# Improving our environment by controlling existing thermal power and desalination plants emission

**A study of emission control in an existing thermal power and desalination plant**


By

***Engr.***

*Abdullah H. Hodhan*

***Operation Division Manager***

***J2&J3***

***Engr.***

*Mohammad N. Al Dahlawi*

***Desalination Specialist***

# TABLE OF CONTENTS

# INTRODUCTION

**Thermal power and desalination plants are major sources of pollution in the Kingdom of Saudi Arabia. The government has assigned PME for the control of pollution, protection of environment and to help in the planning, designing, executing and operating of these facilities; that will be applied in a manner which shall not adversely effect the population**

**PME (Presidency of Metrology and Environment)**

## *Objective of the study*

***To reduce thermal power & desalination plants emission to meet PME standards which shall help in promoting health, safety, welfare of the population and protecting kingdom's environment in general.***

# Discussion of the study

***In order to reach that objective two studies have to be carried out:***

***1) Life assessment study of the existing plant.***

***2) Environmental impact study***

# Life assessment study of an existing Plant

# Costs

The existing plant costs include the following:

1) Fixed Cost

   Is the capital invested in the installation of that plant and includes the following :

   a) Land, Building and Equipment cost.
   b) Interest
   c) Depreciation
   d) Insurance
   e) Management cost

2) Operating cost

   Includes the following :

   a) Maintenance cost
   b) Spare parts cost
   c) Fuel and chemical cost.

3) Total cost is the sum of fixed cost and operation cost.

# Performance and Reliability

Majority of power and desalination plants in Saudi Arabia are financed by the government. However, it must be efficient and cost effective to exploit the national resources. The prime duty of a designer is to design a plant which produce its product at the lowest cost and highest overall efficiency and reliability.

# Economical evaluation of an existing plant

1) In order to consider any plant as economically feasible the following items must be covered:

   a) Recovery of the fixed cost of the plant.

   b) Recovery of the operating cost.

   c) Satisfactory profit.

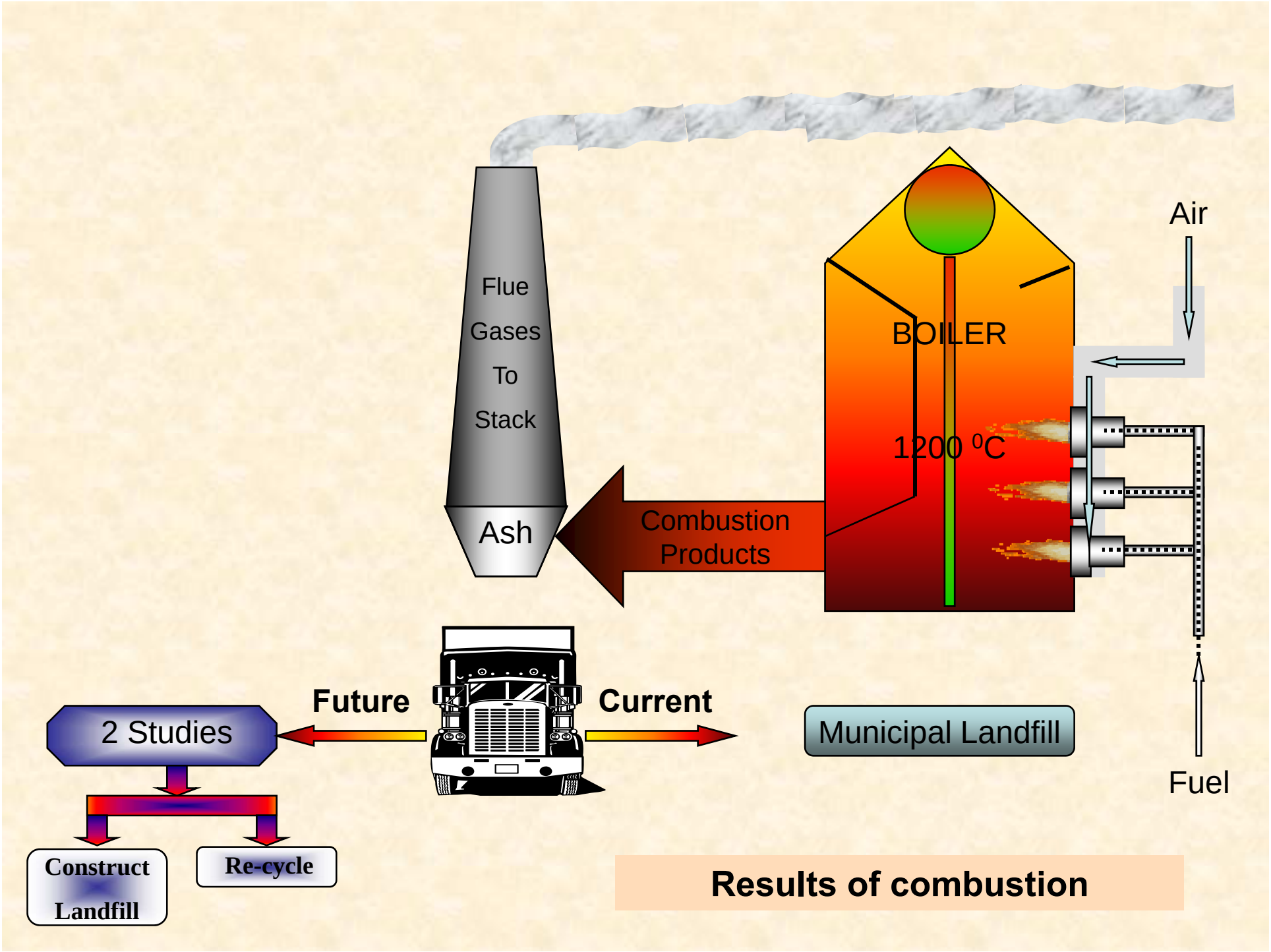
2) To evaluate an existing plant to predict the return period of its initial investment and the expected profit gained, two financial indicators are commonly used:

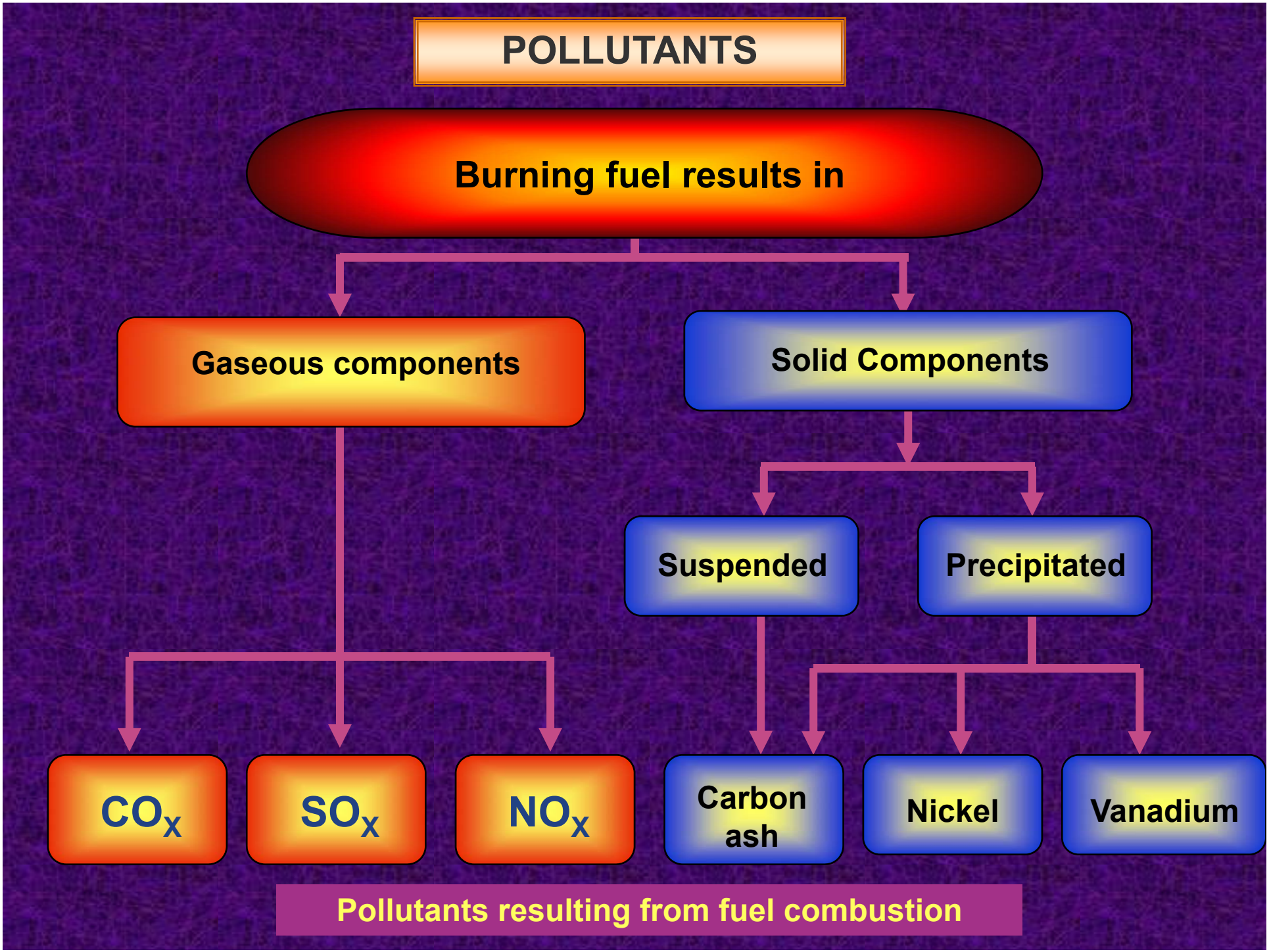
   a) Pay back method.

   b) Net present value method.



# Environmental impact study


Flue
Gases
To
Stack
Ash
BOILER
1200 $^{0}$C
Air
Combustion
Products
Fuel
Future
Current
2 Studies
Municipal Landfill
Construct
Landfill
Re-cycle
Results of combustion


POLLUTANTS
Burning fuel results in
Gaseous components
Solid Components
Suspended
Precipitated
$CO_X$
$SO_X$
$NO_X$
Carbon ash
Nickel
Vanadium
Pollutants resulting from fuel combustion

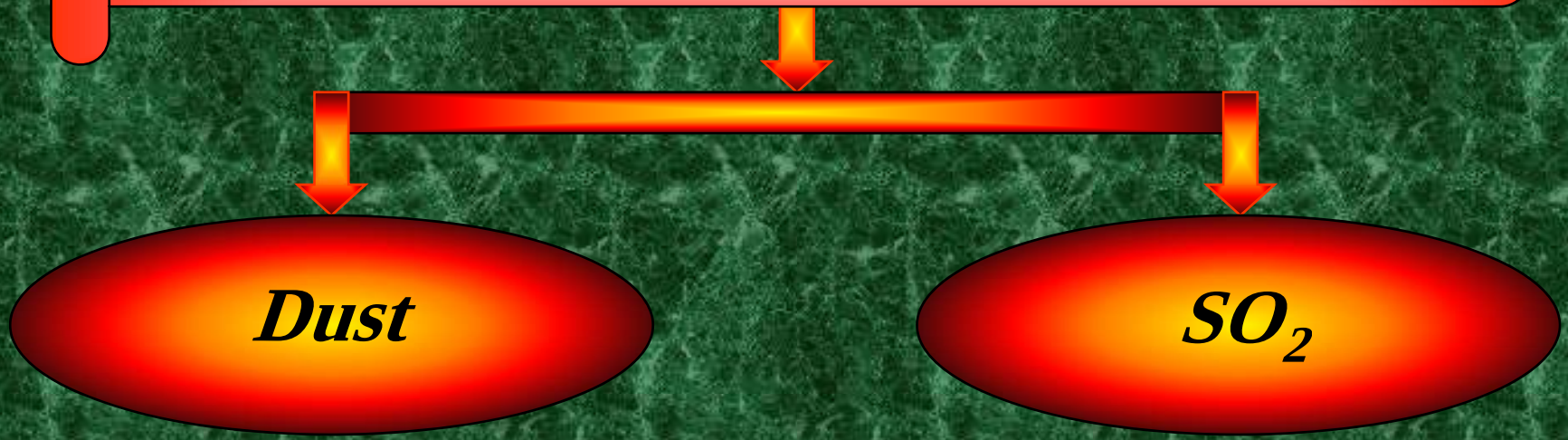
# *Environmental considerations*

The main environmental aspect in connection with the study are as follows:

1. **Stack emissions.**
2. **Sea water effluents.**
3. **Soot.**

# Stack emissions

**The most critical parameters to be maintained according to PME limits in stack emissions**



# The following table shows the emission concentration of pollutants in the flue gas from Jeddah SWCC phase# 4 stack:

| pollutants | unit | current | PME | future |
|---|---|---|---|---|
| Dust | $mg\backslash Nm^3$ | 370 | 142 | <50 |
| | mg\MJ | 112 | 43 | <15 |
| $SO_2$ *at 55% efficiency of absorber | $mg\backslash Nm^3$ | 5400 | 3200 | <2400 |
| | mg\MJ | 1700 | 1000 | <750 |
| $SO_2$ *at 65% efficiency of absorber | $mg\backslash Nm^3$ | 5400 | 3200 | <1900 |
| | mg\MJ | 1700 | 1000 | <600 |

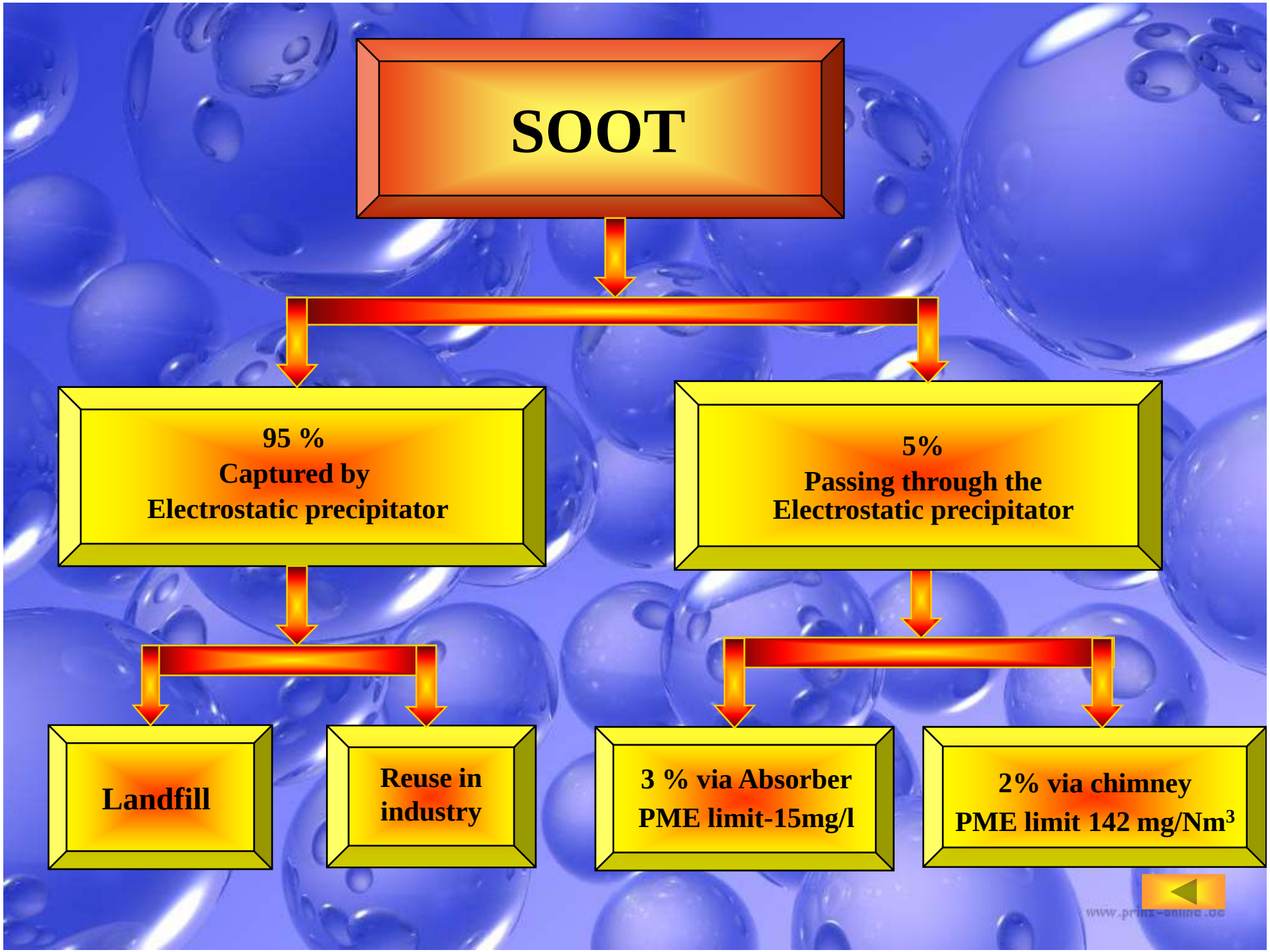
# Sea water effluent

**The most critical parameters to be maintained according to permissible PME limits**

- pH
- Chemical Oxygen Demand (COD)
- Heavy Metals (H.M.) included in the total suspended solids (TSS)

**Sea water effluent at SWCC Jeddah Plant's outfall**

| Parameters | Unit | Current | PME | Future |
|---|---|---|---|---|
| Ph | - | > 8 | 6 | ≥6 |
| COD | mg\ l | 2.7 | 150 | 3 |
| TSS | mg\ l | nil | 15 | Traces |

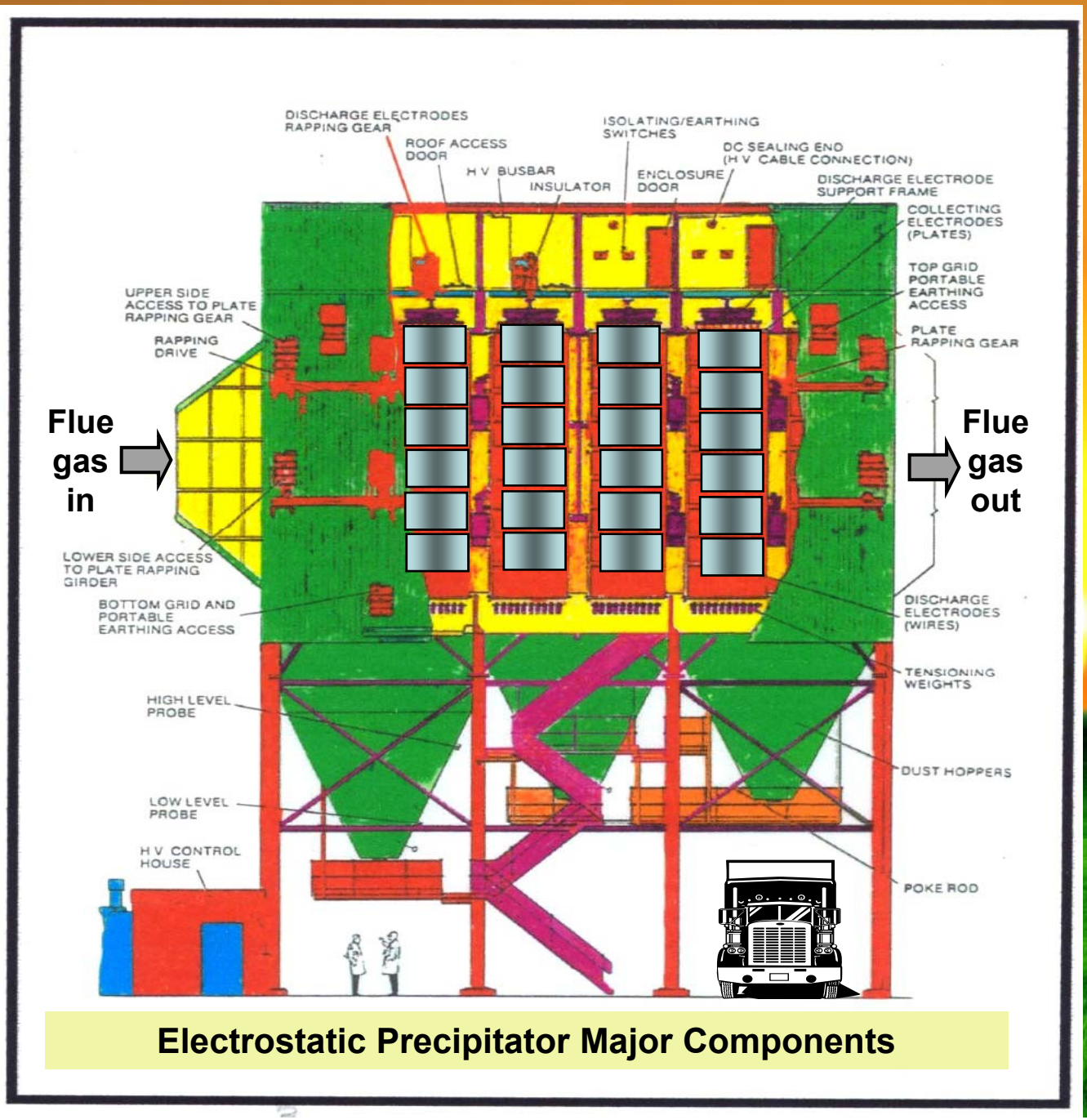

SOOT
95 %
Captured by
Electrostatic precipitator
5%
Passing through the
Electrostatic precipitator
Landfill
Reuse in
industry
3 % via Absorber
PME limit-15mg/l
2% via chimney
PME limit 142 mg/Nm3

# Fuel oil Specification

| Parameter | Unit | Result | Test Method |
|---|---|---|---|
| Water Content | By crackle test | + ve | ASTM D-95 |
| Total acid number | Mg KOH/ gm | --- | ASTM D-974 |
| Kinematic Viscosity | Cst @50$^0$C | 169 | ASTM D-445 |
| Specific Gravity @ 15.6$^0$C | - | 0.963 | ASTM D-1298 |
| API Gravity | Degrees | 15.44 | ASTM D-287 |
| Flash point (P.M. closed cup) | $^0$C | 77 | ASTM D-93 |
| Gross calorific value | J / g | 43059 | ASTM D-2382 |
| Sulphur content | % W/W | 3.41 | ASTM D-129 |
| Ash | % W/W | 0.058 | ASTM D-482 |
| Sediments (by toluene extraction) | % W/W | 0.024 | ASTM D-473 |
| Carbon residue (conradson) | % W/W | 10.8 | ASTM D-189 |
| Vanadium | ppm | 46 | ASTM D-1548 |
| Sodium | ppm | 9.5 | ASTM D-1318 |

**Solid pollutant**

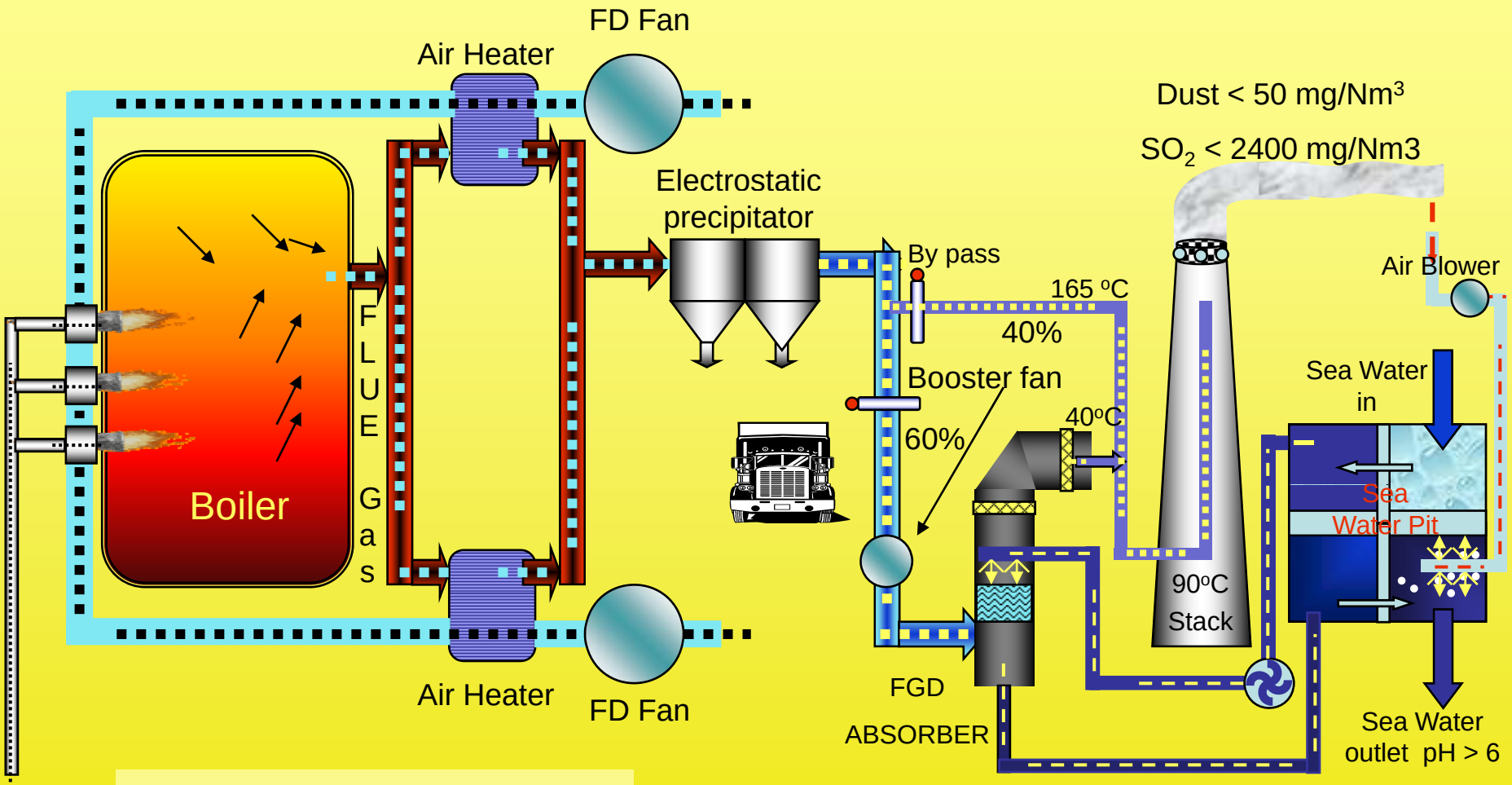
**The solid pollutant will be captured in the ESP as shown in figure**




**Electrostatic Precipitator Major Components**

# Gaseous pollutant treatment

The gaseous pollutant will be treated by F.G.D in the following way:




**FGD Project suggested for J4 plant**

# Case Study

This study has been carried out at SWCC Jeddah plant phase# 4

1 **Feasible FGD Processes**

2 **Final Evaluation of Feasible Processes**

# Jeddah plant – phase 4

| | |
|---|---|
| **Commissioning Date :** | **Started 1981** |
| **Electrical generation:** | **5 Turbines, each produce 125 MW** |
| **Water production:** | **10 Desal Units, each produce 912 $m^3/h$** |
| **Steam generation:** | **5 Boilers, each produce 600 tons / h** |
| **Flue gas emitted:** | **5 Boilers, each produce 500,000 $nm^3/h$** |

# Selection of Appropriate FGD Process

Consider the following factors:

1- Properties of fuel- amount of sulphur, ash & other constituents

2- Size of boiler- to determine the capacity of FGD equipment

3- Type of firing- To determine pollutants emitted

4- Availability of seawater

5- Cost of absorbent

6- Pollution control regulations (PME limits)

# Feasible FGD Processes

1. Wet Processes
2. Dry Processes
3. Semi dry process
4. Other Processes

**Only 3 FGD processes have been found to be feasible & economical for Jeddah Phase 4 use:**

- **Alt 1. Sea water process**
- **Alt 2. Wet limestone/gypsum process**
- **Alt 3. Dry lime process**

# Final evaluation of feasible processes

*Two techniques have been used:*

1) Economic evaluation
2) Sensitivity evaluation

# Economic evaluation

| no | Item | Unit | Alt1 | Alt 2 | Alt 3 |
|---|---|---|---|---|---|
| 1 | Capital Investment | Million SR | **273.75** | 281.25 | 236.25 |
| 2 | Life Expectancy | Year | **15** | 15 | 15 |
| 3 | Operation & Maintenance cost | Million SR/ yr | **42.2** | 53.0 | 57.75 |

**Note: From the above table Alt 1 shows the lowest cost**

# Sensitivity Evaluation

| Parameter Variation | Unit | Alt 1 | Alt 2 | Alt 3 |
|---|---|---|---|---|
| Base case | Million SR/ yr | 42.2 | 53.0 | 57.75 |
| Investment -10% for Alt2 and Alt3 | Million SR/ yr | 42.2 | 49.2 | 54.5 |
| - 5 Years life expectancy | Million SR/ yr | 51.0 | 62.1 | 65.4 |
| + 5 Years life expectancy | Million SR/ yr | 38.1 | 48.8 | 54.2 |
| Discount rate + 2% | Million SR/ yr | 46.2 | 57.2 | 61.2 |
| Discount rate - 2% | Million SR/ yr | 38.4 | 49.2 | 54.5 |

**Note:** From the above table Alt 1 shows the lowest cost

**The sea water FGD process is considered to be the most appropriate**

# CONCLUSION

To continue the running of an existing thermal power & desalination plant and satisfy PME requirements, two types of studies shall be carried out:

1) Life assessment study.

2) Environmental impact study.

A result of that it is possible to calculate the yearly total cost for the life extension, new FGD plant installations including capital investment, operation and maintenance costs.

# RECOMMENDATION

**To improve our environment and to comply with PME standards.**

**A) For future power and desalination plants, it is strongly recommended to install FGD system.**

**B) For existing plants, life expectancy and environmental impact assessment has to be carried out prior to take any decision by plants management.**


Thank you