OPPORTUNITY FOR ACCESSING TRANSITIONAL DEROGATION PROVIDED FOR IN ARTICLE 10 C OF THE DIRECTIVE 2003/87/EC, FOR ELECTRICITY PRODUCTION

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Abstarct: Directive 2009/29/EC amending Directive 2003/87/EC, so as to improve and extend the greenhouse gas emissions allowance trading scheme of the Community is bringing major changes to the EU ETS from 2013.
The main change is that electricity generators will no longer receive free allowances, except for cases falling within Article 10c. As a result, electricity generators will need to integrate purchase of auctions of CO_2 allowances needed to cover emissions, opposed to the current status where certificates are free allocated.

Keywords: CO_2 emissions, Emission Trading Scheme, transitional derogation

1. Introduction

"Energy - Climate Change" Package, sets 2020 goal of reducing greenhouse gas (GHG) emissions in the EU, by at least 20% from 1990 levels. This can be increased to 30% if other developed countries adopt similar targets as part of a future global environmental post - 2012.
In Romania, the condensing and cogeneration power plants have lower performance compared to developed European countries, due to wear of 60-70s technologies.
About 80% of the thermal power plants at national level were installed during 1970-1980, currently having outdated their average life time.
66% of condensing groups were older than 30 years, 18% have the age between 20-30 years, only 16% being under 20 years old, Fig. 1.

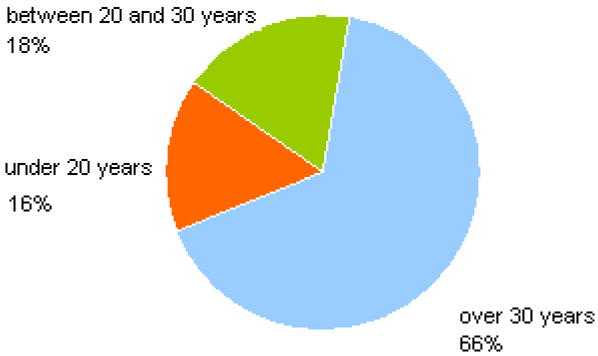

Fig. 1. Structure by age of the condensing plant. Total installed capacity 7542 MW (31.12.2009)

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53% of the cogeneration power plants have over 30 years old, 30% have the age between 20-30 years, only 17% being under 20 years old, Fig. 2.

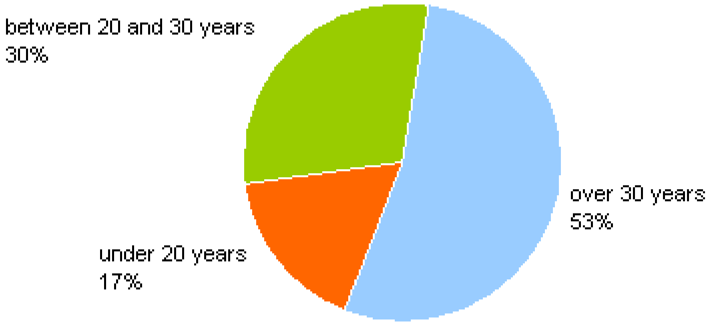

Fig. 2. Structure by age of cogeneration plants. Total installed capacity 4655 MW (31.12.2009)

The power plants have lower efficiency due to wear of 60-70s technologies (around 30%) - with the exception of retrofitted coal power plants that reach at 33%. These values are 65-70% of the efficiency of modern groups, which currently operates in most developed European countries.
Since 2013, electricity sector will no longer receive free allocation for GHG emissions. Thus, electricity producers will need to purchase in auctions all of the certificates required to cover the generated emissions.
Therefore, investments for retrofitting of fossil fuel power plants overlap with environmental regulations provided by the EU legislation and with substantial funds necessary to purchase CO_2 certificates.
The free allocation is given to Member States to modernize the electricity production sector. Transitional derogation allows the possibility of creating a fund from which to finance the investments for the energy sector modernization.

2. Provisions of the Directive 2009/29/EC amending Directive 2003/87/CE, on transitional free allocation for electricity generation

Aspects of free transitional derogation for electricity are included in Art.10c (2) and Art.10c (3) of Directive 2003/87/EC, amending Directive 2009/29/EC, and contain the following provisions:

- transitional free allocations shall be deducted from the quantity of allowances that the respective Member State would otherwise auction;
- in 2013, the total transitional free allocation shall not exceed 70% of the annual average verified emissions in 2005-2007 from such electricity generators for the amount corresponding to the gross final national consumption of the Member State concerned and shall gradually decrease, resulting in no free allocation in 2020;
- for those Member States which did not participate in the Community scheme in 2005, the relevant emissions shall be calculated using their verified Community scheme emissions under the Community scheme in 2007;
- Member State concerned may determine that the allowances allocated pursuant to art. 10c may only be used by the operator of the installation concerned for surrendering allowances with respect to emissions of the same installation during the year for which the allowances are allocated.

3. Member State Eligibility

According to paragraph 1 of the Directive 2009/29/EC amending Directive 2003/87/CE Art.10c, Member States may give a transitional free allocation to installations for electricity production, provided that one of the following conditions is met:

- (a) in 2007, the national electricity network was not directly or indirectly connected to the network interconnected system operated by the Union for the Coordination of Transmission of Electricity (UCTE), or

- (b) in 2007, the national electricity network was only directly or indirectly connected to the network operated by UCTE through a single line with a capacity of less than 400 MW, or
- (c) in 2006, more than 30 % of electricity was produced from a single fossil fuel, and the Gross Domestic Product (GDP) per capita at market price did not exceed 50 % of the average GDP per capita at market price of the Community.

Romania meets the requirement included in article 10c.(1)(c) stipulating the following: “in 2006, over 30 % of electricity was generated from fossil fuels and the GDP per capita did not exceed 50 % of the average GDP per capita in relation to the Community market prices”. For Romania, the meeting of the provisions of article 10c.(1)(c) is indicated in the table 1.

Table 1

Justification for Romania eligibility

No.	Element	Value	Supporting document
1.	Share of electricity generated from coal, in Romania, in 2006	40%	Energy balance and structure of the energy equipment for 2006, supplied by the National Institute of Statistics
2.	GDP per capita, in Romania, in 2006, in relation to the Community market prices, as a rate of the GDP UE27	38%	Eurostat data
3.	GDP per capita, in Romania, in 2006, in relation to the Community market prices, as a rate of the GDP UE25	39,5%	Eurostat data

4. Eligible Installations

In accordance with article 10c paragraph (1) of the Directive 2009/29/EC amending Directive 2003/87/CE, member states may provide transitional and free emission allowance allocations to the electricity generation installations.
In accordance with article 3.2 paragraph (19) of the Communication from the Commission (2011/C 99/03), electricity generation are installations that exclusively generate electricity, as well as installations generating electricity and heat in cogeneration. This category does not include installations that also perform some other activity, even if this activity is not included in Annex I of Directive 2003/87/EC revised.
In terms of commissioning, in accordance to the provisions of article 3 of the Communication from the Commission (2011/C 99/03), eligible installations are installations that were commissioned by 31.12.2008, as well as installations for which the investment process was physically initiated by 31.12.2008.

5. Allocation Methodology at Member State level

In accordance with Commission Decision on guidance on the methodology to transitionally allocate free emission allowances to installations in respect of electricity production pursuant to Article 10c(3) of Directive 2003/87/EC, Member States should decide on the allocation methodology to be applied. They should apply the same allocation methodology to all installations eligible for transitional free allocation of emission allowances under Article 10c of Directive 2003/87/EC on their respective territory for which data on verified emissions for the period from 2005 to 2007 exist, in order to avoid undue distortions of competition.
Moreover, they should consider that an allocation methodology based on benchmarks would likely result in more limited distortions of competition.

6. Allocation Methodology at installation level

In accordance with article 10c paragraph (3) of the Directive 2009/29/EC amending Directive 2003/87/CE, allocation methodology at installation level can be:

- allocation under the verified emissions in 2005-2007, or
- an ex-ante efficiency benchmark based on the weighted average of emission levels of most greenhouse gas efficient electricity production covered by the Community scheme for installations using different fuels. The weighting may reflect the shares of the different fuels in electricity production in the Member State concerned.

- **Transitional free allocation of emission allowances based on the verified emissions in 2005 – 2007**

Where a Member State decides to allocate free emission allowances based on verified emissions of eligible installations in the period from 2005 to 2007, the number of allowances allocated to each eligible installation shall not exceed the annual average emissions of the eligible installation in the period from 2005 to 2007 adjusted with a view to reflecting the performance of each installation in terms of emissions based on the relation between the total annual average emissions of eligible installations in the period from 2008 to 2010 and the total annual average emissions of eligible installations in the period from 2005 to 2007.
Where an eligible installation generates electricity and heat, only emissions that are strictly attributable to the production of electricity shall be taken into account. In the case of combined heat and power production (CHP), shall be calculated emissions attributable to the production of electricity.

- **Transitional free allocation of emission allowances based on an ex-ante efficiency benchmark**

Ex-ante Efficiency Benchmark based on the weighted average of emission levels of most greenhouse gas efficient electricity production covered by the Community scheme for installations using different fuels.
In this case we use a reference value, which is applied to the relevant production data to the installation concerned.
If doesn't exist the relevant production data for some installations, then it is determined by multiplying the installed capacity by a factor representing the average annual load for all facilities that generate electricity in the Member State.
The reference value will be based on official data provided, provided where it is possible by the same source.

7. Estimated value of free allocation under art.10c

The maximum amount of free allowances allocated at the Member State level is determined by following steps:
Step 1: Determine the average annual emissions from 2007 of the eligible installation;
Step 2: Determine the relation between the annual average 2007 of Gross Final National Consumption (GFNC) and the annual average 2007 of Total gross Electricity Production (TGEP);
Gross Final National Consumption (GFNC) is not a term defined or used in international statistics such as Eurostat, but is determined in the context of Article 10c as follows:

- excludes imports of electricity;
- excludes exports of electricity;
- includes the consumption of electricity transmission and distribution;
- includes electricity consumption for electricity generation.

The formula to calculate GFNC is provided below:

$$GFNC = FEC - NETIMP + \left\{ \left[\frac{FEC - NETIMP}{TGEP + NETIMP} \right] \times TDL \right\} + \left\{ \left[\frac{FEC - NETIMP}{TGEP} \right] \times CEG \right\} \quad (1)$$

Where:

GFNC – Gross Final National Consumption of Electricity
FEC – Final Energy Consumption (in terms of electricity)
NETIMP – Net Electricity Imports
TGEP –Total Gross Electricity Production
TDL –Transmission and Distribution Losses
CEG – Electricity Consumption of the Electricity Sector

Step 3: Determine the total quantity for free allocation in 2013, at national level – the average annual emissions calculated in step 1 will be multiplied by the percentage calculated in step 2.
The result obtained in step 3 will reflect the amount of allowances to cover 100% of generated emissions related to the GFNC. To obtain the total amount allocated for free in 2013, the result obtained in step 3 will be multiplied by 70%.
The formula would determine the maximum quantity of free allowances for Romania, pursuant to Article 10c (2):

$$TQFA_{2013} = \frac{GFNC_{2007}}{TGEP_{2007}} \times AAQE_{2007} \times 70\% \qquad (2)$$

Where:
$TQFA_{2013}$ – Total Quantity for Free Allocation in 2013
$AAQE_{2007}$ – Annual Average Quantity of Emissions from eligible installations in 2007

To determine TQFA were taken into account annual average quantity of emissions from eligible installations (AAQE), as a percentage of total verified emissions.
Thus, for 2013, was obtained a Total free quantity allotted of 18,631,916 certificates, at the level of Romania taking into account that the EMAVIE value is 31,834,994 t CO_2.

8. National Investment Plan

In accordance with article 10c paragraph (1) of Directive 2003/87/EC, the Member State concerned shall submit to the Commission a national plan that provides the following:

- investments in retrofitting and upgrading of the infrastructure and clean technologies;
- diversification of their energy mix and sources of supply for an amount equivalent, to the extent possible, to the market value of the free allocation with respect to the intended investments, while taking into account the need to limit as far as possible directly linked price increases.

Pursuant to Article 4.1 (23) Communication from the Commission (2011/C 99/03) - Guidance document on the optional application of Article 10c, the national plan should be based on a number of common principles designed to best ensure a fair and consistent implementation of the objectives accruing from Directive 2003/87/EC in general and Article 10c in particular.

These principles of eligibility are:

- **Principle 1**: The national plan should identify investments, which, directly or indirectly (investments in networks and ancillary services), contribute to decreasing greenhouse gas emissions in a cost effective manner.
- **Principle 2:** The investments identified in the national plan should designed to eliminate in the future, to the extent possible the situations referred to in Article 10c (1), letter (a) (1) and (b) (2) and the first condition of (c) (3) of Directive 2003/87/EC.
  (a) In 2007, the absence of direct or indirect connection to the former UCTE grid.
  (b) In 2007, connection to the former UCTE grid exclusively by one line with a capacity under 400 MW.
  (c) In 2006, over 30 % of the electricity was generated from a single fossil fuel.
  The manner in which the investments contribute to the elimination of requirement (c) was analyzed for Romania, respectively the reduction of the allowance of electricity generated by the combustion of coal.
- **Principle 3:** The investments should be compatible with each other and other relevant Union legislation. They must neither reinforce dominant positions nor unduly distort competition and trade in the

internal market and, where possible, should strengthen competition on the internal market for electricity.

- **Principle 4:** Investments identified in the national plan should be additional to investments Member States must undertake in order to comply with other objectives or legal requirements occurring from Union law. They should also not concern investments, which would be required to match increasing electricity supply and demand.
- **Principle 5:** Investments identified in the national plan should contribute to diversification and reduction in carbon intensity, of the electricity mix and the sources of energy supply for electricity production.
- **Principle 6:** Investments should be economically viable in absence of the free allocation of emission allowances under Article 10c of Directive 2003/87/EC.

9. Conclusions

Given the current situation of groups included in NES, are required investments in retrofitting and upgrading, for meeting the requirements of efficiency and environment.
Accessing the transitional derogation provided for in article 10 c of the revised Directive 2003/87/EC, represents an opportunity for the energy sector in Romania, which has a unavailability of funds for modernization. The derogation allows the establishment of a fund, from which it can finance a part of the necessary investments in the sector.
Operators who do not get back the investment found are not disadvantaged because they anyway must buy certificates.
The analysis of risks, benefits and disadvantage arising from the application of the derogation provided for in Art. 10 c, it follows:
From the point of view of the authorities:

- The application of the derogation provided in Article 10c has the following advantages:
  - It creates a significant support for sustaining the electric power production sector by the authorities;
  - It partially relieves the electric power producer from ensuring the necessary funds for acquiring GHG emissions certificates during the period of carrying out the investment.
- The application of the derogation provided in Article 10c has a major disadvantage for the authorities as they have to develop entities responsible for elaborating and managing the National Investment Plan and the financial mechanism, involving periodical monitoring, checking and reporting, leading to an increase in administrative costs. The administrative costs could be sustained also from adequate free allotting funds.

References

[1] 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
[2] Commission Decision of 29.3.2011 on guidance on the methodology to transitionally allocate free emission allowances to installations in respect of electricity production pursuant to Article 10c(3) of Directive 2003/87/EC
[3] Communication from the Commission “Guidance document on the optional application of Article 10c of Directive 2003/87/EC (2011/C 99/03)”
[4] Strategia energetică a României pentru perioada 2007 – 2020 actualizată pentru perioada 2011 – 2020 (Romanian Energy Strategy for the period 2007 - 2020 updated for the period 2011 - 2020)

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IMPLEMENTING A PERSONALIZED SYSTEM FOR MONITORING AND REPORTING CO_2 EMISSIONS

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Abstract: As target of the EU regarding the emission trading scheme one mentions the promotion of devices properly design to reduce efficiently from technical and economic point of view GHG by economics operators with activity that generate this kind of emission, in order that the completion of the commitment assume by EU under Kyoto Protocol be Iess expensive.

Starting with 1st January 2007, installations which develops activities as provided by Annex I of GD 780/2006 [4], which transpose in national legislation Directive 2003/87EC [1], will have to monitor and report the GHG emissions according to Order 1175/2006 [2]. This means that the operators will have to monitor all activity data and quality parameters, to document and archive monitoring data developed by all sources, to draw up the annual report and also to retain it and all the data used for emissions calculation for at least 10 years.

One will demonstrate that, for all these problems, the ECO2 Premium-CIA system is a solution; being software designed to fulfill the obligation under condition of respecting the national monitoring guidelines.

Key words: European emission trading scheme, monitoring and reporting of CO_2 emissions, annual report, ECO_2 Premium-CIA

Notations*:*

EU-ETS – European emission trading scheme, Directive 2003/87CE on setting the emission trading scheme [1];
GHG – greenhouse gas
EF – emission factor [t_{CO2} /TJ], [t_{CO2}/t], [t_{CO2}/m^3];
OF – oxidation factor, [%];
CF – conversion factor, [%];
NCP – net calorific power, *[TJ/t], [TJ/m^3].*

1. Introduction

As a EU member state, Romania carried out the transposition in the national legislation of the Directive 2003/87CE [1] (EU ETS), belonging to the environmental community acquis and allows establishing the emission (GHG) trading scheme.

The sectors and activities under EU ETS, according to Annex no. 1 of GD no. 780/2006 [4], are indicated in Table 1.

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Table 1

Sectors and activities included in Annex no. 1 of GD no. 780/2006 [4]

Name sector ETS	Name ETS activities
Activities in the energy field	Firing installations with a rated thermal power higher than 20 MW (except for the installations for dangerous and municipal waste); Oil refinery installations; Coke furnaces; Metal ore roasting or caking plant (including ore bearing sulphur content)
Ferrous metal production and processing	Installations for producing cast iron or steel (primary or secondary melting), including continuous casting installations, with a production capacity higher than 2.5 tons/hour; Installations for producing the cement clinker in rotating furnaces with a production capacity higher than 500 tons/day, installations for producing lime in rotating furnaces with a production capacity higher than 50 tons/day or in other types of furnaces, non-rotating, with a production capacity higher than 50 tons/day.
Mineral industry	Installations for glass manufacturing, including glass fiber, with a melting capacity higher than 20 tons/day; Installations for manufacturing pottery by firing, especially tiles, bricks, fire-resistant bricks, slabs, sandstone or faience plates, with a production capacity higher than 75 tons/day; and/or with a furnace capacity higher than 4 m^3 and with a density set for each furnace higher than 300 kg/ m^3.
Other activities	Industrial installations for producing: a) wood pulp or from other fiber materials; b) paper and cardboard, having a production capacity higher than 20 tons/day.

2. Operators' obligations in the EU – ETS context

Starting with the 1st of January 2007, the operators of the installations under the Directive have to meet the CO_2 emissions monitoring and reporting requirements, according to the provisions of the current legislation on the GHG emissions (CO_2), involving the following actions [2], [3]:

- Monitoring the activity data and quality parameters (NCP, EF, OF, carbon content) for fuel flow rates/raw matter used in installations generating CO_2 emissions;
- Drawing up the annual GHG emissions report for each EU ETS installation, a report that will be validated by an accredited check body;
- Managing and archiving for a 10 year period the monitoring reports, as well as the relevant data used for calculating the annual CO_2 emissions (activity data, NCP, EF, carbon content, OF, CF);
- Analyzing the carbon market and efficiently managing the allotted GHG emissions certificates for choosing the best moment for their transactioning.

The bulk of requested data for meeting the regulations provided in the GHG emissions trading scheme is increasing, as well as the non-conformity risk or that of losing data at the level of the installation.
The possible problems that might occur are generated by:

- losing data and interruptions in the operational flow;
- recording and/or transmitting process-data reporting;
- data processing requiring time alloting;
- potential financial losses that can be costly, as a result of a wrong decision.

3. Best solutions for monitoring and reporting greenhouse gas emissions

The EU ETS impact on the activity of the installations can be reduced by efficiently managing the GHG emissions certificates, as a result of a thorough process of scheduling and analyzing the evolution of the generated CO_2 emissions.

A best efficient solution for CO_2 emissions monitoring and reporting at the level of the EU ETS installation is represented by the implementation, at the level of the installation, of a professional software that should collect all the necessary data into a cetral database, from which various types of reports can be generated.
Such a solution is represented by the software ECO_2 Premium CIA, allowing the entry and processing of all the data relating to CO_2 emissions, according to the monitoring methodology specific of each installation provided in the measure Plan regarding the GHG emissions monitoring and reporting, approved by ANPM.

The ECO_2 Premium CIA implementation at the level of the installation allows:

- The data entry by various users from different locations in the installation, at the place of data generating;
- The data entry with the same frequency with which they are obtained;
- Meeting all the EU – ETS monitoring and reporting requirements;
- Real time surveying of the GHG emissions values currently held;
- Minimizing the risk of a negative result check;
- Easy, easy to use access interfaces for entering data into the system.

The monitoring and reporting process presupposes the involvement of several departments/services in the installation that have management, processing, coordination, monitoring and reporting responsibilities.

The implementation of the proposed solution - ECO_2 Premium CIA – for the general case of an installation for which the monitoring and reporting process presupposes the involvement of the chief executive officer and of three departments/services allows efficiently managing the data flow, developing according to the fundamental circuit in Figure 1.

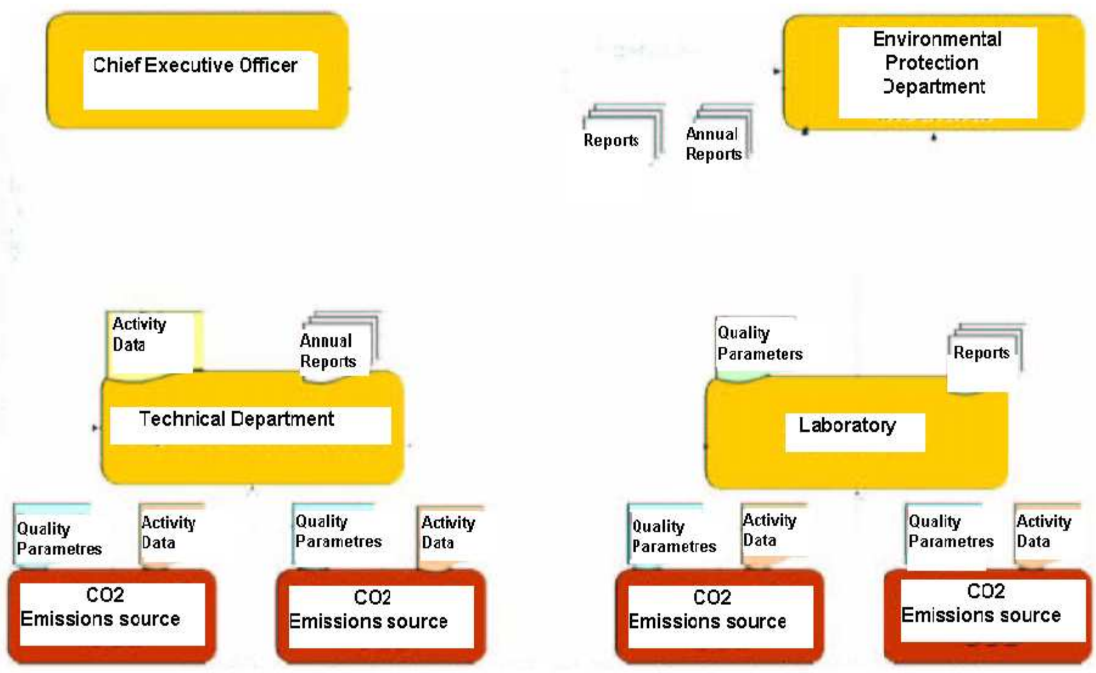

Fig. 1. Fundamental circuit of data flow in the case of implementing ECO_2 Premium CIA

ECO_2 Premium CIA includes separate data entry interfaces for each user engaged only in a certain zone of the monitoring and reporting process, thus reducing the risk of entering false or incomplete data, in the context of offering also the possibility of controlling the data administration mode in a central location, by a central administrator.

The individual access interfaces offers users (depending on the role appointed in the company) the fulfilment of the following assignments:

- entering the data necessary for calculating CO_2 emissions;
- accessing and checking input data;
- generating GHG (CO_2) emissions monitoring reports;
- monitoring and scheduling the CO_2 emissions from the installation.

It is underlined that for the analyzed fundamental circuit it is ensured, by means of individual access interfaces, the fulfilment of the following assignments:

A. For the position of Chief Executive Officer
   1. Supervising and coordinating the process of monitoring and reporting the CO_2 emissions from the installation;
   2. Generating the report "change journal" for surveying the changes performed in the database;
   3. Viewing (checking) the data and constants;
   4. Access to all the generated reports;
   5. Scheduling and checking CO_2 emissions from the installation.

B. For the environmental department
   1. Viewing the activity data and quality parameters checking;
   2. Entry and the possibility of changing the constants EF, OF, CF, NCP.
   3. Access to some reports;
   4. Generating monthly/trimestrelly;
   5. Generating annual GHG emissions reports, requested by the competent authority.

C. For the Technical Department:
   1. Entering activity data for fuels, raw matter, products, respectively;
   2. Generating and accessing some types of reports.

D. For the Laboratory:
   1. Entering quality parameters for fuels/ raw matter/materials/products;
   2. Generating and accessing some types of reports.

By implementing the information system we develop at the level of the installation an extremely valuable multiple database linked to:

- the identification data of the installation, data on the sources generating CO_2 emissions;
- data on the consumption and quality parameters of the fuel, raw matter, products, respectively, the level of approach applied for CO_2 emissions monitoring;
- the CO_2 emissions calculating methodology.

Starting from this database at the level of the installation, in which are entered and stored all the data necessary for calculating the CO_2 emissions from the installation, the software generates reports, meeting the reporting requirements provided for in the current legislation on GHG emissions.

According to the requirements of each user, there is the possibility to carry out various reports for data recording, processing and making internal decisions. Besides the monitoring report on GHG emissions required by the competent authority, ECO_2 Premium CIA allows users the possibility to generate other types of reports, as for instance:

- The Report for the accredited check body;
- The laboratory tests Report;
- Other types of personalized reports, adapted to the specific requirements of each operator, as for instance, the "change journal" type report, comprising all the performed changes involving the nature, type, author, change parameters, etc.

The accredited check body report contains all the raw data necessary for calculating the CO_2 emissions. The applied formulas and final results offer thus the possibility of reducing the time allotted to the checking process, by viewing the calculating methods used and the emissions corresponding to each type of fuel, raw matter, respectively, used in the installation. Another function increasing the usefulness

of the software is the CO_2 emissions scheduler that by means of an on-line connection to the Point Carbon allows calculating the value of the held certificates and their correlation to the CO_2 emissions from the installation, thus offering the possibility of efficiently managing the certificates by real time knowledge of the certificate surplus or deficit.
ECO_2 Premium CIA is designed personalized according to the monitoring methodology specific of the installation. Therefore, it is secured and implicitly provided with access rights, according to the role of each participant in the monitoring and reporting process.

4. Advantages of using a professional tool

Configuring and implementing at the level of the installation a professional tool, personalized according to the GHG (CO_2) emissions monitoring and reporting methodology specific of each EU ETS installation, allows the simultaneous data entry in several locations, their secured storage in the developed database in the installation and the quick generation of reports necessary for meeting the legal requirements.

At the same time, ECO_2 Premium CIA offers the possibility of simulating the various scenarios necessary for quantifying from an economic point of view, the effects generated by possible changes in the installation or production structure.

Upon the experience of the users who implemented such a system at the level of the installation, we found that the use of the ECO_2 Premium CIA leads to the certain improvement of the process of managing and monitoring the data used for calculating the CO_2 emissions from the installation, reducing human errors, that can be quantified at a percentage of about 1-2% of the total generated emissions quantity.

The system allows the real time correlation of the generated to the number of certificates obtained (quantitatively and valuably quantified), representing an economic tool that offers the possibility of choosing the best moment for trading the certificates and avoiding possible financial loss. We specify that the failure to return on time the number of certificates equal to the emissions generated during the reporting period, leads to pay of penalties (40 Euro/tCO_2 for the first EU ETS period, 100 Euro/tCO_2 for the second EU ETS period) [1], [4].

5. Conclusions

Under the conditions of transposing in the national legislation the Directive 2003/87 CE (EU ETS) [1], establishing the emissions trading scheme, the obligations incumbent on it, referring to the CO_2 emissions monitoring and reporting and the complexity of the data necessary to draw up the annual CO_2 emissions report, in implementing a computer system at the level of the installation.
As proved, a viable solution is, therefore, the ECO_2 Premium CIA software package as an efficient CO_2 emissions monitoring and reporting tool and that helps managing all the aspects relating to CO_2 emissions.
Among the advantages this computer system at the level of the installation we mention, as a general conclusion that it is allowed:
- to monitor and report CO_2 emissions according to the EU – ETS requirements and the national legislation and the automatic generation of GHG emissions monitoring reports;
- to collect directly the data from the system with the same frequency with which are generated, thus eliminating the human errors and increasing the accuracy of GHG emissions determination;
- to survey in real time the value of the CO_2 emissions currently held and the possibility of choosing the best moment for trading GHG emissions certificates;
- reducing the time allotted to the check process and implicitly reducing the corresponding costs;
- the security of the entered data, the database archiving and restoring.

References

[1] Directiva 2003/87/EC (EU ETS), de stabilire a schemei de comercializare a certificatelor de emisii de gaze cu efect de seră la nivelul Comunitații Europene, care amendează Directiva 96/61/EC
[2] Decizia Comisiei 2007/589/EC, de stabilire a Ghidului pentru monitorizarea şi raportarea emisiilor de gaze cu efect de seră în conformitate cu Directiva 2003/87/EC, care reglementează metodologia de monitorizare şi raportare a emisiilor de GES pentru a doua perioadă EU ETS (2008-2012);
[3] Ordinul nr. 1175/2006 pentru aprobarea Ghidului privind monitorizarea şi raportarea emisiilor de gaze cu efect de seră;
[4] Hotărârea Guvernului nr.780/2006, pentru stabilirea schemei de comercializare a certificatelor de emisii de gaze cu efect de seră;
[5] “Aplication of the Emissions Trading Directive by EU Member States - Reporting year 2006" EEA Technical &Report No.4/2007
[6] Carbon Finance, Sonia Labatt, Rodney R White, Environmental Finance, 2007
[7] Special Issue - What determines the price of carbon?" Carbon Market Analyst
[8] “Tendances Carbone", Bulletin mensuel du marche europeen du CO_2, mai 2007

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GETICA CCS A FULLY INTEGRATED DEMONSTRATION PROJECT IN ROMANIA

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Abstract: The Government of Romania intends to build a CCS demo project as presented in the Memorandum *„Action Plan to implement a Demonstration Project regarding Carbon Capture and Storage (CCS) in Romania"* signed by the Prime Minister in 17 February 2010.

To achieve this desideratum the Government of Romania, represented by the Minister of Economy, Trade and the Business Environment was addressed to the Romanian engineering companies with extensive experience in reducing pollutant emissions in industrial activities, special for energy producing and geological matters.

The Romanian CCS Demo Project will capture, transport and safely store in excess of 1.5 Million tons per year of CO_2, based on a removal efficiency of 85% from the flue gases emitted by lignite fired power station. The CCS project will consist of the full chain of components for CCS including: CO_2 Capture Plant, transportation by pipeline and underground storage.

A Call for Proposals & National Ranking Program has established the best location is Unit No. 6 of the Base Load TURCENI Power Plant.

The plant will be sized to remove in excess of 85% of the CO_2 contained in the flue gases produced for an equivalent of 250 MW net power output.

The CO_2 will be transported to the nearest suitable storage site by an onshore pipeline, using as possible the existing routes for natural gases oil network.

The available underground data has been identified, for the region of the future CCP, within a radius of 50km. No less than 11 possible onshore storage sites have been identified.

Keywords: demonstration project, carbon capture, CO_2 transport, CO_2 storage, CO_2 emissions, storage capacity injectivity

1. Introduction

Romanian Government is decided to implement a CCS demo project as major target in its efforts to reduce CO_2 and for this the following actions were done:

July 16, 2009 Action Plan to prepare Romania for "Energy-Climate Change" Legislative Package Entry into Force and Implementation (the Ministry of Economy, Trade and the Business Environment, the Ministry of Environment and Forests, the Ministry of Public Finance)

February 17, 2010 Action Plan to implement a Demonstration Project regarding Carbon Capture and Storage (CCS) in Romania (the Ministry of Economy, Trade and the Business Environment)

March 25, 2010 Promoting CO_2 Capture and Storage in Romania (under the auspices of the Romanian Presidency and Parliament)

July 14, 2010 Carbon Capture and Storage – Keynote Address 1 – Regional Energy Forum – FOREN 2010 (World Energy Council – Romanian Member Committee)

August 17, 2010 Order no. 1508 regarding some measures to prepare and promote "CCS demo project CCS in Romania" (the Ministry of Economy, Trade and the Business Environment).

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Getica CCS Demo Project is a Governmental demonstrative project, officially sustained by the Prime Minister and coordinated by the Ministry of Economy, Trade and Business Environment - METBE and supported by Global CCS Institute.

Getica CCS Demo Project is an **integrated CCS project**, comprising the full chain: **capture, transport and storage of CO_2.**

The activity for implementing a CCS project in Romania has started based on the NER 300 (New Entry Reserve having an excedent of 300 millions of green house gases certificates to be used in financing CCS projects as part of a competition lead by European commission) financing opportunity, and also based on other important considerations, likely:

- CO_2 storage potential in Romania;
- more than 150 years of history in the oil and gas industry;
- great share of fossil fuels in electricity generation;
- target to reduce the CO_2 emissions.

From the beginning this action benefit of a great opportunity - **the support from Global CCS Institute – Australia**.

Besides, we performed a detailed risk analysis, necessary for the NER300 application, with the support of French company OXAND.

The project will be implemented and operated by a **new Project Company (PC)**, set up especially for this scope. The company is new, but, in fact, the shareholders of the company are three existing companies, owned by the Romanian state as majority shareholder, with large experience in power generation field and oil & gas field (transport and storage):

- CE Turceni SA - electricity generation company
- SNTGN Transgaz SA - natural gas transportation company
- SNGN Romgaz SA - natural gas extraction/storage company

each of the companies covering one aspect of the project based on their expertise, namely CO_2 capture, transport and storage.

The project was selected following a national ranking process for CCS projects proposals, initiated by METBE, addressed to the all great CO_2 generators in Romania.

The project is co-ordinated by an Inter-Ministerial Steering Committee established by METBE Order no 1508/2010 which includes representatives of METBE, Ministry of Environment and Forest - MEF, Ministry of Public Finance - MPF, National Agency for Mineral Resources - NAMR, National Autority for Scientific Research - NASR, Turceni Power Complex, SNTGN Transgaz, SNGN Romgaz.

2. Location of GETICA CCS Project

The CCS demo project will be implemented in Romania, country located at the crossroads of Central and South - Eastern Europe, North of Balkan Peninsula. Romania became one of the EU 27 member states, starting with 2007.

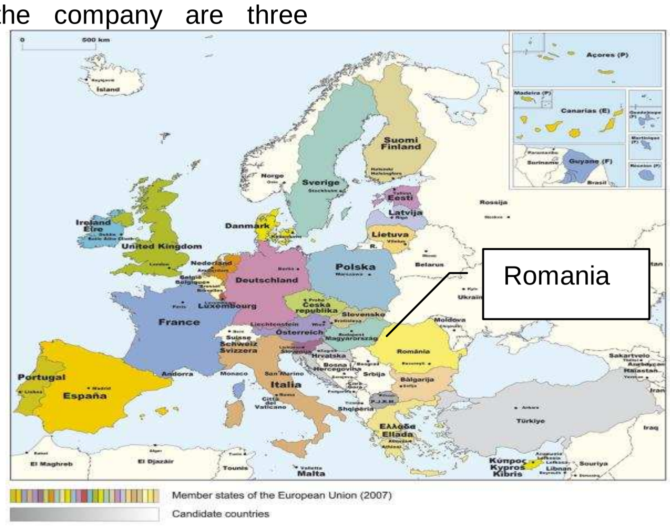


Fig. 1. Project location at EU level

The project location will be in the so called **"Development Region no 4 - South West Oltenia, county Gorj"**.

The region contains 5 counties: Dolj, Olt, Vâlcea, Mehedinți and Gorj and has a population of 2,279,849 inhabitants,

representing 10,6% of the total population of the country.
The localities network includes 40 cities (of which 11 municipalities), 408 communes and 2070 villages. The important cities are Craiova (300,182 people), Râmnicu-Vâlcea (111,701people), Drobeta Turnu-Severin (109,444 people), Târgu Jiu (96,318 people) and Slatina (80,282 people).

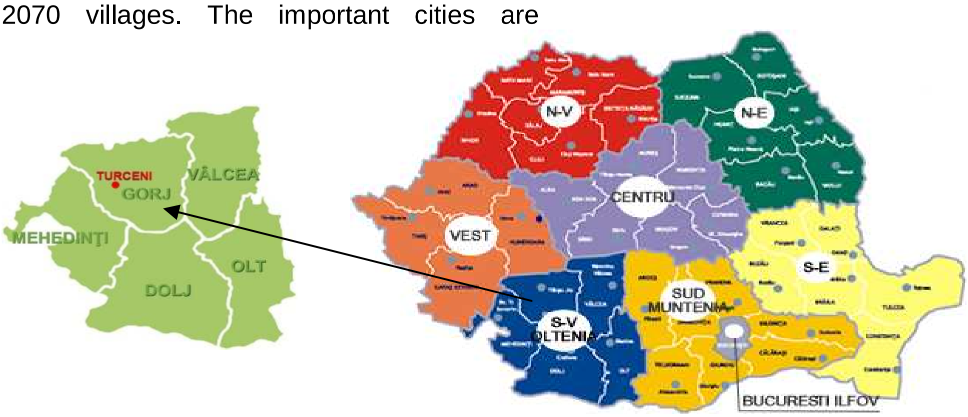
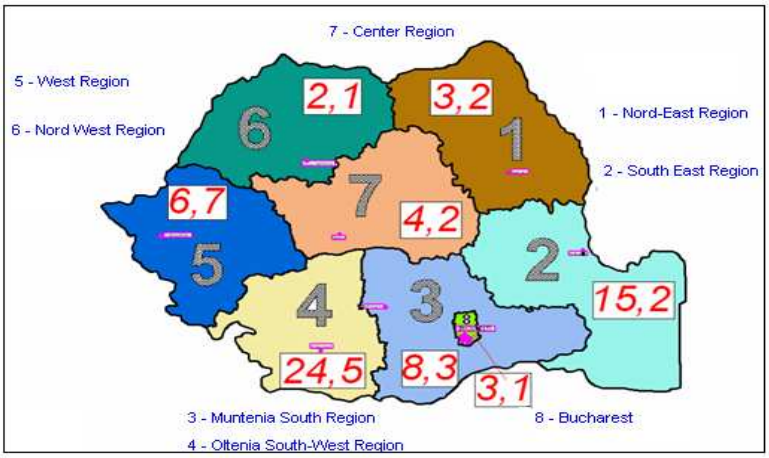


Fig. 2. Project location at national level

The nearest city around the project location is Târgu Jiu, located at a distance of around 55 km from S.C. Energy Complex Turceni S.A.
Regarding the Romania Development Region no. 4, it has to be underlined the following:
✓ *The industry represents a sector with a major impact on the environment*, the main industrial pollutant sources in this area being the following:

- **Energy industry** and transports;
- Chemical industry;
- Metallurgical industry;
- Petrochemical industry;
- Manufacturing Industries and Construction;

✓ *In terms of verified CO_2 emissions,* this region is characterized by **the biggest quantity of CO_2 emissions at the national level**, as it is presented in the following map:



Source:"Promoting CCS in Romania", ISPE & GeoEcoMar
Note
1. The reference values are for year 2007 (in which was generated the biggest quantity of verified CO_2 emissions at the national level).
2. The CO_2 emissions at Romanian's regional levels contain only CO_2 emissions higher than 100,000 tons/year.

Fig. 3. Verified CO_2 emissions per Romanian regions, 2007, in $MtCO_2$

✓ *The main industrial sector which generates important quantity of CO_2 emissions* is the **Energy Sector with the power plants burning local coal – lignite**, which in terms of CO_2 emissions represents **more than 96% of total region's CO_2 emissions.**

3. Description of the power plant

The "***GETICA CCS Demo Project***" will be implemented **in a power plant – base load**, **one of the strategic electricity suppliers to Romanian National Energy System**

Turceni PP and the adjacent lignite mines are part of SC Complexul Energetic SA, a state owned company originally built with 7 units of 330 MW.
Currently the power plant operates 4 to 6 units, depending on the market request. The long term investment strategy is showing that just 4 units will continue to be operated.
The Unit No. 6 of 330 MW will be retrofitted in the next 3 years. As shown in the figure below the financial package is already closed.

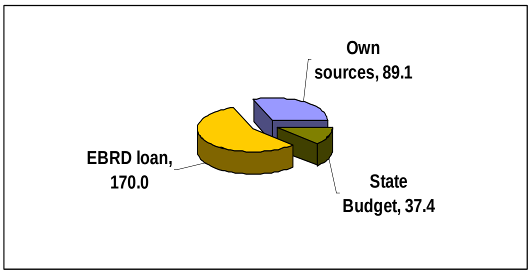


Fig. 4. Structure of financing source to retrofitted Unit no. 6 of Turceni PP (mil. Euro)

The bidding process for the EPC selection is ongoing; it is expected that on the beginning of year 2012 the EPC for retrofitting of the unit to be decided.
In the same time the SO_2 emission limit value will be achieved, due to fact that a flue gases desulfurization system (FGD) will be installed.
In Turceni PP will be installed a new system to evacuate and deposit the ash and slag (dense fluid) in order to respect the request of the Waste Directive (Directive 1999/31/EC).
The Unit no. 6 will operate at least 15 years after retrofitting and will have all the installations needed to comply with the provisions of environmental legislation.
The facts described above was an important criteria in selecting Unit No. 6 to be the Romanian CCS demo project, because this unit will be in 2015 in operation. A new power unit in Romania has uncertainties to be ready and commercial operated before 2015, mostly because of the reduced financing possibilities during the actual economic and financial crisis.

4. Capture technology

The capture technology provider is currently focusing on two main categories of Capture technologies, Oxy-Combustion and Post-Combustion.
This strategy arises, not only because these technologies will be the most economically viable and sustainable solutions for the customers, but also because these technologies can be retrofitted to the installed base - an essential component to meeting future emission targets.

There are significant R&D efforts in the field of CCS and there is a number of pilot and demonstration projects throughout the world, working toward full scale commercialization to be available to market in 2015.
During this validation process of the CCS solutions, to avoid the risk of stranded assets, it is necessary to have a "CCS Ready" plant concept for existing and new power plants. This concept takes into account the necessity of who purchase or retrofit plants today to be ensured that they will not be penalized financially, when the technology becomes available. Capture ready will limit the time for plant outages and unnecessary expense and ease the integration at the time of installation of the CO_2 capture plant.
The optimum technology choice on post combustion carbon capture technologies should be tailored to the specifics of the individual projects. This on consideration of the project site, technological boundary conditions and integration specifics, but also setting the envisaged realization time schedule in relation to the degree of maturity of the technologies, which are in different stages of development and maturity.
Considering the time schedule of the Getica CCS demo project, the selection concentrates on Chilled Ammonia Process (CAP) and the Advanced Amine Process (AAP), as they are the technologies furthest in development and closest to commercialization.
The Carbon Capture Plant (CCP) will be based upon the absorption of the CO_2 from the flue gases using Chilled Ammonia Process (CAP). This technology is easy to integrate in an existing Power Plant.

The selected technology was already implemented in a number of successful pilot and demonstration units across the globe. The experience gained in the pilot plants will be included in the design of the Getica CCS Demo Project carbon capture plant.

The objective of the CAP demonstration plant is to further validate the process under industrial scale conditions.

The CCP will treat an equivalent flow of flue gases, for 250 MWe of gross electrical output, extracted before Unit no. 6 WFGD exhaust.

This project, when operational, will have a CO_2 capture rate of more than 85% from the flue gases flow. The captured CO_2 stream will be compressed and transported by pipeline for sequestration in deep saline aquifers.

The Chilled Ammonia Process is a new technology with encouraging prospects regarding performance and emissions based on extensive laboratory and pilot testing.

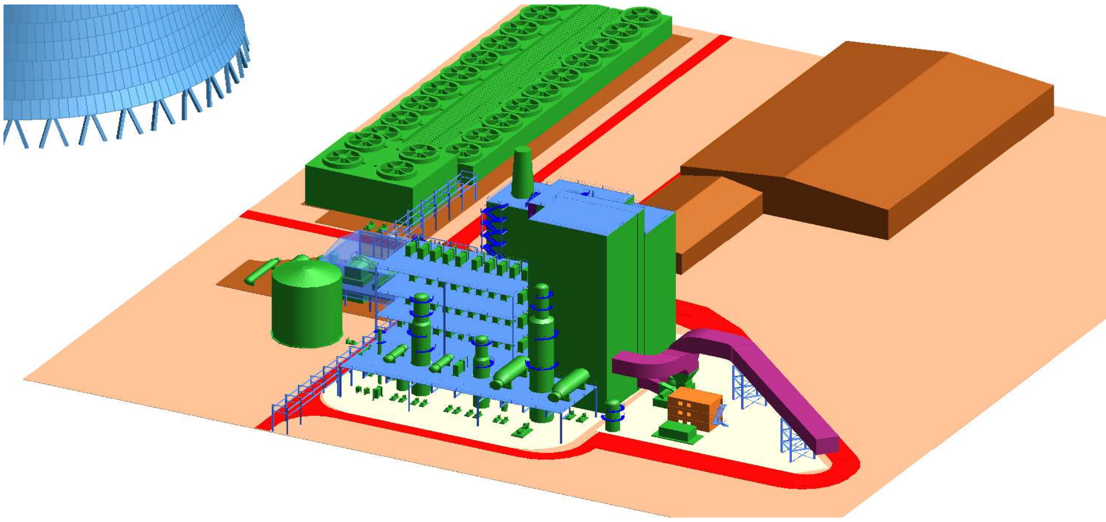


Fig. 5. Turceni CO_2 Capture Plant View

The process uses an ammoniated aqueous carbonate solution to absorb CO_2 from the flue gases at ambient pressure and low temperature. Ammonia is a common, widely used and low cost chemical, readily available on the market from multiple sources.

The ammonia reagent in the CAP plant lends itself to fewer permitting requirements, including any waste disposal issues that may arise.

Ammonia is an energy-efficient reagent for regeneration from the capture of CO_2. Ammonia is not susceptible to contamination of the flue gases and will be replenished in low consumption rates, as it will exhibit a very low (ppm level) and controllable loss in the CAP process.

From the standpoint of plant operations, the chilled ammonia process has demonstrated stable operation at turndown conditions. The CAP process offers the flexibility and ability to follow daily and weekly changes in plant load requirements without impact on the process.

The flue gases from a typical WFGD system can be delivered to the CAP process without any additional treatment facilities.

The by-product from the CAP facility is a liquid ammonium sulphate stream.

The ammonium sulphate can be used for sulphate based fertilizers, so it is a feedstock for chemical facilities.

This opens opportunities for the by-product to be commercialized. For this stage of the project, it was considered that the by-product will be given as it results from the process, without any conditioning, and with no price, to a possible user of ammonium sulphate, from Romania (preferably) or from the international market, and the user will support the costs of transportation. For the next stages of the project (FEED), if the discussions and agreements with the potential local users or buyers of the by-product will be unsuccessful, a market analysis shall be conducted for the European Community markets.

Since gaseous emission and liquid waste streams are harmless, no additional treatment facilities are required.
The Chilled Ammonia Process consists of the following process units, as depicted:

- CAP Flue Gases Conditioning;
- CAP CO_2 Absorption;
- CAP Water Wash and CO_2/NH_3 Stripping;
- CAP regeneration;
- Chiller (Refrigerant) System ;
- CO_2 Compression and Dehydration.

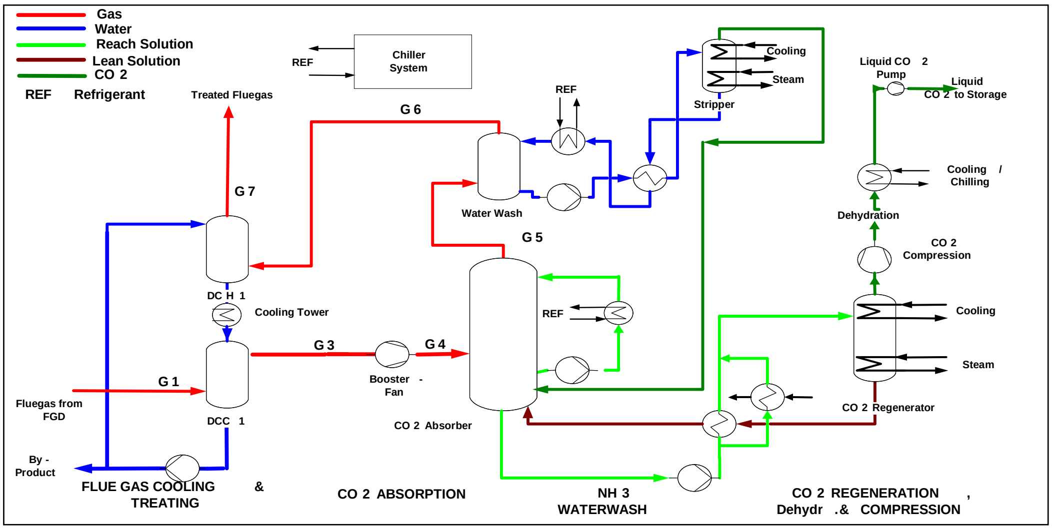


Fig. 6. Simplified Process Scheme for CAP

A part of flue gases (G1) leaving the wet flue gases desulphurisation is diverted by means of a new ductwork to the CAP plant while the other part is sent directly to the stack. Cool flue gases from DCC1 (G4) enter the CO_2-Absorber and flows from there to the Water Wash Column for gaseous ammonia slip control. The flue gases stream (G6) is then sent to DCH1 to scrub the remaining ammonia from the flue gases and to reheat the treated flue gases. The residual (treated) flue gases (G7) leaving the CAP plant will be returned to the stack or cooling tower. The CO_2 rich solution from the CO_2 Absorber is heated in the Regenerator to desorb primarily the CO_2. Lean solution from the Regenerator is returned to the Absorber. The CO_2 product is further treated to meet the required specification and then compressed to the required delivery pressure.

5. CO_2 transportation

The CO_2 transportation will be performed by onshore pipeline. Dense phase CO_2 has been selected for long distance transportation, as being the most cost effective solution.A 40 km long pipeline was considered to transport the CO_2 from the CCP to the storage site.

The pipeline route has been determined considering specific constraints: the specifics of the areas crossed by the pipeline, the terrain features, the population density in the area, the archaeological sites in the vicinity, and environmental considerations. Due to the fact that the pipeline will pass nearby populated areas, the provisions of the norms and regulations in force have been observed. As a rule, a minimum clearance of 500 m from the existing villages and building has been considered.
The pipeline will be installed in a hilly area, and some sections of the pipe route are subject to landslides.
The pipeline design pressure-temperature envelope is: 0÷140 bar, 0÷50ºC. The operating range is 80÷120 bar, 0÷40ºC.
In the area there are other 3 power plants using local lignite: Rovinari PP (1300 MWe), Craiova II PP (300 MWe) and Işalniţa PP (600 MWe). For the future it can be considered **a CO_2 transportation network** if the existing power plants will decide to implement the CCS technology as a viable alternative to buying CO_2 allowances under EU ETS (Directive 2009/29/EC).

6. Storage location and type

A preliminary screening of the power plant area has been performed by GeoEcoMar in order to create a first, temporary list, of potential CO_2 storage sites. The area of investigation was selected as circular, with a 50 km radius around Turceni power plant. This area comprises a small part of the western sector of the Moesian Platform and Getic Depression.

In this area of investigation, only aquifers in the Tertiary formations have been considered as potentially suitable for CO_2 storage locations.

This type of formations are located at depths (greater than 800 m and no more than 3000 m) suitable to develop a CO_2 storage project (which needs to be located at a depth deeper than 700 m for the CO_2 to be in its supercritical state but shallow enough to avoid excessive well construction costs).

The Tertiary has also generally been better studied over the years in the process of oil and gas exploration and exploitation.

Fig. 7. Geological setting of the investigation

The selection of potential CO_2 storage sites was made based on all the data that were made available by oil and gas companies, comprising 241 2D seimic lines and 141 well information packages, geological cross-sections, geological and geophysical maps and data from literature. The selection was made by considering an investigation area of 50 km radius around Turceni.

The criteria on which the selection was made are presented below:

- Depth of the reservoirs. There were identified reservoir sequences in Tertiary and Mesozoic formations, but the depth of the Mesozoic reservoirs is greater than 3000 m, implying bigger costs for a possible storage. For this reason it was decided to focus on Tertiary deposits.
- The lithology and properties of the reservoir formations. The Tertiary deposits are mainly siliciclastic, comprising sandstones, conglomerates and sands altering with shale. Their average porosity is 14% and average permeability of 50÷100 mD.
- The existence of a seal with good lateral continuity, not crossed by any faults or fractures that could jeopardize the safety of storage and with sufficient thickness to ensure containment.
- The storage capacity. Only the reservoirs with sufficient storage capacity that could accommodate the CO_2 captured from Turceni were selected.

The analysis of the available data concluded that the best solution for storage would be the Sarmatian formation.

Based mainly on data owned previously to the Feasibility Study by GeoEcoMar, 11 possible storage sites were selected. After the acquisition of additional data from oil and gas companies, this list was reduced to 7 potential storage sites and the final selection lead to the identification of 2 sites (Zone 1 and Zone 5) being the best suitable for CO_2 storage in terms of storage capacity, structural framework, reservoir properties and seal.

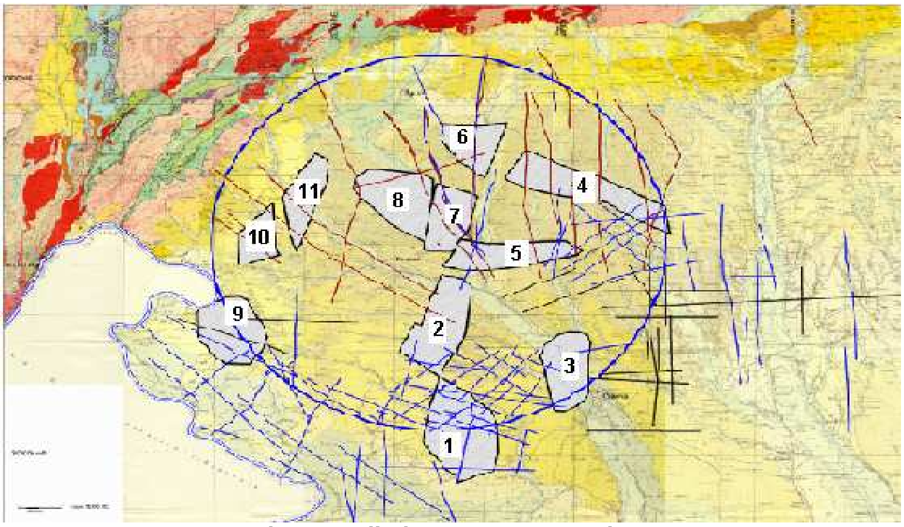


Fig. 8. Preliminary 11 storage sites

The selection of these 11 sites was made mainly on the structural criteria, on the existence of a structural trap, of a proper seal and on the thickness of the reservoirs. The reservoirs for all these potential storage sites are Tertiary deposits (Sarmatian sequences) made of sandstones, conglomerates and sands alternating with shales situated between 1000 and 3000 m depth. According to the data from outcrops and wells, the sandstones and conglomerates have relatively high porosities and permeability. Although the older geological formation developed under the Tertiary deposits are proved to have good reservoir properties, they were not taken into consideration due to their great depth (3000÷4000 m) which would have led to higher storage costs.

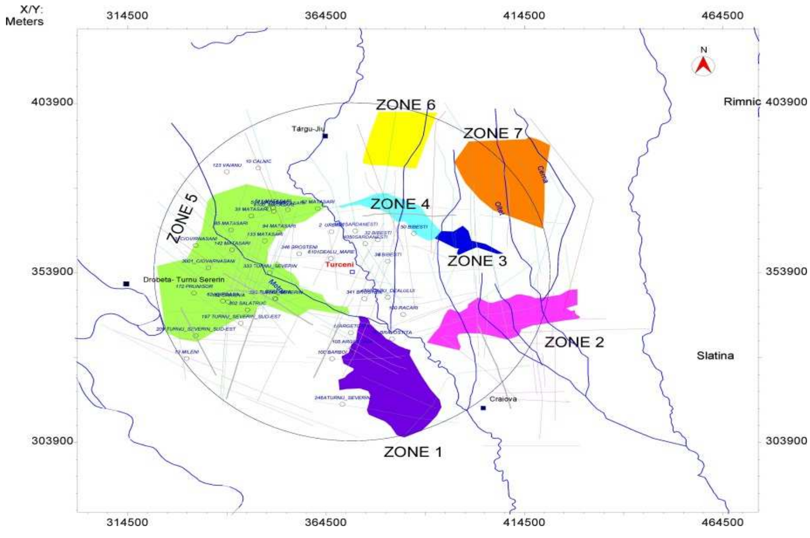


Fig. 9. Location of the 7 potential CO_2 storage sites

A more detailed analysis of the collected data conducted after the preliminary selection of 7 sites concluded that the best suitable storage sites are Zone 5 and Zone 1. For these sites the selected storage solution is deep saline aquifer. Both reservoirs are made of several

Sarmatian sequences composed from course sediments.
The static and dynamic modelling performed for each of the sites lead to a first characterization of their associated storage complexes to be completed and finalized during the Appraisal.
Preliminary performance and risk assessment have been conducted on both possible storage sites, Zone 1 and Zone. The conclusions of this assessment lead to the development of an appraisal strategy focused on Zone 5 as the most suitable storage site, but not excluding Zone 1 as back-up option. The appraisal strategy is meant to cover the identified data gap by acquiring that information needed to complete the site characterization started during the Feasibility Study.
The target geological volume for Zone 1 vertically extends from the base of Tertiary up to the top of Sarmatian (including 2 reservoir sequences located at 1800÷2100 m depth and the caprock formed by the overlaying Sarmatian sequences). Its lateral boundaries are constrained by the most northern bounding fault and the pinch-out of the reservoir formations on the western boundary, by the pinch-out of the reservoir formations on the southern boundary, while the northern and southern boundaries have been arbitrarily drawn and will be better defined as soon as the performance and risk assessment of Phase 2 have been completed.
The target geological volume for Zone 5 vertically extends from the top of Burdigalian up to the top of Sarmatian (including 4 reservoir sequences located at 1400÷2000 m depth and the caprock formed by the overlaying Sarmatian sequences). Its lateral boundaries are constrained by the bounding faults on the western and northern sides, by the reservoir formations pinch-out in the south and have been arbitrarily drawn for the eastern flank and will be better defined as soon as the performance and risk assessment of Phase 2 have been completed.
In terms of Appraisal strategy, this is meant first to cover the data gap identified during the performance and risk assessment work and to complete the site characterization for the selection of a single site to be further developed.

The objectives of the Appraisal are:

- Prove the existence and quality of the caprock
- Provides data on the overburden (presence of a secondary caprock, of shallow potable aquifers…)
- Acquire local reservoir petrophysical, geomechanical and geochemical data to confirm the characteristics of the reservoir
- Identify promising zones for injection from a structural point of view
- Prove the containment performance of the zones identified above
- Provide a detailed mapping of the lateral and vertical extent of all the faults either bounding or located within the zone, with a special focus of the bounding faults for fault stability and conductivity (lateral and vertical).
- If some faults are found to extend above the caprock (and secondary caprock if found to be present), show that they are vertically sealing.
- If they are going to “see” CO_2, show that the bounding faults are laterally sealing.
- Provide a map of the reservoir heterogeneities

The Appraisal strategy (Phase 2) is based on the assumption made, based on the preliminary dynamic simulations that Zone 5 is more promising as storage site. Therefore it was decided that after an initial 2D campaign conducted in parallel on both zones, the focus would be initially put on Zone 5 and that Zone 1 would be fully appraised, only if Zone 5 was considered to be not suitable for CO_2 storage after a first appraisal well. The 3D seismic survey will be made only on the zone chosen as the most suitable after the first step of Phase 2.
The design of the surface and injection facilities will be made at the beginning of the Development Phase (Phase 3) and will be based on the characterization made in Phase 2. Still, the preliminary dynamic simulations shown that up to 9 injectors could be needed for Zone 1 and 5 injectors for Zone 5, with a relative large distance between them.
The finalized definition of the storage site (proposed during FEED & Detailed Engineering) will include the validated locations of the injection wells and associated surface facilities, including the compression/pumping station.

7. Concluzion

The scope of Romanian Government is to develop a full-chain operational CCS demo project till 2015 in order to:

- contribute to the National CO_2 reduction targets;
- reducing greenhouse gas emissions as a part of the global effort for to minimize the climate changes;
- addressing CCS specific barriers, for further deployment of commercial large scale projects at national level and in the Eastern European region, thus supporting the global CCS market development.

The main objectives of the **GETICA CCS Demo Project** were:

- to determine the appropriate available technology to be used for the Carbon Capture and to develop the optimized thermal integration of the CCP into the power plant with resulting performance profile of the power plant;
- to determine the preliminary design and costs for the CO_2 pipeline;
- to select a shortlist of 2 possible onshore storage sites and to conduct all activities for the development of the Basis of Design for the Appraisal wells construction and evaluation;
- to have a clear view on the estimated costs and schedule of the overall Project, including the investment conclusions and preliminary decisions;
- to prepare the regulatory environment for the safe and efficient construction / operation for each stage of the full chain CCS Project;
- to asses a preliminary environmental impact of the CCS Project;
- to define the Knowledge Sharing targets and means.

References

[1] ”Inventarul Național al Emisiilor de gaze cu efect de seră', Raportul asupra Inventarului Național, martie 2009, www.anpm.ro;
[2] “Planul Național de Alocare pentru România 2007 și 2008-2012”;
[3] “Strategia energetică a României pentru 2007-2020”, Ministerul Economiei, Comerțului și Mediului de Afaceri (www.minind.ro);
[4] Raportul Final asupra Proiectului FP6 ”Evaluarea capacității europene de stocare geologică a dioxidului de carbon” - ”GeoCapacitate UE” (26 partenri, inclusiv GeoEcoMar-România) (www.geocapacity.eu);
[5] Raportul Final asupra Proiectului FP6 “Extinderea rețelei de captare și stocare a CO_2 la noile state membre” - ”CO_2 Net East” (8 parteneri, inclusiv GeoEcoMar-România) (www.co2net.ro);
[6] Studiul de Fezabilitate pentru retehnologizarea grupurilor 3 și 6 de 330 MW – CTE Turceni, ISPE, 2004
[7] Studiul de Fezabilitate pentru instalarea instalației de desulfurare a gazelor de ardere la grupurile nr. 3, 4, 5 și 6 de 330 MW – CTE Turceni, ISPE, 2004
[8] Studiul de Fezabilitate pentru colectarea, pregătirea, transportul și depozitarea în locurile de depozitare a cenușii și zgurii în faza de fluid dens pentru grupurile nr. 3, 4, 5 și 6 de 330 MW – CTE Turceni, ISPE 2006
[9] Studiul de Fezabilitate pentru proiectul demonstrativ CCS GETICA – GCCSI, ISPE, 2011.

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STRATEGIC DIRECTIONS FOR THE DEVELOPMENT OF ROMANIAN ENERGY SECTOR

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Abstarct: This paper proposes that, based on the current situation in the electricity sector, to examine some crucial elements for energy strategy while meeting the targets set by the legislative package "Energy - Climate Change" of the EU. The main objectives resulting are:
1. a 20% reduction of GHG emissions at EU level at least compared to 1990;
2. a 20% increase in the share of renewable energy sources (RES) in total EU energy consumption;
3. a 20% reduction in primary energy consumption and the increasing energy efficiency.
Evaluation of electricity consumption in the long term is based on demographic and the main macroeconomic indicators trends: gross domestic product (GDP), demographic trend (total population).
The final result of the analysis is the new power needs to ensure on long term the safety conditions for consumers taking into account issues such as:
1. the retirement of the existing units at the expiration of the life time;
2. availability of primary energy resources in the country and their costs;
3. possible fuel imports at international market prices;
4. using the best technologies;
5. impact of using RES over National Power System, especially wind power plants;
6. influence the cost of CO_2 emission allowances and the introduction of CCS technology.
Analyzing a strategy regarding the energy sector in terms of electricity security supply, the minimum cost criterion have to be completed by climate change mitigation and limitation of primary energy imports dependence.

Keywords: primary energy resources, climate change, security of supply

1. Introduction

This paper proposes that, based on the current situation in the electricity sector, to examine some crucial elements for an energy strategy while meeting the targets set by the legislative package "Energy - Climate Change" of the EU. The main objectives resulting are:
- a 20% reduction of GHG emissions at EU level at least compared to 1990 level;
- a 20% increase in the share of renewable energy sources (RES) in total EU energy consumption;
- a 20% reduction in primary energy consumption and the increasing energy efficiency.

Long term evolution of electricity consumption is based on demographic and main macroeconomic indicators trends: gross domestic product (GDP) evolution, total population evolution etc.
- Gross domestic electricity consumption has to follow a continuous increase of the overall energy efficiency of the Romanian economy by the continuous improvement of the electrification of all sectors.

2. Objectives

2.1 The objectives and the main directions for national power sector development in 2035 year perspective

The overall objective of the strategy is to ensure the conditions of the energy sector to meet energy needs in the medium and long term, at affordable prices, appropriate to a modern market economy and a civilized standard of living, in terms of quality, safety supply, with respect principles of sustainable development.

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Having in view the role of energy for society and for the all economic sectors, the development of this sector is done under the supervision of the State, through the development and enforcement of a sectoral strategy and short term by implementing the policies related to the strategic document.
The role of the strategy is to define the main directions of development of power sector in Romania during 2011 - 2035, having in view the social and national economic development, the situation in the electricity sector in close correlation with energy - environment policy of European Union.

2.2 Strategic objectives

In a context of increasingly globalized, the Romania's energy policy is made through the changes and developments which taking place at national and European level. In this context the Romania's energy policy must be correlated with similar documents at European level to ensure our country's policy convergence with EU policy in this area.
The energy Strategy will pursue the achievement of the main objectives of the new EU energy - environment policy, objectives assumed by Romania.

It will identify the ways and measures to achieve the following objectives:
- The energy security;
- The competitiveness of the electricity market;
- The environmental protection and mitigation of climate change;
- The further development of the competitive market;
- The attracting capital for modernization of energy sector.

3. The current situation of the power sector in Romania

a) Internal resources of primary energy

Romania has a wide range, but in a reduced quantity of fossil and mineral energy resources as: oil, natural gas, coal, uranium ore, and a great potential of renewable energy resources.
A fair assessment of the possibilities for covering the primary energy needs in the future, should start from the current situation of proven reserves, combined with realistic estimates of potential resources in close correlation with resource consumption forecasts determined by the final energy demand.

From this point of view can be made the following estimates:

- The lignite reserves can ensure their efficient operation for another 40 years at a production level of about 30 million to. / year. In the extraction sector the level of state intervention is "low" being limited to grants of subsidies only for the underground operation that will be eliminated.
- With regard the hard coal, the perimeter restriction and underperforming mines closing led to a situation where only about 30% of the total geological reserves of hard coal is found in the concession perimeters of the National Hard Coal Company (CNH-SA). According to the recently adopted EU Directive, the EU allowed to continue the explotation with subsidies for hard coal until 2018 and this fact makes the strict application of a mine closure program that generates losses. It is estimated that development costs and elimination of subsidies on production (required by the EU) will lead to reduction of domestic production hard coal competitiveness and to the significant reduction of production. In terms of cost from the economic and energy point of view the electricity production from domestic hard coal without subsidies is marginal.

According to the National Agency for Mineral Resources (NAMR) the situation of hard coal and lignite resources is presented in table 1, and of the resources / reserves of crude oil and natural gas in 2010 is presented in table 2.

Table 1

Hard coal and lignite resources in 2010

Fuel type	Geological resources	Exploitable geological resources	Exploitable geological resources in concession premises	Exploitable geological resources in non-concession perimeters	Estimated insured period (years)
Hard coal (mill.to)	1,416	602	229	373	260
Lignite (mill.to)	9,659	3,297	318	2,979	115

Table 2

Resources / reserves of crude oil and natural gas in 2010

Fuel type	Geological resources	Sure reserves	Estimated insured period (years)
Crude oil (thou. To.)	2,024,024	54,882	15
Natural gas (mill.cm)	660,602	109,284	10

This reserve provides gas and oil production for another 12 to 15 years.

b) Import dependence

Primary energy production in Romania based on the exploitation of fossil energy reserves, coal and oil as well as those of uranium ore, in the most optimistic case, will not grow in the next 2-3 decades. It follows that the coverage of primary energy demand growth in Romania will be achieved through increased the use of renewable energy resources and imports of primary energy – natural gas, oil, coal, nuclear fuel. For the analyzed period, Romania will remain dependent on imports of primary energy. The dependence degree will depend on the discovery of new exploitable internal resources, the degree of integration of renewable energy and the success of the energy efficiency growth measures (table 3).

Table 3

Import dependence during 2002 – 2009

Year	2002	2003	2004	2005	2006	2007	2008	2009
Import – export balance (10^3 toe)	8.95	10.53	11.85	10.54	11.62	12.50	10.82	6.63
Primary energy consumption (103 toe)	36.48	39.03	39.02	37.93	39.71	39.16	39.80	34.33
Dependency degree (%)	24.50	27.00	30.40	27.80	29.40	31.90	27.20	19.30

c) The electricity production

The evolution of electricity production in Romania during 2000-2009 is presented in table 4.

Table 4

Gross electricty production (TWh)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electricity production	51.93	53.86	54.93	56.64	56.48	59.41	62.69	61.67	64.95	58.02

The structure of electricity production in 2009 by type of power plants is shown in figure 1. It can be seen that 52.46% of this production was based on power plants that burn fossil fuels.

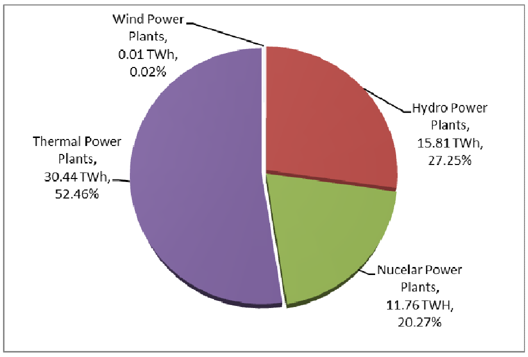

Fig. 1. Gross electricity production in 2009 (58.02 TWh)

d) The installed capacity of National Power Sector

The total installed capacity of National Power System during 2005 – 2009 on power plants type is shown in Figure 2.

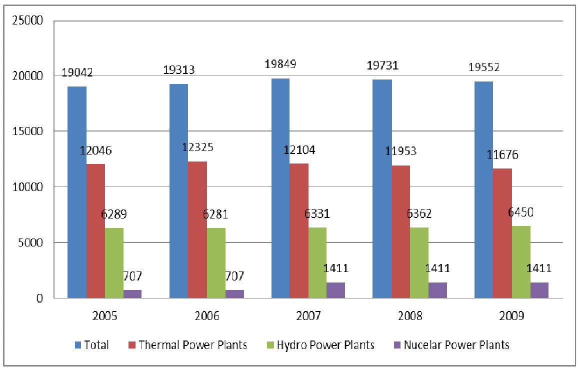

Fig. 2. Gross installed capacity during 2005–2009 (MW)

e) The technical status of thermal power plants

• *Thermal power units*

About 80% of thermal power units were installed in Romania during 1970-1980, currently having passed their standard lifetime of service (figure 3 and figure 4).

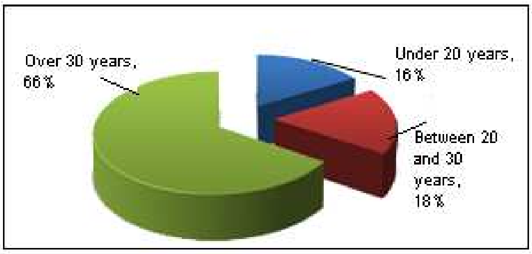

Fig. 3. Structure by age of condensing power plants in 2009

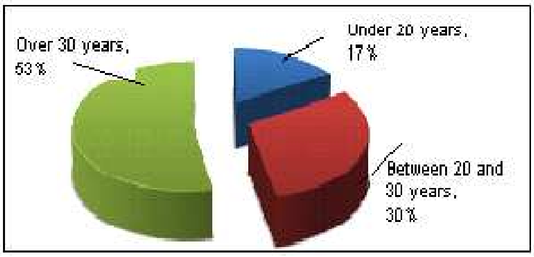

Fig. 4. Structure by age of cogeneration power plants in 2009

The thermal power units were achieved with 1960-1970 years technologies and have low performances around 30% - unless rehabilitated coal groups, reaching 33%. This efficiency is 65-70% of modern groups, which currently operates in most European developed countries.

• *Hydro-power units*

Over 30% of installed capacity in hydro power units has a lifetime between 25 and 45 years. Structure by age of hydro power units is shown in figure 5.

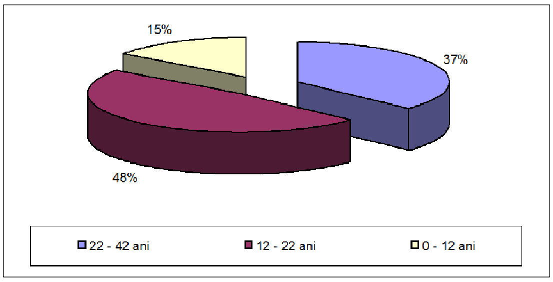

Fig. 5. Structure by age of hydro-power units in 2009

4. Forecast on Development of National Power System during 2011 – 2035

a) Macroeconomic development – the framework for determining energy demand

To assess the electricity consumption during 2010 - 2035 were considered the main macroeconomic indicators and demographic developments:

- Gross domestic product (GDP);
- Demographic evolution (total population).

Proposed developments are based on forecasts on the evolution of GDP during 2010 - 2014 prepared by the National Institute of Economic Research (INCE - July 2010) and the National Commission for Prognosis for the years 2010, 2020 to 2030 (NCP - September 2010).

The macroeconomic development scenarios developed were as follows:

- The reference scenario builds on the basic macroeconomic parameters close to those envisaged by the Government, in conjunction with the IMF agreement.
- Unfavorable scenario 1 and unfavorable scenario 2 involving the conditions of the internal and external business environment less favorable.

The reference scenario was constructed considering the following assumptions:

- The real economy will pass the recession phase, but gradually and slowly.
- Economic growth is supported by market absorption or by modest recovery of exports.
- The unemployment rate remains relatively high in 2010 - 2011, after which tends to decrease.
- The trade deficit for the entire period does not exceed unbearable limits.

- Public budget deficit will decrease and finally tend to reach the EU standards.

The unfavorable scenario 1 compared with the reference scenario assumes:

- The economic growth will slow.
- Exports remain consistently below the baseline scenario.
- The government deficit will reduce general, remaining above the reference scenario.

Unfavorable scenario 2 is virtually derived from the previous compression assuming inflation by income, monetary and budgetary spending more restricted.

The evolution of GDP during 2010-2035 for the three development scenarios is shown in figure 6.

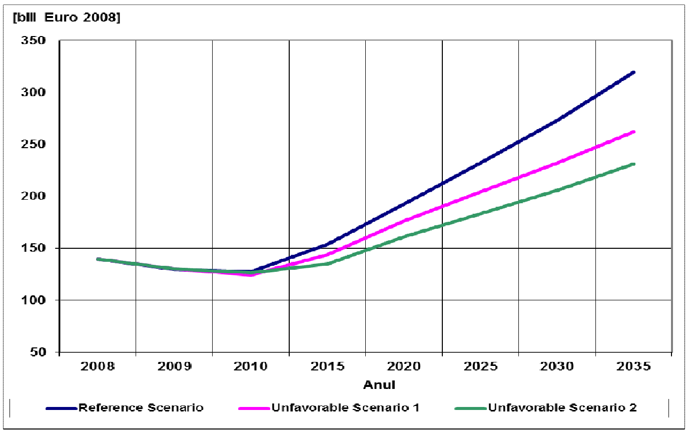

Fig. 6. Scenarios for the evolution of GDP during 2010 – 2035

b) The forecast of electricity consumption

To the three scenarios of the evolution of GDP correspond three scenarios for domestic electricity consumption. Scenarios, so constructed provide a continuous increase of overall energy efficiency of the Romanian economy and the continuing improvement of electrification of all sectors.

These two goals are expressed through two specific indicators:

- The energy intensity expressed in [kWh/1000 Euro];
- The electricity consumption per capita in [kWh / capita].

The evolution of net domestic electricity consumption is shown in figure 7.

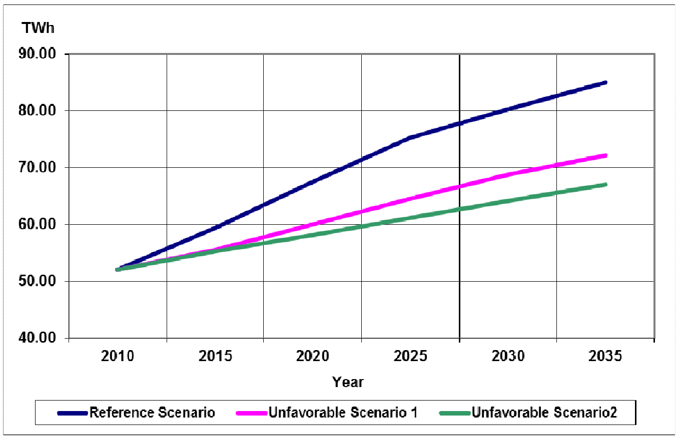

Fig. 7. The evolution of net domestic electricity consumption during 2010 – 2035

c) The need for new capacity in NPS during 2011 - 2035

For evaluation the new capacity needs in NPS for the analyzed period were taken into account:

- The evolution of the existing power plants in operation due to the withdrawal from service of some units at the achievement of the standard life time, for rehabilitation etc.;

- The evolution of the energy and electricity consumption based on macro - economic and demographic development projections;
After the analysis resulted the installed capacity that will be retired from operation at the achievement of standard life time (table 5) and the evolution of existing capacity considering the retirements from operation (table 6).

Table 5

The capacity units need to be retired from operation at achievement of standard life time (MW)

Capacity	2010 - 2015	2016 - 2020	2021 - 2025	2026 - 2030	2031 - 2035	Total 2010 - 2035
Installed capacity	3,920	1,724	1,075	2,190	2,187	11,096
Net capacity	2,641	1,511	859	1,935	1,953	8,899

Table 6

The evolution of existing capacity considering the retirement from operation (MW)

Capacity	2010	2015	2020	2025	2030	2035
Installed capacity	20,092	16,172	14,448	13,373	11,183	8,996
Available capacity	17,693	14,690	13,025	12,052	10,268	8,426
Net capacity	16,445	13,804	12,293	11,434	9,795	8,124

5. Conclusions

Total investment required for the installing the new electricity generation capacity needed in the period 2011 – 2035 (14,000 MW gross installed capacity, excluding RES) is about 30-40 billion Euro.
A series of technical-economic analysis efficiency of various technologies and new groups have been made in order to highlight their relative efficiency, namely the competitiveness on the internal electricity market. Were taken into account investment and operating costs (based on efficient technology and cost of domestic and imported fuel) in compliance with the load duration curve (base or peak load and respectively capacity utilization). It was also considered the post-2020 technology developments, the decreasing of investment costs and different scenarios for changes in the cost per tonne of CO_2 and fuel prices in the country and import.
Analyses carried out, including the sensitivity of cost per tonne of CO_2 shows that:

- For base operation, the economical order of new projects, during 2020 is as follows:
  - The rehabilitated units of 330 MW on lignite expected to be completed during 2011 to 2015 (with extension of lifetime with 15 years);
  - Groups 3 and 4 of Cernavoda nuclear power plant;
- For the peak and half peak load curve the hydro power plants is the most efficient solution for producing electricity using renewable energy sources, followed by wind power plants (without support schemes). The most expensive solutions are the gas turbines functioning in open circuit gas and the photovoltaic power.
- The system integration of the electricity produced from wind, biomass and solar require support schemes (green certificates) to make them competitive for investors, but lead to higher electricity prices at final consumers.
- For the period 2020 - 2035:
  - The most efficient way to produce electricity, having in view the possible evolution of fossil fuels prices on the international market and the CO_2 certificates price evolution is a new nuclear power plan;
  - New unit of 500 MW on lignite with supercritical parameters and CCGT unit on natural gas have high efficiency in terms of CO_2 certificates price evolution between 40 and 60 Euro/t CO_2;
  - The import of hard coal for 500 MW units or more with supercritical parameters is as marginal solution the most expensive.
- For the peak and half peak area the economic order it is the one previous resulted.

In conclusion the development of power plants over the next 20-25 years will be based on continued use of coal (lignite) in the country, but in modernized and new units with high performance, the continuing development of new hydropower plants, on continuing the nuclear program and the development of new capacity using renewable energy resources - wind, biomass, etc. The balance of power and energy will be achieved by importing natural gas for Combined Cycle with Gas Turbine (CCGT) plants with high performance. With this structure, capacity and electricity production will ensure compliance with the commitments to the EU to reduce CO_2 emissions and increasing energy production from renewable energy resources.

References

[1] “Romanian Energy Strategy for the period 2007 - 2020 updated for the period 2011 - 2020”, www.minind.ro, 2011
[2] “Energy balance and energy equipment structure", National Institute of Statistics, collections
[3] *Alexandru Pătruți*, “Fossil fuel resources technically and economically recoverable, the legal framework, a key factor in promotion”, Bucharest, August 2011
[4] “International Energy Outlook”, U.S. Energy Information Administration, 2010
[5] “Re-industrialization of Romania - Policies and Strategies "ASPES, June 2010
[6] IEA Technologies Perspectives”, IEA, 2008.
[7] Study of re organization and development of the power generation sector in Romania, for increase of security and competitively in the conditions of free market - Phase II - development of the power generation sector, ISPE, 2007.

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