gas | 2.56 | 3.13 | 2.51 |
| **Emissions** | | | |
| mass flows: | | | |
| NOx kg/h | 456 | 361 | 195 |
| SO2 kg/h | 4,571 | 2,000 | negligible |
| SO2 kg/h (with FGD [4)]) | 456 | 361 | - |
| CO2 t/h | 599 | 463 | 298 |
| specific: | | | |
| NOx kg/MWh | 0.65 | 0.52 | 0.28 |
| SO2 kg/MWh | 6.53 | 2.86 | negligible |
| SO2 kg/MWh (with FGD[4)]) | 0.65 | 0.52 | - |
| CO2 kg/MWh | 856 | 662 | 428 |
| **Additional Consumption** | | | |
| Limestone (FGD) kg/h | 7,000 | 2,550 | - |
| Processwater (FGD) m3/h | 120 | 90 | - |
| **Additional Residues** | | | |
| Ash (to be disposed) kg/h | 20,124 | negligible | - |
| Gypsum (FGD) kg/h | 12,064 | 4,520 | - |
| Wastewater (FGD) m3/h | 4 | 1 | - |
| **Other Aspects** | | | |
| Land for coal yard/ash disposal | yes | no | - |
| Impact by ash transport and disposal | yes | no | - |
| Influence on waterway by fuel transport | yes | yes | - |
| Cooling water demand/discharge | higher | higher | - |
| Risks (e.g. oil spill, traffic accident) | increased | higher | - |

1) 1% S, LHV = 27,6 MJ/kg
2) 0,7 % S, LHV = 42,7 MJ/kg
3) LHV = 39,4 MJ/Nm3
4) FGD: Flue Gas Desulphurisation


Specific CO2 Emissions (kg/MWh)
1,000
800
600
400
200
0
Conventional Coal-fired PP
Conventional Oil-Fired PP
Gas-Fired CCPP


NOx and SO2 Emission Mass Flows (kg/h)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
NOx
SO2
SO2 with FGD
Conventional Coal-Fired PP
Conventional Oil-Fired PP
Gas-Fired CCPP


Specific SO2 and NOx Emissions (kg/MWh)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
NOx
SO2
SO2 with FGD
Conventional Coal-fired PP
Conventional Oil-fired PP
Gas-fired CCPP

# Environmental Impact Assessment Report
# of 700 MW EXTENSION OF DEIR ALI
# Combined Cycle Power Plant Project

# SECTION G

# ENVIRONMENTAL MANAGEMENT PLAN

# SECTION G: ENVIRONMENTAL MANAGEMENT PLAN

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# 1. INTRODUCTION AND INSTITUTIONAL REQUIREMENTS

## 1.1. INTRODUCTION

The EXTENSION OF DEIR ALI Combined Cycle Power Plant with a capacity of 700 MW will in the same site of Deir Ali Power Plant where 700 MW have been installed Combine Cycle Two Gas Turbines, Two HRSGs and one Steam turbine with all accessories and ancillaries with Dry cooling system Heler type be implemented in a distance of 2 km from DEIR ALI village. Infrastructure systems are already present (roads, power transmission lines) or need to be constructed (gas- and water pipeline). The development of this project is in terms of World Bank and EC policies designated an “Environmental Screening Category A” project, for which the EIA report shall include an Environmental Management Plan (EMP).

According to the World Bank Operational Policies (OP.4.01, January, 1999, revised in August 2004) the EMP shall describe mitigation, monitoring and institutional measures to be taken during implementation and operation of the project to eliminate adverse environmental and social impacts, or reduce them to acceptable levels.

## 1.2. LEGAL DOCUMENTS

As a main legal Document regarding the requirements of environmental monitoring the Guidelines of World Bank (OD 4.00, October 1989 and OP 4.01, January 1999) is used.

## 1.3. MONITORING AGENCIES

In Syria, the GCEA (General Commission for Environmental Affairs) within the Ministry of State for the Environment (MoE) is responsible for nation wide environmental management, including environmental monitoring, data evaluation and control.

# 2. MITIGATION MEASURES

## 2.1. DESIGN PHASE

There are no mosques, natural forests, or wildlife sanctuaries in the project area that could be encroached upon by the construction or operation of the EXTENSION OF DEIR ALI power plant. Therefore, measures for encroachment limitation of populated, cultural and protected sites are not necessary. The project will be established on empty land with in the site of Deir Ali. Due to this no people have to be resettled and no Resettlement Action Plan is required for this project.

The Design of the combined cycle power plant EXTENSION OF DEIR ALI is characterised by high efficiency and natural gas as fuel for normal operation, which ensures that:

- The emissions of CO, dust, $SO_2$ and NOx are minimised and will meet the relevant Syrian Standards as well as the Guidelines of WB and EC

- The requirements of the WB's Noise regulations (no EC directives existing) will be respected.

- The wastewater treatment systems will be completed according to the requirements of the WB's guidelines.

- All required safety measures (fire prevention with adequate control measures, workers health and safety) will be in accordance with the NFPA.

## 2.2. CONSTRUCTION PHASE

The following measures will be considered during the construction phase of the EXTENSION OF DEIR ALI Power Plant:

**Protection of ground water and soil quality:**

- Disposal of solid waste (construction waste, sand, stone etc.) and waste grease and oil from construction equipment to the soil and local ground water will be prevented. All the waste will be collected and transported to the approved provincial disposal sites

- Installation of adequate sanitation systems (for example mobile toilet facilities) for workers to prevent untreated or inappropriate domestic waste water discharge and there is the existing permanent facilities in the Power plant (see also “Section E, Chapter 2.4”).

- The site of the extension of Deir Ali will be completely isolated from the existing site by temporary fence during the execution period for safety reasons and the responsibility reasons sine both existing gas turbines in operation at this stage and the steam turbine will be putting into operation in 2009 when the extension in the execution phase.

**Protection of air quality:**

Air pollution during the construction phase (mainly during civil work activities) may occur mainly due to dust emission. The EPC-Contractor will be required to implement and apply the following measure to mitigate dust and prevent traffic accidents:

- Limit the speed within the construction site, and the access road leading to the site
- Install a wind sealed fence at the border of site
- Vehicles transporting open loads of construction materials such as sand or clay shall be covered where necessary

And to avoid the sands coming into the air intake filters of the existing Gas Turbines we expect the these filters will be consumed more than expected.

**Noise:**

To reduce noise during the construction phase appropriate measures shall be taken to comply with local regulations:

- Prohibition of noisy activities during the night.
- Speed restrictions to be applied to heavy / articulated vehicles, which pass through residential areas.

**Impact by Traffic:**

To maintain the traffic safety it is considered to keep the traffic slow which will pass through residential areas by appropriate measures such as speed limits and giving safety education to the drivers:

A summary of all important impacts during the construction phase and the applied mitigation measures are given in the following Table G 1:

**Table G 1: The main Project Impacts and Mitigation Measures during Construction Phase**

| No. | Impact | Possible Effects | Assessment / Mitigation Measures |
|---|---|---|---|
| 1 | Land used | Space requirement | Approx. 10 ha of total 67 ha PEEGT owned space is required |
| 2 | Traffic / Transportation | Increase in traffic volume | Temporarily affects. Transport of all plant equipment by road. Keep the traffic slow for safety |
| 3 | Construction labour and activities | Increase in air pollution, noise and waste quantity | Temporarily affects. Avoiding of dust pollution by periodic watering of site during civil works. Avoiding of noisy activities during the night. Wastewater and solid waste disposal according to the local regulations |
| 4 | Socio-economic | Employment aspects | positive effects on temporary employment for local workers |

## 2.3. OPERATION PHASE

During operation phase of the EXTENSION OF DEIR ALI Power Plant the following impacts on the ambient media air, soil and ground water are possible to be controlled by the power plants operating modes:

- Flue gas emissions into the atmosphere (e. g. $NO_x$, $SO_2$, CO)
- Noise within the plant boundary
- Solid waste disposal
- Ambient air quality
- Waste water discharge
- Sanitary water discharge
- Noise outside of the Plant boundary

**Air Pollution:**

As investigated in Section E, the $NO_x$ and $SO_2$ emissions of EXTENSION OF DEIR ALI power plant will be below the considered national and international standards due to application of a modern and highly efficient combined cycle technology (see Table G 2). No additional mitigation measures for the further reduction of these emissions are required.

**Noise:**

The EXTENSION OF DEIR ALI power plant is located at least 1 km from the nearest residential areas. To reduce noise level in the neighbourhood and to protect workers in the

plant, EXTENSION OF DEIR ALI CCPP will be designed in a way that the equipment will meet the requirements mentioned in “Section B, Chapter 4.4.”, e.g. by installing silencers.

**Table G 2: Comparison between the EXTENSION OF DEIR ALI Emissions and Standards**

| | **EXTENSION OF DEIR ALI Emissions mg/Nm$^3$** | **EC Standard mg/Nm$^3$** | **World Bank Standard mg/Nm$^3$** |
|---|---|---|---|
| Dust | Negligible | Not defined | 50 |
| $NO_x$<br>- Main fuel natural gas<br><br>- Emergency fuel distillate oil (Max. 30 hours/a) | <br>51<br><br>150 | <br>75<br><br>120 | <br>125<br><br>165 |
| $SO_2$<br>- Main fuel “natural gas”<br><br>- Emergency fuel “distillate oil” (Max. 30 hours/a) | <br>Negligible<br><br>32.4 t/day<br>374 mg/Nm$^3$ | <br>Not defined<br><br>Not defined | <br>119 t/day<br><br>112.6 t/day<br>2000 mg/Nm$^3$ |

Comment: Fuel oil can only be used in emergency operation for a maximal hours of 30 hours per year

**Water consumption:**

The EXTENSION OF DEIR ALI CCPP will use only a limited amount of fresh water as process water and potable water. Due to the selected cooling concept (dry cooling system), there is no need for the cooling water for thermal cycle process. Fresh water demand of 30 to 50 m$^3$/h will be supplied via pipeline from Almesmieh , Zahnan , Baiat wells. This fresh water demand has no material impact for the current users of this water source. Because of the considered dry cooling tower system no additional cooling water is required

**Industrial and sanitary solid wastes:**

- Sanitary Solid Waste:
  In the operation phase the quantity of sanitary waste from workers is minimal and will be transported to waste water treatment plant and after collected in an evaporation pond.
- Industrial Solid Waste:
  Industrial solid waste such as packs, cloths saturated with oil and/or grease and sludge extracted from a treatment system will be gathered and treated or transported to an appropriate place for disposal in accordance with local requirements.

**Fire prevention:**

Fire prevention and control at the EXTENSION OF DEIR ALI CCPP will be designed in accordance with NFPA (National Fire Protection Association) Standards.
The fire fighting truck will serve both sites the existing and extension during the excution period and operation period

A summary of all important impacts during operation phase and the applied mitigation measures are given in the following Table G 3:

**Table G 3: The Main Project Impacts and Mitigation Measures during Operation Phase**

| No | Impact | Possible Effects | Assessment / Mitigation Measures |
|---|---|---|---|
| **1** | Climate | Greenhouse effect | Minimising of specific $CO_2$ emissions by high plant efficiency and natural gas as fuel (427 kg/MWh) |
| **2** | Emissions | $NO_x$ and $SO_2$ pollutions | Limitation of $NO_x$ emission by applying of modern combustion technology (normal operation lower than 50 mg/Nm$^3$)<br>Limitation of $SO_2$ emissions by using of natural gas as main fuel. Distillate oil can only be used for max. 30 days/year and max. 1 week continuous operation |
| **3** | Ambient air quality | Increasing of pollutant concentration | Impact minimised because of use of combined cycle technology with gas as main fuel. Stack height supports good dispersion |
| **4** | Noise | Plant surrounding | Applying noise protection measures in order to meet the required standard |
| **5** | Fresh water demand | Water availability | Due to considered dry cooling concept only a limited fresh water quantity (30 to 50 m$^3$/h) is required |
| **6** | Wastewater discharge | Soil and ground water pollution | Applying of wastewater treatment in order to meet the required standards |
| **7** | Solid waste disposal | Pollution of soil and ground water | The solid waste should be disposed by an authorised local disposal company according to local regulations |
| **8** | Socio-economic | Country and future development | The impact of the project on the local and Syrian socio-economic development can be assessed as very high |

# 3. MONITORING

## 3.1. ORGANISATION OF ENVIRONMENTAL MANAGEMENT

In order to properly assess environmental impacts of the EXTENSION OF DEIR ALI Thermal Power Plant as well as evaluate the effectiveness of mitigation measures applied for the abatement of environmental pollution a program of monitoring and oversight of the project will be implemented. This oversight program will be implemented by the GCEA (General Commission for Environmental Affairs) in cooperation with the EXTENSION OF DEIR ALI Plant Management Board.

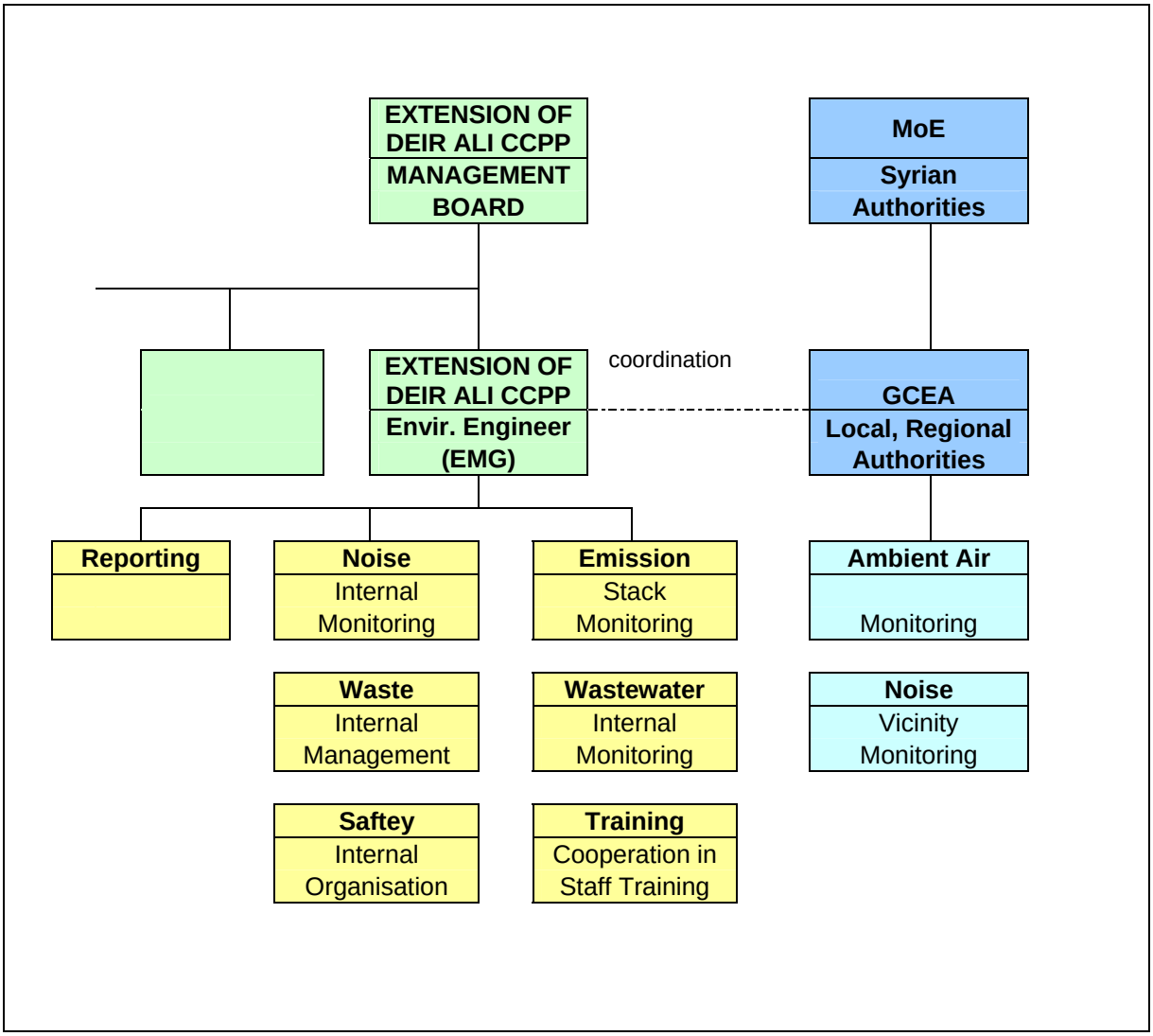
Figure G 1 indicates a possible organisation of the environmental management and monitoring of the EXTENSION OF DEIR ALI Combined Cycle Power Plant.

The EXTENSION OF DEIR ALI Management Board should be responsible for the internal environmental management and monitoring of the plant. For this purpose, the board will have to nominate and appoint an Environmental Engineer as head of an environmental management group (EMG). This group shall be responsible for the execution of environmental related issues such as:

- Stack emission monitoring
- Internal noise monitoring
- Internal waste management
- Waste water monitoring
- Labour safety
- Coordination with local and regional authorities (GCEA)
- Power plant related reporting.
- Cooperation in performing labour/staff training
- Ambient air monitoring
- Noise monitoring at residential area
- Waste management for the total complex
- Coordination with Syrian authorities

The organisation of the environmental management of EXTENSION OF DEIR ALI shall be set in place early in order to commence work during the construction phase.

**Figure G 1: Organisation of Environmental Management for EXTENSION OF DEIR ALI Power Plant**




## 3.2. ATMOSPHERIC POLLUTION MONITORING

Impacts on air quality shall be monitored, by measuring the emissions of the EXTENSION OF DEIR ALI power plant as well as by monitoring the ambient air quality and meteorological parameters in the area around the plant site.

The Environmental Management Group (EMG) of EXTENSION OF DEIR ALI Power Plant shall be responsible for the execution and evaluation of the emission measurements at the stacks of the plant and for the ambient air quality monitoring. The measurement and

monitoring activities shall be performed by the GCEA (General Commission for Environmental Affairs). All monitoring activities shall be coordinated between the parties involved.

The following Table G 4 summarises the recommended scope and plan of air pollution monitoring:

**Table G 4: Atmospheric Pollution Monitoring Plan**

| | **Parameter to be monitored** | **Location / Method /Frequency** | **Responsibility Estimated Cost** |
|---|---|---|---|
| Construction Phase: | *Ambient Air:*<br>Dust | • EXTENSION OF DEIR ALI site and surrounding<br>• Approx. monthly during civil work activities | EMG of EXTENSION OF DEIR ALI PP<br>Measurement cost:<br>10'000 USD |
| Operational Phase | *Emissions:*<br>$NO_x$, $SO_2$, CO, $O_2$<br>Temperature | • Stack<br>• Analysers with evaluation unit<br>• Automatic, continuously | EMG of EXTENSION OF DEIR ALI PP<br>Cost of instruments:<br>Approx. 150'000 USD |
| Operational Phase | *Ambient Air:*<br>$NO_x$, $SO_2$ | • Site surroundings<br>• Ambient air monitoring stations<br>• 2 times per year (summer and winter) | GCEA<br>Measurement cost:<br>approx. 15'000 USD/year |
| Operational Phase | *Meteorological Parameters:*<br>Wind velocity and direction, Temperature, pressure, humidity | • Site surroundings<br>• Ambient air monitoring stations<br>• 2 times per year (summer and winter) | GCEA<br>Cost included in above position |

## 3.3. NOISE MONITORING

During operation phase, noise measurements shall be performed in order to monitor the noise level within the boundary of the EXTENSION OF DEIR ALI plant as well as the residential area outside of the plant site. The EMG of EXTENSION OF DEIR ALI CCPP shall record the measurements at the plant boundary. The measurements should be performed by GCEA according to the World Bank regulations (EC Directive concerning noise not defined).

Table G5 summarises the noise monitoring plan.

**Table G 5: Noise Monitoring Plan**

| | Parameter to be monitored | Location / Method /Frequency | Responsibility |
|---|---|---|---|
| Construction Phase | Noise levels | • site boundary, close to nearest residential area<br>• Portable acoustimeter<br>• During peak hours of construction | EMG of EXTENSION OF DEIR ALI PP<br>Approx. 2000 USD |
| Main equipment of Deri Ali PP (e. g. turbines, generators) | Noise levels | • 1 m from equipment<br>• Portable acoustimeter<br>• 1 time per month | EMG of EXTENSION OF DEIR ALI PP<br>Approx. 2000 USD |
| Noise at surroundings of site | Noise level | • Outside EXTENSION OF DEIR ALI CCPP site, close to nearest residential area<br>• Portable acoustimeter<br>• 2 times a year | GCEA<br>Approx. 3000 USD |

## 3.4. WATER POLLUTION MONITORING

The discharge of wastewaters from within the EXTENSION OF DEIR ALI power plant boundary shall be monitored regularly by the EMG of EXTENSION OF DEIR ALI CCPP during the operation phase.

The monitoring plan of EXTENSION OF DEIR ALI power plant is shown in Table G 6:

**Table G 6: Water Pollution Monitoring Plan**

| Item | Parameter to be monitored | Location/Frequency | Responsibility |
|---|---|---|---|
| Effluent discharge | pH, susp. Solids, oil/grease, $BOD_5$, COD, coliforms, temperature | • At boundary of EXTENSION OF DEIR ALI PP, before discharge into irrigation pond<br>• 1 time / month | EMG of EXTENSION OF DEIR ALI PP Measurement in plant laboratory<br>Approx. 2000 USD |

# 4. TRAINING PROGRAM

It is recommended to conduct a consulting and training program for key personnel of EXTENSION OF DEIR ALI Power Plant. This will ensure that highly qualified staff will take over the responsibility and will work on environmental management and monitoring. The training program should be performed in coordination with the responsible local authorities.
PEEGT will state in ITB for the consultant who will supervise the works to send envromental eng. For two months for this purpose some of the trainee will be from EXTENSION OF DEIR ALI Power Plant and some from PEEGT office in addition to the training course by the EPC contractor

The consulting and training program should commence towards the end of the construction period and be completed in the first few months of operation. The detailed scope and schedule may be established later, an initial brief outline of a possible scope, what could partly be supplied by the EPC-Contractor, is given in the Table G 7.

**Table G 7: Brief Summary of Consultant / Training Services**

| Activity | Subject | Specialist | Duration Months |
|---|---|---|---|
| Consulting | Preparation of training program | Environmental Engineer | 1 |
| Consulting | Support in establishing environmental management group and management program | Environmental Engineer | 1 |
| Training | Environmental monitoring of thermal power plants and potential mitigation measures | Environmental Engineer | 2 |
| Training | Emission monitoring equipment:<br>• Requirements<br>• Specification<br>• Operation<br>• Maintenance | 1 Environmental Engineer of EXTENSION OF DEIR ALI Power Plant | 1 |

| | | | |
|---|---|---|---|
| Training | Wastewater analysis and, waste management | 1 Environmental Engineer of EXTENSION OF DEIR ALI Power Plant | 1 |
| Training | Worker safety and health aspects | 1 Environmental Engineer of EXTENSION OF DEIR ALI Power Plant | 1 |

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# SECTION F

# ANALYSIS OF ALTERNATIVES

# SECTION F: ANALYSIS OF ALTERNATIVES

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# 1. INTRODUCTION

In this section alternatives to the EXTENSION OF DEIR ALI CCPP project shall be compared, concerning site and especially technology and design, with respect to their potential environmental impacts and suitability under local conditions.
First some remarks will be given on the situation without the new EXTENSION OF DEIR ALI power plant and on possible alternative sites. Then feasible alternatives in technology for power generation from fossil fuels will be discussed and compared with the 700 MW EXTENSION OF DEIR ALI Combined Cycle Power Plant project. The two alternatives are:

- 700 MW Oil-fired conventional power plant
- 700 MW Coal-fired conventional power plant

# 2. SITUATION WITHOUT THE PROJECT

In case the 700 MW EXTENSION OF DEIR ALI Combined Cycle Power Plant project would not be realised, there would be no any negative environmental impacts on the area around EXTENSION OF DEIR ALI Site. From other side no positive socio-economic impacts for local and national development would be achieved. The implementation of the EXTENSION OF DEIR ALI CCPP belongs to one of the most important infrastructure development program of the Syrian Government.

Less electricity supply paired with a higher electricity demand will lower the economic development possibilities of the area and the supplied cities. The growing amount of industry, hospitals and other important facilities whose need for electricity must be covered to maintain a persistent increase of economic potential will be decelerated or even stopped by collapsing electricity networks or insufficient energy supply.

Peasants, who are the major population in the surrounding villages, could not profit from an additional irrigation source for agriculture.

# 3. CONSIDERED ALTERNATIVES

## 3.1. ALTERNATIVES TO SITE

The site for the EXTENSION OF DEIR ALI CCPP was chosen due to the following advantages, which were proven to be the most suitable:

- The plant will be constructed close to a substation, which is already present on the site. This is leading to lower investing costs and land usage
- The proximity to Damascus and Jordan benefits the energy transport without high losses in the lines
- Settled peasants profit from treated wastewater, that will be provided for irrigation
- Infrastructure like a paved road to the site and a highway with an access point in 7 km distance is already present
- Hospital and school is already established in EXTENSION OF DEIR ALI village. In case of health problems medical treatment is close and children of plant workers can use the present education facilities
- The area is not sparsely populated. In case of an accident in the plant like fire, the surrounding villages will not or just slightly be affected.
- The facilities of the existing site such as the buildings, the gas pipeline ,the staff , the existing D.O. fuel taks…

These points are far outweighing disadvantages like:

- Water has to be delivered from wells 25 km away
- No gas field close to site

## 3.2. ALTERNATIVES TO TECHNOLOGY

The following two alternative technologies for power generation from fossil fuels will be discussed and compared with the EXTENSION OF DEIR ALI CCPP concept, particularly in connection to the environmental impact aspects:

- Generation of 700 MW by an oil-fired conventional plant
- Generation of 700 MW by a coal-fired conventional plant

It is assumed that these power plant alternatives will be equipped with sufficient abatement measures in order to meet the strong limits of European Community (EC Directive 2001/80/EC) for particulate, $NO_x$ and $SO_x$ emissions:

- Particulates max. 30 mg/Nm$^3$
- $SO_2$ emission: 200 mg/Nm$^3$
- $NO_x$ emission: 200 mg/Nm$^3$

### 3.2.1. Fuel Oil-Fired Power Plant

**Design**

A conventional power plant has been considered using fuel oil with the same composition as foreseen for the EXTENSION OF DEIR ALI CCPP Project (see “SECTION C, Table C 2”). For the environmental comparison with the EXTENSION OF DEIR ALI CCPP Project, the relevant plant data are as follows:

- Net efficiency: 40%
- LHV: 42.654 MJ/kg
- S-content: 0.7 Wt %
- Fuel consumption: 148 t/h

The main flue gas data for an oil fired 700 MWe conventional power plant are as follows:

- Flow rate $Nm^3/h$ (dry, 3% ref. $O_2$): 1'802'000
- $NO_x$ $mg/Nm^3$ // ppmv (dry, 3 % ref. $O_2$): 200 // 98
- $SO_2$ $mg/Nm^3$ // ppmv (dry, 3 % ref. $O_2$): 1'120 // 390
- $SO_2$ $mg/Nm^3$ // ppmv (dry, 3 % ref. $O_2$) with FGD: 200 // 70
- $CO_2$ kg/kg fuel: 3.13

The $SO_2$ emission limit of 200 $mg/Nm^3$ can be achieved through a flue gas desulphurization plant (FGD) with limestone as additive and gypsum as end product. The NOx emission limit of 200 $mg/Nm^3$ should be met through installation of NOx burner systems.

Since the total power generation will only be produced by steam turbine, the demand of cooling air of this alternative will be approximately 50 % higher than for EXTENSION OF DEIR ALI CCPP project, in which about 70 % of power will be produced by gas turbines. The operation of FGD plant for reduction of $SO_2$ emissions will cause also additional consumables (limestone, process water, etc.) and produce additional residues (gypsum, FGD wastewater).

**Potential Environmental Impacts**

The potential environmental impacts are higher than for the EXTENSION OF DEIR ALI CCPP plant concept, because of:

- Higher $CO_2$ emission
- Higher $NO_X$ emission

- Higher $SO_2$ emission
- Higher particulate emissions
- Additional consumables and water demand for FGD
- Higher burden to roads due to transport of fuel and disposal by truck
- Higher risks of oil spill and fire
- FGD residues to be treated and to be disposed

Taking all these scenarios clearly indicates that the potential environmental impacts to be considered regarding an oil-fired power plant of the same generation capacity have to be assessed clearly higher than those for EXTENSION OF DEIR ALI project which is based on a gas-fired combined cycle power generation concept.

**Suitability and Economic Aspects**

Considering the above-mentioned higher expenditure, which will be incurred for the fuel transport, higher demand of plant area for fuel storage in connection with lower efficiency and in case of flue gas treatment additional consumables, residue disposal etc., it can also be expected that, from an economical point of view, this concept clearly falls below the EXTENSION OF DEIR ALI CCPP plant concept and, as such, should not be considered for implementation.

### 3.2.2. Coal-Fired Power Plant

**Design**

A conventional coal-fired power plant is considered for the comparison with EXTENSION OF DEIR ALI CCPP. An average quality of coal is assumed as fuel, with the following composition:

**Table F 1: Assumed Coal Composition**

| Analysis | Wt % |
|---|---|
| C | 69,80 |
| H | 4,10 |
| O | 4,65 |
| N | 1,30 |
| S | 1,00 |
| Cl | 0,05 |
| Ash | 10,50 |
| Water | 8,60 |

For the environmental comparison with the EXTENSION OF DEIR ALI CCPP, the relevant plant data are as follows:

- Net efficiency: 39%
- LHV of coal: 27.6 MJ/kg
- S-content in coal: 1.0 Wt %
- Fuel consumption: 234 t/h

The plant will be equipped with the following equipment to ensure a safe operation within the given emission guidelines of EC:

- Electrostatic precipitator for fly ash removal.
- Flue gas desulphurisation plant (FGD) for reduction of $SO_2$ emissions
- Low NOx Burners and SCR Plant (selective catalytic reduction) of $NO_x$ emissions

The main flue gas data for a 700 MWe conventional coal fired power plant are listed below:

- Flow rate $Nm^3/h$ (dry, 6 % ref. $O_2$): 2'282'000
- $NO_x$ $mg/Nm^3$ // ppmv (dry, 6 % ref. $O_2$): 200 // 98
- $SO_2$ $mg/Nm^3$ // ppmv (dry, 6 % ref. $O_2$): 2'000 // 700
- $SO_2$ $mg/Nm^3$ (dry, 6 % ref. $O_2$) with FGD: 200 // 70
- $CO_2$ kg/kg fuel: 2.56

Additional expenditure will arise due to coal unloading, storage and transportation facilities and due to bottom ash and fly ash handling and disposal. Similar to the oil-fired power plant described in Section 3.2.1, the operation of FGD plant requires additional consumables and causes additional residues. The $NO_x$ emission reduction in SCR Plant requires ammonia ($NH_3$) as additive.

**Potential Environmental Impacts**

The potential environmental impacts are higher than for the CCPP plant concept, because of

- Higher $CO_2$ emission
- Higher $NO_X$ emission
- Higher $SO_2$ emission
- Higher particulate emissions
- Additional consumables and water demand for FGD
- Additional consumables for SCR plant
- Bottom ash and fly ash to be disposed

- FGD residues to be treated and to be disposed
- Higher burden to traffic due to ash and coal transport
- Additional land requirements for coal yard and ash disposal site.

The operation of an ash disposal site will have adverse impacts on the local environment such as air pollution created by ash disposal activity. Consequently, this may adversely influence the natural eco-systems in the surrounding area.

Taking all these scenarios collectively, it clearly indicates that the potential environmental impacts to be considered regarding a coal-fired power plant of the same generation capacity, has to be assessed clearly higher than those for a gas-fired combined cycle power plant.

**Suitability and Economical Aspects**

The installation of a coal-fired power plant similar sizes will cause at leas two times higher investment costs than the EXTENSION OF DEIR ALI Power Project. Considering this aspect as well as the other disadvantages, such as higher space demand, additional consumables requirements, coal transport and residual dispose aspects, the installation of a coal fired power plant can not be assessed as a better alternative.

## 4. COMPARISON AND CONCLUSION

In Table F2 the main plant characteristics and data of the investigated alternatives are compiled and compared with those of the EXTENSION OF DEIR ALI combined cycle project. The comparison of the main emissions between these alternatives and EXTENSION OF DEIR ALI CCPP are shown in the following Figures:

Figure F1 shows the comparison of the greenhouse gas $CO_2$.

Figure F 2 shows the comparison of the mass flows for the pollutant gases $NO_X$ and $SO_2$. For oil and coal-fired alternatives, the plot shows the mass flows with and without FDG. $SO_2$ for the gas fired CCPP is less than 1 mg/Nm$^3$ anyway without treatment.

Figure F 3 shows the specific pollutant emissions per kg/MWh.

Considering all above gained results, the combined cycle technology can be technically and environmentally assessed as the most suitable alternative for the implementation at the EXTENSION OF DEIR ALI site.

**Table F 2: Comparison of Power Plant Alternatives and EXTENSION OF DEIR ALI Plant Concept**

| Plant Data | Conventional Coal-fired PP | Conventional Oil-fired PP | Gas-fired CCPP |
|---|---|---|---|
| Fuel | Coal [1)] | Oil [2)] | Natural gas [3)] |
| power MW el. | 700 | 700 | 700 |
| efficiency % | 39 | 40 | 55.5 |
| Lower heating value MJ/kg, MJ/Nm3 | 27.6 | 42.7 | 38.1 |
| fuel consumption kg/h, Nm3/h | 234'000 | 148'000 | 118'677 |
| reference O2 % | 6 | 3 | 15 |
| **Flue Gas Data** | | | |
| Nm3/h (dry, ref. O2) | 2'282'000 | 1'805'200 | 3'820'300 |
| NOx mg/Nm3 // ppmv (dry, ref. O2) | 200 // 98 | 200 // 98 | 51 // 25 |
| SO2 mg/Nm3 // ppmv (dry, ref. O2) | 2'003 // 700 | 1'121 // 390 | negligible |
| SO2 mg/Nm3 //ppmv (dry, ref. O2) with FGD | 200 // 70 | 200 // 70 | - |
| CO2 kg/kg fuel, kg/Nm3 gas | 2.56 | 3.13 | 2.51 |
| **Emissions** | | | |
| mass flows: | | | |
| NOx kg/h | 456 | 361 | 195 |
| $SO_2$ kg/h | 4'571 | 2'023 | negligible |
| $SO_2$ kg/h (with FGD [4)]) | 456 | 361 | - |
| $CO_2$ t/h | 599 | 463 | 298 |
| specific: | | | |
| NOx kg/MWh | 0.65 | 0.52 | 0.28 |
| $SO_2$ kg/MWh | 6.53 | 2.86 | negligible |
| $SO_2$ kg/MWh (with FGD[4)]) | 0.65 | 0.52 | - |
| $CO_2$ kg/MWh | 856 | 662 | 428 |
| **Additional Consumption** | | | |
| Limestone (FGD) kg/h | 7’000 | 2’550 | - |
| Process water (FGD) m3/h | 120 | 90 | - |
| Ammonia (SCR Plant)[5)] kg/h | 210 | - | - |
| **Additional Residues** | | | |
| Ash (to be disposed) kg/h | 20'100 | negligible | - |
| Gypsum (FGD) kg/h | 12'060 | 4’520 | - |
| Wastewater (FGD) m3/h | 4 | 1 | - |
| **Other Aspects** | | | |
| Land for fuel storage | yes | yes | No |
| Land for ash and residual storage and disposal | yes | yes | No |
| Impacts on transport and disposal aspects | yes | yes | No |
| Possible risks (e.g. oil spill, traffic accident) | yes | yes | No |

1) 1% S, LHV = 27,6 MJ/kg
2) 0,7 % S, LHV = 42,7 MJ/kg
3) LHV = 38.1 MJ/Nm3

4) FGD: Flue Gas Desulphurisation
5) SCR: Selective Catalytic Reduction Plant

**Figure F 1: Comparison of specific $CO_2$ Emissions of Alternatives**

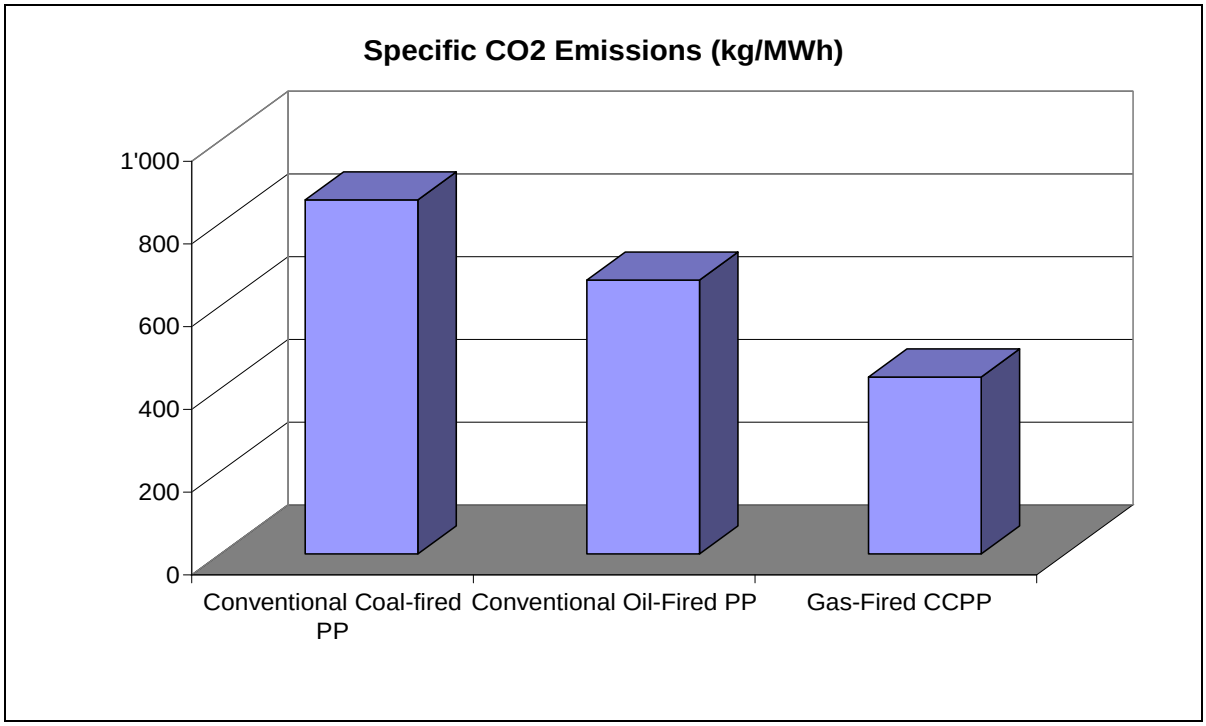


**Figure F 2: Comparison of NOx and $SO_2$ Mass Flows of Alternatives with and without considering FGD for Coal- and Oil fired Power Plants**

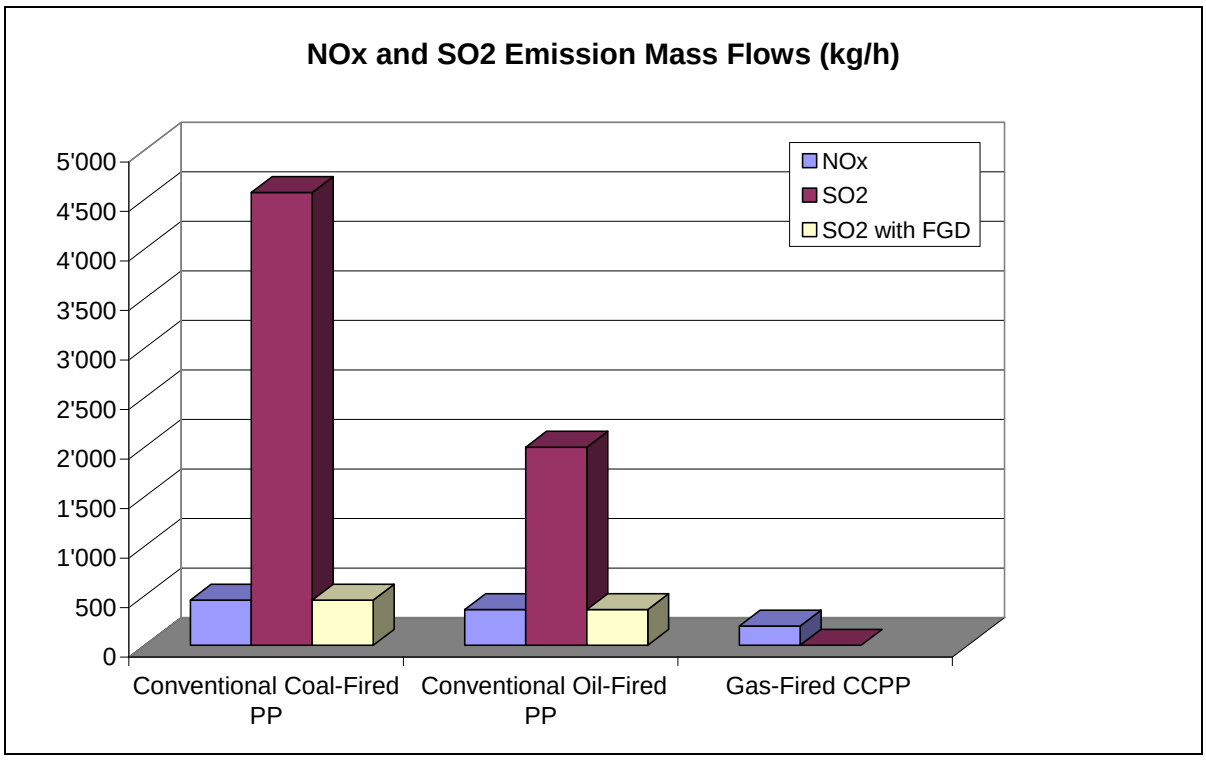
NOx and SO2 Emission Mass Flows (kg/h)
5'000
4'500
4'000
3'500
3'000
2'500
2'000
1'500
1'000
500
0
NOx
SO2
SO2 with FGD
Conventional Coal-Fired PP
Conventional Oil-Fired PP
Gas-Fired CCPP

**Figure F 3: Comparison of Specific $NO_x$ and $SO_2$ specific Emissions of Alternatives with and without considering FGD for Coal- and Oil fired Power Plants**