Work Placement - 2sd year

EDF Polska – AGH University of Science and Technology

Maxime ROLLAND
Ecole des Mines de Douai

2009 -2010

Placement as a TECHNICIAN
(2sd Year)

Duration : 13 weeks between May and September

Type of work proposed : The trainee takes on the work of a technician and tries to understand the problems confronting the company

Industrial sector : No limit

Work programme : After getting acquainted with the different services and the specific problems which the firm may have to solve, the engineering student may take part in all the work normally asked for a technician

The trainee could :

- Integrate a team of technicians or work under the responsibility of an Engineer
- Take on responsibilities
- Deal with organization methods

ECOLE DES MINES DE DOUAI

ROLLAND Maxime

Internship Report

Technician (2sd year)

Optimization the use of biomass in Poland (for EDF)

Promotion 2012 **2009-2010**

Acknowledgements

First I would like to thanks AGH University and EDF Polska for having allowed me to do my internship in their research lab.

Then I would like to thanks my supervisor, Mr. Artur Wyrwa for having provide me the opportunity of this internship and for the time he devoted to me.

Finally I would like to thank the work team, Mr. Janusz Zyśk, Mr. Marcin Pluta and Anna Stężały for the help they gave me and their welcome

Whole project group would like to express our gratitude to Electricite de France (EDF) for giving us the opportunity to work on the *Optimizing Environment Protection Investments of EDF Polska Companies to meet the Sustainable Development criteria* (ENVIRO) project.

We gratefully acknowledge Mr. Stanislaw Blach from EDF Polska and Prof. Louis Jestin for their supervision and professional advice. We are also indebted to other EDF experts for valuable discussions.

We would like to thank all the Project partners and other people involved. In particular thanks to Mr. Adam Gula from AGH UST.

Table of content

Internship Presentation

Subject and objectives

The topic of our internship is to optimize the use of biomass in Poland.

For this, we must develop a model using the General Algebraic Modeling System (GAMS) software which allows to calculate the CO_2 emissions, energy embedded and cost. This model must take into account several parameters : planting, harvesting, transport, conversion of biomass…
We must find a compromise which allows to have low CO_2 emissions and energy embedded, while having a low cost. The goal : optimize the use of biomass in Poland.

To realize this model on GAMS, we must search on the internet to find the energy embedded and CO_2 emissions for each stage (planting, fertilizer, transport,…). When this values are found, we will put them in Excel sheets which will be used in the software GAMS. After this, I will have to writte code in GAMS in order to create a model which is working. A GUI (Graphical Users Interface) will be develop.

Schedule

Our schedule was always the same. Our days began at 9:00 am and ended around 4:00 pm. We had an hour break to lunch. Our days off were Saturday and Sunday. On Friday, it was possible to leave work earlier.

During the first six weeks, we have developed the model in GAMS software (code) and we have done research on the internet to find data. After this, until the end of the internship, we tried to optimize this model by creating a GUI, which content a lot of functions in order to giving a pleasant form to this model (Visual Basic Form).

Abstract & Keywords

In recent years, a continuous increase has been observed in the use of biomass as fuel in the power sector. This is mainly due to the fact that biomass is classified as renewable energy source (RES) and its burning causes 'neutral' CO_2 emissions.

In the context of sustainable development, everybody knows that energy will become a precious resource. In order to preserve the Earth and limit losses (energy embedded, CO2 emissions), EDF Polska is interested by a study to use biomass as fuel: it could permit, after the development of a model with GAMS software, to analyze energy and CO2 emissions embedded in biomass delivery to EDF Polska plants.

Our work was in this perspective. Indeed, the scientific objective of the work is to develop this model that will support decision-making process of EDF Polska, by showing the optimal supply chain of biomass in sense of minimization of total energy embedded in its processing and transportation..

First of all, we had to become familiar with GAMS, then, look for the data that we needed, as the energy and CO2 embedded for planting or for the transport of this biomass, for example.

When it was done, we had to think about how to improve the model to make it as accurate as possible and discover what factor consumes more energy and emits more CO2 in order to minimize environmental impacts.

Keywords

♣Biomass	♣ Optimization	♣ Electricity
♣ Model	♣CO2 emission	♣ Renewable Energy
♣ Research	♣Energy embedded	♣ Power Plant

Introduction

In the context of sustainable development, everybody knows that energy will become a precious resource. In order to preserve the Earth and limit losses (Energy embedded, CO2 emission,..), EDF Polska is interested by a study, in order to use Biomass as fuel: it could permit, after the development of a BioLOG model, to analyse energy and CO_2 emissions embedded in biomass delivery to EDF Polska plants.

Poland is one of the thirty most polluting countries in the world. Indeed, there are the most polluting factories as Elektrownia Bełchatów which is a coal plant that has emitted over 30 Mt CO2 in 2008. Thus, to overcome this problem, Poland has decided to start using biomass to generate bio-electricity.

Biomass is organic non-fossil material of biological origin - including forest and mill residues, agricultural crops and wastes, wood and wood wastes, animal wastes, livestock operation residues, aquatic plants, fast-growing trees and plants, and municipal and industrial wastes. This biomass is used to produce bio-electricity. Indeed, one of the most important rules of development of EDF is sustainability it becomes necessary to take this aspect into account in making decisions about logistics and technological choices to minimize negative environmental impacts.

In order to improve the production of the bio-electricity, some researchers work on this and try to reduce the cost and the impact on the environment of this biomass.

I Presentation of the compagny :

A. AGH University of Science and Technology

The desire to create the Academy of Mining in Krakow was born in 1912 by a group of mining engineers and activists. The Academy had to wait until the end of the First World War to begin its activities. It was inaugurated on the 20th of October 1919 by the Head of State, Józef Piłsudski.

During the Second World War, the building was occupied by the Nazis. After the war, a group of professors, staff members and students reclaimed the ruined main building of the Academy and more than 500 students began their courses.

In 1969, the university was named the Stanisław Staszic University of Mining and Metallurgy.

Figure 1: AGH University **[1]**

Today, AGH University of Science and Technology is the second largest technical university in Poland, located in Krakow. It is composed of 15 faculties and two inter-faculty schools :

- Faculty of Mining and Geo-engineering
- Faculty of Engineering and Industrial Computer Science
- Faculty of Electrical Engineering, Automatics, Computer Science and Electronics
- Faculty of Mechanical Engineering and Robotics
- Faculty of Geology, Geophysics and Environmental Protection
- Faculty of Mining Surveying and Environmental Engineering
- Faculty of Materials Science and Ceramics
- Faculty of Foundry Engineering
- Faculty of Non-Ferrous Metals
- Faculty of Drilling, Oil and Gas
- Faculty of Management
- Faculty of Fuels and Energy
- Faculty of Physics and Applied Computer Science
- Faculty of Applied Mathematics
- Faculty of Humanities
- Inter-Faculty School of Power Engineering
- Inter-Faculty School of Biomedical Engineering

Currently, in the university, there are over 34,000 students who can gain qualifications in 30 branches of studies and over 170 specializations. AGH University serves the science, economy and society through educating students and the development of the scientific and research staff, as well as conducting scientific research.

The faculty of Fuels and Energy, where we work, is one of the youngest faculties at the University of Science and Technology. It was created to meet the growing demand for fuels and energy of the highest quality and the requirements of sustainable development based on effective implementation of clean energy and green renewable energy. **[2]**

B. EDF Polska

EDF (Electricité de France) is a major player in the production of electricity and heat all around the world. This group was installed in Poland since 1993. It became one of the largest groups of the country, and today, it tries to combine energy production and environmental protection.

The activities of EDF Group in Poland are co-ordinated by the EDF Polska, a ten-person team seated in Warsaw, 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. It president is Philippe Castanet.

Figure 2: EDF plants in Poland **[3]**

EDF Group in Poland consists of one trading company whose key areas of its activity are energy trade on wholesale market as well as supply of energy to end consumers and also several plants generating heat.

As a world-wide energy group, EDF plays a significant part in economic and social development and is responsible to future generations for environment protection. All Polish EDF companies act upon the rules of sustainable development. An outstanding example of this engagement is the project of "Coal Recovery Plant from waste coal piles”. We have to notice that all the companies have obtained 14001 certificates. **[3]**

II. Work completed

A. Background

1. The process :

Many chemicals pollute the atmosphere, but the main element is the CO_2.
The use of biomass in EDF Polska plants has great importance to make it possible to fulfill its strategy to meet renewable energy sources quotas in forthcoming years. Experiments of co-firing have already been made in different plants as ERSA (Elektrownia Rybnik S.A.) and Kogeneracja and is being spread to ECK and ECW with a target of 500 kt/year of dry biomass in 2010. EDF Polska plans as well to invest in co-injection in Kogeneracja and ECK, followed by ERSA, in order to achieve a new goal of 2 Mt/year of biomass in 2020.

In order to ensure the supply of biomass and to achieve the target of 60% of non-wooden products in the biomass mix required by the Polish Administration, investigations have been conducted on agriculture by-products, energy crops and recycled products in order to make it available at a competitive price while mitigating the risks connected to the development costs. Quite often overlooked is the energy embedded in the cultivation of biomass, its processing and transportation to the place where its chemical energy is converted to heat and/or electricity.
As one of the most important rules of development of EDF is sustainability, it becomes necessary to take this aspect into account in making decisions about logistics and technological choices to minimize negative environmental impacts. But, this production has also an impact on the environment, and the mission of researchers is to know how to improve the production to minimize this impact and the cost of the biomass.

Indeed, there are different processes for the use of biomass. We consider that the system consists of the following :

- The first process : The fields, where biomass is grown and harvested
- The second : The storages, where biomass is stored and eventually processed for example, dried, pelletized…
- The third : The sidetracks, where biomass is loaded on train cars
- The last process : The destination

Figure 3 : Different processes for the use of biomass **[4]**

Throughout this process, we must consider the different parameters which are highly polluting.

In the first process, the element which is a problem for the environment is mainly diesel. Indeed, fuel consumption is very important to plant and harvest. Furthermore, the manufacture of fertilizers and pesticides emits CO2.

In the second process, the energy for drying and pelletizing is significant and consequently, the emission of CO2 is significant too. Moreover, storing biomass too long may be a waste of money. The biomass is bulky, the storage should not take long time to make room for other biomass which have just been harvested.

The transport is a major emitter of CO2 because the fields are located relatively far from the places for storage and from the power plant.

We will study only two types of biomass: the willow and the maize (which is the corn and the stover), and only three forms of biomass : Raw, Chips and Pellets.

It was assumed, for our work, that willow and maize is chipped on fields and then transported to the storage areas located nearby, where it can be further processed i.e. dried and pelletized.

Then, biomass in the form of chips or pellets is transported by heavy duty vehicles (trucks) to the sidetracks where it is loaded into the train cars and delivered to the destination sites. **[4]**

2. The GAMS software:

Our main work tool was GAMS Software. This software, the General Algebraic Modeling System (GAMS) is a high-level modeling system for mathematical programming and optimization. It allows to build large maintainable models that be adapted quickly to new situations. GAMS is specifically designed for modeling linear, non-linear and mixed integer optimization problems. The system is especially useful with large, complex problems. **[5]**

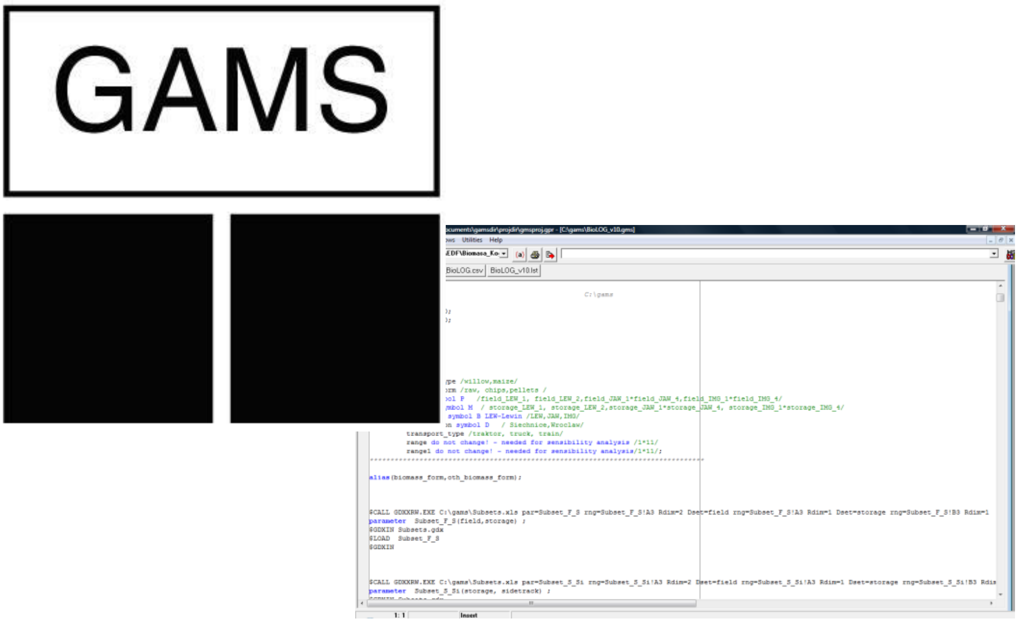


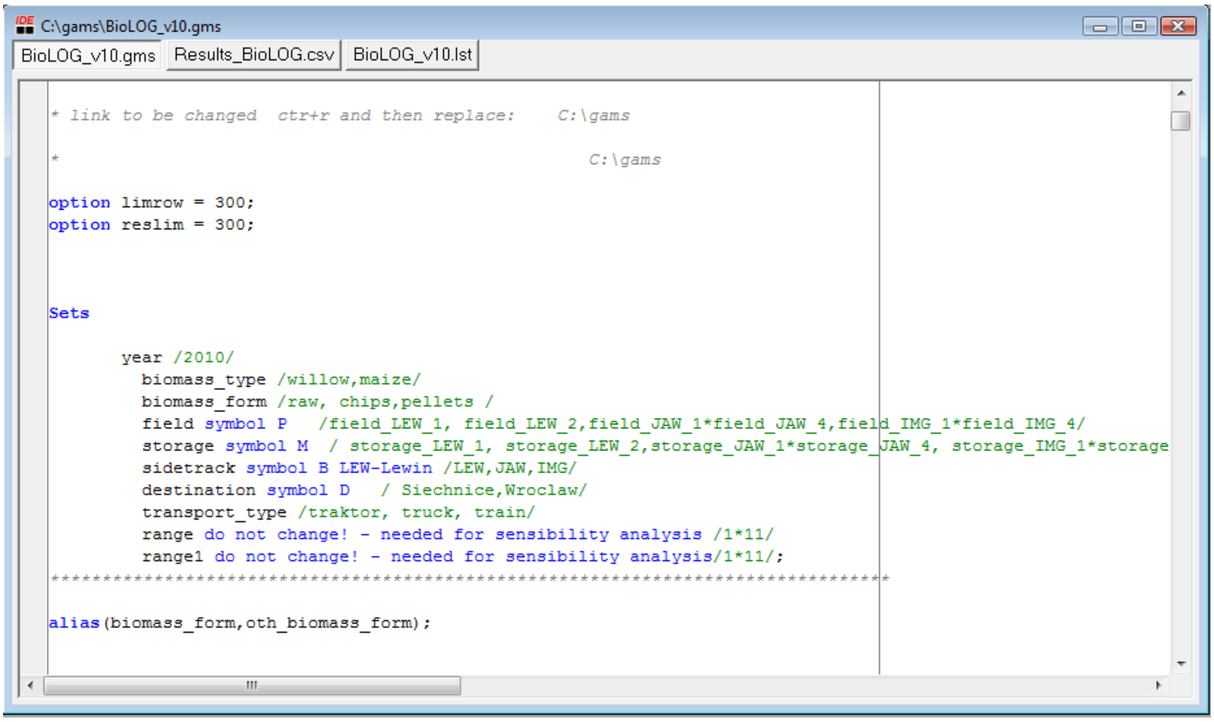
Figure 4 : GAMS Software **[5]**

The basic components of the structure of a GAMS model are:

INPUT	OUTPUT
- Sets - Data - Variables - Equations - Model and Solve statements - Display statements	- Echo Print - Reference Maps - Equation Listings - Status Reports - Results

Figure 5: Basis component of a GAMS model **[5]**

Sets are the basic building blocks of a GAMS model, corresponding exactly to the indices in the algebraic representations of models.




```
* link to be changed  ctr+r and then replace:    C:\gams

*                                                  C:\gams

option limrow = 300;
option reslim = 300;



Sets

       year /2010/
         biomass_type /willow,maize/
         biomass_form /raw, chips,pellets /
         field symbol P   /field_LEW_1, field_LEW_2,field_JAW_1*field_JAW_4,field_IMG_1*field_IMG_4/
         storage symbol M  / storage_LEW_1, storage_LEW_2,storage_JAW_1*storage_JAW_4, storage_IMG_1*storage
         sidetrack symbol B LEW-Lewin /LEW,JAW,IMG/
         destination symbol D   / Siechnice,Wroclaw/
         transport_type /traktor, truck, train/
         range do not change! - needed for sensibility analysis /1*11/
         range1 do not change! - needed for sensibility analysis/1*11/;
*******************************************************************************

alias(biomass_form,oth_biomass_form);
```

Figure 6: The sets of our model

3. Optimization :

In order to improve a process, optimization is the most part of the time required. We will see an example of optimization.

Minimize the function f, where

$$f(x_1, x_2) = -4x_1 + 3x_2,$$

subject to the conditions

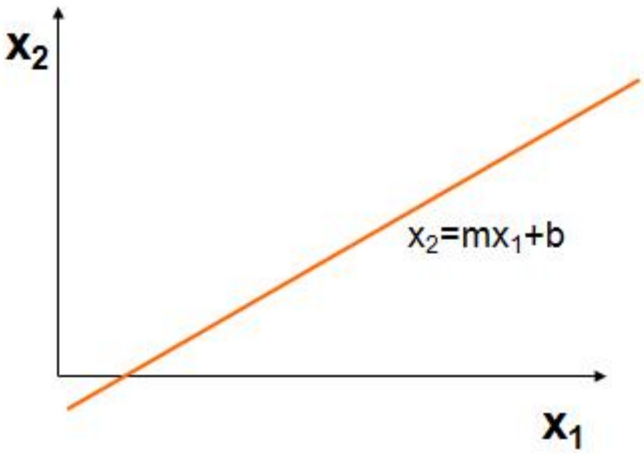
$$\begin{cases} x_1 - 2x_2 \geqq -4, \\ 2x_1 + 3x_2 \leqq 13, \\ x_1 - x_2 \leqq 4, \\ x_1 \geqq 0, \quad x_2 \geqq 0. \end{cases}$$

The goal is to minimize the function f: find the lowest values for X1 and X2, in order to have the lowest value for the function f, respecting the conditions.

$$f(x_1, x_2) = -4x_1 + 3x_2,$$

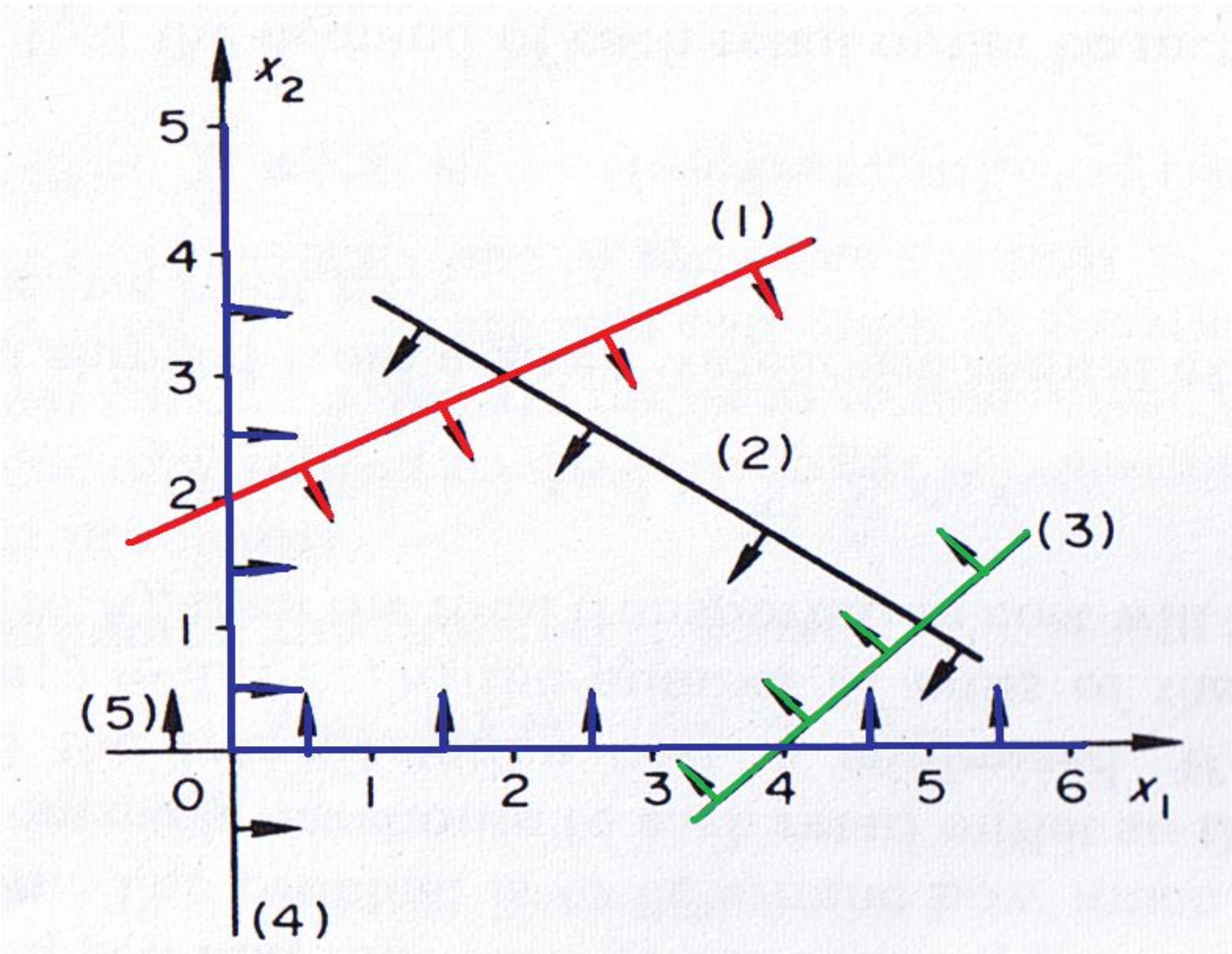
We can consider that X1 and X2 are dependant, so can be linked by the equation:

$x_2 = mx_1 + b$ (with m and b twoa real constants)

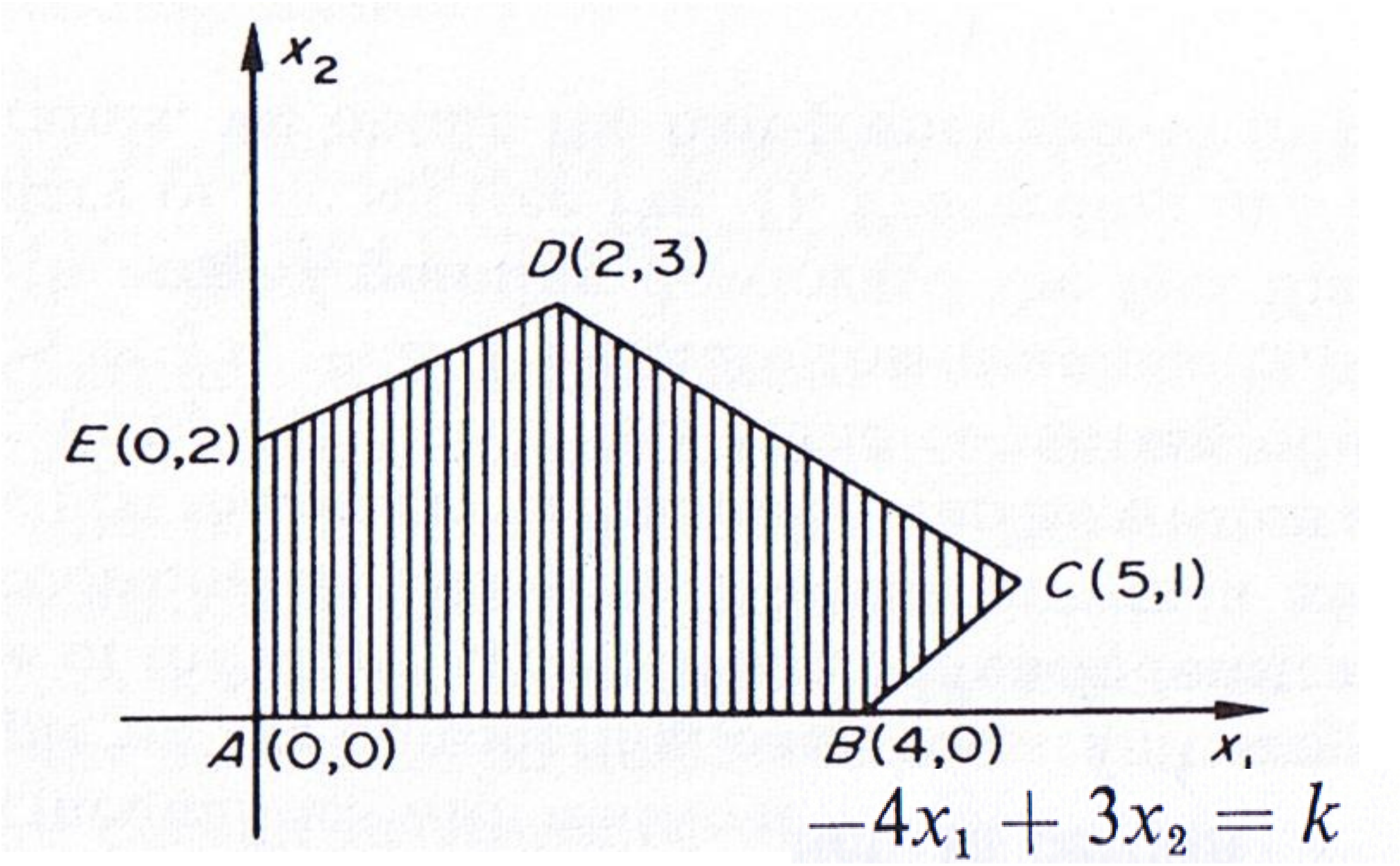


$$(1)\ x_1 - 2x_2 \geqq -4,$$
$$(2)\ 2x_1 + 3x_2 \leqq 13,$$
$$(3)\ x_1 - x_2 \leqq 4,$$
$$(4)\ x_1 \geqq 0,\ (5)\ x_2 \geqq 0.$$

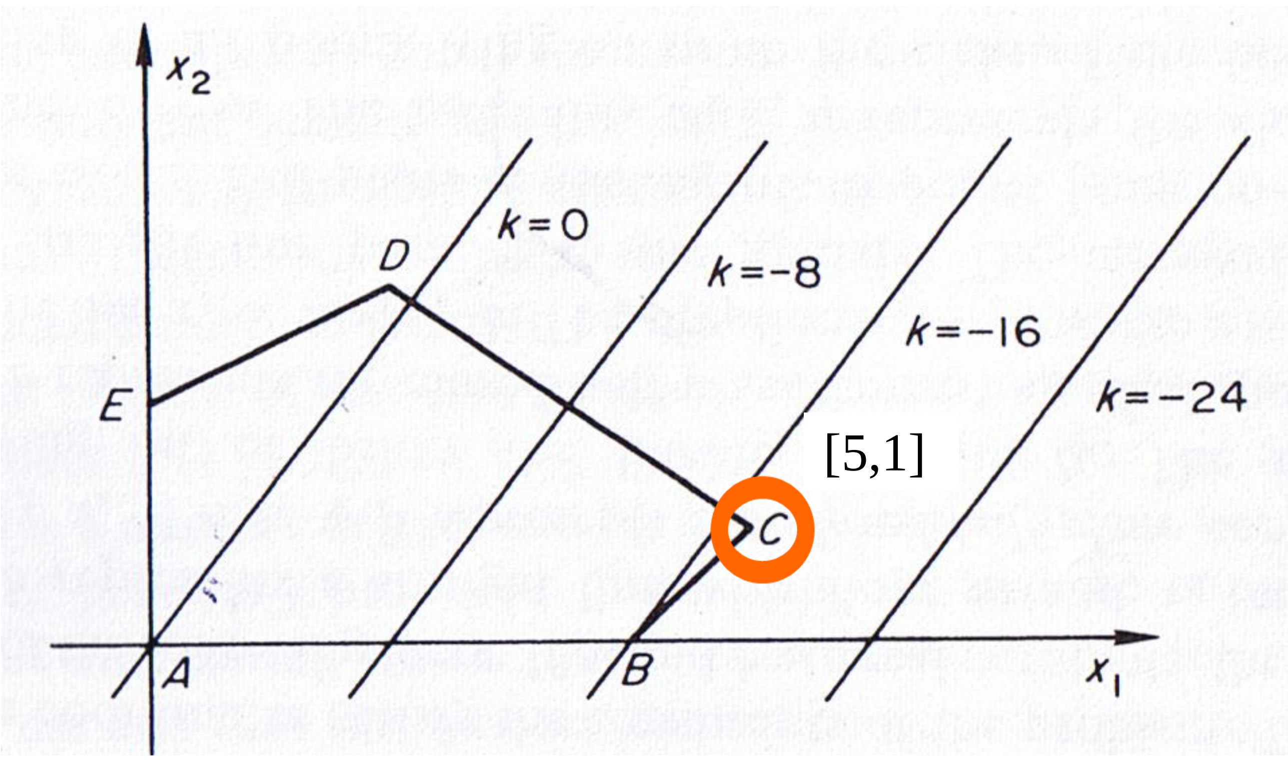
Now, we can represent this conditions with a graphic:



So the area which contains the possible values for X1 and X2 is represented by hatching:



For several values of k, we can draw their representations:



Now, we know that, for minimize f, we have to find the greatest value for X1, and the lowest for X2 : we can easily understand that the solution is the point C. So we can calculate the value of :

$$k = -4 \cdot 5 + 3 \cdot 1 = -17.$$

So in order to minimize f, we have to take:

X1=5 and X2=1

B. BioLOG

1. Our model : BioLOG

The aim of our work, during this internship, is to optimize the use of biomass in Poland. With the software GAMS, we will create a model that will allow us to calculate the energy embedded and CO2 emissions throughout the process. Then, we will try to optimize the use of biomass by reducing energy losses and emissions of CO2.

In our model, we have seven most important sets:

- biomass_type which is the different type of biomass (we have to specify in the software, the name of this biomass, here: willow and maize)

- biomass_form, which is different form of biomass: raw, chips (raw cut) and pellets (chips with densification).

- We have to give the different place where biomass is treated: field, storage, sidetrack, destination (it is the power plants).

- transport_type, which is the different type of transport: tractor, truck and train.

To run the model, we have to define some parameters, which are the “conditions” of the model. We can write this parameters as a list, a table or import the parameters from an excel file. This is what we have done.

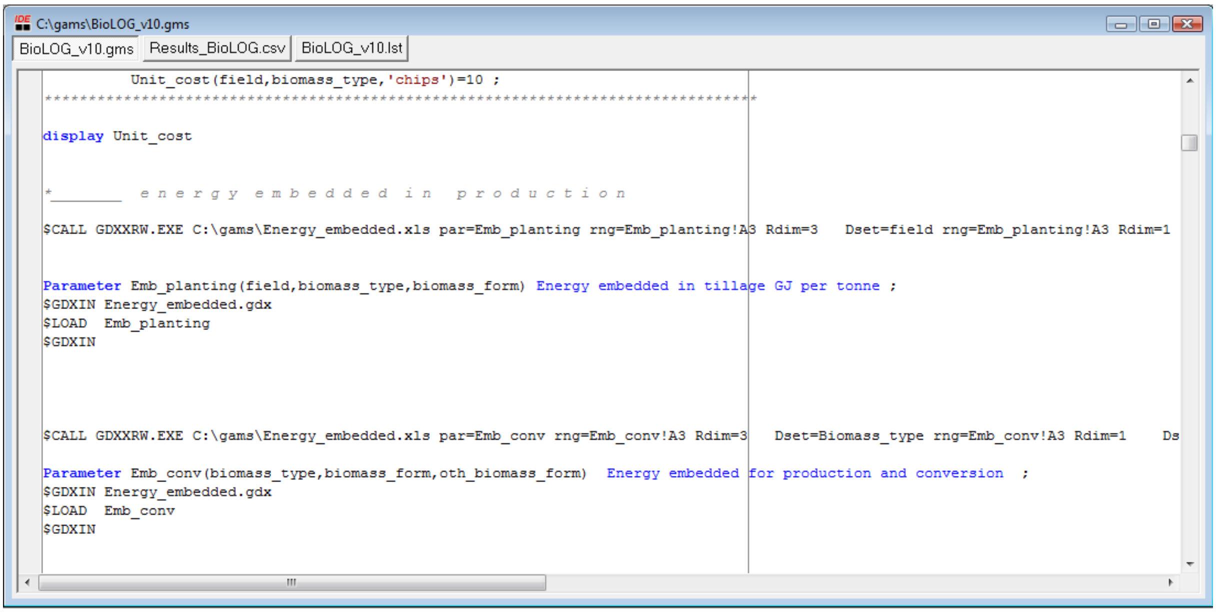


Figure 7: Parameters imported from Excel file

The different parameters are:

- The distance between each place: field to storage, storage to sidetrack and sidetrack to destination place.
- The demand for biomass in destination place and the cost of the biomass.
- The energy embedded in production, for planting, conversion and drying of biomass and the energy embedded in transport, for tractor, truck and train.
- The CO_2 embedded in production, for planting, conversion and drying of biomass and the energy embedded in transport, for tractor, truck and train.

To import the data from an excel file to GAMS, first of all, we had to do a table in Excel. We had to give to the table a proper form in order to GAMS can read it as a parameter.

	A	B	C	D
1	ded kgCO2 per ton and km			
2	biomass_type	biomass_form	transport_type	CO2_embedded_tr
3	maize	raw	traktor	0,03
4	maize	raw	truck	0
5	maize	raw	train	0
6	maize	chips	traktor	0,03
7	maize	chips	truck	0,09
8	maize	chips	train	0,023
9	maize	pellets	traktor	0
10	maize	pellets	truck	0,09
11	maize	pellets	train	0,023
12	willow	raw	traktor	0,03
13	willow	raw	truck	0
14	willow	raw	train	0
15	willow	chips	traktor	0,03
16	willow	chips	truck	0,09
17	willow	chips	train	0,023
18	willow	pellets	traktor	0
19	willow	pellets	truck	0,09
20	willow	pellets	train	0,023

Figure 8: Table of parameter (C02 embedded in transport) in Excel

In the first column, there are the sets, and in the last column, the data that correspond to the sets: this is the parameters.

Then we had to use a code to import this table in GAMS. This code is:

```
$CALL GDXXRW.EXE C:\gams\CO2_embedded.xls
par=CO2_transp rng=CO2_transp!A3 Rdim=3
Dset=biomass_type rng=CO2_transp!A3 Rdim=1
Dset=biomass_form rng=CO2_transp!B3 Rdim=1
Dset=transport_type rng=CO2_transp!C3 Rdim=1
Parameter CO2_transp(biomass_type,biomass_form,transport_type)
$GDXIN CO2_embedded.gdx
$LOAD  CO2_transp
$GDXIN
```

$CALL GDXXRW.EXE C:\gams\CO2_embedded.xls : With this, we call the Excel file called CO2_embedded which is saved in the folder gams, in the Disk C.

Par=CO2_transp rng=CO2_transp!A3 Rdim=3 : With this line, we define the parameter. We call this parameter: CO2_transp. The rng (range) specifies in which Excel sheet, the table must be taken. A3 is the box where begins the table. And the Rdim determines how many sets there are.

Dset=biomass_type rng=CO2_transp!A3 Rdim=1
Dset=biomass_form rng=CO2_transp!B3 Rdim=1
Dset=transport_type rng=CO2_transp!C3 Rdim=1 : With this, we just write the different sets, in which sheet they are, in where box begin the columns and the dimension (1 for one set)

$GDXIN CO2_embedded.gdx
$LOAD CO2_transp

$GDXIN : With this, we load the Excel file and GAMS can read the data in the table. The Excel file is imported.

If we don't use an excel file, the parameters can be write in list or table. Our first model GAMS had not the code to import the Excel file, so the parameters were like in the figure 9.

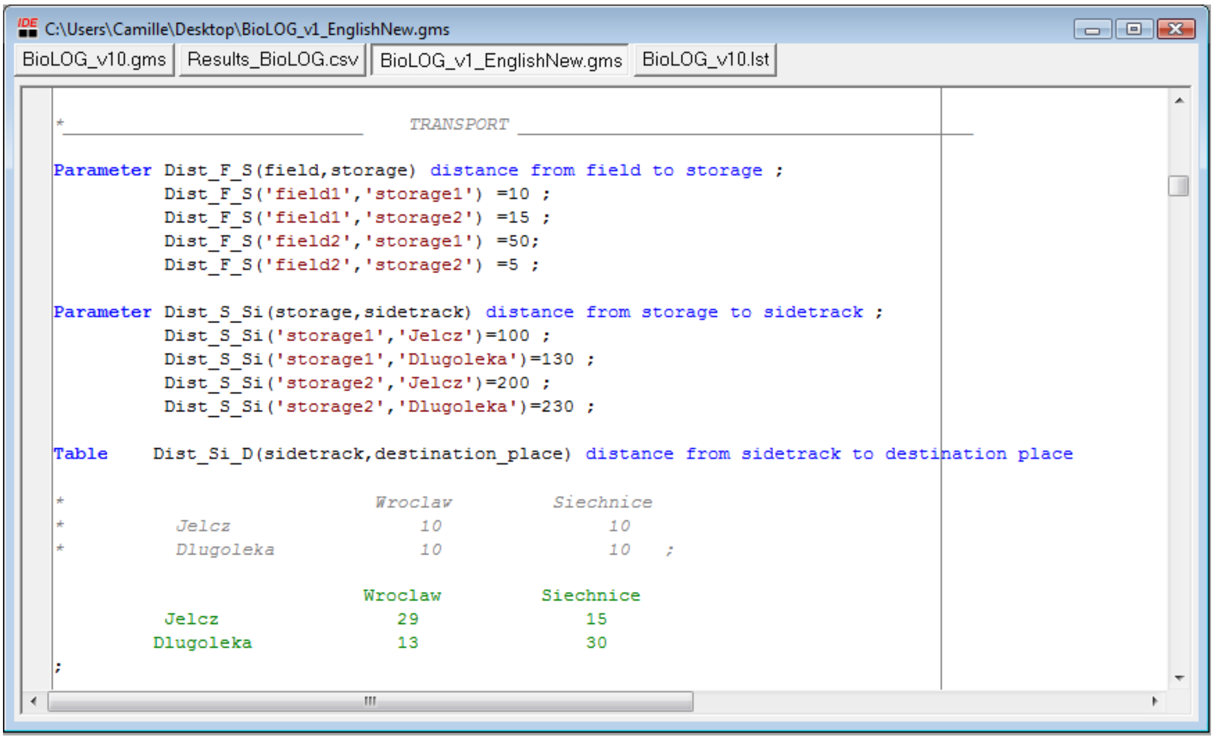


Figure 9: Parameters listed in GAMS

The variable statement of GAMS-expressed model only serve to declare the variables used in the rest of the program. Each variable is given a name, a domain if appropriate, and (optionally) text. Our model contains the following example of a variable statement:

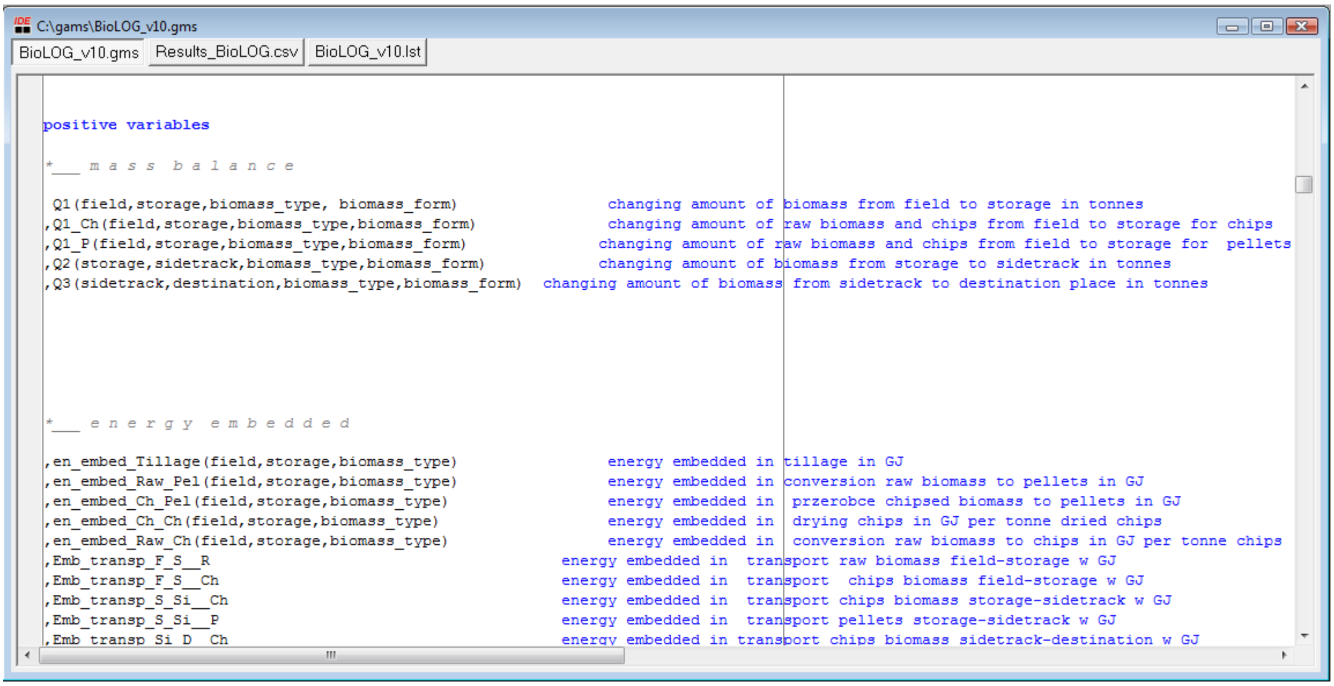


Figure 10: The positive variables

The main variables were defined as follows:

$Q\_Ch_{F,S,t,bf}$ - Biomass dedicated for chips. The amount of biomass cuttings and chips entering to the storage and processed up there (chipped or dried), [Mg]

$Q\_Pe_{F,M,t,,bf}$ - Biomass dedicated for pellets. The amount of biomass raw and chips entering to the storage, and up there pelletized, [Mg]

$Q2_{M,B,t,bf}$ - The amount of biomass chips and pellets directed from storage to sidetrack [Mg]

$Q3_{B,D,t,bf}$ - The amount of biomass chips and pellets directed from sidetrack to destination place, [Mg]

Finally, the most important and most complicated part of GAMS model is where there are the equations. They encompass both equality and inequality relationships, and they are used both to declare and define these relationships. These equations can be used to defined values or limits for the variables declared in the previous variable statements. In figure 11, there is an example of an equation that we used in our model for energy embedded in tillage.

```
********************************************************************************
*                        E N E R G Y   E M B E D D E D                         *
********************************************************************************

*___________________________ ES  T I L L A G E

Balance_ener_embed_Tillage(field,storage,biomass_type)..

         en_embed_Tillage(field,storage,biomass_type) =E=

                  Q1_Ch(field,storage,biomass_type,'raw')     *Emb_planting(field,biomass_type,'raw')   +
                  Q1_P(field,storage,biomass_type,'raw')      *Emb_planting(field,biomass_type,'raw')   +
                  Q1_Ch(field,storage,biomass_type,'chips')   *Emb_planting(field,biomass_type,'chips') +
                  Q1_P(field,storage,biomass_type,'chips')    *Emb_planting(field,biomass_type,'chips')
;
```

Figure 11: An Equation of our GAMS model

In this equation (fig 10) we can observe that the energy embedded in tillage, is the sum of the amount of each biomass type in each field multiply by the energy embedded to plant this biomass.

We have to be very careful to write equation because we must take the correct spelling of parameter, variable etc and do not forget some balance which could give a bad result.

The model statements precise which equations should be taken into account during the resolution. We do not need to ignore any equation, so we can plainly use the statement:

model model_name /all/;

GAMS has no explicit entity called the "objective function". To specify the function to be optimized, you must create a variable and a solve statement. The solve statement precise which model to solve, the variable which should be optimized, if it should be maximized or minimized, and the solution procedure (linear lp or non linear for example nlp)

Solve Biomasa using LP minimizing h; where h is 'all cost" in our model.

2. Research Data:

To use the model created with the software GAMS, we had to find data on the Internet and scientific journals. Indeed, in order to calculate the energy embedded and CO2 emissions for a precise path of biomass, we needed to know it for each step of the process.

We have narrowed our search to two types of biomass: the maize and willow. We had to find the energy and CO2 embedded for planting, harvesting, drying, transport but also for the transformation of biomass into pellets or chips. Once again, we have narrowed our search to three transformations: raw to chips, raw to pellets and chips to pellets.

Process	Cumulative energy [GJ / ton of biomass] (GJ / km / ton-transport)	Cumulative CO_2 emissions [$kgCO_2$ / ton of biomass] ($kgCO_2$ / km / ton-transport)
Growing willow	0,81	33,95
chipping	0,137	9,175
drying	3,5	52,35
Pellets from biomass raw	3,52	16
Pellets with wood chips	2,37	110,4
transport	0,0016	0,05195

Figure 12: The energy of a cumulative process for willow

Process	Cumulative energy [GJ / ton of biomass] (GJ / km / ton-transport)	Cumulative CO_2 emissions [kg CO_2 / ton of biomass] (kg CO_2 / km / ton-transport)
Growing maize	1,819	42,4
chipping	0,137	9,175
drying	3,5	52,35
Pellets from biomass raw	2,39	41
Pellets with chips	2,29	30
transport	0,0016	0,05195

Figure 13: The energy of a cumulative process for maize.

This work lasted one month during which we have carefully read many scientific journals such as you find in Appendix 1. Indeed, we do not just find a single good value, we must be able to verify this value with other journals made by other authors. If it is the same values, we can take it into account in our model. When we found intervals of data, we have created excel tables with low values, high values and medium values. Thus, we could see different scenarios when we ran the model on GAMS.

It is a work that requires patience, concentration and a good analytical mind.

3. ***Graphical User Interface (GUI):***

To make the model more attractive and easier to use, my placement tutor asked me to create a graphical interface. As we were three to do this internship, this work has been done especially by me.
Having really participated in this part of the optimization of the model, I will go into details.

Firstly, I had to design a logo for our model: after some votes, we choose this one.

Figure14: Logo for our model

In order to be as convenient as possible, I had to know what it could be good for our software or not. After discussion of options and key points of our GUI, I had to find who write the code: as we wanted to work on Excel, I had to control VBA and his vocabulary.

Firstly, I had to create an Userform on VBA, and create some buttons: to close our software, to show our logo, to execute BioLOG,..

After this first stage, I had to develop some codes with the help of the researchers. I will take example of code which permit to check if there are no lacks in excel sheets.

In fact, in order to avoid errors during the execution of GAMS, it's important to perform a checking on the accuracy of excel sheets. After reflection about the structure of our code, I wrote it as we can see on this picture.

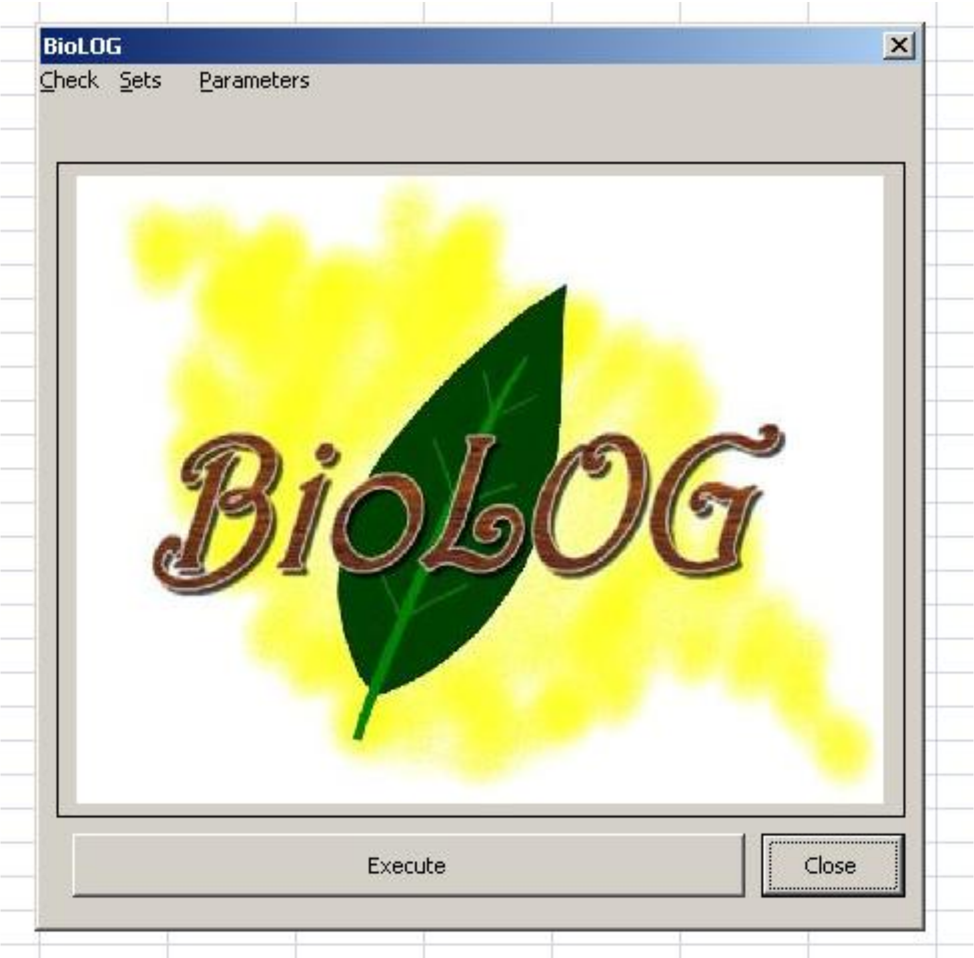


Figure 15: Main view of our GUI

We can easily understand that this code had to be written in several steps:

- To import excel sheet
- To activate excel sheet
- To count the number of theoretical values
- To identify concerned cell area
- Check in this area the correct spelling of sets
- To display if it's ok or not, with the number of errors and their location.

  (Several excel sheets had to be take in account)

```
Private Sub CommandButton1_Click()

Workbooks.Open Filename:="C:\Users\Maxou\Desktop\Gams\NOUVEAU\v10\Production_demand.xls"

NOM = ActiveWorkbook.Name

Workbooks(NOM).Worksheets("Production").Activate

ActiveWindow.DisplayWorkbookTabs = False

Application.DisplayFullScreen = True

Dim toto As Range
Dim Compteur As Double
Compteur = 0
For Each toto In Range("B3:B100")
If toto.Value <> "" Then Compteur = Compteur + 1
Next

Dim u As Integer
u = 0

For I = 3 To Compteur + 2
If Cells(I, 2).Value = "maize" Or Cells(I, 2) = "willow" Then
u = u + 1
End If
Next
```

Figure 16: first part of code which permit to checks lacks in excel sheets

```
If u <> Compteur Then
MsgBox ("There is problems in Production_demand")
End If

If u1 <> Compteur1 Or u2 <> Compteur2 Or u3 <> Compteur3 Then
MsgBox ("There is are some problems in CO2_embedded")
End If

If u4 <> Compteur4 Or u5 <> Compteur5 Then
MsgBox ("There is are some problems in Biomass_parameters")
End If

If u6 <> Compteur6 Or u7 <> Compteur7 Or u8 <> Compteur8 Then
MsgBox ("There is are some problems in Energy_embedded")
End If

If u = Compteur And u1 = Compteur1 And u3 = Compteur3 And u2 = Compteur2 And u4 = Compteur4 And u5 = Compteur5 And u6 = Compteur6
MsgBox ("Biomass_type is checked - all it's OK")
End If

End Sub
```

Figure 17: End of code which permit to checks lacks in excel sheets

Finally, because of purposes of clarity and simplicity of use, we decided to create menu: it will permit to select one of the numerous excel sheets or to check eventual lacks for example. The code was complex, and I had to use some helps from internet for this one.

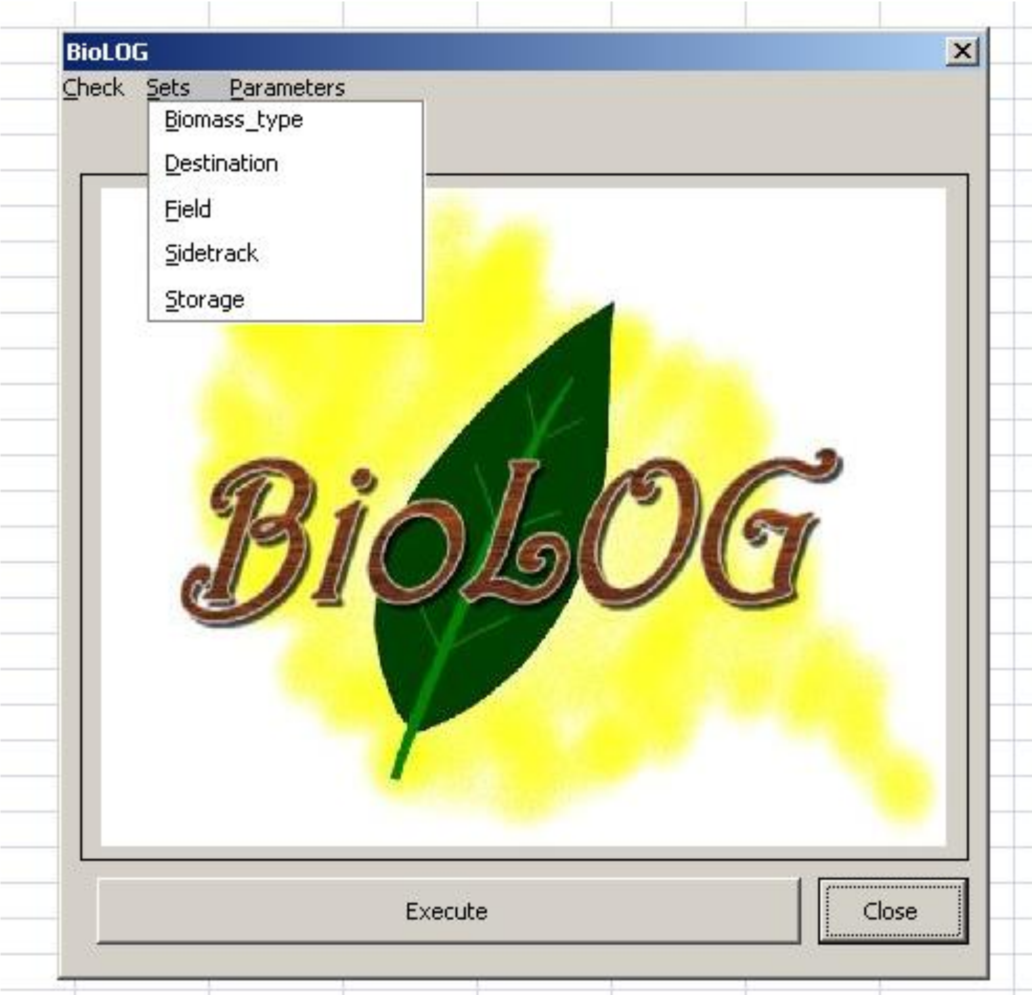


Figure 18: View of our menu

	A	B	C	D
1		&Check		
2			&Values	FileValues
3		&Sets		
4			&Biomass_type	FileBiomass_type
5			&Destination	FileDestination
6			&Field	FileField
7			&Sidetrack	FileSidetrack
8			&Storage	FileStorage
9		&Parameters		
10			&Demands	FileDmd
11			&Production Field	FileProduction
12			&Distance	FileDistance
13	stop			

Figure 19: Code for building menu

It was a difficult part, and the only option that I found was to write the names contents in the menu on excel sheet, as this figure.

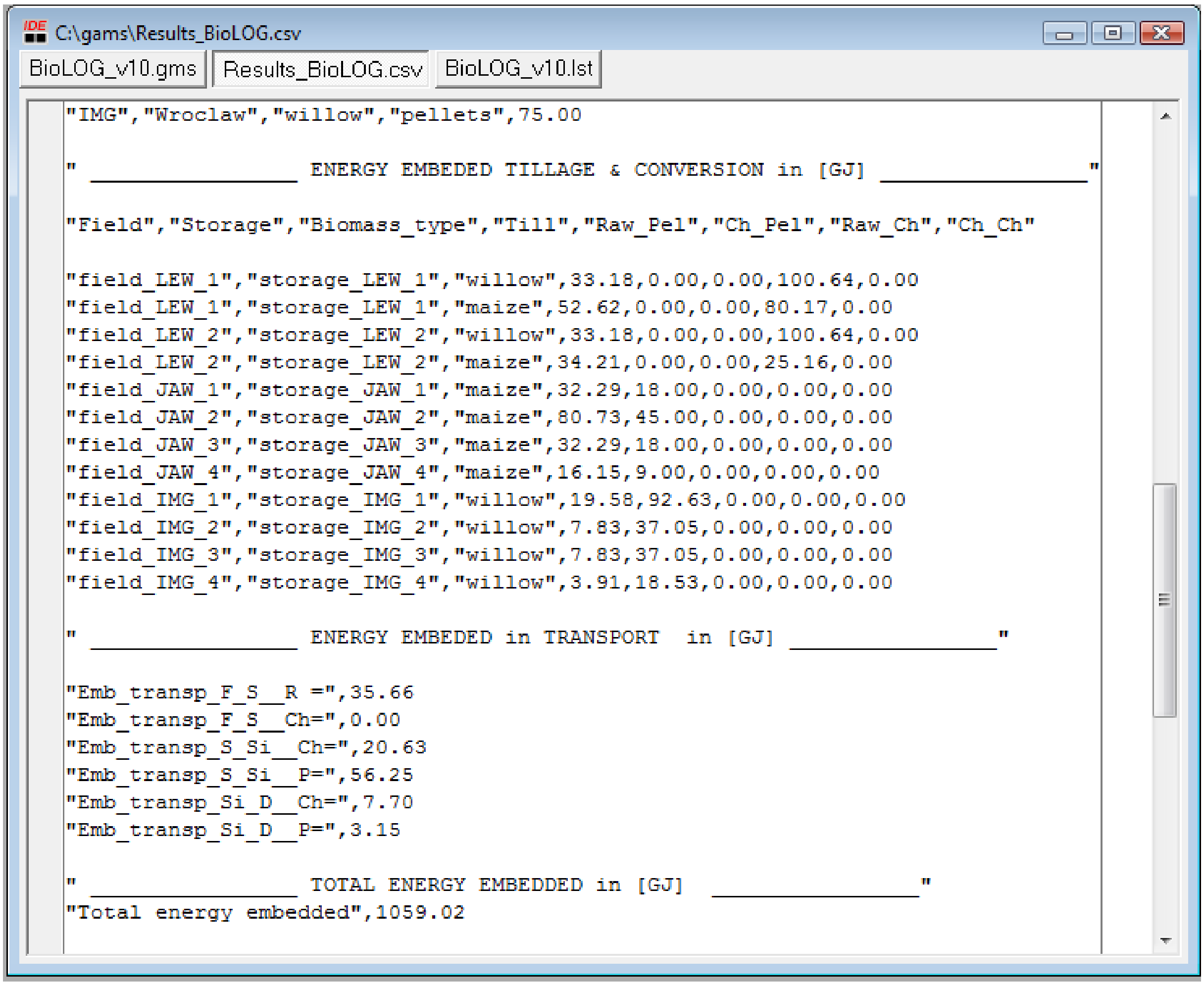
```
Private Sub BuildMenu()
'-------------------------------------------------------------------------
' Purpose   : This is the routine that builds the entire menu structure
'-------------------------------------------------------------------------
    Dim oMenuSheet As Worksheet
    Dim oCell As Range
    Dim oCtl As MSForms.Control
    Dim oLastctl As clsMenuEvents
    Dim oLastctl1 As clsMenuEvents
    Dim oParent As Object
    Dim iLevel As Integer
    Dim iTopMenu As Integer
    Dim iVertPos As Integer
    Dim iLevel1Ct As Integer
    'initialise collection
    Set mcolMenuControls = New Collection
    'Where is my menu definition?
    Set oMenuSheet = ThisWorkbook.Worksheets("FormMenu")
    'Nesting level of menu (max is 2 at the moment)
    iLevel = 1
    iTopMenu = 0
    For Each oCell In oMenuSheet.UsedRange.Columns(1).Cells
        If iLevel = 1 Then
            'If we're at top level, the parent is the form itself
            Set oParent = Me
            iVertPos = 0
        End If
        'End of menu definition has been reached
        If UCase(oCell.Value) = "STOP" Then Exit For
        If oCell.Offset(, iLevel) <> "" Then
            Set oCtl = oParent.Controls.Add("Forms.Label.1")
            Set mcMenuEvents = New clsMenuEvents
            Set mcMenuEvents.Ctl = oCtl
            With mcMenuEvents
                Set .ParentFormInstance = Me
                .Caption = oCell.Offset(, iLevel)
                .Ctl.Name = "lblMenu" & iLevel & .Caption     ...
```

Figure 20: One little part of our code which permit to create menu

After all this steps, GUI (Graphical User Interface) seemed to be operational. After many tests, we could see it was indeed functional, and relatively simple to use, as we expected.

C. Results

Once the model done, we can run it, and display the results. These results are listed, but it is not very clear to read.



C:\gams\Results_BioLOG.csv

BioLOG_v10.gms | Results_BioLOG.csv | BioLOG_v10.lst

```
"IMG","Wroclaw","willow","pellets",75.00

" _________________ ENERGY EMBEDED TILLAGE & CONVERSION in [GJ] _________________"

"Field","Storage","Biomass_type","Till","Raw_Pel","Ch_Pel","Raw_Ch","Ch_Ch"

"field_LEW_1","storage_LEW_1","willow",33.18,0.00,0.00,100.64,0.00
"field_LEW_1","storage_LEW_1","maize",52.62,0.00,0.00,80.17,0.00
"field_LEW_2","storage_LEW_2","willow",33.18,0.00,0.00,100.64,0.00
"field_LEW_2","storage_LEW_2","maize",34.21,0.00,0.00,25.16,0.00
"field_JAW_1","storage_JAW_1","maize",32.29,18.00,0.00,0.00,0.00
"field_JAW_2","storage_JAW_2","maize",80.73,45.00,0.00,0.00,0.00
"field_JAW_3","storage_JAW_3","maize",32.29,18.00,0.00,0.00,0.00
"field_JAW_4","storage_JAW_4","maize",16.15,9.00,0.00,0.00,0.00
"field_IMG_1","storage_IMG_1","willow",19.58,92.63,0.00,0.00,0.00
"field_IMG_2","storage_IMG_2","willow",7.83,37.05,0.00,0.00,0.00
"field_IMG_3","storage_IMG_3","willow",7.83,37.05,0.00,0.00,0.00
"field_IMG_4","storage_IMG_4","willow",3.91,18.53,0.00,0.00,0.00

" _________________ ENERGY EMBEDED in TRANSPORT  in [GJ] _________________"

"Emb_transp_F_S__R =",35.66
"Emb_transp_F_S__Ch=",0.00
"Emb_transp_S_Si__Ch=",20.63
"Emb_transp_S_Si__P=",56.25
"Emb_transp_Si_D__Ch=",7.70
"Emb_transp_Si_D__P=",3.15

" _________________ TOTAL ENERGY EMBEDDED in [GJ]  _________________"
"Total energy embedded",1059.02
```

Figure 21: Results listed in GAMS

GAMS calculates the energy and the CO2 embedded in the production of biomass and also the price of this production.

The results can be presented more elegantly. Below is a copy with the results presented.

Results BioLOG

Version I. Copyright:ENVIRO, contact:awyrwa@agh.edu.pl

_________________ Q1- Amount FROM FIELD TO STORAGE in [ton]_________

Field,Storage,Biomass_type,Biomas_form,For_CHIPS,For_PELLETS

field_LEW_1,storage_LEW_1,willow,raw,1.30,0.00

_________________ Q2- Amount FROM STORAGE TO SIDETRACK in [ton] ________

Storage,Sidetrack,Biomass_type,Biomas_form,Amount

storage_LEW_1,LEW,willow,chips,1.00

_________________ Q3- Amount FROM SIDETRACK TO DESTINATION in [ton] ____

Sidetrack,Destination,Biomass_type,Biomas_form,Amount

LEW, Siechnice, willow, chips 1.00

_________________ ENERGY EMBEDED TILLAGE & CONVERSION in [GJ] ___________

Field,Storage,Biomass_type,Till,Raw_Pel,Ch_Pel,Raw_Ch,Ch_Ch

field_LEW_1,storage_LEW_1,willow,0.65,0.00,0.00,1.21,0.00

_________________ ENERGY EMBEDED in TRANSPORT in [GJ] _________________

Emb_transp_F_S__R =0.08
Emb_transp_F_S__Ch=0.00
Emb_transp_S_Si__Ch=0.06
Emb_transp_S_Si__P=0.00
Emb_transp_Si_D__Ch=0.04
Emb_transp_Si_D__P=0.00

_________________ TOTAL ENERGY EMBEDDED in [GJ] _________________
Total energy embedded,2.03

_________________ CO2 EMBEDED TILLAGE & CONVERSION in [kg] ________

Field,Storage,Biomass_type,Till,Raw_Pel,Ch_Pel,Raw_Ch,Ch_Ch

field_LEW_1,storage_LEW_1,willow,44.20,0.00,0.00,27.99,0.00

_________________ CO2 EMBEDED in TRANSPORT in [kg] _________________
CO2_transp_F_S__R =0.78
CO2_transp_F_S__Ch=0.00
CO2_transp_S_Si__Ch=4.50
CO2_transp_S_Si__P=0.00
CO2_transp_Si_D__Ch=1.15
CO2_transp_Si_D__P=0.00

_________________ TOTAL CO2 Emissions in [kg] _________________
Total CO_2 emissions 78.62

In order to read more easily the results, we exported these results in an Excel file. The results are thus in an Excel table.

	A	B	C	D	E
1				chips	pellets
2	LEW	Siechnice	willow	176	
3	LEW	Siechnice	maize	44	
4	JAW	Wroclaw	maize		75
5	IMG	Wroclaw	willow		75
6					

Figure 22: Results exported in Excel

To export the results, we had to use the following code (an example for energy embedded in tillage):

```
file Results_energy/ 'C:\gams\Results_energy.xls'/;
execute_unload "results.gdx" en_embed_Tillage.l
execute 'gdxxrw.exe results.gdx o=results_energy.xls var=en_embed_Tillage.l '
```

First of all, we had to give a name to our file and to determine where it will be. After, we had to determine which parameter we want to exported in Excel.

After that, the results can be presented such below for each scenario i.e. L (low), M (medium), H (high) for delivery of one ton of chips in order to analyze the results.

	Energy embedded [GJ]		
Process	**Low**	**Medium**	**High**
Tillage	0,38	1,05	1,73
Conversion	1,14	1,23	1,31
Transport	0,18	0,18	0,18
Total	1,7	2,46	3,22

Figure 23: Results energy embedded for each scenario

	CO_2 emissions embedded [kg]		
Process	**Low**	**Medium**	**High**
Tillage	32,21	44,14	55,97
Conversion	12,6	27,63	42,67
Transport	6,43	7,08	7,73
Total	51,24	78,85	106,37

Figure 24: Results CO2 embedded for each scenario

We launched the GAMS software for a very accurate model used by EDF Polska. This model is called BioLOG.

Above, the model we have studied:

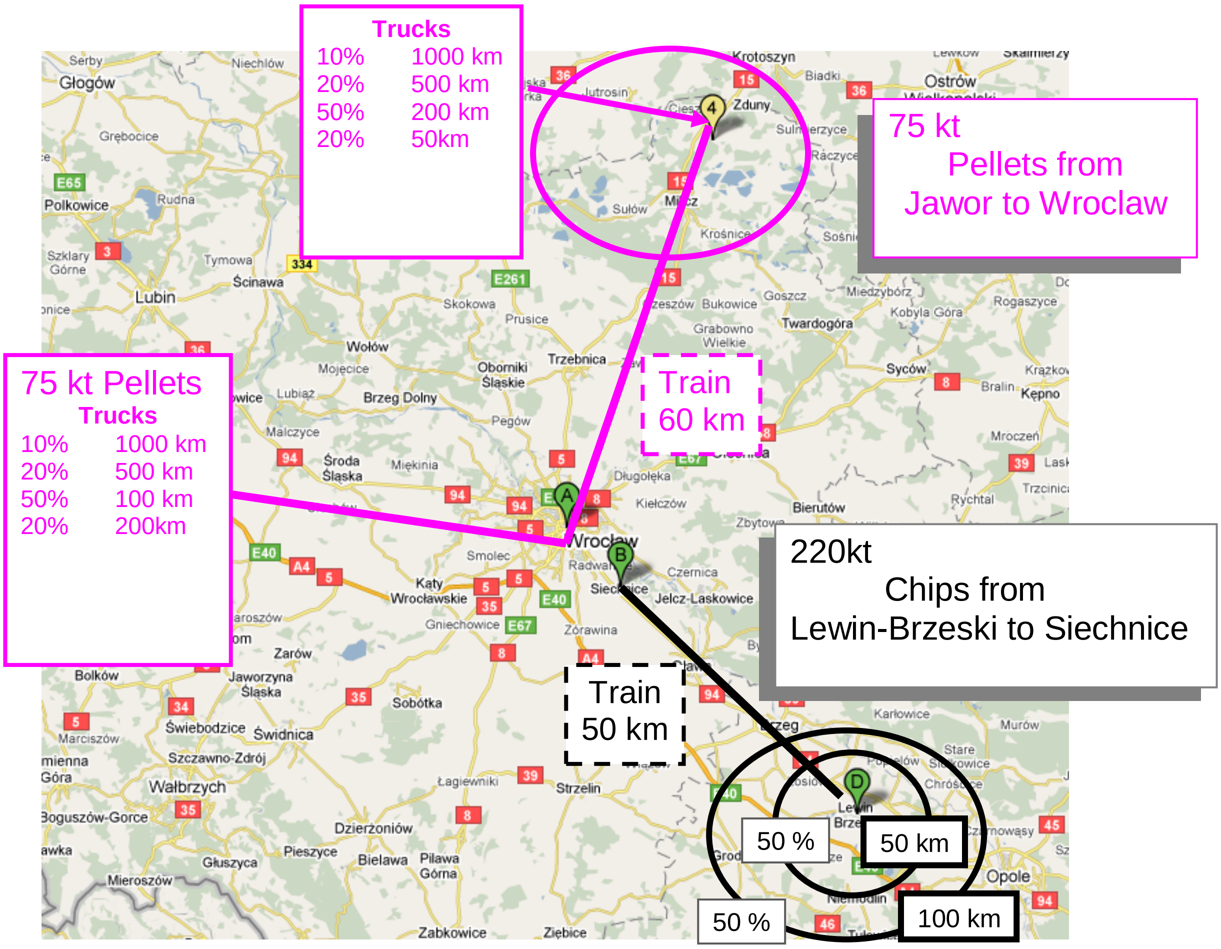


Figure 25: Biomass delivery plan to EC Wrocław and EC Czechnica **[4]**

BioLOG was used to calculate the energy and CO_2 emissions embedded in biomass delivery to EC Wrocław and EC Czechnice. The following assumptions have been made:

- **EC. Czechnica**

220 kt of chips will be delivered to the city of Siechnice by train from sidetrack located in Lewin Brzeski. Biomass will be delivered by trucks from two storage places in equal amounts. These storage places are located 50 km and 100 km from the sidetrack. The chips will be made in 80% from willow and in 20 % from maize.

- **EC. Wrocław**

150 kt of pellets will be delivered to the city of Wrocław. 75 kt of pellets will be delivered by trucks to the sidetrack and by train to the destination place. Another 75 kt of pellets will be delivered to EC Wrocław directly with the use of heavy duty vehicles from storage places located 100, 200, 500, and 1000 km away. It was assumed that 50% of pellets will be produced from willow and 50% from maize.

Then, we ran GAMS for the different places and the entire model to calculate the energy embedded and the CO_2 embedded. Here are the results:

	Energy embedded [TJ]		
Process	**Low**	**Medium**	**High**
Tillage	353,80	672,30	990,82
Conversion-chips	306,61	326,19	345,79
Conversion-pellets	275,26	443,26	611,26
Transport	123,39	123,39	123,39
Total	1059,06	1565,14	2071,26

Figure 26: Total energy embedded in delivery of biomass to EC. Wrocław and Czechnica.

	CO_2 emissions embedded [t]		
Process	**Low**	**Medium**	**High**
Tillage	17671,52	21153,26	24599,14
Conversion- chips	3035,01	7026,64	11018,26
Conversion -pellets	4275,00	4275,00	4275,00
Transport	6637,34	6435,84	6637,34
Total	31215,87	38890,74	46529,74

Figure 27: CO_2 emissions embedded in delivery of biomass to EC. Wrocław and Czechnica.

Then, we calculated the efficiency for the different places and for the entire model. For this, we used the following formula:

$$\eta_n = \frac{E - PE}{E}$$

where:

η_n - energy carrier efficiency,

E – specific energy content in the energy carrier (heat value),

PE – specific energy of biofuel production process.

So we had to do research in scientific journals to find the different values of heat value for pellets and chips.

	Heat Value (MJ/kg)
Willow chips	14
Maize chips	14,5
Willow pellets	17,5
Maize pellets	17,9

Figure 28: Heat value

After we calculated the energy delivered and, with GAMS, the energy embedded. Then, we applied the formula above and we found the following efficiency :

	Efficiency
Lewin to Siechnice	0,84
Jawor to Wroclaw (with train)	0,78
IMG to Wroclaw (without train)	0,80
Total	0,82

Figure 29: Efficiency for the BioLOG model

III. ASSETS AND PERSONNAL IMPRESSIONS

This internship as technician with a duration of 13 weeks was beneficial to me, both professionally and on a human level. Indeed, the lengthy duration of the work placement allowed me to familiarize myself with the work and get better acquainted with the people who worked in the office. In addition, this training helped me to improve my English. In fact, we had to discuss in English with researchers, but for example, software and codes required English language too.

We are three students of the Ecole des Mines de Douai to have done this internship in Poland. We worked at AGH University, in the faculty of Fuels and Energy. We were a total of seven people working in the office.
The working atmosphere was very pleasant, and people in the office were very nice and often available. They were always willing to answer our questions and gave us advice on the visits that we could do on the weekend to explore Krakow.

During this internship, we participated in the development of a model on GAMS software for the company EDF Polska. To present this project to EDF, we prepared a report with the results and improvements that the members of the team thought to add. Through projects and reports that we have done in the first and second year at the Ecole des Mines de Douai, we have put our skills into practice.
In addition, we had several meetings with our boss and team members during which we presented the progress of our work and we had to explain to the other members of the group what we were doing and what was the purpose of this work.
These exercises were very interesting and allowed me to speak to people in English. This allowed me to present my work to few people but also to communicate in English on my work.

Through these oral presentations, but also to the work required, I could improve my English. Indeed, during this work placement, I worked a lot on programming (for GUI, Visual Basic, and Gams for the model). I made some researches on the Internet and scientific journals too. I had to learn some specific language (VB, Gams code, ect..) , and in order to help me, I searched on web : all searches were conducted in English, I read documents in English and of course, I communicated in English with the members of the office. And when I went out to discover Krakow, I spoke English in the city. I have to admit that I was totally impressed to notice that Polish are bilingual or are speaking well English contrary to the average French people. I think I have really improved my listening and reading comprehension of the English language. Furthermore, this internship strengthened my view of the importance of speaking English fluently to be listened to and well understood by other people. In the beginning, it was quite hard for me to speak in English. But the duration of our internship was very good : now, I can speak more easily than before , with greater ease.

During my free time, I discovered a country that I did not know, a country steeped in history. I could see how deep the country has been bruised because of Second World War. So, I used this trip to Poland to go in the concentration camps of Birkenau and Auswitch, or to visit a Salt Mine. It was a very interesting day, very emotional and very rewarding.

I also walked a lot in Krakow. It is a city full of charm and very pleasant. The architecture is very nice and the place of the Rynek is very beautiful. I visited the sights of the city as the Wawel Castle, Jewish Quarter, the numerous churches ... The country seems very attached to his Catholic roots. The places of memory of former Pope Jean- Paul II are very present in Krakow. Religion has a real importance in the culture. And I made a lot of polish friends, and we will stay in contact.

To conclude, I really enjoyed this internship because we have learned a lot about Poland. We have seen, for example, currently the majority of electricity was produced with coal which is very polluting but Poland is looking for ways to reduce energy consumption and CO_2 emissions in this field, including using biomass. In addition, Krakow is a pleasant city to visit and why not, in the coming years to return to Krakow for a weekend or holiday. These three months have been an excellent opportunity to discover a new culture.

CONCLUSION

This internship permitted me to improve professional skills. I could appreciate how a project group, composed of researchers wishing to develop a product for a company (Here, it was for EDF).

Numerous domains specific to that project group were very instructive. This immersion in Poland is thus a real boon for my personal development and for my future career.

Also, I had the opportunity to deepen my knowledge and techniques. At the same time, I found out in detail the operation of GAMS, a software which permit the optimization, commonly used in the world of work. Being able to learn to master this useful tool was extra motivation.

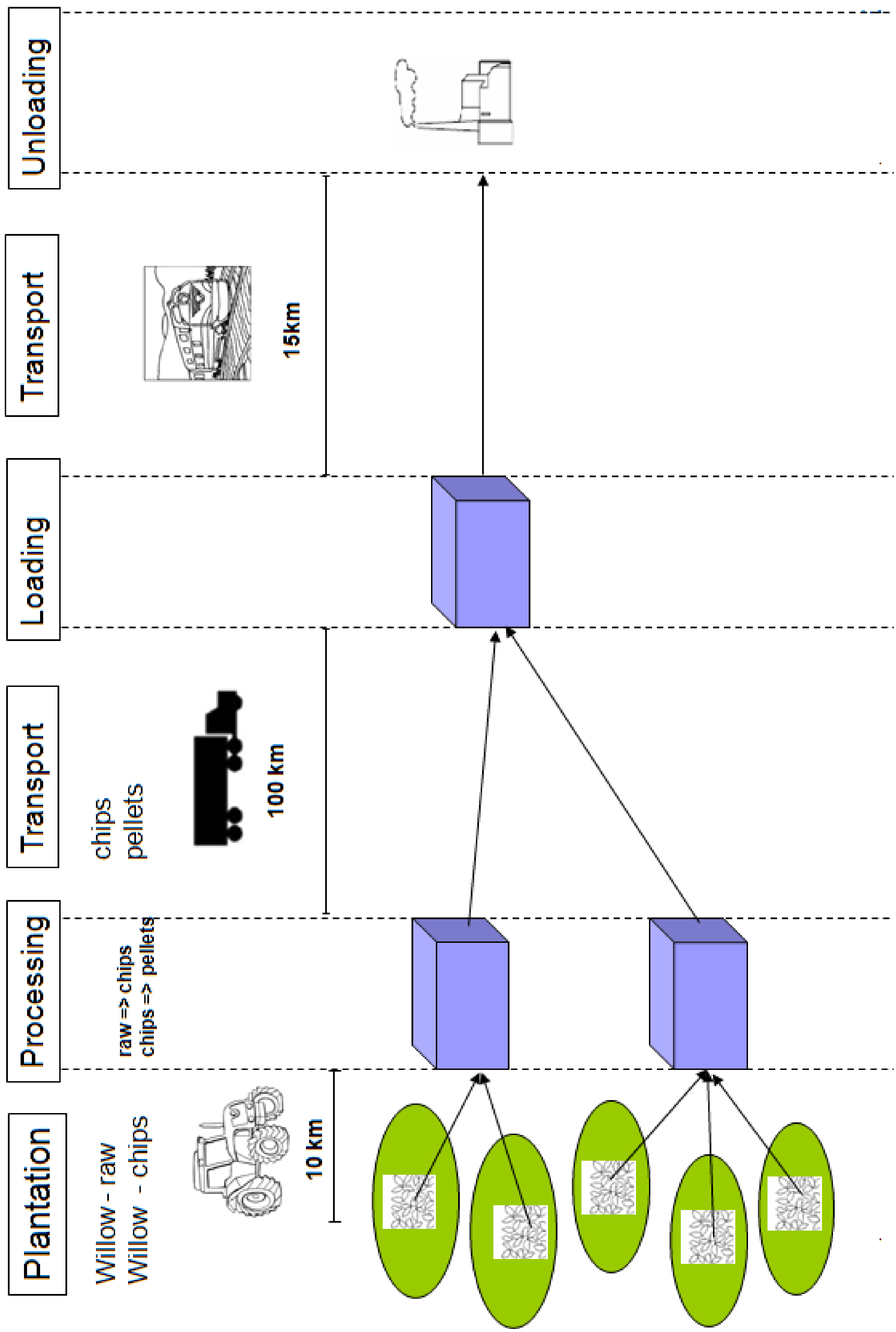
Other disciplines such as software development or the graphic interface were obviously well addressed, and I come away from this experience with concepts and concrete notions. I learned, watched, analyzed, and also realized!

It brought me a plus in general culture, and a real value because of improved to my technical skills: GAMS, VBA, GUI,.

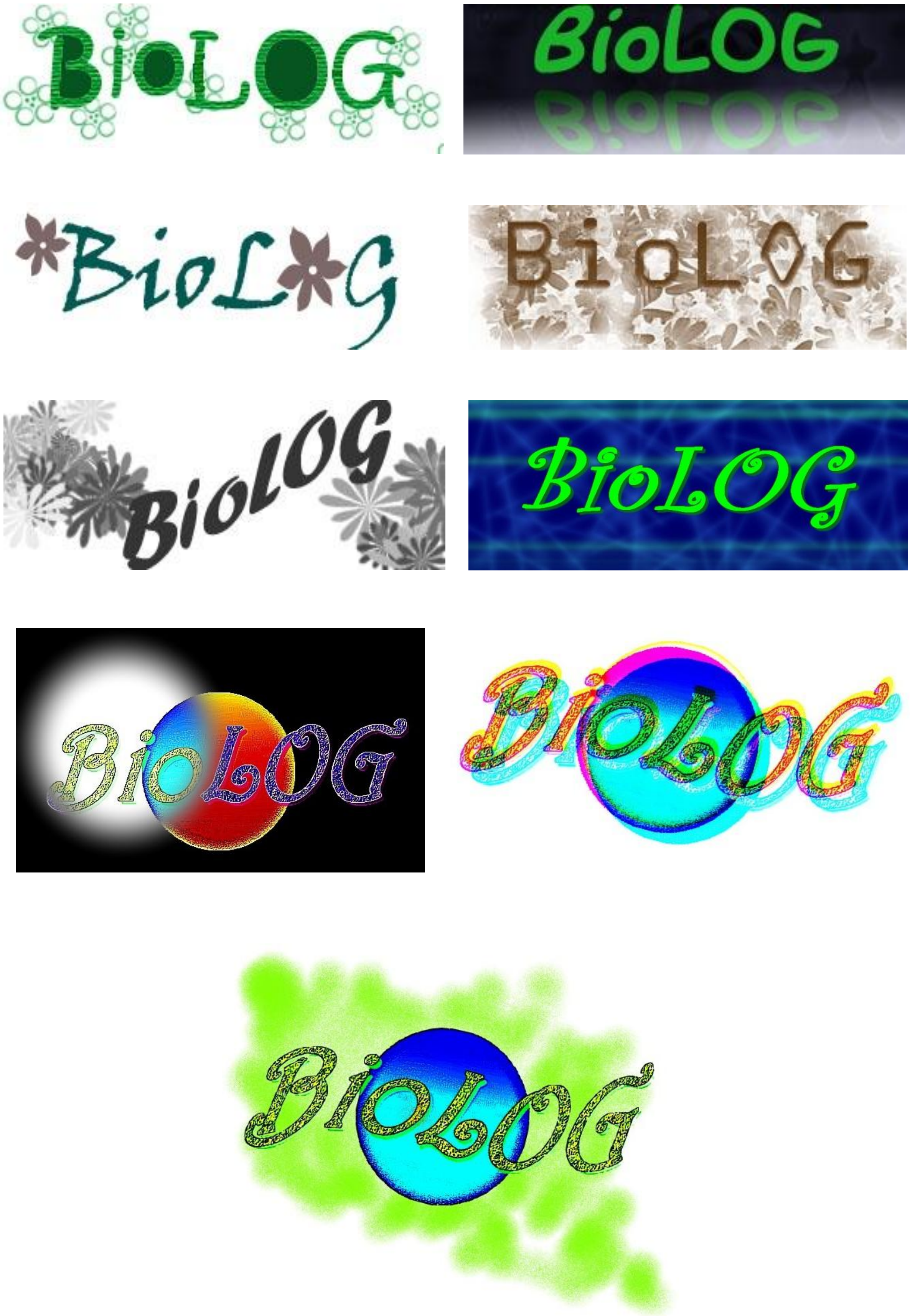
On the other hand, this internship was very educational on a personal level: the daily with researchers helped me identify and acquire new skills and working methods. I can take the example of the analytical mind, which is the researcher's own today. He can't let his work to luck, and must be initiated and reflected, these things are very difficult to reconcile usual.

By working in group, I also developed my personality and some human qualities. I think these qualities will be necessary for my future career in engineering.

This experience which showed me the world of work was actually beneficial-professionally as personally. What emerges clearly is that I still have a lot to learn, at the level of skills (human, technical, ..) but especially about the workplace and its operation ...


Plantation
Willow - raw
Willow - chips
10 km
Processing
raw => chips
chips => pellets
Transport
chips
pellets
100 km
Loading
Transport
15km
Unloading

EMISSIONS OF CO_2 FROM BIOMASS PRODUCTION AND TRANSPORTATION IN AGRICULTURE AND FORESTRY – BÖRJESSON - 1996


BioLOG

REFERENCE TABLE

[1] http://home.agh.edu.pl/~ppsn/images/agh_main_building.jpg

[2] http://www.agh.edu.pl/en

[3] http://www.edf.com/

[4] R&D Project Report - Optimizing Environment Protection Investments of EDF Polska Companies to Meet the Sustainable Development criteria (ENVIRO PROJECT) – Report prepared to present the work at EDF Polska

[5] http://www.gams.com/ (**A GAMS TUTORIAL by Richard E. Rosenthal)**

[6] http://silkyroad.developpez.com Utiliser les contrôles dans un UserForm (VBA Excel)