ENERGY POLICIES ON WET FLUE GAS DESULPHURIZATION

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Abstract - Energy and environmental problems are closely related, since it is nearly impossible to produce, transport, or consume energy without significant environmental impact. The environmental problems directly related to energy production and consumption includes air pollution, climate change, water pollution, thermal pollution, and solid waste disposal. The emission of air pollutants from fossil fuel combustion is the major cause of urban air pollution. Burning fossil fuels is also the main contributor to the emission of greenhouse gases.

Keywords: pollutants removal, wet flue gas desulphurization, fossil fuel combustion

1. INTRODUCTION

Energy and environmental problems are closely related, since it is nearly impossible to produce, transport, or consume energy without significant environmental impact. The environmental problems directly related to energy production and consumption includes air pollution, climate change, water pollution, thermal pollution, and solid waste disposal. The emission of air pollutants from fossil fuel combustion is the major cause of urban air pollution. Burning fossil fuels is also the main contributor to the emission of greenhouse gases [1].

The negative impact of the Romanian energy sector on environment is currently a source of concern.

The programs for environmental protection in the energy sector are extremely expensive. Targeted investments consist of flue gas desulphurization ($DeSO_x$) installations, burners for reduction of nitrogen oxides from flue gases ($DeNO_x$) and filters for dust retention.

2. GOVERNMENTAL PROGRAMS OF INVESTMENTS IN FLUE GAS DESULPHURIZATION

We are taking into account the governmental program Sector Operational Program “INCREASE OF ECONOMIC COMPETITIVENESS” - SOP IEC.

The starting point for SOP IEC is the analysis of the current situation of entrepreneurship and innovation, with special emphasis on the small and medium-sized enterprises sector (SME_s), on resources for RDI sphere, on ICT sector, and on energy efficiency and environment protection issues in the energy and industry sectors.

It is followed by the SWOT analysis, on which the development strategy is built. The SOP IEC also contains a description of the priority axes, key areas of intervention and proposed operations, as well as financial tables, implementation provisions, partnership arrangements.

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The general objective of SOP is the increase of Romanian companies' productivity, in compliance with the principle of sustainable development, and reducing the disparities compared to the average productivity of EU. The target is an average annual growth of GDP (Gross Domestic Product) per employed person by about 5.5%. This will allow Romania to reach approx. 55% of the EU average productivity by 2015.

Taking into account both the identified possibilities for improvement of the competitive position of Romanian enterprises to cope with the challenge and to be able to use the opportunities arising from operating on the European Single Market and the areas eligible for the ERDF (European Regional Development Fund) support, the following Priority axes have been identified in the SOP IEC [2]:

- Priority Axis 1: An innovative and eco-efficient productive system;
- Priority Axis 2: Research, Technological Development and Innovation for competitiveness;
- Priority Axis 3: ICT for private and public sectors;
- Priority Axis 4: Increasing energy efficiency and security of supply, in the context of combating climate change (**Key Areas of Intervention -** *Efficient and sustainable energy (improving energy efficiency and environmental sustainability of the energy system - investments in flue gas desulphurization installations, burners with reduced NO_x and filters on refurbished/upgraded groups of large combustion plants)*;
- Priority Axis 5: Technical Assistance.

The present situation analysis as well as the conclusions of the SWOT analysis showed that Romania's economy competitiveness is much lower than the EU-25 average. Romania has to recover the significant disparities with regard to the knowledge-based society. Productivity is a major component of competitiveness and determines both the level of an economy's well being at a certain moment, and its growth potential in the future.

3. FLUE GAS DESULPHURIZATION

3.1 Flue gas desulphurization (FGD) description

Wet FGD technology, which is based on using limestone or lime as a reagent, is a wet scrubbing process and has been the FGD technology most frequently selected for sulfur dioxide (SO_2) reduction from coal-fired utility boilers. The wet FGD flue gas treatment system is typically located after removal of particulate matter from flue gas either by a baghouse or by an electrostatic precipitator. The cleaned gas is discharged to the stack. This type of FGD system removes SO_2 by scrubbing the flue gas with either a limestone or lime (reagent) slurry. The wet FGD process is considered a commercially mature technology and is offered by a number of suppliers. [3]

Flue gas is treated in an absorber by passing the flue gas stream through a limestone or lime slurry spray. In typical absorber designs, the gas flows upward through the absorber countercurrent to the spray liquor flowing downward through the absorber. However, other designs are also available, including co-current and countercurrent designs, and where the gas is forced through the liquor in a froth-type bubbling absorber. In a typical design, slurry is pumped through banks of spray nozzles to atomize it to fine droplets and uniformly contact the gas. The droplets absorb SO from the gas, facilitating the reaction of the SO_2 with reagent in the slurry. Hydrogen chloride present in the flue gas is also absorbed and neutralized with reagent, causing an accumulation of chloride ions in the process liquid. Some of the water in the spray droplets evaporates, cooling the gas at the inlet from approximately 150°C to 50°C-55°C, and saturating the flue gas with water. The desulfurized flue gas passes through mist eliminators to remove entrained droplets before the flue gas is sent to the stack (Figure 1).

$$SO_2 + H_2O \rightarrow H_2SO_3 \quad (1)$$

$$CaCO_3 + H_2SO_3 \rightarrow CaSO_3 + CO_2 + H_2O \quad (2)$$

$$CaSO_3 + \frac{1}{2}O_2 + 2H_2O \rightarrow CaSO_4\, 2H_2O \quad (3)$$

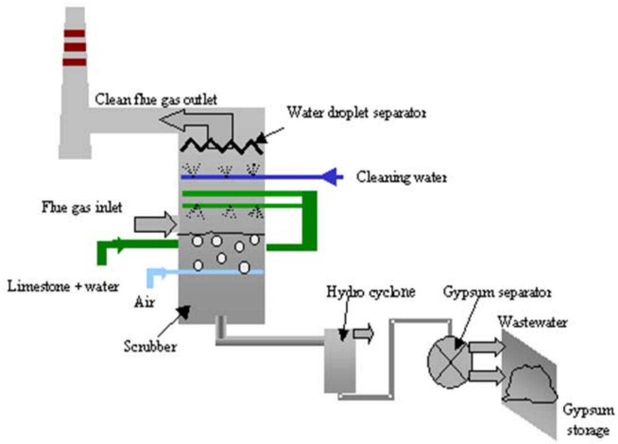

Fig. 1. Scheme of wet flue gas desulphurization plant.

In most wet FGD systems, SO_2 collection efficiency is controlled by selecting appropriate design features for the system. For example, the quantity of liquid sprayed relative to flue gas is related to the SO_2 collection efficiency needed and is referred to as liquid-to-gas (L/G) ratio. Higher L/G ratios improve SO_2 removal by exposing the gas to more absorbing liquor. However, higher L/G ratios also consume more power, and this design feature must be factored against other important design features, including type of reagent [4].

After contacting the gas, the slurry collects in the bottom of the absorber in a reaction tank. The slurry is agitated to prevent settling. Limestone or lime consumed in the process is replenished by adding fresh limestone or lime slurry to the reaction tank.

In the LSFO process (limestone with forced oxidation), the slurry is also aerated in the reaction tank to oxidize calcium sulfite hemihydrate ($CaSO_3 \cdot \frac{1}{2} H_2O$) to calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$), or gypsum, which precipitates. This is where the term "forced oxidation" originates and it distinguishes this process from older, more troublesome limestonebased "natural oxidation" technology. The oxidized slurry is then recirculated to the spray headers. A portion of the slurry is withdrawn to remove the precipitated gypsum. Typically, this slurry is dewatered in a two-stage process involving a hydroclone and vacuum filter system to produce a gypsum cake for disposal or sale. Water removed from the gypsum slurry is returned to the process. A portion of this water is removed from the system as wastewater to limit accumulation of corrosive chloride salts in the process liquid.

In the MEL process (magnesium-enganced lime with forced oxidation), the slurry is aerated for the same reason, but in a separate tank, ultimately producing a gypsum cake similar to the LSFO process. Water removed from the gypsum and soluble magnesium salts are recycled to the process with a portion removed as wastewater for chloride control.

3.2. Wet FGD process advantages and disadvantages compared to dry FGD technology

3.2.1. Process advantages

The LSFO and MEL technologies have the following advantages when compared with other FGD technologies (Figure 2 and Figure 3):

1. Well-established FGD technology on a variety of world coals with proven reliability;
2. SO_2 removals of 95% are common and removals as high as 98% can be attained;
3. Adequate and commercially viable suppliers offer the technology;
4. Reagents used by the process are plentiful and readily available;
5. Waste gypsum is stable for landfills without blending with fly ash and lime;
6. Can be designed to produce wallboard-grade gypsum as a saleable by-product;
7. The FGD system is not sensitive to boiler operational upsets and typical operating modes, such as cycling duty.

3.2.2. Process disadvantages

The LSFO and MEL technologies can have the following disadvantages when compared with other FGD technologies:

1. The LSFO process circulates large quantities of slurry with the attendant high pumping power consumption;
2. The pressure drop across the absorber increases the induced draft (ID) fan power consumption;
3. These processes can produce a large volume of gypsum. The salability of this by-product is dependent on a sufficiently sized gypsum market near the plant;
4. The high potential for corrosion requires extensive use of costly corrosion-resistant alloys or nonmetallic liners as materials of construction for the absorber and other system components.

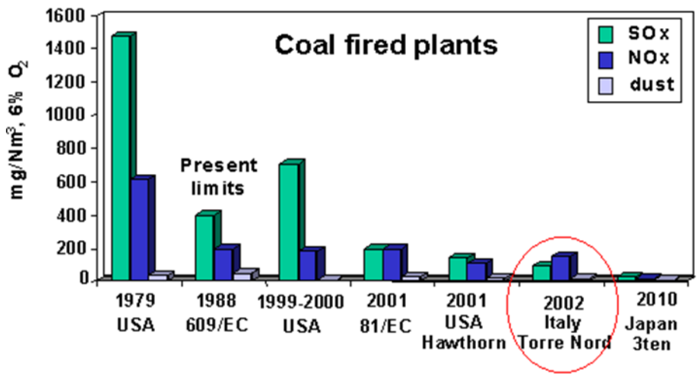

Fig. 2. Recent trend of emissions limits.

	Fuel	MWe	NO_x	SO_2	Particulate	Year
Mellach (A)	Coal (< 1% S)	250 + heat	180	110	10	1986
Hawthorne (USA)	Coal (< 1% S)	550	65	150	22	2001
Boxberg (D)	Lignite	907	150	350	10	2002
Haramachi (J)	Coal (< 1% S)	2x1000	120	200	25	1997
Tomatoh-Atsuma (J)	Coal (< 1% S)	2x700	100	143	10	2000
Tachibana-Wan (J)	Coal (< 1% S)	2x1050	90	143	10	2002
Hekinan (J)	Coal (< 1% S)	2x1000	30	75	5	2001
New units (Japan)	Coal (< 1% S)	700÷1000	50	75	5	-

Fig. 3. Effective emission values for best reference power plants worldwide.

3.3. Seawater processes

In England, flue gas desulphurization using seawater discharged from the plant cooling system was first implemented in the 1930s. This approach was, in part a replacement for freshwater scrubbing, which offered low buffering capacity and required the addition of chalk to increase SO_2 removal efficiency. Scrubbing flue gas with seawater has been practiced in smelter refinery and industrial and utility boiler applications. There are currently over 6.5 million Nm^3h of flue gases being scrubbed by seawater with guaranteed SO_2 removal efficiencies of up to 99%. Some properties of seawater are given in Table 1 and Figure 4.

There are two basic seawater FGD process concepts: one uses the natural alkalinity of the seawater to neutralize absorbed SO_2, the other uses added lime. All commercial seawater FGD processes rely on the alkalinity of the bicarbonate in the seawater to neutralize the SO_2 thereby producing sulphite or sulphate, the latter a natural constituent of seawater. A lime-based seawater FGD process has been proposed by Bechtel.

Table 1. Typical seawater properties.

Property	
Sulfur Concentration, mg/l	500-900
Magnesium Concentration, mg/l	1300
pH	7.5-8.5
Alkalinity, mili-echivalent/l	2.2-2.4

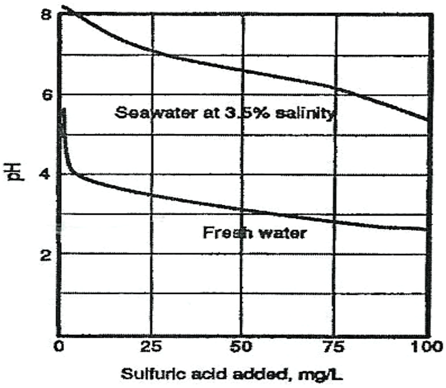

Fig. 4. The effect of acid addition on the pH of seawater and fresh water.

Environmental effects are the major consideration with all seawater FGD processes. Suppliers of these processes claim that the effluent does not endanger the marine environment. This is supported by a number of independent studies.

The environmental impact of the Bechtel seawater FGD process effluent, which contains low concentrations of gypsum, fly ash, and non-leachable trace metals, was extensively studied using EPA-800. Several species of marine organisms were subjected to the effluent, and the effects of seasonal variations were included. It was concluded that no detrimental impact from the effluent discharge is foreseen and that the diluted seawater scrubber system is not detrimental to marine environments. The oceans contain a very large amount of sulphur as sulphate. If this sulphur in the sea were spread out as an even layer, the total ocean area of the world would be covered by a 5-foot thick layer of sulphur. If all the sulphur in all the known oil and coal reserves were added to this layer, the thickness would only increase by the thickness of a sheet of paper [5].

Environmental requirements often dictate the design of seawater FGD systems. In the United States, EPA coastal water quality standards specify an initial mixing zone (IMZ) where the discharge at the IMZ boundary shall not vary more than 2 units from the natural pH value. Initial mixing is defined to be completed when the momentum-induced velocity of the die charge ceases to produce significant mixing of the effluent. If a seawater FGD process is being considered, an environmental assessment of the local receiving waters should be made. This assessment should include evaluations of depth profiles, currents, and tidal variations, water quality, effluent dilution and dispersion conditions, existing stationary and mobile marine life, and impact of the installation.

3.4. Flakt-Hydro seawater process

The Flakt-Hydro process is a once-through process that absorbs the SO_2, by utilizing the natural alkalinity of seawater. A schematic diagram of the process depicting a typical equipment arrangement is shown in Figure 5. After particulate removal, the flue gas enters a high turn-down absorber via the inlet quencher duct. The quencher protects the absorber from high temperatures while also removing some SO_2. Alternatively, a gas-to-gas heat exchanger may be used for this purpose. The absorber is the counter current type with saddle packing.

The total L/G typically varies between 30 and 110 gpd1. The flue gas flows up through the absorber and is desulfurized and cooled by the seawater. A mist eliminator at the absorber exit removes entrained water droplets, and the flue gas is reheated (if required) prior to discharge. Sulphite-laden water is discharged to the sea as is or treated prior to discharge. Treatment consists of aeration after mixing with fresh seawater to achieve optimum conditions. Aeration oxidizes the sulphite ions to sulphate ions. Oxidation reduces the COD, raises the O_2 content, and increases the pH back to the initial value. Increasing the velocity of the discharge via effluent pumping may also be used to meet the EPA standard for pH at the IMZ boundary. Dilution with additional seawater may be used to adjust effluent properties.

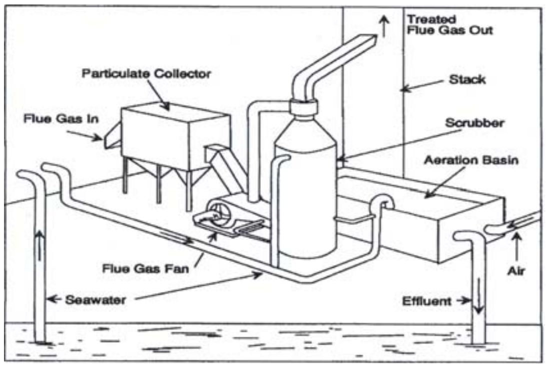

Fig. 5. Typical Flakt-Hydro Seawater process schematic.

4. CONCLUSION

The programs for environmental protection in the energy sector are extremely expensive. Targeted investments consist of flue gas desulphurization ($DeSO_x$) installations, burners for reduction of nitrogen oxides from flue gases ($DeNO_x$) and filters for dust retention [6].

The key points are to contribute to reducing the energy intensity through the implementation of new technologies in order to increase productivity, especially to industrial end-users and to increase the use of renewable energy sources. An important support will be given to implementing new technologies in order to reduce emissions of energy plants (essential to the National Energy System), and to diversification of interconnection networks in view of strengthening security of energy supply, which lies at the basis of any sound economic system.

In accordance with the principle of preventing or reducing pollution at source, it is necessary to introduce best available technologies for the reduction of flue gas emissions, to endow power and heating plants with flue gas desulphurization installations, to install electro filters for reducing powder emissions and to replace existing burners with new ones that will reduce the NO_x emissions (NO_x being an indirect GHG – greenhouse gas). At the same time, new investments concerning environmental compliance of some existing power plants are not economically and technically justified without previous refurbishment /upgrading [7].

Pollution is the result of activities at the global level and nations may be required to implement international agreements that address current pollution practices. As environmental problems become global in scope, international cooperation is needed to solve them. International and regional organizations may play a key role in developing a consensus on what types of collective action should be pursued. Although the role of international organizations is extremely important, one should not forget that environmental problems require action at the national and local levels [8].

The circumstances around the global climate change issue have been different. The causes of global climate change are less well understood, and there are a lot of uncertainties and discrepancies about its principal dangers. Mitigation and adaptation responses imply far-reaching, costly and controversial changes in economic, technological and political behavior implying personal and national present-day sacrifices on behalf of an uncertain future. Another obstacle has been the inviolability of sovereignity that occurs in action plans adopted by the United Nations. Because of the magnitude and uncertainty of these issues, delaying and avoiding action has been an attractive option for many policy makers. The international response to the global climate change issue is still in progress [9].

Combustion of fossil fuels generates gaseous pollutants, including sulphur dioxide, which are believed to be responsible for various adverse effects on humans, wildlife, vegetation, and man-made structures. The control of these pollutants has become a significant issue on the agendas of governments worldwide, resulting in national and regional initiatives to reduce emissions. Since power generation generally represents the largest single, controllable source of sulphur dioxide emissions, this industry has been especially challenged by environmental regulations.

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