Study on Laws, Regulations and Standards on Energy Efficiency, Energy Conserving and Emission Reduction of Industrial Boilers in EU

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Abstract: Industrial boilers are widely applied in such fields as factory power, building heating, and people’s lives; China is the world’s largest producer and user of industrial boilers, with very high annual energy consumption; clear requirements have been put forward by China on the energy efficiency since the “11thFive-year Plan” with the hope to save energy and reduce emission by means of energy efficiency standards and regulations on the supervision and control of various special equipment. So far, the energy efficiency of industrial boilers in China has been improved significantly but there is still a gap with the EU states. This paper analyzes the policies of energy efficiency, implementation models and methods of supervision and implementation at the EU level from laws, regulations, directives as well as standards; the paper also puts forward suggestions of energy conserving and emission reduction on the improvement of energy conserving capacity of industrial boilers in China through studying the legislations and measures of the developed countries in energy conserving of boilers.

1. Preface

Industrial boilers, generally referring to the steam boilers with the rated steam pressure of more than 0.04MPa but less than 3.8MPa, and the hot water boilers of various parameters with the rated water pressure of more than 0.1MPa; they are important thermal power equipment that are widely applied in such fields as factory power, building heating and people’s lives. China is the world’s largest producer and user of industrial boilers, with considerable annual energy consumption. Clear index requirements have been put forward by China on the aspects of energy efficiency and environment protection of industrial boilers in the “12thFive-year Plan”; under the effective supervision of the boiler management department, good results in energy conserving and emission reduction have been achieved by means of energy efficiency standards and regulations on the supervision and control of various special equipment. Nevertheless, the energy efficiency of industrial boilers in China still has a gap with that of the EU states.

This paper analyzes the framework system of laws, regulations, directives and standards at the EU level, sorts out the parts relating to boilers, and explores the implementation models and methods of EU on policies and measures for energy efficiency of boilers. The paper analyzes the stipulations and standards of EU directives of each member state of EU and discusses the energy conserving indexes of industrial boilers of each member state as well as implementation modes. Through the study, the energy efficiency management and energy efficiency standardization system of industrial boilers in EU are investigated and sorted out, so as to understand and learn the energy efficiency implementation.
2. Classification and Energy Efficiency Index Requirements of Boilers in EU

The EU, one of the regions with the highest energy efficiency in the world, always hopes to maintain its leading position in energy intensity, energy conserving technology and energy efficiency standards. It is referred in a document of the EU that, “energy efficiency” means using less energy inputs to maintain the same level of economic activities or services. In the Energy Charter Treaty, the “improvement of energy efficiency” is defined as “maintaining the same production of unit goods or services without decreasing quality, or keeping the same production, and reducing the amount of energy necessary to achieve such output”.

2.1. Performance Indexes Involved in Directives

According to the classification of MEErP and EU PRODCOM, European Commission and European Community (NACE) divide boilers with different combustion types into different categories by boiler capacity; according to different categories, the energy efficiency and performance indexes required in the directives propose 4 kinds of requirements[1], i.e. combustion efficiency, thermal efficiency, fuel to fluid efficiency, and heat content of generated vapor. The calculation of efficiency has different definitions in different standards, but it reflects the same content. The efficiency calculation method in EN 12953-11:2003 is:

\[ \eta_b = \frac{Q_{\text{out}}}{Q_f} \]

The efficiency calculation method in EN 12952-15:2003 is:

\[ \eta_b = \frac{Q_f - Q_{\text{loss}}}{Q_f} \]

In addition, the EU attaches great importance to energy conserving effect and the environmental protection characteristics of boilers and specifies the pollutant discharge coefficient; this value is also used in the evaluation of industrial boilers. There is a relatively objective consideration in this value on the interaction between the discharge coefficients of various pollutants (NOx, Sox, particulate matters, etc.) and the energy efficiency. The pollutant discharge coefficient can be expressed as a ratio of one kind of discharged pollutant (in mass or volume) and the amount of energy / vapor produced by the boiler. The pollutant discharge coefficient will directly affect the flue gas temperature and combustion, thus indirectly affecting the boiler efficiency. This value is also affected by other factors, such as combustor type, fuel type, and pollutant control equipment. In addition, it relates to the combustion temperature and NOX discharge.

On the EU directives and standards, boiler energy efficiency (if any) is the first level of assessment requirement; capacity, vapor discharge and pollutant emission coefficient are the second level of assessment requirement; all the assessment requirements restrict the industrial boilers.

2.2. Boiler-related directives and standards

The EU issued a large number of directives on energy-conserving and environment protection in order to ensure the implementation of policies on energy-conserving and emission reduction. The EU has passed the boiler efficiency guideline (Guideline 92/42/EU Council)[1], which defines the classification of boiler, specifies the minimum efficiency requirements of heating boilers for domestic and commercial purposes, and divides the boilers under 400kW into standard, low-temperature and condensing boilers. The weighted average of boiler efficiency under 30% load is selected in the test as the standard efficiency, i.e. EU standard efficiency. According to the test, different types of boilers are divided into three standard efficiency levels (calculated by low calorific value); the EU standard
efficiency is 82%-88% for standard boilers, 88.5%-91.5% for low-temperature boilers, and 97.5%-99.5% for condensing boilers.

The Eco-design Directive (Directive 2009/125/EC[2]), a framework director, specifies the design principles of industrial product design; it does not directly specified specific mandatory requirements to environment requirement conditions and standards as well as product types, only specifies corresponding measures to certain products, and analyzes the relationship between products and users. This directive involves 7 major categories; boiler products belong to ENER 1 category[3] under the HEAT SUPPLY category under the stipulations of this directive; the specified boiler products are under 40kW; that corresponding directive is formulated to this category of product is decided by the living and consumption conditions of the EU residents; most of their living environments requires self-heating or community heating; therefore, this directive only targets on the small fuel and gas boilers (40kW) and their accessories, etc. Similar directives also include the Energy Labelling Directive (Directive92/75/EC[4]) which was introduced to boiler products in 2010 (2010/30/EU[5]). Same as the ecological design standards, the directive has direct or indirect effects on energy consumption and energy efficiency of boiler products.

Directives directly related to industrial boilers are Energy Efficiency Directive and Emission Trading Directive. The above directives are formulated for industrial boilers that provide vapor and hot water with a power greater than 40kW. The Energy Efficiency Directive (2012/27/EU) is carried out under the framework of Energy Services Directive (2006/32/EC)[6] and based on the National Energy Efficiency Action Plan (NEEAP) of each member state of the EU; the Directive proposes framework requirements for the energy utilization and energy consumption of new equipment and related accessories and specifies the energy conserving obligation plan for each member state of the EU. The Emission Trading Directive (2003/87/EC)[7] establishes a greenhouse gas emission trading scheme within EU and is also a framework directive; it is aimed to reduce the emission of greenhouse gas; the directive contains relevant requirements on energy efficiency indexes for covered products; such indexes combine with the emission requirements and have more stringent requirements on products.

The Industrial Emissions Directive (2010/75/EU)[8] is gained by integrating former Directive 78/176/EEC, Directive 82/883/EEC, Directive 92/112/EEC, Directive 1999/13/EC, Directive 2000/76/EC, Directive 2008/1/EC and Directive 2001/80/EC and covers a wider range of boiler products. This directive specifies the emissions of boilers of different capacities, requires that recyclable and renewable technologies can be used to realize the emission indexes in the terms, and requires to meet the energy efficiency indexes so as to avoid any risk of environmental pollution. In addition to the above mentioned directives, the directives involving boilers and pressure vessels are as follows[9]:

- Gas Appliances Directive (2009/142/EC)
- Pressure Equipment Directive (97/23/EC)
- Simple Pressure Vessels Directive (2009/105/EC)
- Construction Products Directive (89/106/EEC)
- Low Voltage Directive (73/23/EEC, 93/68/EC)
- Machinery Directive (2006/42/EC)
- WEEE Directive (2012/19/EC)
- RoHS Directive (2011/65/EC)
- National Emission Ceiling for Pollutants Directive (2001/81/EC)
- Energy Taxation Directive (2003/96/EC)

These directives echo with the above mentioned eco-design directive, energy efficiency directive and trading directive in corresponding terms. Although the directive is only a framework document, it is of guiding significance for the EU states to formulate corresponding requirements.

2.3. Implementation of energy conserving policies for industrial boilers in EU
In 1986, the EU passed the *EU Energy Policy*, laying a foundation for European energy policy and defining the goal of European energy policy by the end of the twentieth century. In the end of 2000, the initial scheme of the European energy strategy, i.e. the *Green Book*, was passed; the concept and objectives of the new policy were formulated in the form of a report and it is planned to formulate and form independent “energy” chapter based on the report as the supplement to the laws. From the perspective of current organizational capabilities, it requires to issue corresponding new energy regulation, implement energy certification, establish energy monitoring standards, promote the European energy directives, and continuously expand, improve and adjust existing corresponding regulations, support with funds, and join hands with relevant enterprises to provide funds for the implementation of planned projects. The issue of an energy strategy in the form of law will help ensure its authority, continuity and transparency.

In addition, the EU is also actively establishing a professional evaluation and inspection mechanism and team. In conjunction with the EU’s energy directives, energy consumption regulations, and new technical methods, evaluation standards and other professional knowledge, the EU trains the personnel of related governments and enterprises and establishes a professional evaluation and inspection mechanism and team to evaluate and inspect the effect of energy promotion and use in a timely manner. The EU technically determines the fields of energy and projects in each field, selects typical industry fields to firstly adopt new technologies, materials and monitoring and management systems according to the technical methods of energy, promotes the successful experience to the entire community, and expands the energy plan to other sectors.

As for energy consuming groups, the EU mainly adopts promotion and publicity to cultivate the energy awareness of the people. The websites, magazines, newspapers, seminars and other media as well as a variety of forms can be employed to promote the various concepts of energy development and popularize the consciousness of energy integration development.

As for the implementation of energy conserving policies and standards of industrial boilers, the EU takes the above mentioned systematic way as the clue, laws, directives, provisions and standards as the guarantees, establishes a special energy management department to make uniform arrangement on the implementation of energy conserving and emission reduction, uses mandatory provisions to constitute the legal basis for the development of energy conservation and emission reduction, and provides specific policies and measures to ensure the implementation of the laws, through which a set of comprehensive operation mechanism of energy conserving and emission reduction policies and laws is formed. There are a principled law framework and specific policy terms and that are continuously revised and improved according to the change of situation.

3. Related Directives and Standards of Energy Efficiency of Industrial Boilers in EU Member States

In the aspect of implementation of energy conserving policies and standards of industrial boilers in EU member states, the measures adopted are similar with the policy framework of the EU, namely under the premise of compliance with the EU directives, each state proposes index requirements and energy efficiency or energy conserving requirements according to the EU strategy to form its own voluntary agreements, and such requirements are also legally binding. However, the policies and standards formulated by each state have their own characteristics according to different national conditions of each state of the EU.

3.1. Germany

3.1.1. Related requirements of policies and standards

In Germany, very detailed and strict standard efficiency values are specified; the weighted average of boiler efficiency under five different loads is used to determine the standard efficiency of boilers; the standard efficiency is called German standard efficiency (calculated by low calorific value). For example, DIN 4702-8 specifies that the boiler loads are 13%, 30%, 39%, 48% and 63% respectively.
Based on the calculations of test results, boilers are divided into 7 grades, namely: constant temperature heating boilers made in 1975 (standard efficiency of 65%-80%), standard boilers (standard efficiency of 82%-88%), low-temperature boilers (standard efficiency of 88.5%-91.5%), modern low-temperature boilers (standard efficiency of 92%-95%), condensing boilers (standard efficiency of 97.5%-99.5%), and improved condensing boilers (standard efficiency of 101%-105%). In 1998, Germany passed three regulations in the Bundesemissionsschutzgesetz (BImSchG) to set requirements on industrial boilers. The three regulations correspond to boilers of different capacities and different combustion materials.

Emission and energy conserving indexes are given in different corresponding regulations. The regulations not only have an impact on the industrial boiler emissions, but also indirectly affect the energy efficiency of industrial boilers. In addition, Germany has “TA-Luft” Management Regulation[10] which defines requirements on corresponding emission to operation temperature of boilers; gas leakage amount is calculated based on the operating temperature and DVI model (AUSTAL2000), and grades are divided; through such method, the efficiency of industrial boilers are indirectly affected[11]. This regulation is implemented under the Federal Pollution Control Act; it is an important supplement to the Federal Pollution Control Act, and belongs to an administrative code.

3.1.2. Implementation of polices and standards

Germany attaches great importance to energy conserving and environment protection. In order to save energy, the German government attaches great importance to energy conserving and emission reduction; in addition to improving the overall quality of energy conserving and emission reduction of the people, Germany has also put forward a relatively high energy conserving goal, i.e.: by 2020, the energy utilization rate would be 20% higher than that in 2006. In order to realize this goal, the German government has taken a series of positive measures. In April 1998, Germany passed the Amendment to Energy Economy Act and expanded its utilization of renewable energy, thus replacing the import of coal and oil; the Renewable Energy Promotion Act established in 2000 legally ensures that operators can make profits and mobilizes people’s enthusiasm for utilizing renewable energy; in March 2000, Germany implemented the Renewable Energy Act (Renewable Energy Priority Act), aiming to protect the climate and environment, ensure the sustainable development of energy supply, and improve the contributions of renewable energy to electricity, so as to achieve the established goal of Germany, namely the proportion of renewable energy in the total energy consumption will be at least doubled by 2020.

Through voluntary agreements, enterprises make commitments in the industrial and trade associations and can get the support of energy tax policy from the state; if an industrial and trade association fails to reach the predetermined goal in the voluntary agreement, the government will restrict it or increase taxes. Ruhr-Westphalia Institute for Economic Research is responsible for monitoring the implementation effect of the German Industry’s Declaration on Climate Protection and submitting a report every year[12].

The German government believes that the target of energy conserving and emission reduction will be impossible without the widespread participation of the public. Therefore, the German government attaches great importance to improving people’s awareness of energy conservation. In the specific practice, German Energy Agency (Deutsche Energie-Agentur) has opened a special free telephone service center and its function is to answer some daily questions about energy conservation for the citizens; the German Federal Consumer Centre Federation (Verbraucherzentrale Bundesverbandes) and its subordinate state branches are the main institutions providing energy saving related information and inquiry services; the establishment of these institutions is convenient for the people, and more importantly, it improves people’s awareness of energy conservation and emission reduction, and makes people save energy in daily life.

Through this top-down approach, Germany’s industrial boiler industry and consumption enterprises are achieving good energy conserving and emission reduction effects.
3.2. France

3.2.1. Related requirements of policies and standards
France has made its own corresponding laws based on the EU directive 2001/81/EU and targeted boilers are existing boilers and new/transformed boilers with the capacity of more than 20MW[13]. Existing boilers with the capacity of more than 20MW shall comply with the NOR: DEVP320297A[14]; and new/transformed boilers shall comply with the NOR: DEVP0210222A22.

Compared with Germany, France has specific energy efficiency indexes for boilers. In 1975, France specified the energy efficiency index values for boiler products and upgraded it to a law after updating a large number of energy efficiency index values in 2007. Currently, the products cover 400kW and 50MW; in order to ensure accurate measurement, it is required that operators must evaluate the energy efficiency at each restarting or after three months of continuous operation for the boilers used after September 14, 1998. The boilers shall be reviewed once every two years and shall meet corresponding operation specification indexes; corresponding energy efficiency statistics results shall be submitted to the French Environment and Energy Management Agency for filing. France pays particular attention to fuel types. The reason is that the energy situation in France is characterized by a shortage of primary energy resources and a growing dependence on energy imports. In order to improve energy dependence and energy efficiency, energy efficiency and environment protection indexes for fuel types are proposed[15].

3.2.2. Implementation of policies and standards
France is an important member state of Organization de cooperation et de development economies (OECD). All member states of OECD are required to formulate environmental objective according to the Kyoto Protocol and the French government encourages the enterprises to realize the objective by voluntary means. During implementation, France mainly targets on the high energy consumption industry and has clear objectives which are determined by the enterprises and the government through thorough dialogues and discussions[16]. France sets an emission cap through the environmental permit system, encourages polluters to voluntarily reduce pollution emissions through subsidies and restricts the efficiency of high energy-consuming products; under the effort of several aspects, energy conserving and environment protection indexes in France’s high energy-consuming industries are realized.

3.3. The Netherlands

3.3.1. Related requirements of policies and standards
The energy efficiency indexes for industrial boilers in the Netherlands are also closely related to emission indexes. Firstly, corresponding environment protection act is formulated based on the EU’S NEC directive (2001/812/EC) and a series of provisions is also formulated based of the NEC report of Netherlands. As for industrial boilers, the most important law and regulation is BEMS. The Netherlands examines the performance standard rate (PSR) and embodies this value in the act. The value is defined as the corresponding NOX emission per unit of GJ (grams of NOX per unit of energy (GJ) used within a facility). The annual NOX emission is the multiplication of PSR and total energy input for the year; therefore, when the emission targets are stipulated, the energy consumption of the boilers is prescribed, so as to promote enterprises to apply high efficiency and low emission boilers.

From the data, the annual PSR index value gradually reduces, which shows that the Netherlands’s requirement for emission is getting lower and lower and in the mean time, it promotes the energy efficiency of boilers becomes higher and higher[17].

The implementation and standard formulation of directives for energy conserving and emission reduction of industrial boilers in the Netherlands are different from that of Germany and France; industries are used as the basis for classification; the emission indexes of different industries are used as the basis and this limit value and PSR are used to affect the energy efficiency of industrial boilers.
3.3.2. Implementation of policies and standards
The Netherlands’s economy grew unexpectedly fast in the 1990s; in order to realize the first phase of voluntary agreement on energy efficiency, namely the national carbon emissions in 2000 decreases by 3%-5% than that in 1994, the Ministry of Economic Affairs of the Netherlands has signed agreements with various industry associations and committed to realize the energy conserving objective by 2000. The second phase of energy efficiency agreement is 2001 to 2012. Voluntary energy efficiency agreements help companies pay more attention to energy efficiency, and help the industry sector find low-cost energy conserving methods within the generally accepted investment standards[18]. During the implementation of the agreement, three parties perform their respective duties. The government provides supports of policy (tax), finance, energy auditing and so on; the industry association prepares a letter of intent to improve energy efficiency and formulates a comprehensive plan of long-term agreement and implement the plan; voluntary companies must develop energy conserving plans and prepare annual inspection reports; the Energy and Environment Agency is responsible for formulating long-term energy efficiency planning, etc. The Ministry of Economic Affairs of the Netherlands gives a lot of support to the companies that have signed voluntary agreements on energy efficiency, including energy investment tax reduction policies, subsidies, detailed audits of industrial equipment (including energy consumption equipment catalogs, energy consumption assessments, and certifications of energy efficiency investments that can produce benefits), coordination of industrial regulations, etc.

At the same time, enterprises shall provide energy conserving plans and annual energy conserving review reports; the industries shall also propose reasonable plans to meet the energy efficiency requirements. Otherwise, enterprises will be punished according to relevant standards and regulations and restricted in tax and other aspects; so, although the Netherlands’s energy efficiency agreements are voluntary, they are legally binding.

3.4. Other EU States
Other EU states have similar requirements for industrial boilers; they are mainly limited to the implementation of the existing pollutant emission and energy efficiency directives required by the EU and have no direct provisions on energy efficiency. For example, Italy, Poland and Spain limit the amounts of pollutants emitted by boilers based on the pollutant emission directives; Sweden makes requirements on domestic boiler pollutant emissions under the directive of 2001/80/EU[19]. The requirements for energy efficiency are usually reflected in the requirements of emission indexes and directly or indirectly impact on the boiler energy efficiency.

4. Summary of Energy Efficiency, Energy Conserving and Emission Reduction Characteristics of Industrial Boilers in EU
Based on the foregoing analysis, the characteristics of energy conserving and emission reduction of industrial boilers in EU and its member states are as follows:

1. The EU formulates framework directives and energy conserving and emission reduction plans; each member state formulated its own energy conserving and emission reduction plans according to its conditions. The plans of each state are not static, but the objectives are very clear.

2. The indexes of member states are realized through mandatory and voluntary means. The states have mandated the audit and reporting of emissions and energy efficiency of industrial boilers and punish the enterprises or industries that do not meet the requirements; however, all indexes for enterprises or industries are conducted through negotiation. Among them, Germany, France and the Netherlands determine such indexes through dialogues; the governments in Sweden, Denmark, Italy and other countries will set up a variety of schemes ahead of schedule and enterprises select one of them; current documents do not show there is any mandatory enforcement in any state.

3. Member states have subsidies of finance, tax and so on to the enterprises using industrial boilers and encourage them to voluntarily eliminate the equipment with high energy consumption and high
pollution and replace them with the ones of high energy efficiency, energy conserving and environment protection.

4. The systems of education and promotion of energy conserving and environment protection are perfect in EU and its member states.

5. Opinions and Suggestions on Energy Conserving and Emission Reduction of Industrial Boilers in China

The legislation and measures of developed countries on energy conservation of boilers are of reference significance for improving the energy conservation work of industrial boilers in China. Corresponding energy efficiency indexes and grades in the standards and provisions of energy conservation of industrial boilers in China should be formulated and revised on the basis of analyzing the energy conserving potential of industrial boiler products according to the current situation and development trend of industrial boiler products. Suggestions are as follows:

1) Adjust the existing capacity division interval of boilers; detail the energy efficiency indexes of boiler products; and add the energy efficiency limit values and energy conserving evaluation values of pulverized coal boilers, coal-water-slurry fired boilers, condensing boilers, biomass boilers, electric heating boilers and waste heat boilers and other products. According to the Implementation Scheme of Comprehensive Improvement Program of Energy Conserving and Environmental Protection of Coal-Fired Boilers, the coal-fired boilers less than 10t/h will be eliminated; standards and regulations of industrial boilers should actively play their roles in promoting and leading the revision to the energy efficiency indexes of coal-fired boilers less than 10t/h so as to cooperate with the implementation of comprehensive promotion program of energy conserving and environment protection of China.

2) Appropriately increase the energy efficiency indexes of anthracite-fired boilers and oil or gas-fired boilers according to the compliance situation of type test results of existing boilers; appropriately adjust the energy efficiency indexes of coal-fired boilers which are not reasonable in practice so as to encourage the boiler enterprises to independently develop energy-conserving products for coal-fired boilers suitable to China’s national conditions and fuel characteristics.

3) Borrow experience from developed countries, combine with the actual operation conditions of industrial boilers in China and introduce the concept of “average annual fuel utilization” as the operation assessment index so as to improve the boiler energy efficiency from the design of products to the system energy conserving capacity of boilers; study the boiler energy efficiency assessment indexes under different loads, test result correction methods, etc. so as to reflect the actual operation level of industrial boilers to the greatest extent.

4) Revise the relevant requirements of energy efficiency tests of boilers according to the new requirements of boiler-related test method standards as the test method standards of boilers have been updated; propose test conditions, test methods and requirements, measured data processing and energy efficiency evaluation principles, and other requirements.

5) Coordinate with boiler-related technical regulations and product standards and propose relevant technical requirements on industrial boilers to realize minimum energy efficiency (including industrial boiler design, type selection, auxiliary equipment, system design, installation, acceptance, fuel management, operation management, equipment maintenance, quality assurance and so on) so as to ensure that the process from design to utilization can meets with the index requirements and comprehensively improve the energy conserving capacity of industrial boilers in China.

References

[1] Eco-design Preparatory Study on Steam Boilers
[2] Commission Regulation (EEC) No 42/92 of 9 January 1992 fixing the minimum levies on the importation of olive oil and levies on the importation of other olive oil sector products, available at http://eur-lex.europa.eu/legal-content/EN
[3] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of eco-design requirements for energy-related
products, http://data.europa.eu/eli/dir/2009/125/oj

[4] Based on information from www.eup-netzwerk.de

[5] Council Directive 92/75/EEC of 22 September 1992 on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances, http://data.europa.eu/eli/dir/1992/75/oj

[6] Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products, http://data.europa.eu/eli/dir/2010/30/oj

[7] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC Text with EEA relevance. ELI: http://data.europa.eu/eli/dir/2012/27/oj

[8] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (Text with EEA relevance). ELI: http://data.europa.eu/eli/dir/2003/87/oj

[9] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) Text with EEA relevance. ELI: http://data.europa.eu/eli/dir/2010/75/oj

[10] Eco-design Preparatory Study on Steam Boilers (ENTR Lot 7). Available on the web: www.eco-steamboilers.eu

[11] Available on the website: https://en.wikipedia.org/wiki/TA_Luft

[12] Emission measurements of industrial valves according to TA-Luft and EN ISO 15848-1.FUGITIVE EMISSION CONTROL. Professor Dr.-Ing. Alexander Riedl, University of Applied Sciences Muenster, Germany

[13] Turner, D.B. (1994). Workbook of atmospheric dispersion estimates: an introduction to dispersion modeling (2nd ed.). CRC Press. ISBN 1-56670-023-X. www.crcpress.com

[14] Mure (2011): FRA5 - Minimum energy performances of boilers, downloaded from http://www.muredatabase.org/, downloaded on the 1st of August, 2013

[15] Source: MURE Database, 2011

[16] Commission of the European Communities: Green Paper -a European Strategy for Sustainable, Competitive and Secure Energy, March 8, 2006.

[17] Voluntary Approaches for Environmental Policy: Effectiveness, Efficiency and Usage in Policy Mixes[R]. Paris, OECD, 2003.