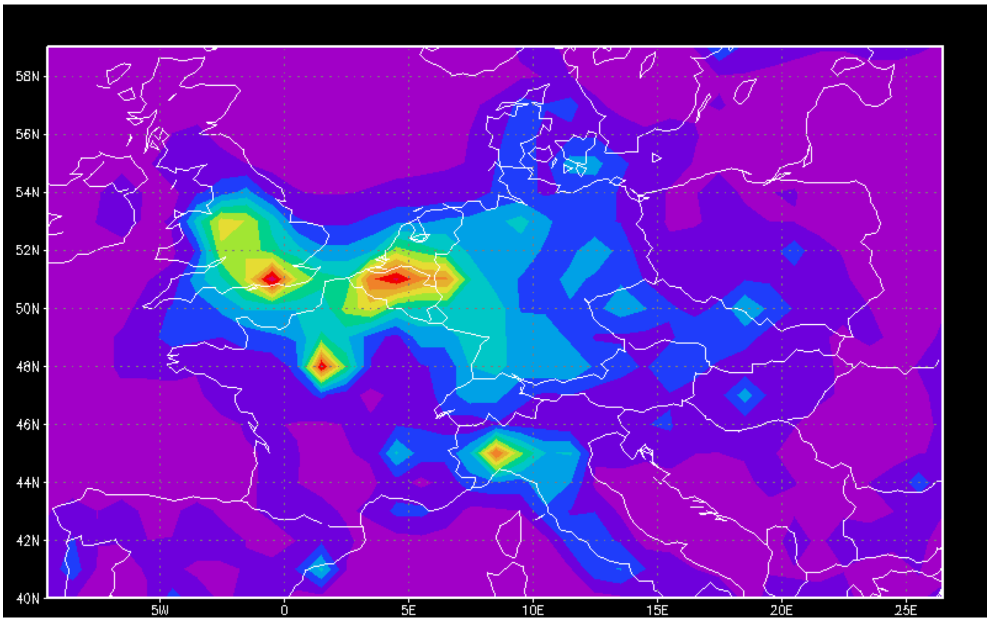
PFE INTERNSHIP REPORT

AGH University of Science and Technology
Faculty of Fuels and Energy
AGH-EDF joined laboratory for environmental impact analysis

Global comparison between France and Poland for two atmospheric pollutants



Modelisation of NOx concentration by Polyphemus for Europe (2005)

Florent SARRAZY
Promotion 2007
Option Environnement et Industrie

12th of March to 30th of August 2007
Cracow, Poland

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Figures and Tables

Acknowledgments

I first want to thank Artur Wyrwa for having accepted my request for training course within his team at the AGH University. I also thank him for his follow-up and time that he took during my various work to form me with the various tools used during this training course.

I thank then, Louis Jestin, technical director of EDF Polska who accepted to follow this training course and who helped me sometime during my stay here.

Lastly, I thank all the team with which I worked at the University: Anna, Beata, Janush and Marcin who were always been there when I needed them and who made me discover Cracow under all these facets.

Timetable

Starting & ending point	Week	Activity
12th of March – 30th of March	Week 11 Week 12 Week 13	**Global comprehension** - Readings about EDF Group in Poland - Readings about the Project - Readings different reports
2th of April – 6th of April	Week 14	Redaction of the chapter about the project and EDF group
10th of April – 27th of April	Week 15 Week 16 Week 17	**Use of Toad for Oracle** Utilization and training of the software Oracle and Toad for Oracle and data-processing SQL language
30th of April – 4th of May	Week 18	Redaction of the chapter about Oracle and Toad for Oracle
9th of May – 25th of May	Week 19 Week 20 Week 21	**Use of RAINS/ GAINS on line** - Global comprehension of the website - First comparison between France and Poland : - *energy policies* - *emissions of pollutants (according to various sectors of emissions)*
28th May- 1st of June	Week 22	Redaction of the chapter about RAINS/GAINS on line

4th of June- 6th of July	Week 23 Week 24 Week 26 Week 27	**Use of Polyphemus / EMEP** - Global comprehension of the software - Modeling maps of concentration and deposition of pollutants - Use of EMEP website to take maps of emission of pollutants
9th of July – 13th of July	Week 28	Redaction of the chapter about Polyphemus and modelled maps
16th of July – 27th of July	Week 29 Week 30	- Comparison for the project between maps of Polyphemus and maps from EMEP - Preparation of a Power Point presentation
30th of July – 10th of August	Week 31 Week 32	**Work on critical loads** - Use maps of critical loads for N and S - Use maps of exceedances for N and S - Comparison between maps
13th of August – 17th of August	Week 33	Redaction of the chapter about critical loads and comments on the maps
20th of August – 30th of August	Week 34 Week 35	- Final redaction of the report - Corrections and impression - Preparation of the return

Abstract

This training course of my last year of the Ecole des Mines de Douai proceeded in Poland between March 12 and August 30 2007 in a team of researches at the AGH University in Cracow.

It was into cotutelle with the AGH University and EDF Polska.

This project at the University has been lunched three years ago to optimize environment protection investments of EDF group companies in Poland so to meet the sustainable development criteria.

The results of the Project are to provide a feedback for building the strategy for the investments into environmental protection for the next 10 to 20 years while answering the increasing need for energy demand.

The group thus works on atmospheric models of dispersion and analyzes the consequences of these pollutants on the ecosystems and human health.

The subject suggested was a comparison between France and Poland for two major atmospheric pollutants the NOx and SOx by using a number of different tools placed at my disposal.

This study showed major differences in the deposition of these pollutants and some various consequences on the ecosystems.

The energy policies, the level of life, the geographical localization of the two countries or the brittleness of the environments are as many factors which were analyzed and which contribute to the differences observed at the time of this study.

This training course finally allowed me to discover Poland and Cracow in particular. City with a past in charge of history and which testifies also to the multiple changes that has undergoes Poland these last years.

Introduction

This training course of my last year of the Ecole des Mines de Douai, option Environment and Industry took place in Poland more precisely in Cracow between March 12 and August 30 2007.

It was held within the AGH University in a group which undertakes researches in the field of the air pollutions and these consequences on the ecosystems and human health. The team is financed by EDF Polska which takes part technically and financially in the studies.

The air pollution is indeed a major problem today. The energy policies of the last years are paid today on the ecosystem with an important acidification and eutrophication in the ground. It is thus a field where many studies are currently on the way and which is the object of many national and european programs of researches.

The subject suggested is the following: The comparison between France and Poland for the atmospheric rejections of two pollutants (NOx and SOx) and theses consequences on the ecosystems. For that, we will use for each phase described after different tools to make our analyzes and to illustrate our remarks.

The environment of work will constitute a first part of this report with the presentation of Poland and Cracow but also the two organizations which support my training course: EDF Polska and the AGH University.

The second part of the work carried out will be cut out in four distinct phases:
- A first phase of data-processing study on SQL language;
- A phase of use of the databases of RAINS/GAINS on line;
- A phase of modeling with the Polyphemus software and use of the EMEP databases;
- And finally, a work on the critical loads and their exceedances of the considered pollutants using maps.

The third part will be devoted to the personal impressions and conclusions related to the undertaken study.

I. Work environment

I.1 Poland and Cracow city

a) Generalities

Poland is a Central European country populated by more than 38 million inhabitants. It is frontier of Germany, Bielorussia, the Czech Republic, Slovakia, Ukraine and Lithuania, as well as Russian enclave of Kaliningrad (see Figure 1). Since 1st May 2004, it belongs to the European Union. However, its currency remains Zloty (PLN). Its capital is Warsaw.

Figure 1: Map of Poland

From the geographical point of view, the Polish landscape consists almost entirely of grounds constituting the European plain of North. The south is however marked by the landscape of Carpathes which forms a natural border with the Czech Republic and Slovakia. The country has a broad opening on the Baltic facilitating exports of agricultural products or manufactured and raw materials (coal) and allowing the creation of shipyards. The border with Germany was fixed on the Oder-Neisse line of the river name and its affluent located at the west of the country.

Economically, Poland has just undergone in fifteen years of deep changes which have affected at various intervals all the sectors with an aim of preparing for adhesion with the European Union (negotiations started since 1994). To leave forty-five years of communism, Poland passed almost without transition of a collectivist economy to a market economy. Modernization with forced march of the country is not completed yet but that did not prevent its integration in the Union.

Lastly, we can note the strong influence of Catholicism in Poland. 95% of the Polish people are declared catholic and 75% practice. This strong devotion influences the cultural and social life of Polish people.

b) Cracow

Cracow where is located the AGH University is one of the oldest cities and most important of Poland. Located at 300 km in the south of Warsaw, Cracow is the capital of Voïvodie of Small-Poland since 1999. Previously, it was the capital of Voïvodie of Cracow since XIVe century. The historical city is located on the Vistula at the foot of the hill of Wawel.

With its 745.000 inhabitants, it is the third larger town of Poland but it is too the arts and scientific center of the country (Figure 2). In fact, Cracow was before Warsaw the capital of Poland and it is always regarded as the true center of the country with its old traditions and its past of more than 1000 years. It is the seat of the Jagellonne University, the oldest university of Eastern Europe.

Figure 2 : Photo of Main market in Cracow

I.2 EDF Polska

EDF has been present in Poland for over 10 years. It has total generation capacity of over 3000 MWe and 5000 MWt. The Group provides a full range of energy and environmental services.

The activities of EDF Group in Poland are co-ordinated by the EDF Polska which is responsible for representing the EDF Group in Poland. Its task is also to guide and co-ordinate activities of service and production companies belonging to the EDF Group in Poland.

The EDF Group in Poland consists also of several heat generating plants (see figure 3) : Elektrociepłownia Kraków S.A, Zespół Elektrociepłowni Wrocławskich Kogeneracja S.A, Elektrociepłownie Wybrzeże S.A, Cergia S.A, Elektrociepłownia Zielona Góra S.A and Elektrownia Rybnik S.A.

Energokrak is the coal purchasing company of the EDF Group in Poland. Total volume of purchased coal reaches 7Mt per year. All the companies have obtained ISO 14001 certificate.

We can notice that Elektrownia Rybnik S.A. is one of the largest power plants in the Polish power system, 8% of the national generation.

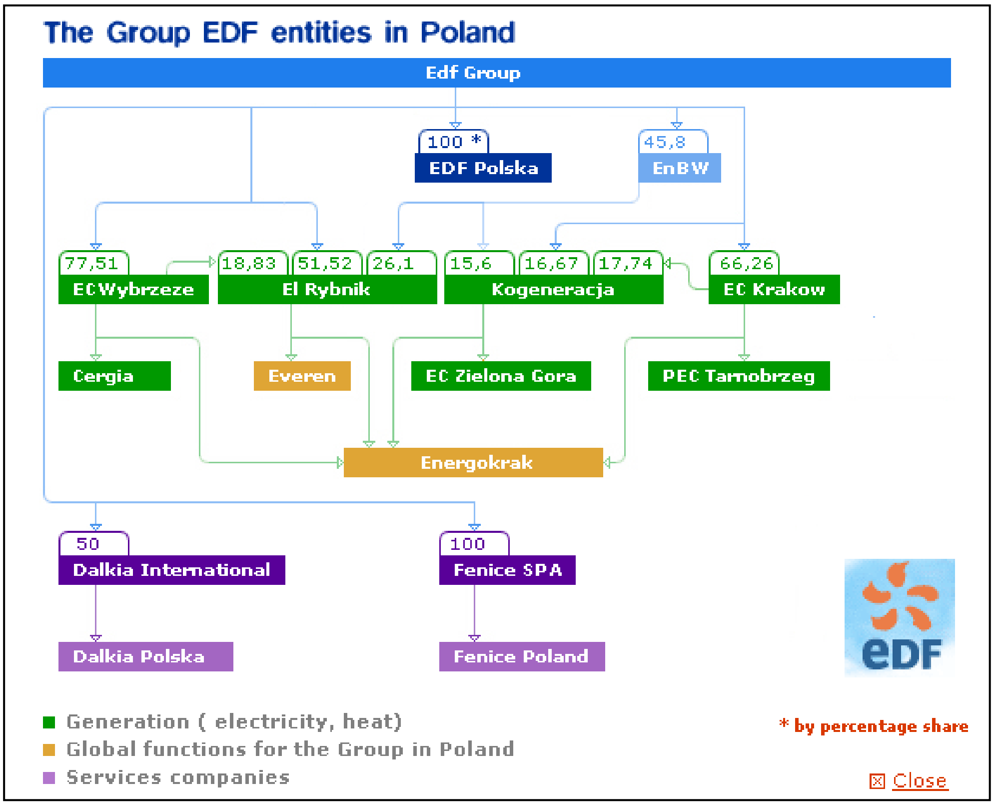

Figure 3 : The EDF Group in Poland

- Case of EC Krakow

EC Krakow belongs to the professional power sector and produces heat and electricity mainly in cogeneration. The generated heat covers 47% of the residential heating demand of the 800,000 inhabitants in Krakow city and is also supplied to several industrial sites and hospitals. The plant has an electrical capacity of 460 MW and a thermal capacity of 1376 MW.

The group works in close cooperation with EC. Krakow.

I.3 Polish energy sector

We will be interested more closely in the Polish energy sector because it directly linked to EDF Polska, the activities of my group and it will be directly in relation with the subject of my report. This sector will be thereafter more detailed.

Poland is a coal-based country which currently uses 42 % of hard coal and 34 % of lignite as primary energy (figures of 2003). Due to the large coal reserves will still remain the main primary energy fuel for power production in the next 10 to 20 years. With generation capacity of 34 GWe, Polish power system is the largest in Central and Eastern Europe. According to the latest national scenarios, the domestic consumption of final energy in 2025 is to increase by 48-55%. The current annual electricity production of 140 TWh is to grow in 2025 by 80-

93%. Despite the huge progress made in the last decade in increasing the energy productivity, the energy intensity still remains approximately twice as high as the current level in the EU-15 countries.

At the present time, the policy of the Polish State has like objective the use of coal in the electric and thermal energy sector with technology guaranteeing the reduction of the emissions of gas and dust. That remains obviously related to the fact that the production of electrical energy and thermal is based on more than 90% on coal and the lignite. Most of the installations in this sector were modernized and can be still exploited throughout 15 to 25 years.

The following figure shows the distribution of the energy sources of supply in Poland.

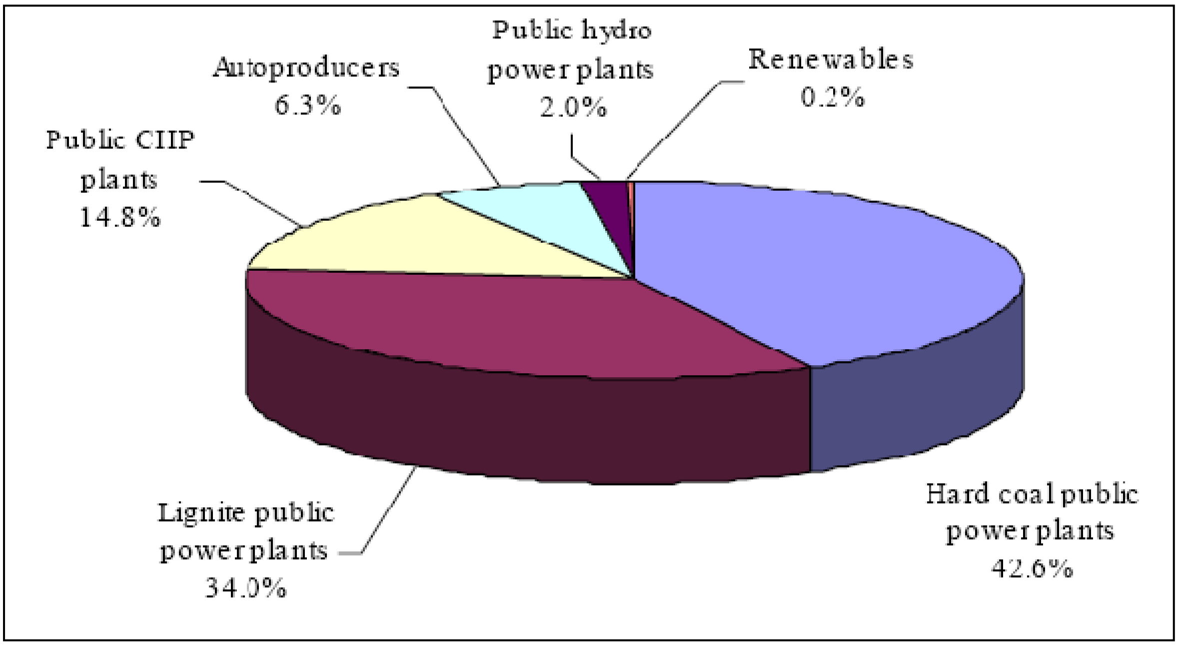

Figure 4: The structure of electricity production in Poland (2003)

It should be noted that the country currently know a debate on the energy policy in particular the security of supply through the question of the gas contracts with Algeria and Norway on the one hand and the participation in the construction of the nuclear thermal power station of Ignalina in co-operation with the Baltic States on the other hand.

Lastly, the case of renewable energies is a true problem for Poland. Indeed, to respect the objectives of the European Commission as regards renewable energies from 2020, the ratio of 20 % of renewable energies (ENR) must be included in the national energy "offer". What is far from being the case for Poland.

Poland also recalls that the construction of a nuclear thermal power station had been stopped in the years 1980 under the pressure of the Polish public opinion. It indicated that this one evolved on the appreciation of the nuclear power thanks to governmental information campaigns before considering that the country would not have an other choice that the nuclear power if the requirements as regards reduction of CO_2 emission were maintained.
Poland estimates today these restrictions of the European Union as regards renewable energies and emissions of CO_2 are unrealistic except attaching its development.

I.4 AGH University and the Faculty of Fuel and Energy

My training course was realized at the AGH University and more precisely in the department Fuel and Energy. I present here briefly the University and the department.

- University AGH (Akademia Górniczo-Hutnicza)
  University of Sciences and Technology (AGH-UST)

The AGH University (see Figure 5) was created at the beginning of 1919 to be a higher academy in Cracow to educate engineers on mines engineering and metallurgy sciences.

The University constantly grew up to become one of the major learning Polish institute in spite of some several turning points in its history: The outbreak of World War II (1939) and transformation periods (1949, 1969, 1979 and 1989). New faculties opened regularly in all the fields until reaching the number of 15 today.

It's is an unusual learning institution, as it is neither a polytechnic nor a university. It is a technical university with a nature department (the Geology, Geophysics and Environmental Protection Faculty) and a more recently established humanities department (Applied Social Sciences).

In 1949 the Academy was renamed and henceforth has been known as Academy (and later University) of Mining and Metallurgy, though the term "mining" had for ages covered metallurgy as well. In 2003 the name of the University was changed to the AGH University of Science and Technology (AGH-UST).

The University has always lived up to its motto: *"Labore creata, labori et scientiae servis"* (Created in labour, I serve labour and science).

Figure 5: The AGH University

<u>*Some figures*</u>:

- 29,000 students
- 15 faculties
- 100 specializations
- 80,000 graduates
- 3,788 workers, including 462 professors and doctors
- Publication of nearly 60000 papers and books

- Faculty of Fuel and Energy[1]

The Faculty of Fuels and Energy is one of youngest faculties at the University of Science. It is 28 years old and was formed from Institute of Mining Chemistry and Physical Chemistry of Sorbents, formely at Mining Faculty, and Department of Coke Engineering and Gas Processing, originating from Faculty of Metallurgy. After 17 years of researches and teaching activities the Institute received the status of a Faculty in 1991 and in 1994 changed its name to Faculty of Fuels and Energy.

- *Education*: Studies at the Faculty of Fuels and Energy are carried out in the following disciplines and specializations: Chemical Technology, Energochemical Coal Processing and Fuels and Energy. Studies at the Faculty are conducted at two levels: Bachelor's and Master's (full-time and extramural). The faculty actually teaches to 850 students with the help of 50 staff members and 14 professors.

- *Researches:* Research at the Faculty of Fuels and Energy is conducted in the following scientific disciplines: Chemical Technology, Chemical Engineering and Environmental Protection, with particular emphasis laid on Energochemical Coal Processing, Carbonaceous and Inorganic Sorbents and Gaining, Conversion and Effective Utilisation of Energy.

Finally, this faculty is hosting the AGH-EDF joined laboratory for environmental impact analysis in which my internship took place.

I.5 Enviro Project

« Optimizing Environment Protection Investments of EDF Polska Companies to Meet the Sustainable Development criteria »

I present here the origin and the characteristics of this project.

This project has been lunched three years ago to optimize environment protection investments of EDF group companies in Poland so to meet the sustainable development criteria.

It’s realized in the Framework of R&D Cooperation between EDF Polska, EDF R&D and the Consortium of Polish Universities. The Framework Agreement between all the Parties was signed on the 24th February 2005. The Framework Agreement provided for the realisation of ENVIRO Project (which was one of the four Project mentioned in the Framework Agreement for realisation in 2005).

The results of the Project are to provide a feedback for building the strategy for the investments into environmental protection for the next 10 to 20 years while answering the increasing need for energy demand. In the process, integrated analyses of environmental impact of EDF companies will be made using Integrated Assessment Model (IAMs) RAINS.

In particular, the ultimate objective is to find the least cost options for the fulfillment of forthcoming regulations mainly derived from the CAFE Program[2]. This is to be achieved in

[1] http://galaxy.uci.agh.edu.pl

several steps. The review of general metrological approach is presented at the figure below (and discussed in more details below Figure 6).

As we can see the key issue is to analyze an environmental and health impact of different energy scenarios associated costs and benefits taking into account external costs of energy production.

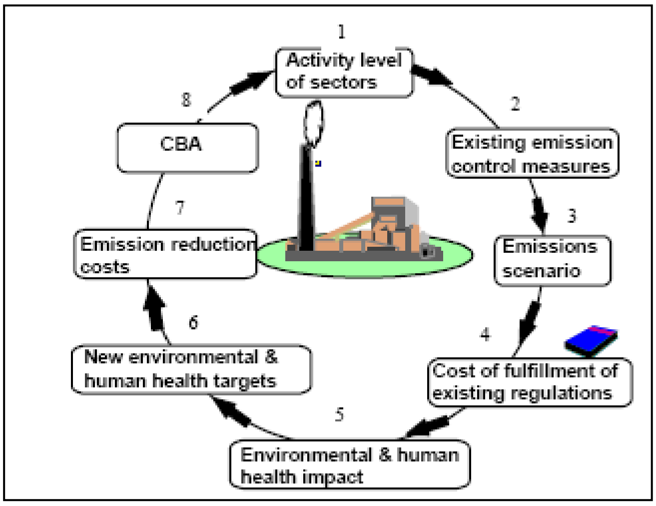

Figure 6 : Metrological approach for the project

As a final result some energy developments scenarios are to be proposed that would enable to fulfill all the international commitments and EU regulation regarding air quality, while maintaining the social and economical equilibrium.

Below the main information about the Project are listed:

1. Why the Project is important

- Emission reduction targets set by the international Conventions[3] UNCLRTAP and UNFCCC, which have been ratified by Poland, as well as EU regulations concerning air quality (CAFÉ), strongly affect the development of the Polish energy sector ;
- The adoption of relevant regulations constitutes a major financial burden for the development of energy sector;
- The number of studies on integrated environmental and health impact assessment of Polish energy sector (and other sectors) also which take into account the external costs, is not sufficient (such studies hardly exist) ;
- It is of great importance to provide the least cost solutions to maintain the environmental, social and economical equilibrium at present and also in next decades.

[2] CAFE Program: The aim of CAFE was to develop a long-term, strategic and integrated policy advice to protect against significant negative effects of air pollution on human health and the environment for Europe. (http://ec.europa.eu/environment/air/cafe/index.htm)
[3] Described in Terminology

2. Genesis of the problem

- Poland is a coal-based country, which currently uses 52% of hard coal and 13% of lignite for its primary energy demand and will still remain the main energy carrier in, at least the next 10 to 20 years ;
- Poland is the largest SO_2 emitter in Europe with significant emissions of other pollutants like NO_x, PMs or Mercury;
- Most of the existing power plants will need complete replacement or overhaul over the coming twenty to thirty years;
- Significant amount of bad quality coal is burnt outside the LCP sector without any emission control measures implemented.

3. Actions undertaken to provide some possible solutions

- Transfer of knowledge and tools from some cooperation with European institutes (CEREA, IIASA and EIfER) to Poland that enable the integrated assessment modeling at the local, regional and transboundary level ;
- Creation of the working group consisting of well known experts in the research area of the Project;
- Strengthening of the cooperation with international institutions.

4. Tasks

- Modeling of atmospheric dispersion of pollutants at the national and regional level (in regards to the latter in particular in regions where EDF companies are present) using POLAIR 3D model;
- Preparation of the emission databases;
- Preparation of the historical data on and modeling of the future activity levels of sectors (giving the emphasis on the energy sector);
- Integrated environmental (and health) impact assessment of Polish energy sector (EDF companies);
- Cost benefit analysis of the environment protection investments of EDF companies;
- Optimization of the investments to meet relevant regulations Further development and improvements of methodology and tools.

5. Objectives of research project

As already mentioned, the analysis is to provide the feedback for building EDF Polska strategy for the investments into environmental protection for the next 10 to 20 years while answering the increasing need for energy demand.

II. Work realized

II.1 Global comprehension

a) Readings

It was necessary at the beginning of my training course to have a phase of intensive reading to understand works and researches which are undertaken within the University and within the project in particular. These readings were articulated around 2 broad topics: The place of EDF in Poland and the group “Enviro-project” itself. The readings are presented in bibliography.

That enabled me to understand why and how such a project was born, why EDF finances this project but also the place of the group at the AGH University and with the other participants in the global project (Polish universities, foreigner research centers …) and the objectives that our group must achieve.

This phase was essential to define with my responsible the plan of this report and the objectives which I was personally to reach (detailed in the following paragraph). That was essential to know which will be the interest of my report and my results and which benefits I could bring to the project during my placement to the AGH University.

b) Work suggested *(see figure 7)*

The principal set of themes of my work in Poland was “the comparison between France and Poland for some atmospheric pollutants (NOx and SOx in particular) by using various tools (softwares and different tools available)”. Using some different tools for two reasons:

- To support my work firstly;

- And for a teaching reason: To know the existing tools for such work, use these tools during my internship and be capable to use again if necessary during my professional future career.

Work suggested (detailed in the timetable and on the figure 7) is:

→ *Utilization and training of the software Oracle and Toad for Oracle and data-processing SQL language*.

- A first phase of work on the databases of the project to be able to be autonomous and handle the data which interests me.

→ *Utilization of the software on line RAINS and GAINS-Europe on line*

- First comparison between France and Poland in terms of energy policies, emission of pollutants according to various sectors of emissions… starting from existing data available for public.

→ *Utilization of the software POLYPHEMUS and use of EMEP databases*

- Comparison between France and Poland by modeling maps of emission, concentration and deposition of pollutants NOx and SOx with a software of modeling: Polyphemus but starting from data available on the website EMEP[4].

→ *Utilization of maps realized by the group and maps from EMEP*

- Work on the consequences of deposition in the ground of these 2 pollutants: Critical loads of N and S and their exceedances which are responsible of acidification and eutrophication of our ecosystems. Use some maps made by the project and EMEP of critical loads and their exceedances for France and Poland. The figure 7 shows the global system of the work presented.

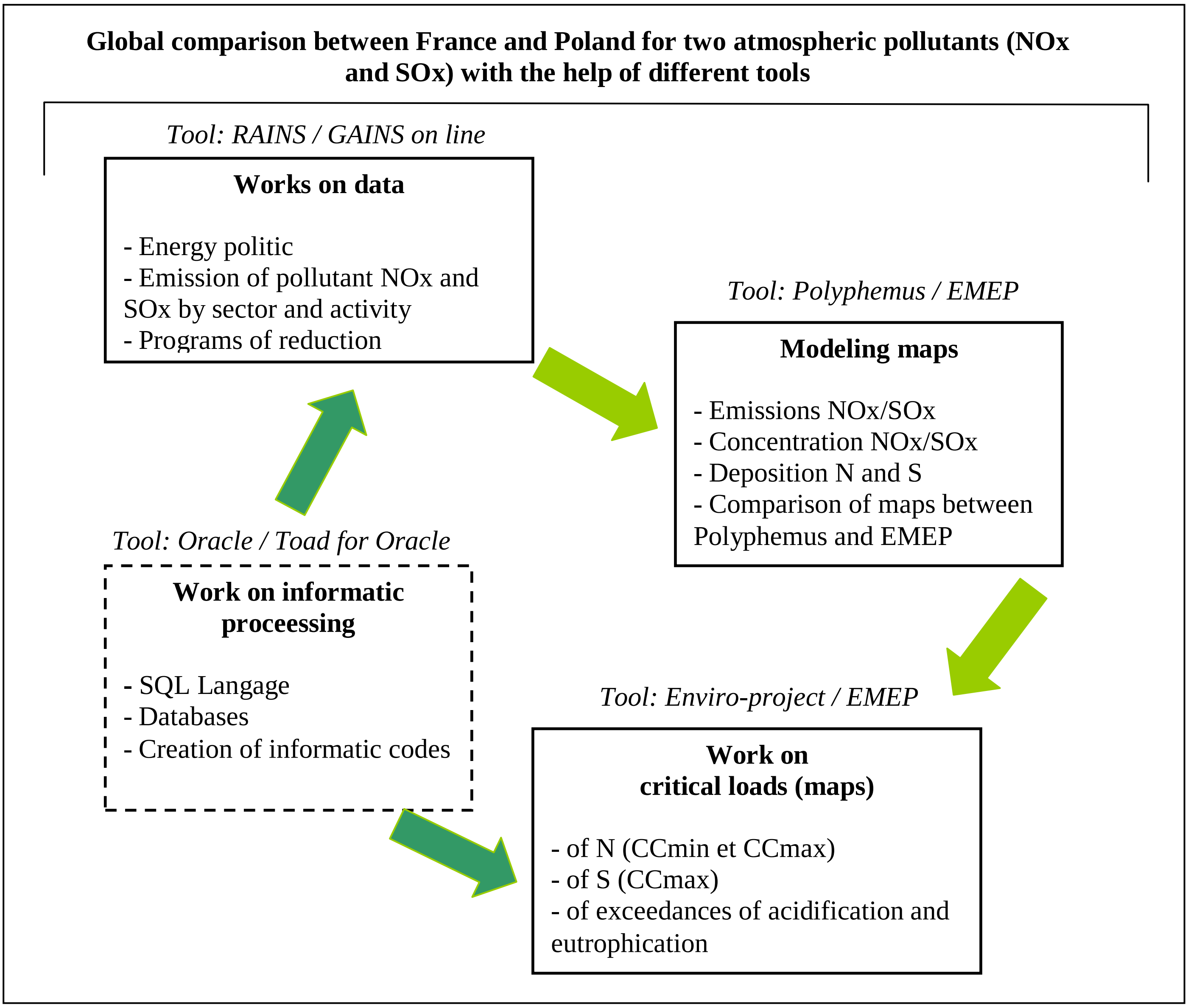

Figure 7: Global system of the suggested work

[4] EMEP : Co-operative program for Monitoring and Evaluation of the long range transmission of air Pollutants in Europe (*www.emep.int*), described after.

c) Informatic knowledges

First preparatory phase of my work in the AGH University, it was necessary for me to improve my knowledge in data processing. Indeed, the databases used within the framework of this project are under a particular data-processing format which was necessary to me to apprehend to be able to handle them. The project works with Oracle[5] and Visual Basic software which allow us to stock and to build databases by using SQL language and its derivatives.

Within the framework of my work, it was expected that I use the existing databases to extract some data (starting with simple requests) which would me useful during my various missions of training course. I thus followed during the first weeks of my placement, a training to understand and use SQL language on simple databases under Oracle (and more particularly under "Toad™ for Oracle" which is a tool used to manage Oracle databases).

These databases concerning all the data collected on the boilers in Poland (number, type, power, age, type of emitted rejections….). These are used after for example to make modelings of pollutant dispersion using other software.

I present thereafter simple examples of type of request ("codes") which I could make.

d) Example of requests under "Toad™ for Oracle"

- Presentation of Toad™ for Oracle[6]

It is a data-processing tool which makes possible to accelerate the development and to facilitate the administration of the Oracle databases. It facilitates the implementation and the control of the good practices of administration and development of the Oracle databases by a reinforcement of its functionalities of automation and reporting. We can test and improve quality of the tested codes since the control of conformity to the standards of development and the good practices until the automatic optimization of SQL code and to the tests of rise in load.

- Use of Toad for Oracle

I just present here the graphic interface and the possibilities offered (figure 8). I will not present in detail SQL requests just the results obtained.

[5] The software are presented and clarified in appendices
[6] Toad™ for Oracle : www.toadsoft.com

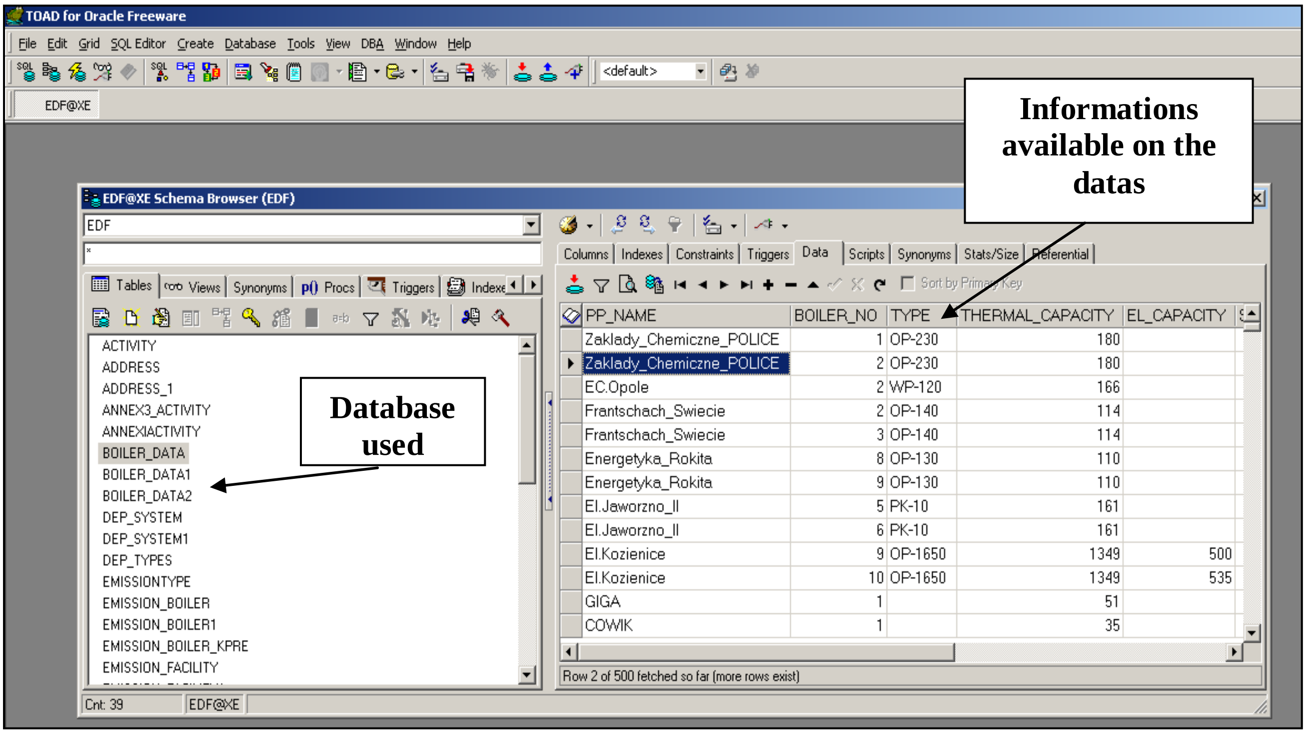

Figure 8 : Graphic interface of Toad for Oracle with the project databases

The following figures introduce the editor of codes which allows us to handle the existing databases. The requests are written in SQL language. Here some examples of requests which I used:

- Selections of data of various sources to be able to compare them (Figure 9):

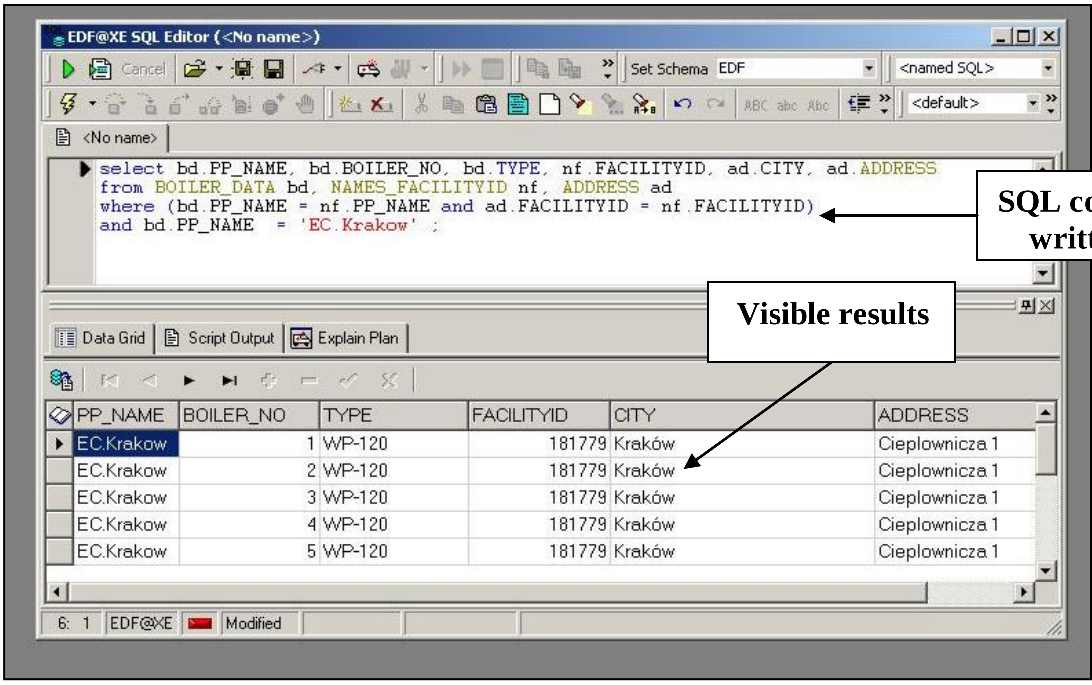

Figure 9 : Selection of data in Toad

- Creation of new tables with existents data (Figure 10):

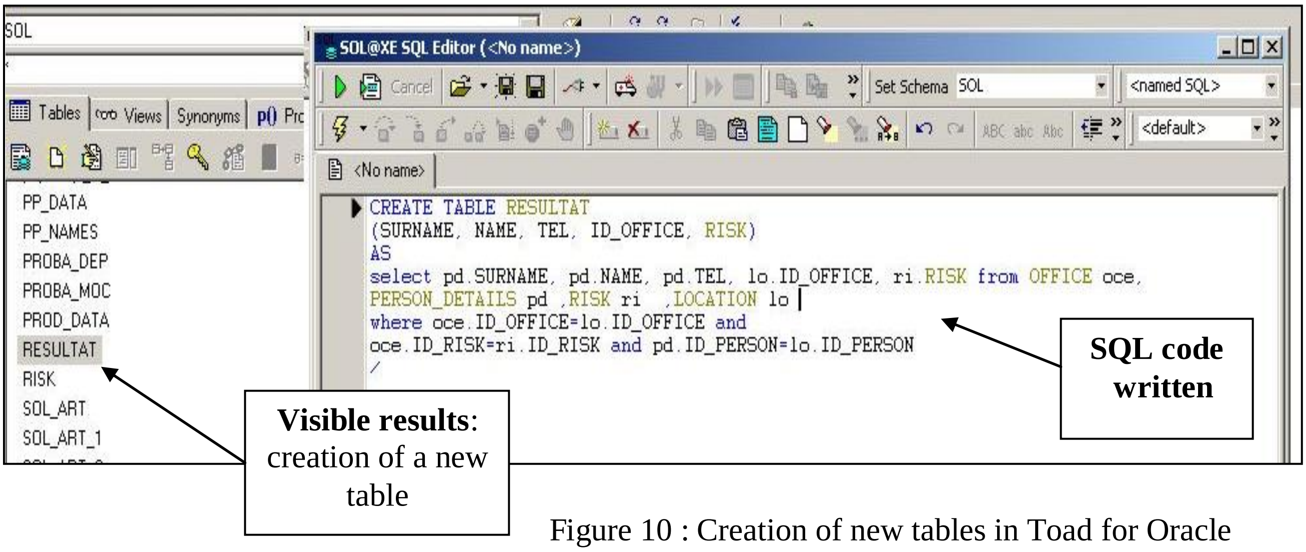

Figure 10 : Creation of new tables in Toad for Oracle

- Updates of data (figure 11):

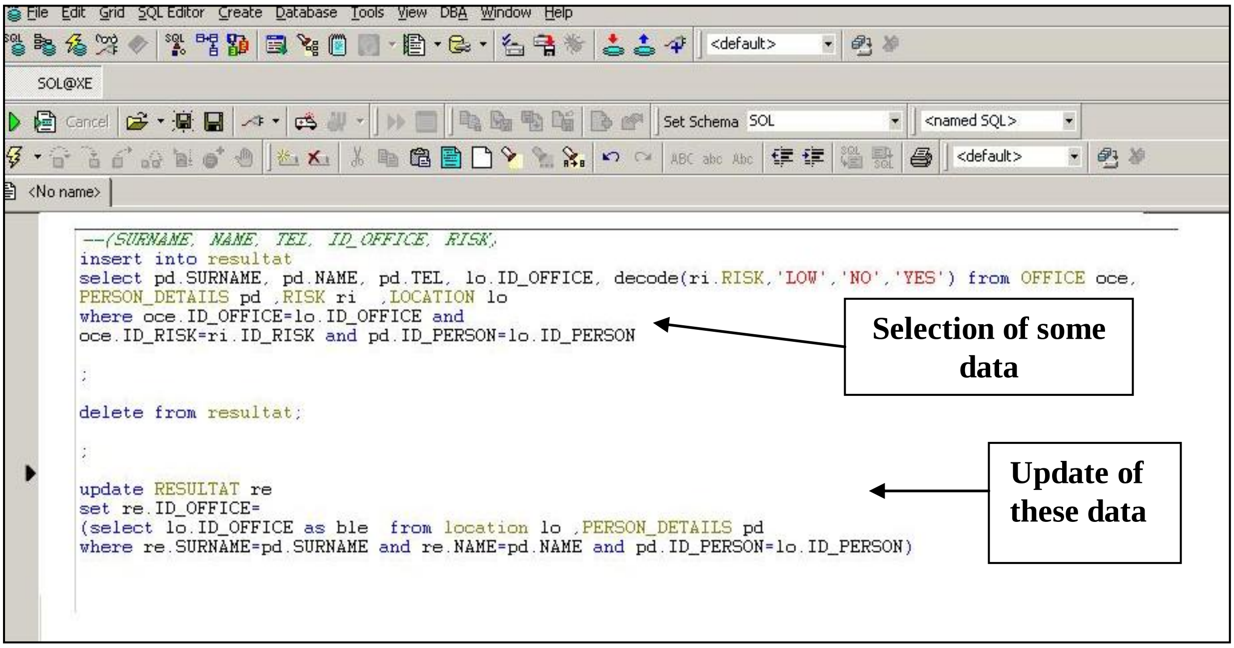

Figure 11 : Some examples of data updating

These examples illustrate the exercises that I could make to learn how to use Toad™ for Oracle and SQL language. That was useful all along of my training course.

II.2 The RAINS model

Regional Air Pollution Information and Simulation
RAINS
Atmospheric Pollution and Economic Development (APD)

a) Global presentation

The Regional Air pollution INformation and Simulation (RAINS) model, developed by the International Institute for Applied Systems Analysis (IIASA) in Austria, combines information on expected trends in anthropogenic activities that cause transboundary air pollution with data on the available options for reducing emissions from these activities and their costs. Dispersion models are used to calculate how these emissions are transported over Europe and how they influence air quality. With the resulting ambient concentrations and deposition fields of the various pollutants, RAINS estimates the impacts on human health and ecosystems. These expected impacts can then be compared with environmental targets, highlighting areas where the assumed measures fail to meet the environmental policy objectives. A unique feature of the model is its ability to investigate the optimal distribution of further reduction efforts across the whole of Europe (from Norway to Italy and from Spain to the Urals) to meet air quality objectives. For this, the current RAINS model balances controls for SO2, NOx, NH3, VOC and particulate (PM) emissions to reduce impacts on human health, acidification and eutrophication.

Recently, the RAINS model has been extended to capture (economic) interactions between the control of conventional air pollutants and greenhouse gases. This GAINS (Greenhouse gas – Air pollution Interactions and Synergies) model includes carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), the F-gases (Klaassen *et al.*, 2004). Thereby, the traditional RAINS model constitutes the air pollution-related part of the GAINS model, while the GAINS extensions address the interactions between air pollutants and greenhouse gases. The baseline projection for the revision of the NEC directive relies for the air pollutants SO2, NOx, VOC, NH3 and PM2.5 on the traditional RAINS model, while the projections for CO2 have been developed with the recent GAINS extensions.

The next figure presents the all possibilities for the RAINS-GAINS software (Figure 12):

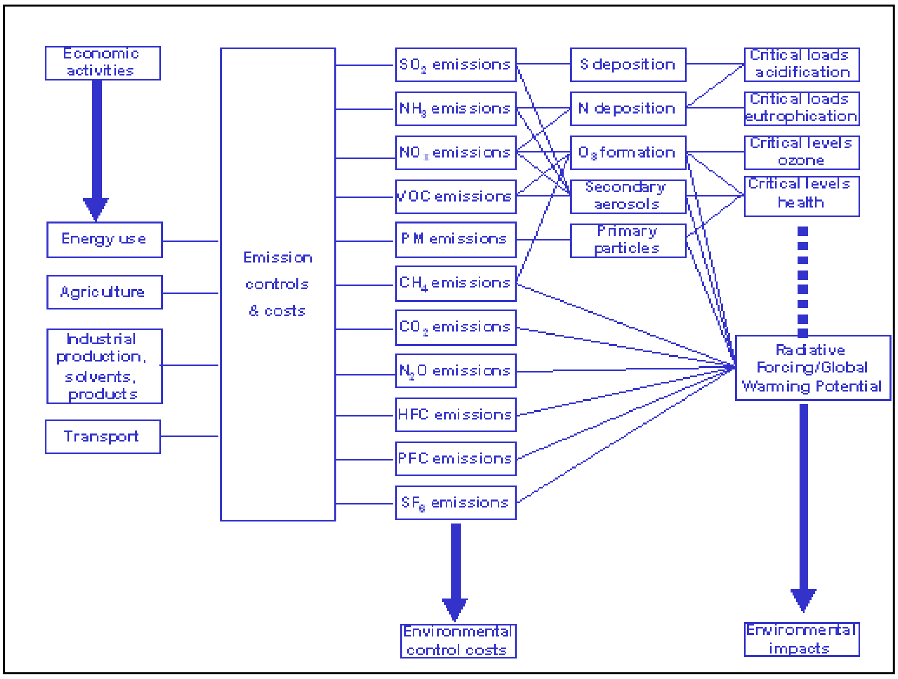

Figure 12: Presentation of Rains software

b) Input data in RAINS-GAINS Europe model

➢ Concept

GAINS
Greenhouse Gas - Air Pollution Interactions and Synergies

With this online version of the RAINS model (which allows on-line access to the GAINS-Europe model), we can explore the environmental impacts of alternative emission control strategies and their economic implications for the various economic sectors in the 43 European countries. The RAINS model follows for a given pathway of economic development air pollutants from their sources (energy combustion, industrial production, agriculture) over their transformation and transport in the atmosphere to their impacts on human health and ecosystems.

For such an analysis, we need to choose from the menu displayed above (see Figure 13):

- A pathway of economic development (“activities”),
- The set of emission control (legislation) that you want to analyze (“control”),

With this information, the model computes (see Figure 13):

- Emissions of the various pollutants that result from your selected economic pathway and the control legislation (“emissions”),
- Costs of the emission control measures you have selected (“costs”), and
- Impacts on air quality, human health and ecosystems (“impacts”).

➢ Results available

Under each tab, we can:

- Display results of the RAINS calculations,
- Examine input data used for the calculations,
- And, if applicable, modify settings and data for your own analysis.

By comparing alternative emission control scenarios we can explore their costs and environmental impacts. With the “optimization feature” of RAINS, we can conduct a systematic search of least-cost packages of measures that achieve environmental objectives.

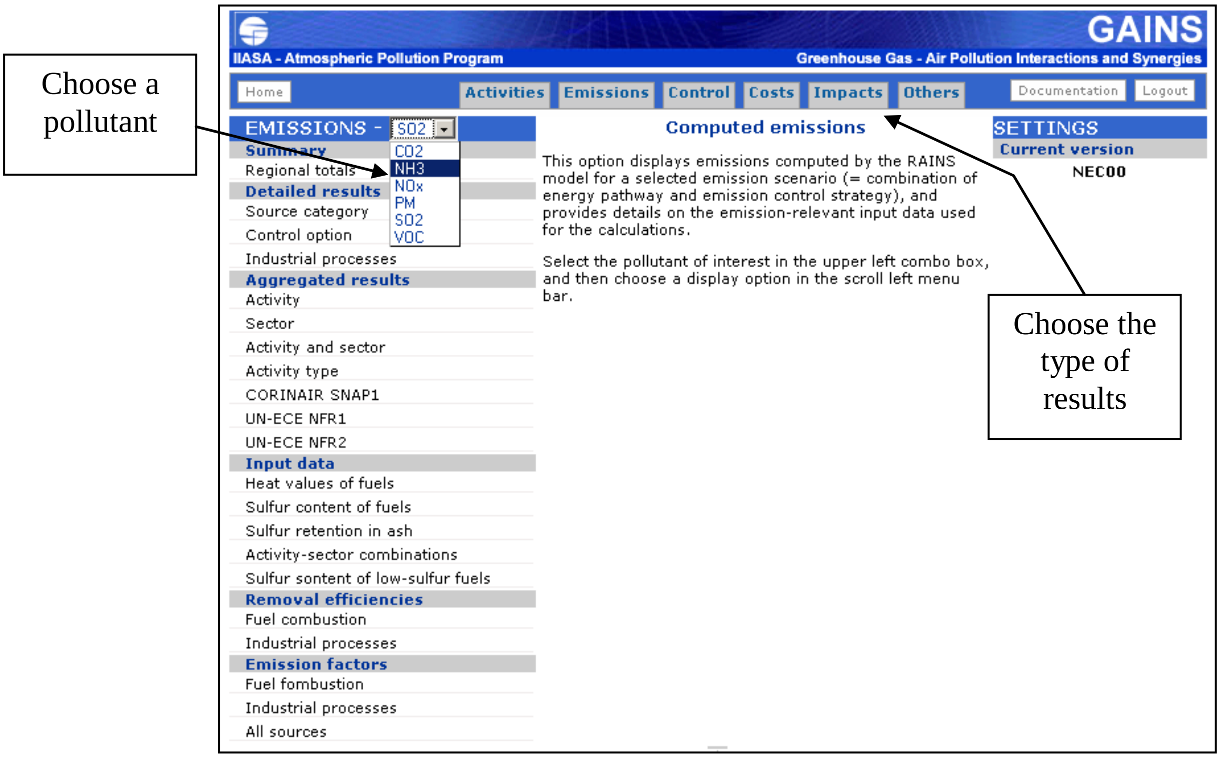

Figure 13: Presentation of the interface of GAINS-Europe on line

c) Presentation of the work with RAINS-GAINS Europe model

In the first time, I will compare the differences of energy politic between France and Poland and after I will make a comparison of the results of pollutant emissions (NOx and SOx) by activities and sectors. Finally, I will analyse the projects of reduction of these pollutants (Scenario De-NOx and De-SOx) in the two countries. All the analysis will be made for a projection to 2020.

This work will introduce the simulations which will come after and will help us to understand the differences of the emitted pollutions for the two countries.

We choose some data in Gains-Europe on line:

- *Scenarios:* National Scenario (NEC_NAT_CLE4REV [7])
- *Results by:* Global consumption of Energy (Industry and Domestic), Activities and Sectors
- *Countries:* France and Poland
- *Emissions:* NOx and SO2
- *Dates:* 2000, 2005, 2010, 2015 and 2020

[7] National baseline scenario (as of December 2006) with emission controls reflecting current legislation (national activity paths, CLE control strategies).

d) Use of RAINS/GAINS-Europe on line

All the tables are presented in the Appendices.

- Comparison of energetic consumption between France and Poland (projection for 2020 in PJ).

For Industries (Power Generation and District Heating)

The associated tables enable us easily to see the energy policy differences between France and Poland.

Indeed, France launched out in an ambitious program of nuclear power stations. The installation of nuclear power stations with 63 GW installed at the end of 1999 per 58 engines makes it possible to contribute to a total value of 71%, nearly 88 Mtep with the produced primary energy in a national way. Per inhabitant, France is the second country in the world for its brut nuclear production with 6,7 MWh per inhabitant and per year behind Sweden (7,9).

Because of this nuclear capacity, France became one of the carbon dioxide less producer countries for example due to energy, the 23rd place of the OECD countries producer of CO2 with only 1,8 ton of carbon per inhabitant and per year.

That also makes it possible France to export electricity in very large quantity (2700 PJ planned for 2020).

The other sources of energy for France remain negligible.

Poland on the contrary put all on its production of high quality coal to ensure its needs for industry in electricity (Poland is the 8th world coal producer with a production of 178 Mt in 2004). But it intends to develop in parallel the gas resource with the construction of new installations although it is tributary of Russia for its supply gas.

It should be noted however that the three Baltic states and Poland study the joint construction of a nuclear power station in the east of Lithuania and that as regards recourse to the wind power, Poland would be well positioned with a working installed capacity at the end of 2005 of 71,8 MW and a production of 0,131 TWh (15th position in the UE-25). It thus diversifies its sources of energy. We can quote the remarks of Mr. Jan Tombiński (ambassador of Poland in France) on the questions relating to energy[8] . He specified that Poland committed itself respecting the ambitious objectives established at the European conference of March 2007 in order to encourage the recourse to renewable energies and to reduce considerably the greenhouse gas emissions.

He fears however that this objective does not go against the economic re-establishment of Poland which should increase its consumption of energy. “We will encounter some problems to reduce the power consumption and we expect an increase in the use of energy”.

The diplomat stresses that coal will remain an important source of energy for Poland and while the country actively seeks to develop other sources like renewable energies and the

[8] Interview given to EurActiv.com the 4/04/2007

biocarburants, another solutions will have to be considered: “The next step will be perhaps the creation of a nuclear power station in Poland”.

For the Transport et Domestic-commercial activities

For the power consumption in housing and the commercial sector, France positioned on two sources: Gas and electricity (2/3 of the overall consumption). Poland, on the contrary diversifies its sources of energy with 11 different sources of energy. We can find more or less in equivalent quantity: coal, gas, electricity, the derivative of oil….Some being rather polluting that does not contribute to decrease the emissions of pollutants.

However, the geothermic sources of water are one of the richnesses of Poland more or less exploited up to one recent period, these are regarded as being most important in Europe. It appear on 1/3 of the country territory and these reserves represent approximately 3,5 billion tons of potential fuel. It would be possible to guarantee the heating for approximately 30 million people. This is why projections for 2020 give a significant part to this type of energy.

For transport as we will see it for pollution by NOx, we find some very important emissions for France in the fuel consumption (more than gas or electricity for the domestic and commercial sector). Poland remains on reasonable consumption for its transport sector.

- Comparison of the results of pollutant emissions (SO2 and NOx) by activities and sectors in kT of pollutant.

- SO2 (some recalls on the compound)

The sulphur dioxide (SO2) results from the sulphur fuel combustion (Diesel). In general it is emitted at the same time as the particles. SO2 is partly responsible for the acid rains (continental scale). The inhaled SO2 molecules are stopped by nasal defences and are thus generally inoffensive. However, in the case of fragile people at very strong rates of inhalation, they can amplify the effects of the other pollutants. In France, transport is responsible for the emissions of SO2 to a total value of 13%.

By Activities

We observe overall for the years to come a significant fall from the SO2 emissions for France and Poland (forecasts until 2020). The SO2 emissions remain important in Poland but it makes important efforts to reduce its emissions (forecast of 857 Kt SO2 against 500 Kt SO2 in France for 2020). It should be noted also that France has many sources of SO2 emissions but in small quantity (12 sources of pollution identified, the most pollutant is the activity “No fuel use”) whereas Poland concentrates them in large quantity on one or two activities (“Hard Coal and Brown Coal”). Lastly, we can announce the weak share of the emissions in Poland coming from renewable energies but it is an activity which is into full rise.

By Sectors

It is noticed easily that for Poland the principal SO2 emission comes from the sector “Power and District Heat Plant”. However this one should reduce its emissions by two in the 10 years to come (estimate in 2000: 980 Kt SO2 for a forecast of 414 Kt SO2 in 2020). The second generating sector of emission is “Combustion in residential-commercial sector”. This is obviously related to the fact that Poland concentrates its activities on the coal which remains a source of very polluting energy.

Whereas for France, all the sectors are polluting but into weak quantities (around 50-70 kT SO2 by sector). Our highest sector of pollution being Processes. It is important to notice that the emissions of certain sectors are in increase for 2020 ("Process, Fuel production and Conversion and Power and District heat Plant").The reason is the emissions come especially from the fixed sources of combustion such as the power stations functioning with the fuel or with coal (more than 90% of the emissions) and theses sectors don't use the best available technology. Finally, transport represents a negligible share in the SO2 emissions. That will not be the case for other pollutants.

- NOx (some recalls on the compound)

The oxides nitrogen (NO and NO2, noted NOx) come from the oxidation of air nitrogen during combustion of the fuel. The nitrogen oxides are precursors of the atmospheric ozone which in the event of strong concentrations is dangerous for health.

NO is not very toxic. Its effects are rather little known and these pollutants seem negligible for the contents which is responsible for automobile pollution. However NO is rather easily oxidized in NO2. It is when it able to be fixed on the air cells and to deteriorate them.

By Activities

We observe overall for the years to come a significant fall from the NOx emissions for France and Poland (forecasts until 2020). But this time, it is France which has the double of the emissions taking into consideration forecast for 2020 (860 Kt NOx for France against 430 Kt NOx for Poland). The most polluting activities remaining the combustion of oils (fuel, gasoline….). The analysis by sectors will allow us to understand this established fact. It should be also noted that we consider an increase in the emissions related to renewable energies because of French policy which encourages the development of this type of energy.

For Poland, it is a little bit different: We find like source of important pollution the combustion of coal also accompanied by the combustion of oils but these emissions remain weak. Poland envisages a rise of the emissions related to the gas distribution for the years to come. This is to be put in relation to the energy policy of Poland which intends to develop this source of energy (see "Energy Consumption by Power Generation").

By Sectors

We easily identify the reason of the strong NOx emissions in France: The transport sector. Indeed, the principal source of nitrogen oxide emission (NOx) in France is the motor vehicle traffic (approximately 45% of the emissions envisaged for 2020). We noted 960 Kt NOx of emissions related to transport for an emitted total of 1475 Kt NOx in 2000 (either meadows of 65%). Efforts are to be implemented although this sector remains most polluting.

This evolution results from the growth of mobility, itself dependant on the growth of the PIB, the evolution of level of life and an increase of use of the private car, the plane for small destinations and the road for the goods.

However, in spite of the increase of the oil consumption, the transport sector was the subject of a weak assistance targeted on the control of energy and on the other hand was affected by various public policies as regards town planning, of investments in infrastructures of transport and taxation. That should change in the years to come.

Lastly, it should be noted that for France only one sector envisages increases in terms of NOx emissions: The sector "Industry, Combustion in boilers". This is to be put in relation to the construction of new installations in this sector.

For Poland, it is the sector "Power and District Heat Plant (existing and new)" which most polluting (35% of the total emissions, rate which drops very little until 2020 because of construction of new installations). The reason is always the same one: Poland privileges coal like source of energy. It's followed a little bit by the transport sector. But Poland plans to reduce by 3 these emissions for 2020.

- Projects of reduction of these pollutants :

Use of "control strategy viewer" of GAINS-Europe on line (a summary of the data is presented in appendices)

Control strategies define how the available emission control measures are applied to the different emission source categories. Control strategies determine the percentage of activity in the entire sector to which a given control measure is to be applied. Control strategies combined with activity pathways define the emission scenarios in RAINS.

In particular, a control strategy may reflect the emission and fuel quality standards resulting from the current legislation in a given country (the Current Legislation - CLE). Alternatively, a control strategy could specify the maximum implementation of all available emission control measures (the Maximum Technically Feasible Reductions - MTFR) to explore the lowest level of emissions achievable with contemporary emission control technologies.

A table for every pollutant is displayed and its shows for the selected country and each emission source category the extent (percent of activities) to which the various emission control measures will be applied over time.

- SO_2

We will examine more closely the sectors and activities identified previously like most polluting and/or in increase.

For France, we had identified three polluting sectors in increase ("Fuel Production and Conversion, Process and Power & District heat plants"). We can notice that efforts are made (applications of measures of controls) to reduce the pollution of the activity "Heavy Fuel oil" and the sector "Fuel production & Fuel conversion-Heavy" (to 85% on the activity) which remains most polluting for the SO_2 emissions. Also, efforts are planned for the years to come to reduce pollution resulting from the sectors "Ind. Process: No fuel uses - Process emissions" (more particularly the sector of the non-ferrous metals, from 80 to 100%).

However, we noted an increase in pollution for these sectors in 2020. These efforts thus do not seem sufficient but especially can be targeted too much on a type of precise activity.

Lastly, the sector “Power & District heat seedlings-Coal/Fuel” is particular. Indeed, the efforts relate to into major part the new installations (100% of measurements of controls) and not the existing installations (except the installations Coal type), which also explains the increase in the emissions of this sector planned for 2020.

For Poland, two activities had been identified as very polluting (“Brown Coal” and “Coal Hardware”) which are in relation to the sectors “Combustion in residential-commercial sector” and “Power & District heat plants (existing)”. It appears as for France that the efforts especially seem to relate to the new installations (at 100%), the existing installations profit from less follow-up (between 30 and 40% on average) for the industry and the little assistance brought to the residential sector. That explains the weak falls of SO2 emissions envisaged between 2010 and 2020.

- NOx

For France, we had identified like sector more polluting: Transport (in relation to the activity “Medium distillated-Fuel oil”. The results show that France made efforts at 2020 for all the type of vehicles and fuel but in limited quantity (30% on average with installation of the EURO standards) on the other hand it put all on the "clean" fuels (Natural gas, Liquefied petroleum gas…) with controls at 100% to lower its NOx emissions.

For Poland, it had been highlighted two polluting activities: “Hard Coal” and “Medium distillated-Diesel/Fuel oil” to put in relation to the transport sector as for France and the “Power & District heat plants (existing). Although Poland intends to develop its sector of industries “Hard Coal”, it envisages large efforts in this sector (with controls between 60 and 100% on average). This is why we observe a very important reduction of the NOx emissions at 2020 (we observe a division by 3 of the emissions). For transport, we notice the same phenomenon as for France: Measures are taken for all the type of vehicles and fuels (installation of the EURO standards) with a more important support for the "clean" fuels.

e) Conclusion

This first phase enabled us to apprehend RAINS/GAINS tool on line which appears very complete and easy to use. We can easily compare the various European countries according to multiple scenarios.

Concerning our first phase of studies, the comparison of France and Poland already allowed us to note several things:

- France and its energy policy based on the nuclear power minimize its SO2 emissions. These are the processes in France which contribute more to this type of emissions. This sector is the subject of control measurements in an important way but only for the new installations. What explains why the SO2 emissions are not envisaged with the fall.
France still rejects much NOx like all the big capitals because of the transport sector. However, new measurements and financial incentives should contribute to decrease these emissions.

- For Poland, its energy policy based primarily on coal makes that this country is the principal European pollutant of SO2. Measurements taken should also concern only the new installations which explain the weak falls estimated for the years to come.
On the other hand, Poland emits few NOx because of a level of life less important than in the countries of the West. But it is a problem that this country will have to manage in the years to come with its development.

The following phases with in particular the realization of maps of pollutant dispersion will allow us to illustrate our remarks here and to identify precisely the sources of pollution in France and Poland.

II.3 Simulations with Polyphemus

a) Presentation of Polyphemus

Polyphemus[9] is an air quality modeling platform which aims at covering the scope and the abilities of modern air quality systems. It deals with applications from local scale to continental scale, using two Gaussian models and two Eulerian models. It manages 5 passive tracers, radioactive decay, photochemistry and aerosol dynamics. The structure of the system includes four independent levels with data management, physical parameterizations, numerical solvers and high-level methods such as data assimilation. This enables sensitivity and uncertainty analysis, primarily through multimodel approaches. On top of the models, drivers implement advanced methods such as 10 model coupling or data assimilation.

In short, Polyphemus is designed and built to:

- Handle several dispersion models, from local scale to continental scale, for passive transport, gaseous chemistry and multi-phase chemistry;
- Host high-level methods in which a model is essentially a black box, e.g., model validation, data assimilation methods, ensemble forecast, models integration;
- Provide facilities to manipulate atmospheric data and to manage numerous physical parameterizations.

It is composed of:

- A chemistry-transport-model (CTM) called Polair3D;
- A library of physical parameterizations called AtmoData;
- A set of programs using AtmoData and designed to generate data needed by Polair3D (deposition velocities, vertical diffusion coefficients, emissions, etc.).

Polair3D mainly solves the chemistry-transport equation, without physical computations in it. Indeed, most fields that are usually computed through physical parameterisations are provided to Polair3D, not computed within Polair3D. For example, the user has to provide pre-computed vertical diffusion coefficients to Polair3D which will then solve the diffusion equation. AtmoData provides the physical parameterizations that Polair3D misses. It is a set of functions that implement parameterizations (e.g. cloudiness diagnosis) or basic formulae (e.g. Richardson number). A complete Polair3D simulation needs the following data:
Meteorological fields: horizontal components of the wind for Polair3D, temperature, pressure, specific humidity, altitudes of cloud basis, rain, and cloud attenuation coefficient, deposition velocities, biogenic and anthropogenic emissions, initial and boundary conditions.

AtmoData may be seen as a toolbox to deal with data for atmospheric sciences. It includes SeldonData which provides an object-oriented framework to deal efficiently with multidimensional data (for example, through input/output operations in many formats). The last part of Polyphemus is a set of programs that generate data for Polair3D. Of course, those programs mainly use functions from AtmoData.

[9] Polyphemus has been developed at CEREA (joint laboratory Ecole des Ponts et Chaussées and Electricité de France R&D, Paris – http://www.enpc.fr/cerea/) and INRIA (CLIME project – http://www-rocq.inria.fr/clime).

So to conclude, a typical simulation of atmospheric dispersion with Polyphemus follows the four following steps (See figure 14):

- **Phase I:** Preparation of i.e. databases: meteorological fields, emission databases, land use coverage (and miscellaneous data associated with land categories), pollutant concentrations at higher scales (e.g. global concentrations, which constitute the boundary conditions for continental simulations), physical parameters associated with chemical species (databases described below).

- **Phase II:** Generation of the inputs for Polair3D from these databases: some fields need to be adapted to the simulation's caracteristics (domain, time step, species). Some other fields such as vertical diffusion coefficients need to be computed on the basis of physical parameterizations. All these fields are strongly linked to the raw data (contained in the previously mentioned databases) since they use these data as input. This step is achieved by using a set of programs that make calls to functions available in AtmoData.

- **Phase III:** Run of Polair3D: the chemistry-transport model is the last step in the simulation process. From the generated input fields, it computes the evolution of the pollutant concentrations.

- **Phase IV:** Realisation of maps (concentration, emission….)

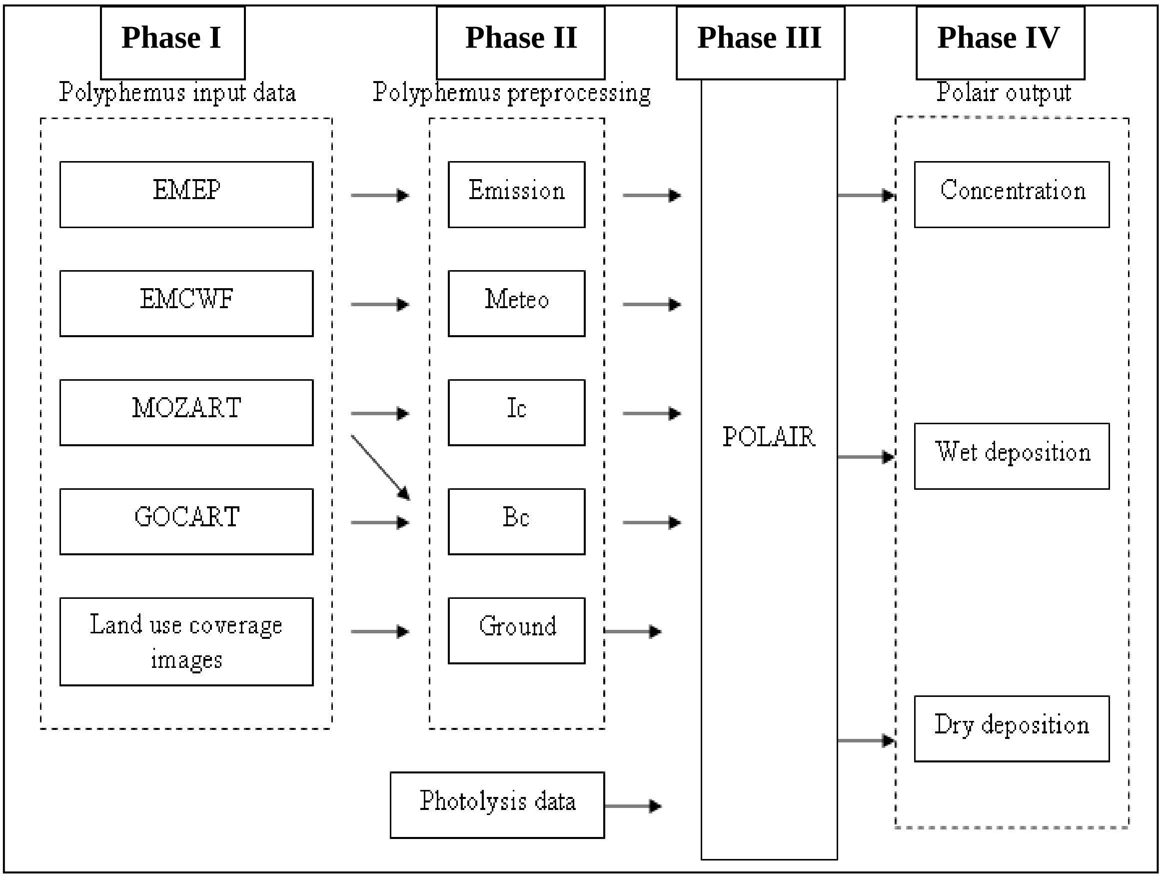

Figure 14 : Polyphemus phases for analysis

b) Presentation of the work with Polyphemus

This model is used in the project for modeling atmospheric dispersion of pollutants at the national and regional level (in regards to the latter in particular in regions where EDF companies are present) using POLAIR 3D model.

For my work, we will model the following maps for Europe (not need to model specifically for France and Poland, the European maps are sufficiently clear) over one year (2005). The maps presented are thus representative of an average over one year:

- Maps of pollutant emission obtained starting from the EMEP[10] website

- Emissions in NOx (T/grid) *(one grid = 50 km x 50 km or 0,5° x 0,5°)*
- Emissions in SOx (T/grid)

These maps will allow us to have a first view of the dispersion of these pollutants for Europe. These are the data which are then used by Polyphemus for the data emissions (see paragraph input data) for modeling maps of pollutant concentration and deposition.

- Maps of polluant concentration

These maps will enable us to illustrate the work already undertaken starting from the data of RAINS and to confirm or not the analyzes already carried out on the two countries.

- Concentration in NOx (µg/m^3)
- Concentration in SO2 (µg/m^3)

- Maps of pollutant deposition

These maps will be useful thereafter for work on critical loads for acidification and eutrophication.

- Deposition in S total (wet and dry, mg/m^2)
- Deposition in N total (wet and dry, mg/m^2)

c) Input data

For the Phase I “input data”, the following data coming from various databases were input in Polyphemus:

- ECMWF (European Center for Medium Range Weather Forecasting) for meteorological data (data from year 2005);
- EMEP for emission data: SNAP categories S1 to S11;
-MOZART2 (Horowitzetal., 2003) for climatological concentrations: Specifically gaseous species from the global chemistry-transport (data from year 2000);
- GOCART (Chinetal. 2000): for aerosols (sulfate, dust, black carbon and organic carbon, data from year 2000);

[10] http://webdab.emep.int

- Land use coverage images for ground data: USGS -24 categories (U.S. Geological Survey) and GLCF (14 categories) (Global Land Cover Facility).

Generated files may be used for simulations using the chemical kinetic scheme RACM (Regional Atmospheric Chemistry Modeling).

d) Phases of simulation: *Realization of maps*

The 4 steps described previously were thus followed step by step. They made it possible to arrive at the maps presented below. An important thing need to be noted is the time necessary for the realization of this study.

- Phase I: 1 day

- Phase II: 2 days

- Phase III: 2-3 days

Moreover, I was helped to carry out these maps because Polyphemus is a complex software to use.

➢ Maps of pollutant emission (EMEP)

- *Presentation of EMEP Program* :

The Convention on Long-range Transboundary Air Pollution (LRTAP), signed in 1979, is one of the central means for protection of our environment. It establishes a broad framework for cooperative action on reducing the impact of air pollution and sets up a process for negotiating concrete measures to control emissions of air pollutants through legally binding protocols.

In this process, the main objective of the EMEP program (Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air pollutants in Europe) is to regularly provide Governments and subsidiary bodies under the LRTAP Convention with qualified scientific information to support the development and further evaluation of the international protocols on emission reductions negotiated within the Convention.

Initially, the EMEP program focused on assessing the transboundary transport of acidification and eutrophication; later, the scope of the programme has widened to address the formation of ground level ozone and, more recently, of persistent organic pollutants (POPs), heavy metals and particulate matter.

The EMEP program relies on three main elements: (1) collection of emission data, (2) measurements of air and precipitation quality and (3) modeling of atmospheric transport and deposition of air pollution (maps). Through the combination of these three elements, EMEP fulfils its required assessment and regularly reports on emissions, concentrations and/or depositions of air pollutants, the quantity and significance of transboundary fluxes and related exceedances to critical loads and threshold levels. The combination of these components provides also a good basis for the evaluation and qualification of the EMEP estimates.

- *Scenarios retained*:

- Expert Emissions / Year 2004 (2005 no available)
- Sectors: all SNAP (S1 to S11)
- Graphic map Mercator (0, 5°x 0, 5°)

SNAP: The emissions in the EMEP database are divided into the following activity sectors:

S1. Combustion in power plants and industry
S2. Non-industrial combustion
S3. Combustion in manufacturing industry
S4. Production processes
S5. Extraction and distribution of fossil fuels
S6. Use of solvents and other products
S7. Road transport
S8. Other mobile sources and machinery
S9. Waste treatment and disposal
S10. Agriculture
S11. Other sources and sinks

- *NOx*

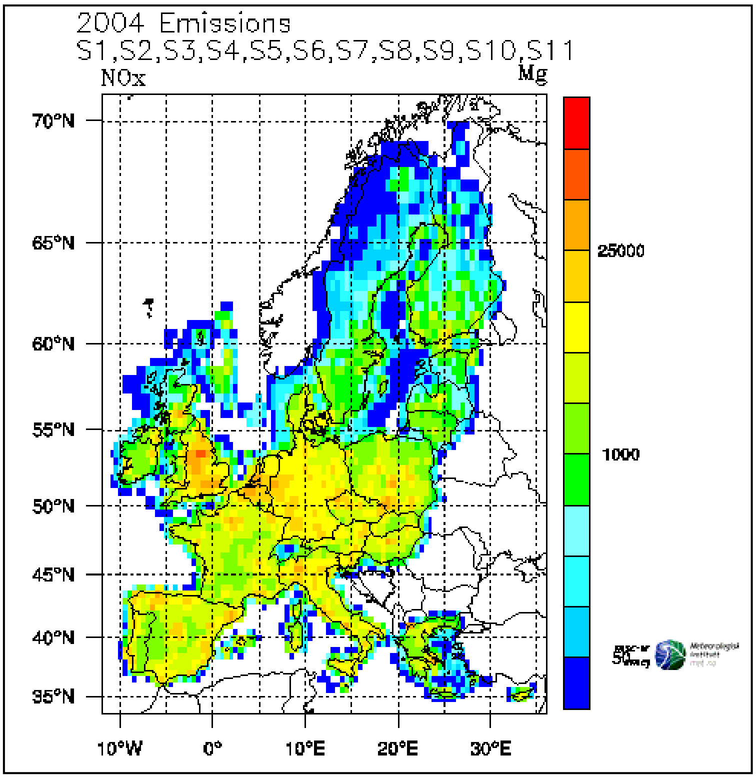

Figure 15 : NOx emission for Europe (T/grid)

This first map (figure 15) shows a relative homogeneity for Europe as regards NOx emissions, these values are nevertheless rather high. We distinguish however already some important emission points like the big capitals (London, Paris or Brussels). These points will be thereafter more detailed on the other maps. The lowest emissions are identified close to the coasts.

- *SOx*

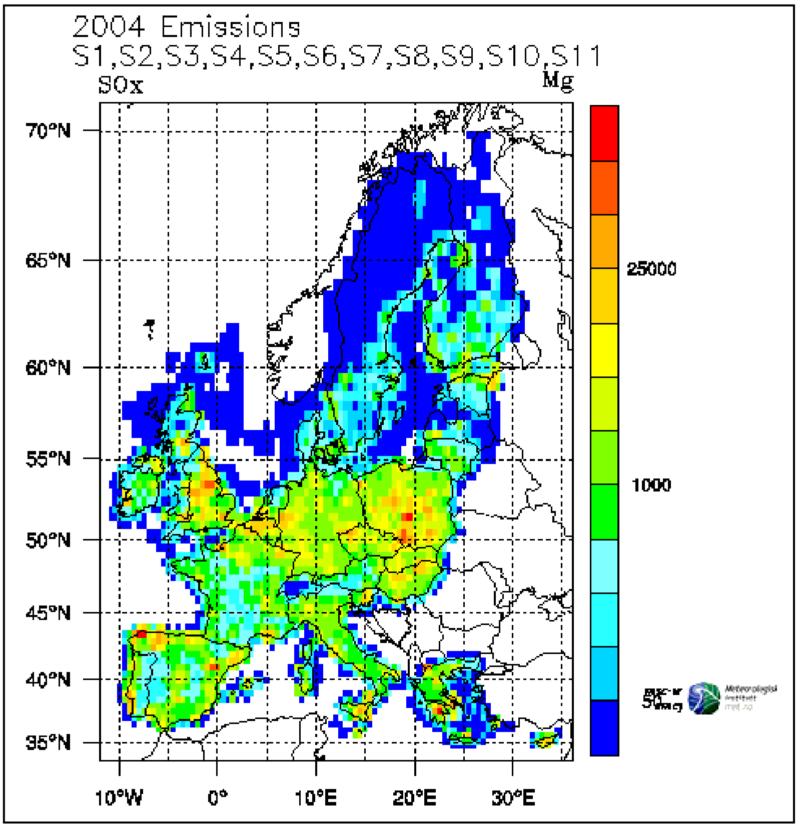

Figure 16 : SOx emission for Europe (T/grid)

This map shows heterogeneities in Europe (figure 16). The Eastern European countries like Poland present important values of SO2 emissions for some localized sectors.

For Western Europe, it is always the United Kingdom and Belgium which present high thresholds. France presents low values in lower part of the European level.

The following maps will allow us to better understand these phenomena. The lowest emissions are also identified close to the coasts.

- Maps of pollutant concentration (Polyphemus)

- *NOx*

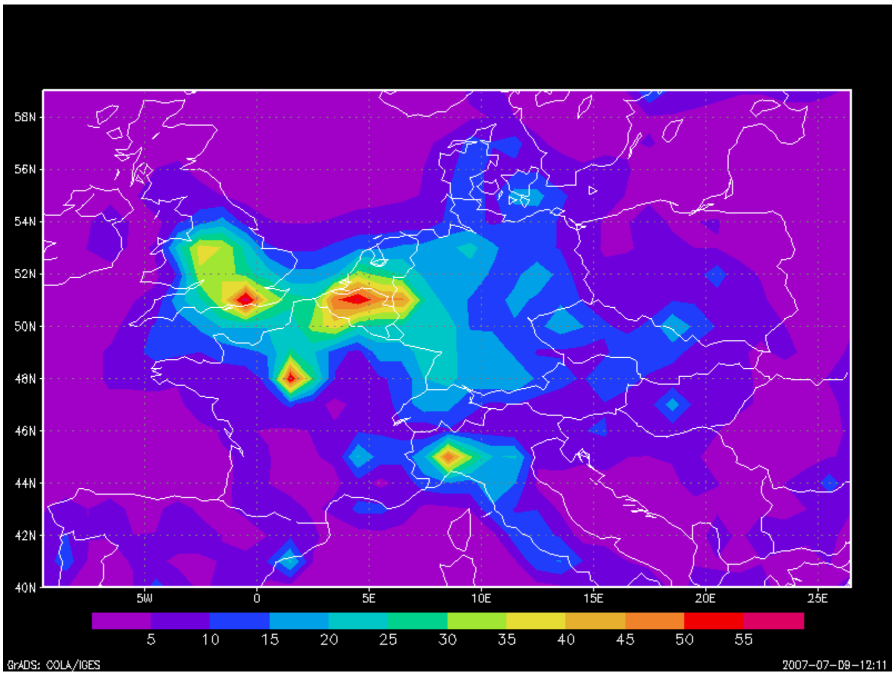

Figure 17 : NOx concentration for Europe (µg/m^3)

It is good to recall as previously known that the NOx[11] emitted result mainly from the transport activity (combustion of fuel) to more than 60% (the remainder being primarily the industry activity "production of electricity" (power station)).We can note several things here:

- The highest concentrations appear for very localized points (figure 17). These points correspond exactly to the big capitals or big European cities: Paris, London, Brussels and Milan. These very big cities have preoccupations with transport with a very important number of cars or too localized industries at the same place. However, we will limit ourselves the analysis of France and Poland.

- For France, the analysis starting from the data of RAINS had already shown important NOx emissions because of transport and industries. That is confirmed here for two points: Paris and Lyon. Paris is a very polluted city with a very strong concentration of cars, trucks and two-wheeled vehicle, its geographical localization in plain does not arrange anything. For Lyon, it is a little bit different the very strong concentration of industries in the Lyons area contributes to this visible NOx issue rate.

- For Poland, it is completely different. The various analyzes with RAINS had shown weak NOx issue rates. That is observable on the map. Two particular points are noted: Warsaw and the area of Cracow. These emissions are more imputable with manufacturing industries (50% in 2000) than road transport (27%).

Indeed, if we take for example the town of Cracow: It is a town of average size (800 000 inhabitants) with an important industrial center (steel-works and power station) and an

[11] It is pointed out that NOx = NO + NO2

important automobile traffic. Industries emit the major part of the sulphur dioxide (SO2) and as much of carbon monoxide (CO) that transport but is also responsible for the majority of the emissions of oxides nitrogen and particles (See Table 1). Whereas in the majority of the towns of Western Europe, transport is the principal source of CO and NOx because heavy industries were moved and often replaced by clean and less polluting industries.

Sector / Pollutant	**CO**	**NOx**	**Dusts**
Transport	48 %	15 %	2 %
Industry	44 %	83 %	89 %
City Economy	8 %	2 %	10 %
Total	100 %	100 %	100 %

(Source : Inspectorate of Environmental Protection in Cracow, 2001)

Table 1 : Pollutant emission for Cracow

- SO2

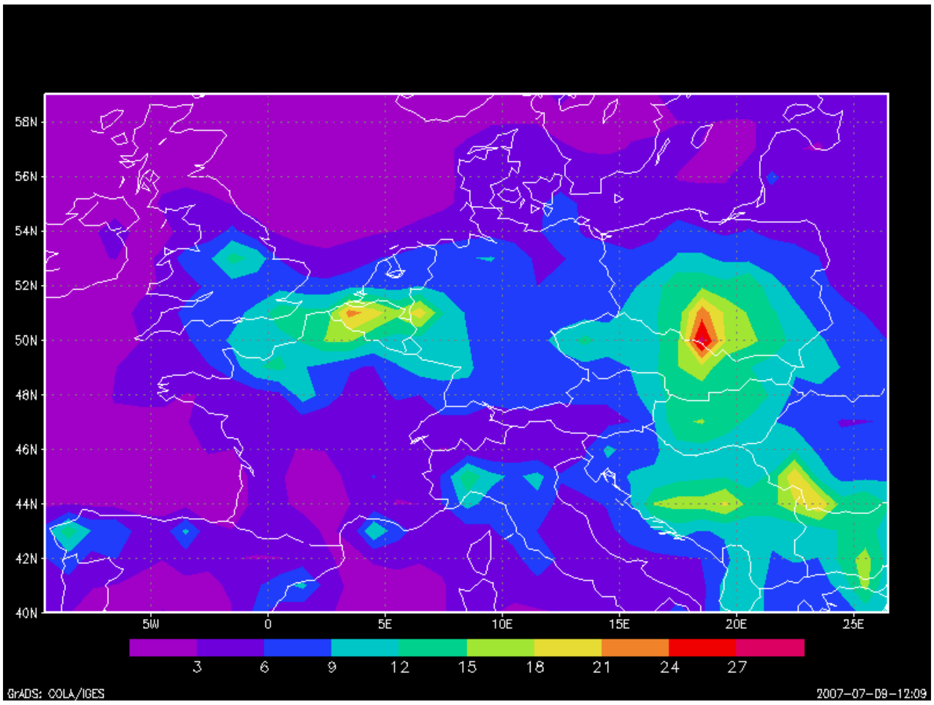

Figure 18 : SO2 concentration for Europe (µg/m^3)

It is pointed out that the dominating sectors of SO2 emissions are industries of electricity production and refining of oil.

- For France (figure 18), we observe that there is no major point of SO2 emissions (the emissions of Paris contribute however to the cloud of pollution coming from the countries bordering). That holds several factors: Due to a fall in fossil fuel use for energy production following implementation of the French nuclear energy programme and, to a lesser extent, energy conservation measures. More recently, this reduction has been the result of legislation being implemented with the aim of reducing the sulphur content of certain fossil fuels (heavy fuel oil, domestic heating fuel, diesel oil) combined with a switch from sulphur-intensive fuels to fuels with a low sulphur content or sulphur-free fuels, such as natural gas.

- It should be however noted that in France the highest concentrations are observed in the Northeast. The reason is the transboundary pollution. The average source/receptor matrices computed by the EMEP models confirm these conclusions. SOx depositions in the northern part of France are largely influenced by emissions from Belgium, Germany and United Kingdom.

- For Poland, the map is very clear. We easily observe the consequences of an energy policy based with 90% for the production of electricity on coal and the lignite. Poland is one of the first European pollutants in terms of SO2 emissions. The focus of pollution in SO2 is localized in the south where many factories produce electricity with coal, precisely in the most polluted regions in Poland: Upper Silesia and so called before Black Triangle. However, Distinct lowering tendency of SO2 concentrations has occurred during the past few years at the Polish area of the Black Triangle.

➢ Maps of pollutant deposition (Polyphemus)

- *Deposition in S total*

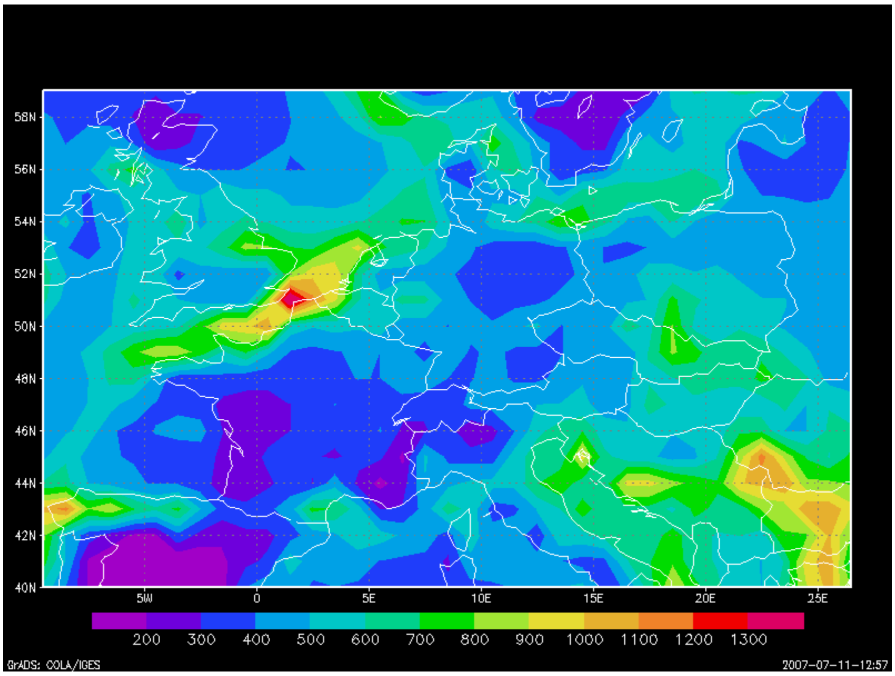

Figure 19 : Deposition in S total (wet and dry, mg/m^2)

The map 19 observed shows the total deposition in S wet and dry together (the total deposition being mainly represented by the dry deposition, it was not necessary to present several maps).

Wet deposition (rain, snow, spindly, fogs or clouds...) is only a part of the total deposition to the ecosystems. The wet deposition dominates in many areas at least those with high precipitation and those with low concentrations of sulphur compounds in air.

In addition to the wet deposition, dry deposition (dry particles or gas) processes and fog and cloud water deposition contribute to the total deposition. The dry deposition contribution is considerable in areas with high concentrations of air pollution and is enhanced in forested ecosystems. Generally, the importance of dry deposition of sulphur decreases and the importance of wet deposition increases with distance from the source.

It also should be known that sulphur dioxide is the main sulphur compound contributing to dry deposition of sulphur in Europe. Sulphate particles contribute to a less extent although in very remote locations the contribution from particulate sulphate can dominate. At such locations however wet deposition will anyway be more important. Since the sulphur dioxide concentrations have decreased more rapidly with the emission changes than both sulphate particles in air and sulphate in precipitation, the importance of dry deposition in Europe has decreased more rapidly than the wet deposition. This can be seen when studying trends for throughfall data. Throughfall data for sulphur has been shown to be a good estimate of total sulphur deposition in forests.

As can be seen on the figure 19, the maximum deposition in S is mainly seen near the important source areas, over the seas and along the coasts.

- For Western Europe and France, the depositions observed are localized in the Manche sea close to an important focus of SO2 emission like already described previously: Belgium.

- For Poland, the depositions observed very close to those observed for SO2 are located in the black triangle in the south of the country.

These results will be useful for us for the following chapter on the critical loads.

- *<u>Deposition in N total</u>*

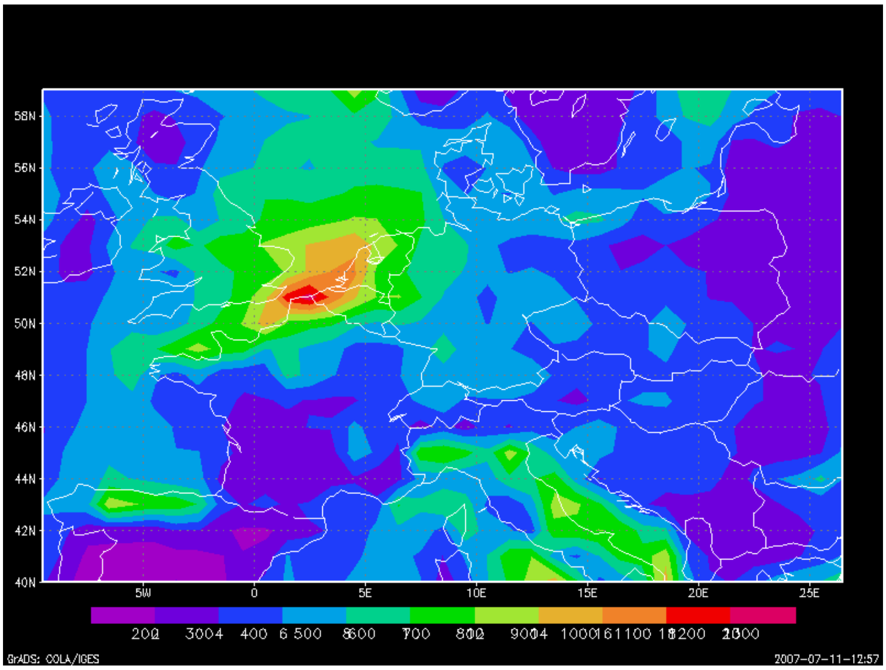

Figure 20 : Deposition in N total (wet and dry, mg/m^2)

The map 20 observed shows the total deposition in N (wet + dry). The deposition of total nitrogen is needed for many applications in the critical load framework. It is defined as the sum of total deposition of:

- Reduced nitrogen (NHx): *[NH3 dry deposition, NH4+ aerosol deposition, NH4+ wet deposition, NH4+ cloudwater/fog deposition];*
- Oxidised nitrogen (NOy): *[NO2 dry deposition, HNO3 dry deposition, NO3 - aerosol deposition, NO3 - wet deposition, NO3 - cloudwater/fog deposition]*.

We observe strong similarities with the map of the total deposition of S. The sectors of pollution are more or less localized at the same places.

Globally, the differences between regions are however more significant than for sulphur. Some countries and regions have succeeded to reduce their NOx emissions with 40-50%. The largest decrease has taken place in the former eastern European countries (Czech Republic, Latvia, Poland and Slovak Republic) and it is the result of their reductions to a large extent arises from closing lignite-fired power plants, restructuring the energy sector and introducing flue gas cleaning technology. Also Germany and Switzerland have achieved a nearly 50% reduction of the NOx emissions. The decrease in the main part of Western Europe is around 30%. In southern Europe, the emissions have not changed and in several Mediterranean countries the NOx emissions have actually increased.

The main decrease during 1990 to 2000 has occurred for stationary combustion in power plants, industry and for residential heating, with almost 40% decrease. The decrease in transport emissions has been of the same order of magnitude as for the total NOx around 25%. A growing concern is for the emissions on international waters due to shipping. These emissions increase in importance (20% of the total emission in 2000) when other emissions are reduced.

- For Western Europe and France, the localized depositions in N total with the Northern point of France are only the consequence of the strong NOx emissions of the three big capitals Paris, Brussels and London already observable on the map of the concentrations of NOx.

It is important to note that for France: 65 to 80 % of nitrate is exported in oxidised and about 35% of reduced nitrogen is exported to the neighbouring countries, in the north (UK, Germany, Belgium) and in the Mediterranean region (Italy, Spain).

These results will be useful for us for the chapter following on the critical loads.

e) Conclusion

This phase of studies enabled us to illustrate and visualize clearly the important zones of pollution in Europe and more particularly in France and Poland.

We could confirm our analyzes and comments which had been made starting from RAINS.

Then, I could use on the one hand, a very powerful software Polyphemus for modeling pollutant rejections but which remains complicated for it use and other part EMEP, tool at the disposal of general public which appears easy to use and very complete.

The last phase of studies on the critical loads will show us the consequences of these depositions of pollutants for the environment by using other tools.

II.4 Critical Loads

From the years 1970, the atmospheric sulphur depositions were indicated like responsible for the deterioration of certain forests in Germany and Scandinavia. The link with the emissions coming from the industrial activities was quickly made. It is now known that sulphur oxides, oxides of nitrogen, ammonia and chlorine rejected into the environment by the human activities have an acidifying effect on the grounds and on natural waters. These substances transported in the atmosphere on long distances form a diffuse and transboundary pollution.

The critical loads concept is an effect-based approach that has been used for defining emission reductions aimed protecting ecosystems and other receptors.

Sustainability indicators are defined for specific combinations of pollutant, effects and receptors. Critical loads provide a sustainable reference point against which pollution levels can be compared.

It can further be used for calculating emission ceilings for individual countries with respect to acceptable air pollution levels (e.g., defined reductions of critical load exceedances).

a) Description of mechanisms: *Definitions*

- Acidification

The acidity of a ground or a surface water is caused by the presence of protons (H+). Their chemical character enables them to be in many reactions while supporting some, by preventing others. They react with many substances of water and ground, solubilizing metals, dissociating the acids organic and intervening in biological operations of many organisms. This presence in broad quantity make an acid area, which is measured by a low pH.

An aqueous area of which acidity increase (and the pH decreases) tends to become oxidizing and, starting from a certain threshold of acidity, less and less favourable with the development of living organisms.

- Eutrophication

Eutrophication is a phenomenon which was initially described for surface water and coastal water. It corresponds to an increase in the productivity of the algae followed of their degradation which leads to a partial or total deoxygenation of area. In lakes, it is a slow and natural phenomenon corresponding to the ageing of the area. It is however accelerated by the anthropic rejections of nutrients (and especially of phosphorus).

The contribution of nutrients increases the productivity of the area and disturbs the natural geochemical cycles, particularly by increasing the demand for oxygen and in modifying flows of nutrients during the degradation of the vegetable matter at the end of its cycle life, for example at the end of the summer.

➢ Critical loads (Figure 20)

The general definition of a critical load is "*a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge*".

This definition applies to different receptors (e.g., terrestrial ecosystems, groundwater, aquatic ecosystems, and/or human health). 'Sensitive elements' can be part or whole of an ecosystem or of ecosystem development processes, such as their structure and function.

Critical loads have been defined for several pollutants and effects resulting from their deposition.

- *Acidification*

Critical loads of sulphur and nitrogen acidity for an ecosystem have been specifically defined at the Skokloster Workshop (Nilsson and Grennfelt 1988) as: "*the highest deposition of acidifying compounds that will not cause chemical changes leading to long-term harmful effects on ecosystem structure and function.*"

Both sulphur and nitrogen compounds contribute to the total deposition of acidity. The acidity input has to be considered in this balance regardless whether it is due to *S* or *N* depositions. Thus, the ratio between sulphur and nitrogen may vary without change in the acidity load.

- *Eutrophication*

In addition to acidification, inputs of nitrogen may influence the eutrophication and nutrient balances of ecosystems. The critical load for nitrogen nutrition effects is defined as: "*the highest deposition of nitrogen as NHx*[12] *and/or NOy below which harmful effects in ecosystem structure and function do not occur according to present knowledge.*"

Critical loads for heavy metals are defined accordingly. The basic idea of the critical load concept is to balance the depositions which an ecosystem is exposed to with the capacity of this ecosystem to buffer the input (e.g. the acidity input buffered by the weathering rate), or to remove it from the system (e.g. nitrogen by harvest) without harmful effects within or outside the system.

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[12] NHx = NH3 + NH4+ ; NOy = NO + NO2 + NO2- + NO3-

The figure 21 explains in details the phenomenon of critical loads.

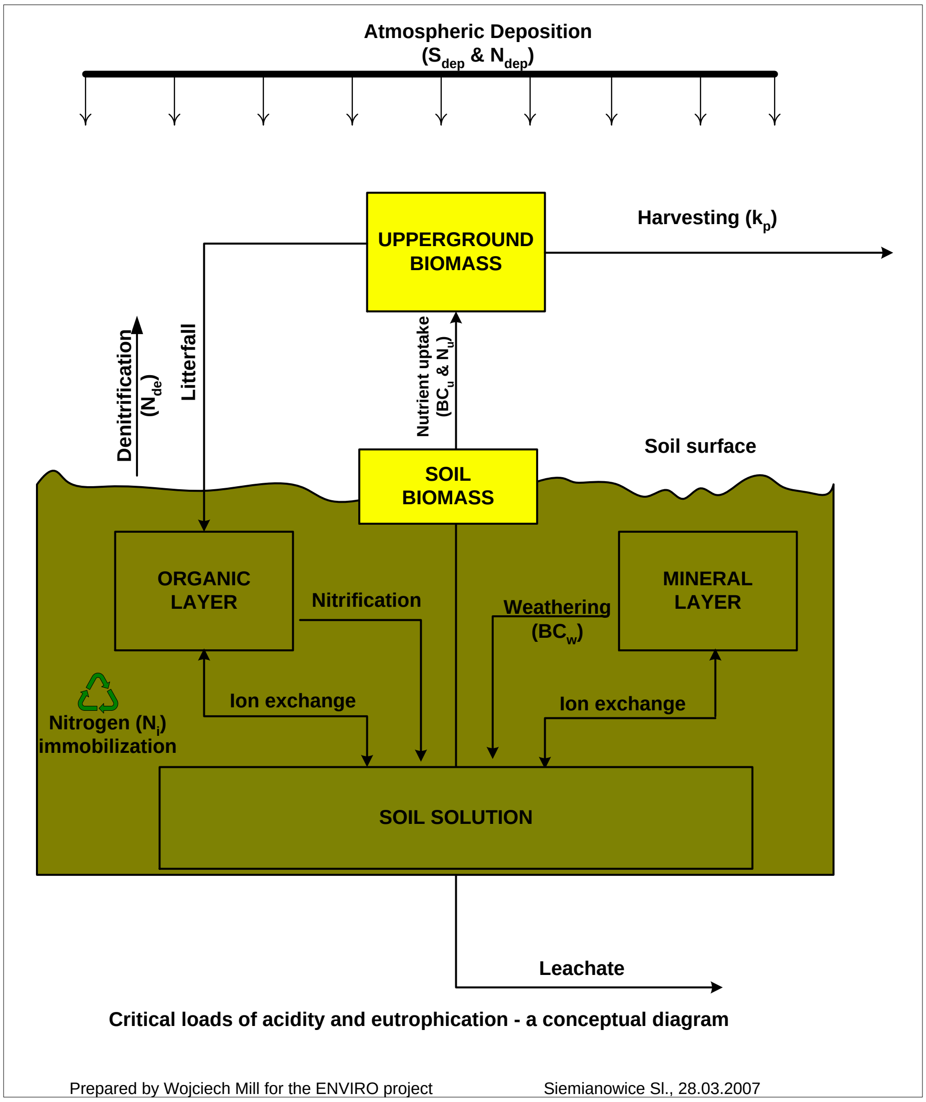


Figure 21: Conceptual diagram for critical loads

The basic equation which governs this system is as follows:

CC(S+N) = CC(S) + CC(N)

$= BC_{dep} + BC_{alt} - BC_{ass} - Cl_{dep} + N_{im} + N_{ass} + N_{de} – Alc_{les}$

where CC represent the critical load (CL or CC), S sulphur, N nitrogen, BC basic cations, Cl the chloride ions and Alc alkalinity. The indices indicate:

- dep: atmospheric deposition,
- alt: the deterioration of the rock,
- ass: assimilation by the plants,
- im: the immobilization in the ground,
- de: denitrification,
- les: scrubbing

b) Modeling Critical Loads

Critical loads can be determined either by steady-state methods or by dynamic models with varying degree of complexity. Since critical loads are steady-state quantities, the use of dynamic models for the sole purpose of deriving critical loads is somewhat inadequate.

However, if dynamic models are used to simulate the transition to a steady state for the comparison with critical loads, care has to be taken that the steady-state version of the dynamic model is compatible with the critical load model.

- Modeling acidity

The first critical loads of acidification were calculated without the acidifying effect of sulphur. They were used as a basis for the protocol of Oslo in 1994.

The deepening of scientific knowledge showed the importance of the products nitrogenized in the processes of acidification. That led to the development of the “functions of critical load “for sulphur and nitrogen. These functions are characterized by three values (Figure 22):

– $CC_{max}(S)$: The maximum critical load of sulphur: It is the maximum sulphur deposit that an ecosystem can tolerate. It is equal to the quantity of bases available minus quantity of acids received by the system: It is calculated as being equal to the sum of basic contributions of cations minus their assimilation by the plants, less the contributions of ion chloride (acidifying anions) and less the alkalinity lost by scrubbing (which represent a loss of basic molecules). This critical load is that which was used for the protocol of Oslo.

– $CC_{min}(N)$: The minimum critical load of acidifying nitrogen: It is the nitrogen deposit which could be compensated by the processes which naturally withdraw nitrogen of the medium. CCmin (N) is thus equal to the quantity of nitrogen immobilized on the particles of the ground, assimilated by the plants and denitrified (lost in the atmosphere in the form of N2O or N2).

– $CC_{max}(N)$: The maximum critical load of acidifying nitrogen: It is the maximum deposit of acidifying nitrogen which can be tolerated by an ecosystem in the absence of deposit of sulphur. The value of CCmax (N) must be taken for all the processes which can counterbalance the acidifying capacity of nitrogen: Bases available in ground (with which CCmax (S) was given) and the processes by which the system consume nitrogen (those which determine CCmin (N)). As for CCmax (S), contributions of other acid anions (Cl-) and the alkalinity lost by scrubbing are withdrawn. CCmax (N) is thus equal to the sum of CCmax (S) and CCmin (N).

Figure 22 schematizes the relations between these values. Couples of values of deposition of sulphur and nitrogen which define points located in lower part of the curve (zone hatched) correspond to non acidifying deposition. All couples represented by points above the curve correspond to acidifying deposition. The curve is chart of the function of critical load and represents an infinity of couples (deposition of nitrogen; sulphur) deposition.

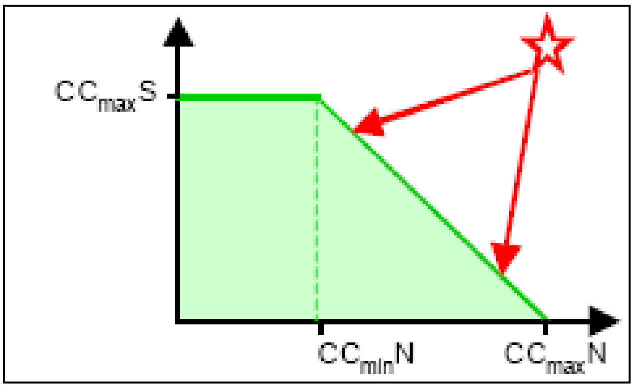


Figure 22 : Function of critical load for sulphur and acidifying nitrogen. The star represent a situation where the critical loads are exceeded, arrows two possible choices of reduction of the emissions indicate (INERIS, 2004).

With a situation of excess given (represented by star on Figure 22), corresponds thus an infinity of scenarios of reduction of the sulphur and nitrogen emissions (including two which are represented by the arrows). Each solution can be selected according to whether it is more advantageous or easier to reduce the nitrogen or sulphur emissions. The processes which cause a reduction in nitrogen in the system can be a function quantity of nitrogen which the system receives or climatic parameters (temperature, moisture, pH…). When such relations are used, pace of the function is modified. If for example, it is possible to calculate denitrification according to deposition, CCmax (N) becomes higher than CCmax (S) + CCmin (N). If effects of the temperature, moisture of the ground or pH are used, the decreasing straight line of Figure 21 becomes a curve (Posch and Al, 1995). In practice, these relations are too badly known to be usually used.

- Modeling eutrophication

The critical load of eutrophication can also be represented on such a diagram. It can be higher (Figure 23-a) or lower (Figure 23-b) than the maximum nitrogenized critical load. When it is lower there, the critical load reduces the zone in which it does not have there a risk of degradation of the ecosystem

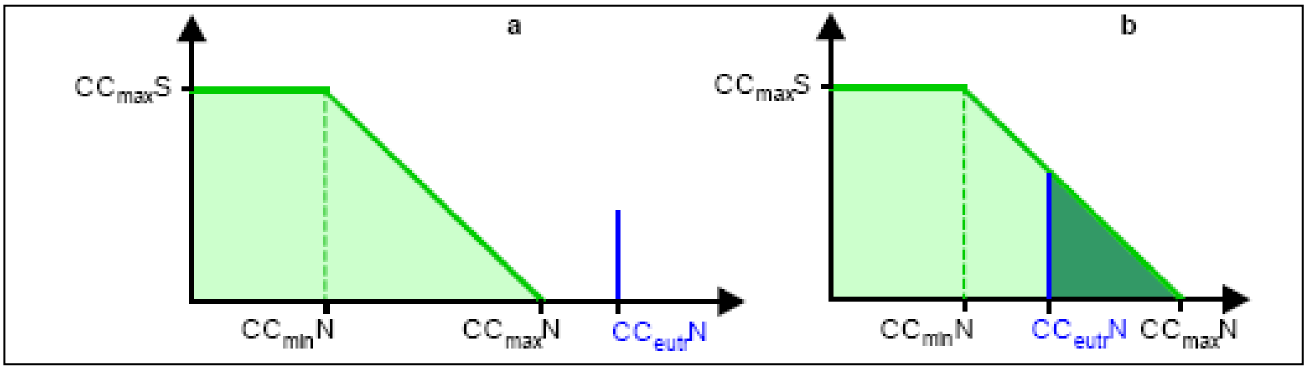


Figure 23: Function of acidifying critical load in relation to the critical load of eutrophication. (a: Eutrophication does not pose a constraint additional. b: Eutrophication causes an additional constraint and the field in which there is not going beyond of the critical load is tiny room to the zone in clear green, (INERIS, 2004)).

c) Presentation of the work with the critical loads

Work was divided into several parts:

- Use of the maps of critical loads and their exceedances of acidity for Poland already realized by the Project using a GIS (Geographic System Information). Comprehension of the system to produce these maps and the codes used under Oracle.

- Use of existing maps of critical loads and their exceedances of acidity and eutrophication available for France.

- Comparison of these maps by establishing a link with already carried out work

It should be noted that the Enviro-project group did not carry out yet maps of critical loads exceedances of eutrophication because of a lack of data.

This chapter was the object of an article which was sent at EDF Polska.

All the maps of critical loads (CCmaxS, CCminN and CCmaxN) are presented in appendices, only the maps of exceedances are commented here because these are most interesting.

d) Use of the data

- Poland

The approach for the Enviro-project group is to combine the integrated assessment model RAINS with the chemistry transport model POLAIR 3D. In principle, integrated assessment modeling enables one to identify the emission reduction scenarios, providing information on how to optimally allocate the emission reduction investments. RAINS makes it possible to estimate the present and future levels of pollutant emissions. Together with air pollution dispersion model POLAIR 3D, it is then possible to calculate also the atmospheric transport of air pollutants, at local and transboundary distances and subsequently related ground level concentration, deposition and finally produce some maps. The latter can be confronted with the threshold values for the protection of ecosystems (e.g. critical load for acidity).

Simultaneously with that, we use Oracle and Toad for Oracle to carry out codes which will make it possible to calculate starting from the provided values the data of critical loads (See chapter Modeling maps).

Lastly, all these data are used in a GIS (here Arcview[13]) to produce maps of critical loads exceedances of acidity by comparison of the data.

The simplified information flow in the system under consideration in this paper is illustrated in the figure 24 below.

[13] ArcView is a full-featured geographic information system (GIS) software for visualizing, managing, creating, and analyzing geographic data.

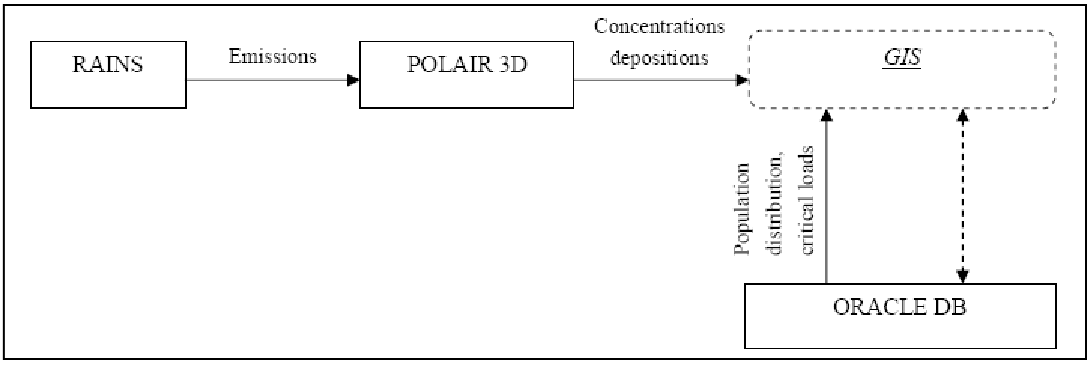


Figure 24: The simplified information flow in the considered system

- France

The knowledge of the ground and water state on the French territory is obtained thanks to specific and local terrain surveys and network of observations which developed since twenty years. Among those which bring the most information useful for the study of the acidification and eutrophication let us quote:

- The network RENECOFOR (National Network of long-term follow-up of the Forest Ecosystems) which falls under the European network of follow-up of the forest damage;

- The network CATAENAT (Total Acid Load on the Terrestrial Natural Ecosystems) in which the total atmospheric deposition are measured since 1993 in full field and under forest cover on 27 of the 102 small squares of network RENECOFOR;

- The French Network of Measurement of the Quality of Grounds (RMQS);

- The network of atmospheric measurements MERA (Measurement of the Atmospheric Repercussions) which was set up since 1990 by the Ministry in charge of the environment and the ADEME (Agency for the environment and energy Management) and is coordinated by the School of the Mines of Douai.

It's appearing that the majority of the studies carried out on the acidification and eutrophication in France and whose results are published relate to the forest areas. Few or not studies seem to be published on other types of areas such as alpine meadows, moors or wetlands.

The maps used for exceedances come from the CEE-NU[14] (Economic Commission on Europe of the United Nations) which certain French networks within the convention of Geneva take part on the transboundary air pollution (Acronym: LRTAP: "*Long transboundary air pollution arranges*"). The data of ground (gathered in each country by researchers) are gathered by the "concerted international Programs" (PIC) but also data of water, forests, vegetation and materials are transmitted to the PIC modeling and cartography.

All these maps are calculated by using the meteorology of the year 2000.

Note: The maps used for critical loads come from the laboratory LMTG UMR 5563 CNRS/UPS/IRD (Toulouse), see Appendices.

[14] http : //www.unece.org/env/lrtap/conv/lrtap_o.htm

e) Comparison between France and Poland in terms of critical loads exceedances

- Poland

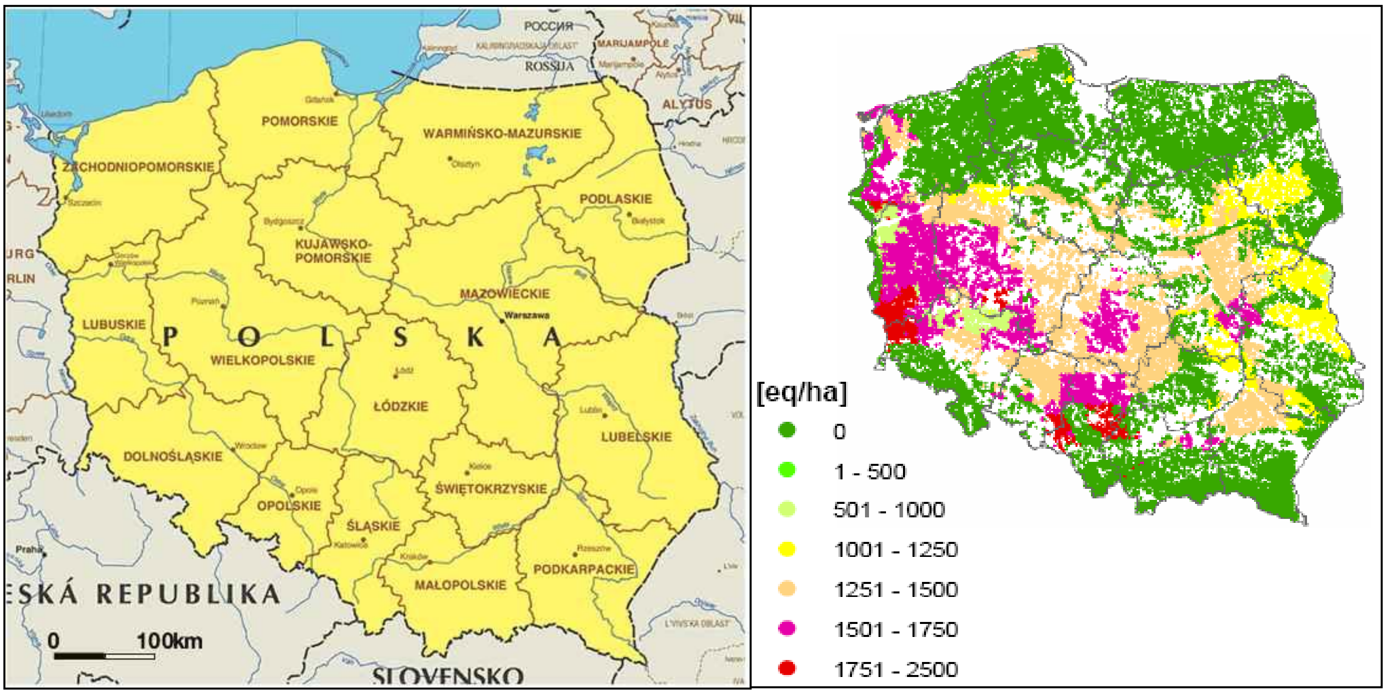


Figure 25 : Critical loads exceedances of acidity caused by deposition of oxidized and reduced N and S for 2005

The map 25 carried out for Poland by the Enviro-project group shows several interesting things. We observe important points of critical loads exceedances of acidity localized in the south and in the west.

All the maps of critical loads (CCmaxS, CCminN et CCmaxN) shows that the most sensitive areas are located in the south-western parts of the country (territory of Dolnośląskie and Opolskie voivodships). Also the central part of Łódzkie voivodship is relatively high sensitive what matters because of the high deposition of sulphur and oxidized nitrogen, resulting from the Bełchatów power plant, one of the largest in Europe. From this map it appears that the central part of Poland is moderately sensitive but the most resistant parts to atmospheric acidification are the northern and the southern regions. It is to note that the major part of Śląskie voivodship, the biggest emission source of acidifying compounds, is quite well protected from acidification.

There are three main reasons for the occurrence of accumulated critical loads exceedances of acidity in Poland. The first one is energy production and the associated emission of acidifying pollutants. This kind of emission sources is responsible for the wide spread spots of exceedances almost allover the country. On the above map there are clearly distinguished areas affected by the power plant activities like the Bełchatów in the Łódzkie voivodship, the surrounding area of the Dolna Odra power plant in Zachodnio-Pomorskie voivodship, the Konin area, Katowice district etc.

Katowice district (Śląskie voivodship) is specific because next to the emission sources from energy production the second important factor acts which is the industry. These results together with the Bełchatów area, in the highest exceedance of tolerable acidity in Poland.

Transboundary fluxes of acidifying pollutants are the third major reason for critical loads of acidity exceedance. The effects of them are detectable in south-western part of the country and especially in the Dolnośląskie and Opolskie voivodships exposed to the fluxes from Germany and Czech Republic.

All these remarks are in direct relation and confirm our preceding analyzes on the emissions and depositions of pollutants in Poland.

For the future, the calculations show that the emissions of air pollutants in Poland will further decrease in the coming two decades. This is a consequence of the current legislation as well as of ongoing structural changes in the energy system. The most significant decrease is foreseen for large combustion installations, in particular for SO2 and NOx. Emissions from agriculture are anticipated to remain almost unchanged. It should be highlighted that small non-industrial installations will remain the substantial contributor to air pollution, in particular when PM emissions are considered. In general, however, for the analyzed energy scenario, the number of people affected by air pollution will be reduced. The same applies to ecosystems, which will be better protected against acidification.

- France

- *Critical loads exceedances of acidity (eq/ha/an)*

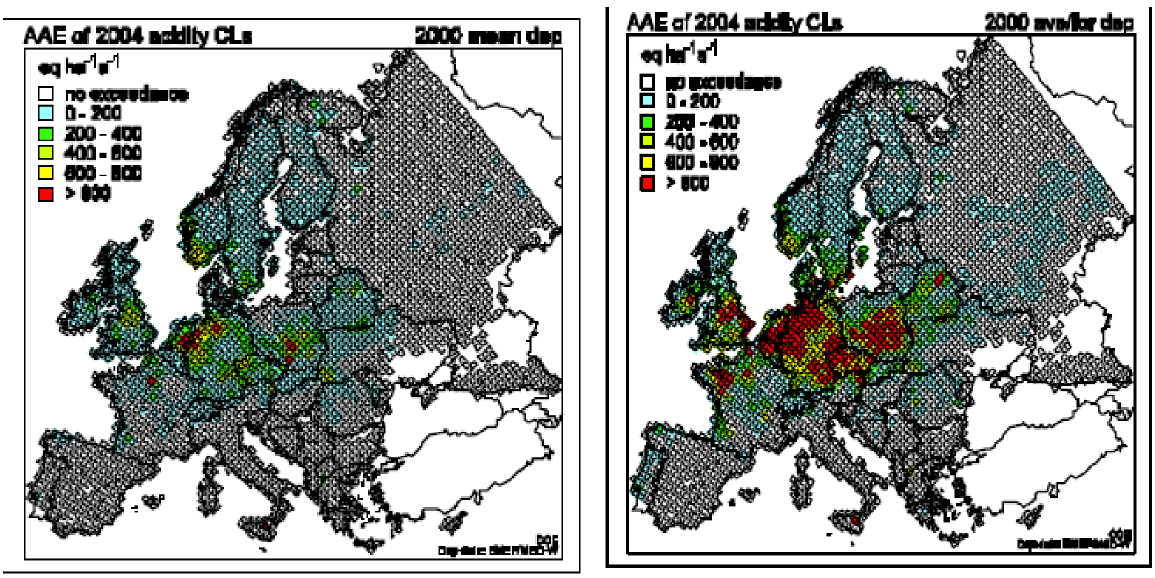


Figure 26 **:** Evolution of the maps of critical loads exceedances for acidification (A: without differentiating the ecosystems, B: by differentiating the ecosystems (forests, plains…))
(Scale: 0-200, 200-400, 400-600, 600-800, > 800)

The two maps 26 (A and B) are presented because modelings taking part of the ecosystems increase the polluting loads considerably because the forest ecosystems have a very strong value in deposition of pollutants so it is better to comment the two maps.

The studies show that the total exceeded surface represents 21,537 km2 (12% of the forest and grassland area or 3.8% of the national area) and exceedances concerns mostly:

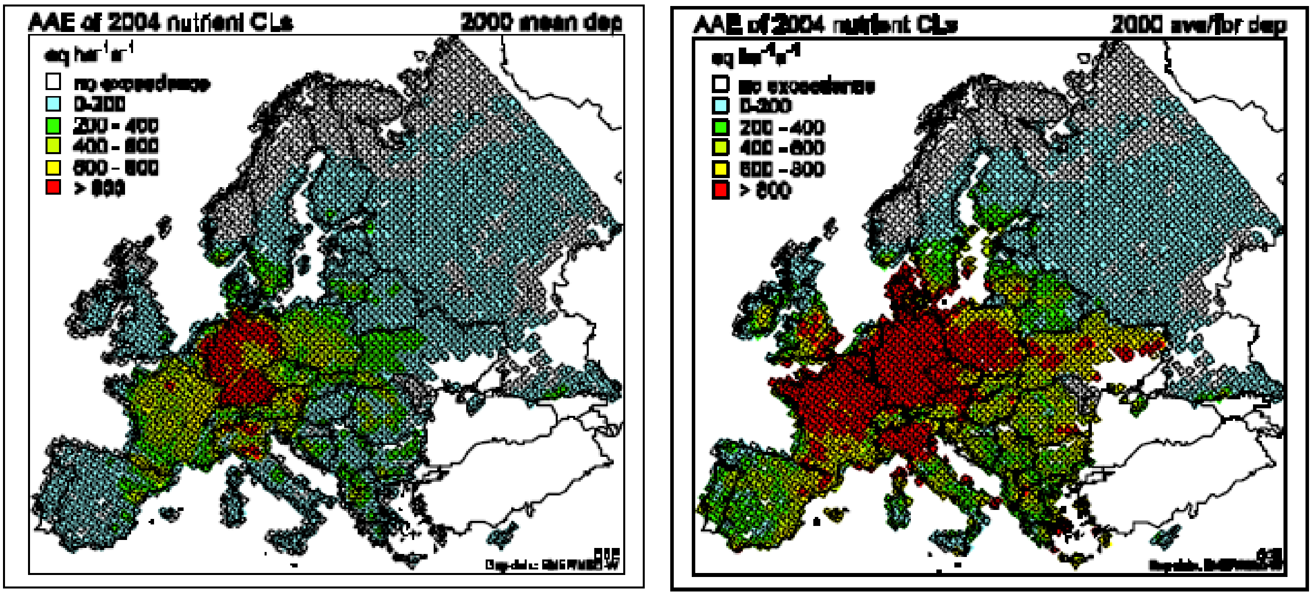
-Southwest of France: acid sands of the Landes forest and marshes;
-Granitic ecosystems of the Massif Central;
-Granitic and sandstone ecosystems on the Vosges mountains;
-Eolian sands in the centre and north of France;
- The Ardennes mountains;
-Shist of Brittany and Normandy.

At the European level, it is Belgium, the North of Germany and Poland which undergo the strongest loads.

These maps enable us to illustrate and confirm our preceding work on the emissions and the depositions of pollutants in S and N. We see clearly the consequences of these emissions on the ecosystems. The answers and the restoration of the ecosystems with polluting loads are however still badly known and are the subject of many studies.

These are useful data for the decision makers to fix values not to exceed and put the good questions. For example: Which objectives in terms of reduction of the effects of the acidification and/or eutrophication can be reasonably achieved within times considered?

- *Critical loads exceedances of eutrophication (eq/ha/an)*



A B

Figure 27 **:** Evolution of the maps of critical loads exceedances for eutrophication (A: without differentiating the ecosystems, B: by differentiating the ecosystems (forests, plains…))
(Scale: 0-200, 200-400, 400-600, 600-800, > 800)

It appears that the entire territory is exposed to high depositions and critical loads exceedances of eutrophication. That shows a global sensitivity of the French ecosystems. Eutrophication seems to be a problem generalized in France.

The most sensitive areas for nitrogen eutrophication are located in the Sologne (Centre part of France) and the Landes marshes (SW), the northern part of Massif Central and the eastern Mediterranean area.

These ranges of critical loads are weak which suggests that the French ecosystems have a weak tolerance compared to the nitrogen contribution of eutrophication.

It proves moreover than eutrophication is awaited for nitrogen deposition in general lower than those which are likely to start the acidification. That also means that for the majority of the French ecosystems, the limits of emission of nitrogenized compounds should be calculated according to the risks of eutrophication rather than risks of acidification.

Then, at the European level, it is the entire France-Benelux countries-Germany-Poland zone which is concerned. What is to be put directly in relation to our preceding analyzes on NOx concentration and deposition in N total.

Lastly, we see also here the interest to comment on several maps because the map B realized by differentiating the ecosystems gives us very high values for the exceedances for France Germany and Poland, which makes difficult the analyzes.

Note: Depending on the deposition data sources, EMEP or RENECOFOR for example, the deduced exceedances will be significantly different. However, regarding both network data, it appears that the entire territory is exposed to high deposition and exceedances.

f) Conclusion

For the critical loads exceedances of acidification, Poland undergoes its energy policy based on coal. Most of the country is touched by these exceedances of critical loads. The most sensitive zones correspond perfectly to the areas of strong industrialization and production of electricity. A fragile environment not arranging anything.
For France, it is different: The areas of exceedances are limited to small zones located generally related to fragile ecosystems with a distribution towards the north of the country. What corresponds to the zones most polluted like already known as previously by NOx and SOx.

Concerning the critical loads exceedances of eutrophication, France and Poland seem very touched. Indeed, these ecosystems are fragile and are very sensitive to the nitrogen deposition. Although Poland has less emissions of NOx and depositions of N that France, this country has already strong exceedances of critical loads. It will be thus a challenge for the two countries to reduce these zones of exceedances through strong policies of reductions of pollution, investments or important financial incentives to control these critical loads exceedances and to reduce them.

III. Personal impressions

This very interesting training course in Poland brought me many things in various fields.

First of all the fact of realizing it in a group of researches within a university in collaboration with an important group makes it possible to be confronted with realities of research: Reports to be returned on precise dates, many meetings of work… but also search for financings, new studies to finance the group.

The research projects carried out here on the air pollutions starting from modelings of many data-processing tools interested me enormously because the air pollution is a major problem today and there will need more and more experts to bring some researches and studies in this field. It is thus a very good thing for me to have been able to take part in such studies.

I could use many data-processing tools in order to do this study between France and Poland. Some appeared simple of use (RAINS or EMEP), others more complex like Polyphemus which required the assistance of somebody to use it. In all the cases, these tools are very useful and the fact of knowing them will be able to help me without any doubt if I need to work on this kind of projects.

However, it is obvious that to control such data-processing tools, it takes time and that requires good bases in SQL for example to handle the databases or in C++ to use software like Polyphemus. I had the occasion during this training course to have a small formation and a small training on these tools but that proves still insufficient to be autonomous in the studies.

Then, the fact of making this placement abroad enabled me to improve my technical and professional English. I thus could take part in many meetings or conferences, present my various English work and acquire a facility in this language. What will undoubtedly be essential for me in my professional future career if I plan to work abroad.

Lastly, this training course gave me the opportunity to discover Poland, Cracow more particularly and its inhabitants. It is a country in charge of stories and traditions which requires time to discover all its facets. Its entry in the European Union and the many investments which are made there confers it today an increasingly important place in Europe and which should not cease increasing in the years to come.

Conclusion

This study suggested on the comparison between France and Poland in terms of atmospheric rejections of pollutants through the use of many tools was rich in lessons and allowed us to highlight lot of things.

First of all, the energy policies of these countries are very different, one based on the nuclear power and the other based on coal have different consequences on the environment. Pollution is not completely the same one and the responsible sectors also vary. France still emits many pollutants through its industries of process whereas for Poland these are electric industries and the sector of the heating (particular and professional) starting from coal which cause much pollution.

The level of life plays also much, France must fight to decrease its NOx emissions caused by an abusive use of transport whereas Poland remains little bit concernated by NOx coming from transport because there is less cars in Poland and they privilege public transport because of low level of life.

The direct consequences of NOx and SO2 pollution are an acidification and an eutrophication of the grounds. We could show that the two countries are hardly concernated in both cases, although their rejections are different. France is rather contaminated in the north because it concentrates there many industries with important pollution also coming from Belgium and Germany for example thus our country strongly undergoes transboundaring pollution. Whereas Poland is contaminated a little bit everywhere with strong zones in the south and the west where also this country concentrates many industries.

Then, France put on non-polluting industries with the development of renewable energies (wind, solar…) accompanied by investments and financial incentives (for transport for example) to decrease its emissions in the future whereas Poland put on the new constructions and the handing-over at the standards of its actual installations of coal to limit its emissions. What will be a problem to Poland because it will have to respect the European regulations in this sector. It would seem that this country cannot maintain its engagements of air pollution reduction except if it slows down its economic development, thing to which Poland is opposite.

In all the cases, France and Poland have challenges to reduce their emissions in the years to come and thus decrease the loads of acidification and eutrophication of their grounds.

It is at this price that we will give for the future generations a healthy environment and a quality of optimal life.

Terminology

CAFE: Clean Air For Europe

CATAENAT: Total Acid Load on the Terrestrial Natural Ecosystems, french network

CEE-NU: Economic Commission on Europe of the United Nations

CEREA : Centre d'Enseignement et de Recherche en Environnement Atmosphérique

CHP: Cogenerated Heat and Power

CO2 : Carbon Dioxide

EDF : Electricité De France

EIfER : European Institute for Energy Research

EMEP: Co-operative program for Monitoring and Evaluation of the long range transmission of air Pollutants in Europe

IAMs : Integrated Assessment Models

IIASA: International Institute for Applied System Analysis

MERA: Measurement of the Atmospheric Repercussions, french network

NEC: National Emissions Ceilings

NH3: Ammonia

NOX: Nitrogen Oxides

O3: Ozone

OECD: Organisation for Economic Co-operation and Development

ORACLE: The database management system (DBMS) software released by Oracle Corporation as Oracle RDBMS, and to individual databases which are managed by such software.

PM: Particulate Matter

RAINS: Regional AIr pollution Information and Simulation

RENECOFOR: National Network of long-term follow-up of the Forest Ecosystems, french network

RMQS: French Network of Measurement of the Quality of Grounds

SNAP: Selected Nomenclature for Air Pollution

SO2: Sulphur Dioxides

SOX: Sulphur Oxides

SQL: Structured Query Language

UNCLRTAP: United Nations Convention on Long-Range Transboundary Air Pollution

UNFCCC: United Nations Framework Convention on Climate Change

VISUAL BASIC: It’s an event driven programming language and associated development environment from Microsoft for its COM programming mode

VOC: Volatile Organic Compounds

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Web sites

- http ://www.iiasa.ac.at/rains : RAINS/GAINS on line and related documentation

- http : //www.unece.org/env/lrtap/conv/lrtap_o.htm : CEE-NU on line

- http : //www.emep.int*:* EMEP on line

- http : //www.euractiv.com

Appendices

A) Selected data of the website RAINS/GAINS Europe on line

B) Maps of critical loads used (CCmaxS, CCminN, CCmaxN) for France and Poland