ERSA 2003 CONGRESS
UNIVERSITY OF JYVÄSKYLÄ, FINLAND

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ABSTRACT

World climate change is one of the main, current, environmental concerns. It is especially so in developed countries, where greenhouse gas emissions, responsible for this change, are chiefly concentrated.

In this paper a study is carried out of the emissions of the gases responsible for climate change in Asturias, where the economic structure involves a significant presence of sectors with highly concentrated emissions of CO_2, the chief greenhouse gas.

Our specific aims are: to determine the emission factors of these gases for the various productive and final consumption sectors of the regional economy; to record the direct emission volumes of these gases for 1995; and to apply the Input-Output analysis of Type I and Type II multipliers in order to establish direct and indirect emissions and direct, indirect and induced emissions, respectively.

DETERMINING THE IMPACT OF ECONOMIC ACTIVITY IN ASTURIAS ON GREENHOUSE GAS EMISSIONS[1]

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1. INTRODUCTION

World climate change is one of the chief, current, environmental concerns. It is especially the case in developed countries, where the main concentrations of the greenhouse gases responsible for this change are to be found. For this reason, in 1992, the United Nations Conference on Environment and Development (UNCED) was held in Rio de Janeiro (Brazil). Its aim was to consider the possibility of setting up world legislation for the climate. Thus, in the same year, the United Nations Framework Convention on Climate Change was drawn up and agreed. The text of this agreement was too ambiguous, so in 1995, in Berlin, the Conference of the Parties to this Framework Convention put forward the need to devise a new tool that would allow the real fulfilment of the aim of the agreement. There then began a process of working out a Protocol that would limit the emissions of greenhouse gases. It was in 1997 that this Protocol was adopted in the 3rd session of the Conference of the Parties celebrated in Kyoto. For the first time there was an agreement to reduce the net emissions of six gases in the industrialised countries (CO_2, CH_4, N_2O, HFC, PFC and SF_6) in the five-year period 2008-2012. This reduction was at minimum to be 5% on the 1990 level.

In 2002, the Autonomous Community of the Principality of Asturias approved an Institutional Declaration for sustainable development and the work to create a Strategy for Sustainable Development, based on the principles set forth in this declaration, was begun. Point 3 of the latter states: "Tendencies threatening sustainability, such as climate change…….should be identified and studied, in order to establish the generating mechanisms and evaluate their impact and temporal evolution." (Gobierno del Principado de Asturias, 2002).

In this paper a study is carried out of the emissions of the gases responsible for climate change in Asturias, whose economic structure involves a significant presence of sectors with a high concentration of CO_2 emissions, the chief greenhouse gas.

The starting point for the analysis carried out was the creation of an environmental Input-Output Table (IOT) for Asturias, using as a base the conventional IOT published by SADEI (1998).The calculation of the emission factors for each greenhouse gas, as well as the determination of the main sources of pollution, set out in section 2 of this paper, form the basis to calculate the physical emissions by the productive and final consumption sectors. Determining the said emissions forms the first part of section 3.At this point also, the estimates are made for direct and indirect emissions, based on Type I multipliers, and those for direct, indirect and induced emissions, as determined by Type II multipliers. The comparative analysis of the results obtained is made in the fourth and last section.

2. EMISSION FACTORS AND MAIN EMITTING SOURCES OF GREENHOUSE GASES IN ASTURIAS .

The sources producing greenhouse gases in Asturias, together with the methodology used to quantify them, are as follows[2]:

2.1.Carbon dioxide (CO_2)

a) Energy

In this section we include CO_2 emissions produced as the result of burning fossil fuels for energy, such in mobile as in stationary sources. When fossil fuels are burnt nearly all the carbon content is released into the atmosphere in the form of CO_2. The quantity of carbon per useful energy unit varies with the type of fuel, some fuels having a much greater potential effect on climate change than others.

The data used for fossil fuel consumption in Asturias in 1995 have been worked out from the regional Energy Statement (Gonzáles Chávez, 1996) and from the

information on sectors and household consumption supplied by the Input Output Tables (SADEI, 1998). Fuel consumption in physical tons for the corresponding sectors in the said year is given in Table1. The methodology used is similar to the one recommended by the IPCC (International Panel on Climate Change) (Miranda, B., 2002).

The emission factors for each type of fuel are:
Domestic coal: 1.987 t CO_2/t; Imported coal[3]: 2.748 t CO_2/t; Petrol: 3.105 t CO_2/t; Diesel fuel: 3.209 t CO_2/t; Kerosene[4]: 0.401 t CO_2/air movement; Natural gas[5]: 2.643 t CO_2/t or 1.9 t $CO_2/10^3m^3$; Propane and butane (PLG): 2.984 t CO_2/t.

b) Industrial processes.

In this section there are included the emissions that arise from certain industrial processes not directly related to energy activities such as the burning of fossil fuels.

The CO_2 emissions from Asturian industrial processes are a direct result of cement and aluminium production. The emissions generated as a by-product of the whole iron and steel industry, when coke is used as a reducing agent, are not accounted for in this section, since these emissions are already included in the energy section underneath the burning of fossil fuels.

The necessary data on clinker and aluminium production are from SADEI (2002). The emission factors are (Miranda, B., 2002 and IPCC, 1997): 0,507 t CO_2/t clinker for the cement production and 1.8 t CO_2/t aluminium for the aluminium production.

2.2 Methane (CH_4)

a) Energy

Methane emitted in the energy sector comes from some of the following sources: uncontrolled fixed combustion; natural gas and oil activities; mobile combustion (transport); mining and handling of coal and aviation.

The Principality of Asturias is affected by the methane emitted in all these activities except those of oil and natural gas. However, in practice only three will be taken into account, as the emissions from uncontrolled combustion are impossible to quantify.

a.1) Mobile combustion: Moving vehicles are one of the main emission sources of two of the six greenhouse gases, methane (CH_4) and nitrous oxide (N_2O). The calculation of methane emissions in this sector is based on a series of factors depending on the type of vehicle, the emission control technology and the kind of fuel.

The emission factors used in this study were (www.eea.eu.int): for petrol-driven vehicles: 1.13kg CH_4/t petrol in the case of private cars with no control technology and 0.314kg CH_4/t petrol for those with a three-way catalyser; for diesel vehicles: 0.083kg CH_4/t diesel for private cars and 0.243kg CH_4/t diesel for heavy load vehicles.

a.2) Mining and coal management: The formation process of coal creates methane and other products inherently. When it is being mined, methane escapes into the atmosphere. Methane emissions also occur when coal is being handled and used, although to a much lesser extent. The emission factors used to determine the methane emissions from Asturian mining were (IPCC, 1997): mining: 10 m^3 CH_4/t production. Post-mining: 0.9 m^3 CH_4/t production. The data on production volume is from SADEI (2002).

a.3) Aviation: The emission factor used is 0.03 kg CH_4/air movement (McGregor et al., 2001). Information on air traffic is from SADEI (2002).

b) Industrial processes.

In Asturias methane emissions from industrial processes are a direct result of coke production. The production data are from www.nalonchem.com The emission factor is 0.5 kg CH_4/tcoke (IPCC, 1997).

c) Agriculture.

Only emissions from livestock (enteric fermentation and manure use) and from the burning of agricultural waste need to be taken into account in the case of the Principality of Asturias. The necessary data on Asturian livestock and agricultural production are provided by INE (1998) and SADEI (2002).

c.1) Enteric fermentation: The methane emission factors with regard to the number of the heads of livestock in kg CH_4/ head are (IPCC, 1997): dairy herd: 100; other cattle: 48; sheep: 8; goats:5; pigs:1.5; horses:18; mules and donkeys:10.

c.2.) Manure management: Methane emission factors in kg CH_4/head are (IPCC, 1997): dairy herd: 44; other cattle: 20; sheep: 0.28; goats: 0.18; pigs: 110; horses: 2.08; mules and donkeys: 1.14.

c.3) Burning of agricultural waste: The quantity of methane emitted as a result of burning agricultural waste can be calculated from the carbon released by the different types of biomass and will vary for each kind of crop (maize and wheat in the case of Asturias). The methane emission factors as a result of the burning of agricultural waste in kg CH_4/t of crop are (IPCC, 1997): maize: 0.94; wheat: 3.38.

d) Sewage

Methane is generated in the anaerobic breakdown stage of sewage treatment when there is a high content of organic material.

The theoretical value of methane emission is of 0.25 kg CH4/kg DBO, DBO being the polluting load of sewage treated in kg per m^3. The data on the volume of sewage treated as well as DBO come from www.ine.es

2.3. Nitrous Oxide (N_2O)

a) Energy

Uncontrolled, fixed combustion and mobile combustion generate nitrous oxide (N_2O). Reference will, therefore, only be made to mobile combustion. As for methane emissions, N_2O ones are calculated bearing in mind the type of fuel used, the technology emission control and the type of vehicle.

The emission factors used in this study were (www.eea.eu.int) for petrol-driven vehicles. 0.071 kg N_20/tpetrol in the case of private cars without control technology and 0.784 kg N_20/t petrol for private cars with a three-way catalyser. for diesel vehicles: 0.165 kg N_20/t diesel for private cars and 0.122 kg N_20/t diesel for heavy load vehicles.

b) Industrial processes

In Asturias nitrous oxide is generated as a sub-product in the production process of nitric acid. Information on the production of this acid comes from www.fertiberia.com. The emission factor used in 5kg N_20/t acid (IPCC, 1997).

c) Agriculture

Nitrous oxide from agricultural activities includes that generated as a result of the oxidation of the nitrogen from the biomass of the farming land and from the nitrogen excreted in the dung of the livestock. The necessary data on Asturian livestock farming and agricultural production are from INE (1998) and SADEI (2002).

c.1.) Manure management: The nitrous oxide emissions from this activity vary according to two characteristic parameters: the type of livestock and the different ways of handling manure. The amount of nitrogen expelled by each animal, transformable into N_20 (see Table 2) is calculated from the amount of nitrogen excreted by each type of livestock (N_{ex}), together with the default values given to express the proportion of manure that is collected following each of the different systems to be found in Western Europe.

The emission factors used (in kg N_20/kg N_{ex}) were the following (IPCC, 1997 and own calculations): liquid type system. 0.0016; daily fertilizer: 0; solid storage: 0.03; meadows and pastures: 0.03; other systems: 0.008.

c2) Burning of waste: The N_20 emissions from the burning of waste are according to the type of crop. The emission factors used (kg N_20/t of crop) were the following (IPCC, 1997 and own calculations): maize, 0.03; wheat, 0.07.

c3) Farming land:

Fertilizers: the emission rate for each kg of nitrogen applied to the land is of 17.678kg N_20/t N (IPCC, 1997 and own calculations). The annual data on the use of nitrogen fertilizers on farming lands in Asturias come from INE (1997) and www.ine.es

Dung: when calculating emissions from the use of dung as fertilizer, the main variable is the type of livestock it is from and its nitrogen content. Its emission factor is 0.015 kg N_20/kg N (IPCC, 1997 and own calculations) and the nitrogen expelled by each type of livestock, the following: dairy herd, 100; other cattle, 70; sheep, 20; pigs, 20; goats, horses, mules and donkeys, 25.

Nitrogen-fixing crops (dry pulses and soya): the corresponding emission factor is of 1.18 kg N_20/t of pulse crop (IPCC, 1997 and own calculations).

Crop residue: these emissions are a direct result of the regional, agricultural production and of their nitrogen content. Grouping together all the factors that influence on the emissions, the calculation is as follows:

N_20 (kg) = { non-nitrogen-fixing crops N(kg)x 0.015 + nitrogen-fixing crops N((kg)x 0.03}x 0.019

Soil cultivation: the emission factor is 7.86 kg N_20/Ha (IPCC, 1997 and own calculations). The data on the number of cultivated hectares in Asturias is from INE (1997)

Atmospheric deposits: Nitrous oxide, released into the atmosphere, is obtained from the nitrogen expelled by the animals (N_{ex}), volatilised in the form of N_20, and the synthetic nitrogen applied to the soil (N_{fert}). N_{ex} are the values given in Table 2.

$$N_20 \text{ (kg)} = \{ N_{fert} \times 0.1 + N_{ex} \times \text{heads} \times 0.2 \} \times 0.0157$$

Lixiviation and run-off: a small amount of the nitrogen applied to the soil, either as a synthetic fertilizer or as dung, is swept away by rain- water. The emission factor is 0.01178 kg N_20/kg N (IPCC, 1997 and own calculations).

2.4. Halogenated hydrocarbons (PFC/HFC) and sulphur hexafluoride (SF_6)

Halogenated hydrocarbons have been calculated as a whole for Asturias. Sulphur hexafluoride emissions are nil.

a) Industrial processes

PFC emissions are from aluminium production. Emission factors, varying according to the techniques used, will be applied to the figures for aluminium production. In Asturias the HS Sodeberg technique is used and its emission factor is 1.00 kg CF_4/t aluminium (IPCC, 1997). The C_2F_6 is one tenth of CF_4.

b) Other emission sources

The remaining emissions of HFC/PFC in Asturias come from transport refrigeration systems and households.

b1) Transport refrigeration systems: the emissions in this case are leaks from refrigerated vehicles. The data for Spain has been used to calculate this (www.ine.es) and, subsequently this data was adapted for the region, using the population ratio between the Asturian and the national one.

b2) Households: the leaks that are occasioned when the refrigerators are destroyed were considered. To calculate the total emissions the data taken was a loss of 100 gr/refrigerator for the gas found in the pipes and 10 gr/100 refrigerators for the spray spread that the refrigerator recovers. (Source: COGERSA).

3. ESTIMATE OF GREENHOUSE GAS EMISSIONS IN THE PRINCIPALITY OF ASTURIAS

In this paper the Input-Output Table for Asturias, corresponding to the year 1995 (SADEI, 1998), has been used with some modifications: linking of the production sectors into twelve[6] and conversion of the Table into euros (see Table 3) .

3.1. Estimate of direct greenhouse gas emissions

On one hand the emissions of the gases which form the object of our study come from the activity of the different production sectors in the economy, and on the other hand from regional household consumption.

The emission sources in the production sectors are two: the burning of fuel to obtain energy and their own production processes. In order to calculate the emissions from the former, we need to know the actual quantity of fuel j used by sector i ($\mathbf{F_{ij}}$) and the emission factors for each type of fuel ($\mathbf{e^k_{ij}}$).The emission factor stands for the amount of pollutant k generated when sector i uses a unit of fuel j. The physical emissions from fuel burning in each sector i are obtained from the product $\mathbf{F_{ij} \times e^k_{ij}}$. There are added to this the emissions from the production process, which are obtained by multiplying the emission factor for each sector ($\mathbf{n^k_i}$), that is, the amount of pollutant k generated per unit output in the production process of sector i, by the total output for the sector ($\mathbf{X_i}$): $\mathbf{n^k_i \times X_i}$. The sum of both products gives as a result the amount of pollutant k generated by the sector i in physical units: $\mathbf{(p_x)_{k,i}}$.

The emissions from consumption in households $\mathbf{(p_c)_{k,h}}$ result from the burning of fuels for energy purposes. The emission factors for each pollutant and type of fuel ($\mathbf{e^k_{hj}}$) are multiplied by the physical amount of each fuel consumed in households ($\mathbf{F_{hj}}$). Only in the case of HFC/PFC gases are emissions from dwellings unrelated to fuel use, but to refrigerator consumption (see previous section).

The total of direct emissions thus calculated are shown in Table 4. It can be seen that greenhouse gas pollution in Asturias comes almost entirely from CO_2 emissions which make up 99.75% of the total. The remainder corresponds almost entirely to

methane, emissions of N_2O and HFC/PFC being practically nil. The big producers of CO_2 are the coke refineries, producing the coke needed for iron and steel activities and the power stations, generating electricity with coal as raw material. Both activities account for 75% of the regional CO_2 emissions. They are followed, though at some distance, by household consumption and the remaining industrial activities as sources of direct CO_2 emissions. With regard to methane, arable and livestock farming together with coal mining generate 99.4% of the emissions. The primary sector is also the main source of N_2O emissions (67.2%), followed by the chemical industry (30.4%). Finally, the HFC/PFC emissions come almost entirely from aluminium production (99.6%).

Once the emissions generated by the different production sectors are known $\mathbf{(p_x)_{k,i}}$ the output-pollution coefficients can be determined $\mathbf{(m_x)_{k,i}}$ which represent the amount of pollutant k, generated in the production of an output unit of the sector i dividing $\mathbf{(p_x)_{k,i}}$ by the output of sector i $\mathbf{(X_i)}$. Thus, it is possible to obtain the matrix k x i of output-pollution coefficients $\mathbf{(M_x)}$ set out in Table 5. This table also includes the vector k x 1 of consumption- pollution coefficients **(Mc).** The elements of this vector are the coefficients $\mathbf{(m_c)_{k,h}}$, which represent the pollution generated per unit of final consumption. They are obtained by dividing $\mathbf{(p_c)_{k,h}}$ by the total household consumption **(C).**

Therefore, the total volume of direct emissions (p) is equal to:

$$p = p_x + p_c = M_x \times X + M_c \times C \qquad (1)$$

Where $\mathbf{p_x}$ and $\mathbf{p_c}$ are vectors k $\times$1 that represent the total direct emission volumes from the production sector and household consumption respectively**.** X is the vector i $\times$1 of sector outputs.

3.2 Estimate of direct and indirect emissions of greenhouse gases: analysis of Type I multipliers.

The analysis of the direct and indirect effects of each sector on gas emissions means one step further in the study of the agents responsible for this kind of pollution. The starting point for this analysis is to be found in the Leontief Demand Model. All the

production activity of an economy is directed towards satisfying the final demand. Towards this aim, each production sector makes an intermediate demand of inputs from other sectors necessary for its production. If we look at the rows of a IOT corresponding to the production sectors, it can be seen how each one of their outputs is wholly meant to satisfy the intermediate demand of the other sectors and the final demand. This can be represented by the following equation:

$$A \times X + D = X \qquad (2)$$

Where **A** is the matrix i × i of regional technical coefficients **(a^R_{ij})**, **X** is the vector i × 1 of sector outputs and **D** the vector i × 1 of the final demand of regional products. Finally:

$$a^R_{ij} = \frac{x^R_{ij}}{X_j}$$

x^R_{ij} being the amount of production obtained in Asturias by sector i which is used by the regional sector j and X_j the output of sector j.

The Leontief inverse matrix **$(I-A)^{-1}$** relates the sector output to the final demand by way of the following formula:

$$X = (I-A)^{-1} \times D \qquad (3)$$

The elements of the Leontief inverse matrix **(b_{ij})** represent the output of sector i needed, directly or indirectly, to produce a final demand unit in sector j.

If the sectors produce to meet a determined final demand, the pollution they generate (px1) can also be attributed to that final demand. That is:

$$p_{x1} = M_x \times (I-A)^{-1} \times D = M_{x1} \times D \qquad (4)$$

Where **M_{x1}** is the matrix k × i of Type I output-production multipliers. Each element of this matrix **(ε_{ki})** is the amount of pollutant k directly or indirectly attributable to a final demand unit in sector i. Thus, Type I multipliers allow the calculation of direct and indirect emissions attributable to each one of the production sectors. Hence,

emissions attributed to a said sector i are not only those for which its production activity is directly responsible, but those generated by the production activity of other sectors seeing to the intermediate input demand of sector i. Indeed, all these emissions are thus attributed to the final demand of sector i. The matrix M_{x1} in the case of Asturias is set out in Table 6.

Vector **p**, representing the total emissions of pollutants, can now be expressed as follows.

$$p = p_{x1} + p_c = M_{x1} \times D + M_c \times C \qquad (5)$$

Direct and indirect emissions per production sector and final consumption appear in Table 7, expressed in physical quantities and as a percentage of the total emissions of each pollutant k. In the case of CO_2 the main sectors of pollution are "Metallurgy and manufacture of metallic products" (35%), which include the iron and steel industry and aluminium production, and "Electric energy, gas, steam and hot water" (28.5%). With regard to methane, 75% of the emissions are caused by "Agriculture, forestry and fishing", "Other manufacturing industries" and "Electric energy, gas, steam and hot water", with each of the three sectors responsible for a similar amount. The primary sector of the economy is again the main emitter of nitrous oxide, with 32% of the total emission; there follow "Other manufacturing industries" with 28% and the "Chemical industry" with 24.4%. Finally, the chief generator of HFC/PFC is "Metallurgy and manufacture of metallic products" as a result of aluminium production. This sector emits 91.7% of the total.

In Table 8 the direct and indirect emissions of the production sectors appear divided into final demand sectors. In this way it is possible to see how the emissions are distributed among the different kinds of final demand, with exports being the area responsible for a greater percentage of emissions.

3.3 Estimate of direct, indirect and induced emissions of greenhouse gases: analysis of Type II multipliers.

The conventional Input-Output analysis of direct and indirect effects stems from the fact that each production sector uses inputs from other sectors to carry out its

production and thus meet its final demand. This analysis is completed with the inclusion of induced effects. To do this one must take into account that the sectors use the labour factor in their production process. This labour factor derives from households, who receive income in exchange. The income obtained is used by the households to pay for their consumption and so the emissions coming from this consumption can be attributed, ultimately, to the production sectors.

The part of household consumption financed by income from labour obtained in the regional production sectors must be considered as endogenous to the system in order to incorporate the induced effects. The household sector is treated as yet another production sector, whose output is the labour factor sold to other sectors and whose input the consumer spending effected.

A broader matrix of inter-industrial transactions **(X*)**, is thus built with an additional column and row. The column collects the household inputs, made up by their domestic consumption (of regional products) **(C_i^R)**. The output of the household sector dedicated to other regional production sectors, whose value corresponds to the labour income paid for each one of these sectors **(W)**, is included in the row.

Starting from X* a broader matrix of regional, technical coefficients is constructed **(A*)** again including an additional column and row. The quotient between household consumption of products from each sector i and total domestic consumption **(C^R)** form the elements of the new column. The elements of the new row are calculated as the quotient between the incomes from labour paid by each sector and their production volume, X_i. This way it is possible to obtain the Leontief inverse matrix Type II: **$(I-A^*)^{-1}$**

Household consumption is no longer considered exogenous as a whole. A part of it, that financed by the incomes from labour paid by the regional production sectors, is endogenised. The coefficients of consumption-pollution **$(m_c)_h$** of the vector Mc are divided into two parts: the coefficients of the household output-pollution **$(m_x)_{k,h}$** and the coefficients of consumption-pollution **$(m_{c^*})_{k,h}$**. The later are calculated for the part of

household consumption that is still exogenous, that is, it is derived from sources of income other than labour.

In Asturias the part of the total household consumption (C) financed by labour income is 0.7369 and the exogenous part 0.2630. The coefficients $(m_x)_{k,h}$ are calculated as 0.7369 x $(p_c)_{k,h}$/W. The coefficients $(m_{c*})_{k,h}$ are 0.2630 x $(p_c)_{k,h}$/C.

Once the coefficients $(m_x)_{k,h}$ are known, it is possible to construct the matrix k×(i+1) of the output-pollution coefficients, now enlarged by a new column corresponding to the said coefficients **($\mathbf{M}^*_x$)**. When this matrix is multiplied by Leontief's inverse Type II, we obtain the matrix k×(i+1) of Type II output-pollution multipliers **($\mathbf{M_{x2}}$)** (see Table 9):

$$M_{x2} = M^*_x \times (I-A^*)^{-1} \quad (6)$$

Pollution generated by the production sectors **($\mathbf{p_{x2}}$)** is calculated as follows:

$$p_{x2} = M_{x2} \times D_{(-h)} \quad (7)$$

where **$\mathbf{D_{(-h)}}$** is the final exogenous demand. This now is no longer all the final demand, the endogenous part of household consumption must be discounted.

Pollution generated by exogenous household consumption **($\mathbf{p_{c2}}$)** is calculated as follows:

$$p_{c2} = M^*_c \times C \quad (8)$$

where $\mathbf{M}^*_c$ is the vector of pollution-consumption coefficients, $(m_{c*})_{k,h}$, corresponding to the exogenous part of household consumption.

The vector **p**, which represents the total polluting emissions, can now be expressed as:

$$p = p_{x2} + p_{c2} = M_{x2} \times D_{(-h)} + M^*_c \times C \quad (9)$$

The direct, indirect and induced emissions per production sector and final consumption are shown in Table 10. For gas, the main polluting sectors are the same as for direct and indirect emissions. A comparative analysis is made in the next section.

Finally, the total direct, indirect and induced emission per final demand sectors appears in Table 11. As with Table 8 it can be seen that the majority of emissions of the different pollutants can be attributed to exports.

4. ANALYSIS OF RESULTS.

In this paper emissions of greenhouse gases have been attributed in three different ways. Firstly, the direct emissions from each production sector and the final consumption were calculated; secondly, the direct and indirect emissions of the production sectors; and, lastly, the direct, indirect and induced emissions attributable to each one of the latter. In each case the results obtained vary, giving rise to a different participation by the different sectors and the consumers in the total emission of pollutants.

In the first place it is important to remember that CO_2 is responsible for practically all greenhouse gas pollution in this region, being 99.75% of the whole. This percentage is higher than that corresponding to Spain or to the European Union. For the former, national emissions of CO_2 in the period 1990-2000 were 79.5% of the total of this type of gas, whereas in the EU the percentage was 80.3% (IHOBE, 2002).

That CO_2 makes up such a large share of the total emissions in Asturias is closely linked to the production structure (see Table 3). The production of iron and steel, metallurgy and the production of electricity in coal-fired power stations, both of which have highly intensive CO_2 emissions, are strongly present in the region (see Table 5). Thus, 39% of the emissions correspond to the "Coke and petroleum refineries" in which is included the coke production used basically in steel- making. This is followed by the production of electrical energy with somewhat more than 36%. Following with a much lower percentage, household consumption accounts for 8.2% and "Other non-metallic mineral products" for about 6% (see Table 4).

These percentages are modified when the direct and indirect emissions for each production sector are estimated (see Table7). Now, the branch of "Metallurgy and

manufacture of metallic products", whose direct emissions of CO_2 do not reach 2%, is responsible for 35% of the emissions. At the same time coke refineries, chiefly responsible for direct emissions, drop to 4.4%, since their coke production is a basic input of iron and steel industry. Electricity generation, second in order of importance in responsibility for CO_2 pollution, has its share cut from 36 to 28.5%, since, again, its output is an input for the remaining production sectors. However, it is still the second highest emitter of this gas. This is due to a great extent to the fact that a large part of its production is not used within the region, but exported to the rest of Spain, approximately 48% (see Table 3). It is worth noting the slump in emissions corresponding to the branch "Other non-metallic mineral products". Cement production is an important part of this and it is a product used as input by other production sectors, especially construction, whose emissions increase.

Because, when calculating direct, indirect and induced emissions, a part of household consumption was endogenised, the exogenous consumption is reduced and, as a result, its CO_2 emissions are now 2% of the whole. By attributing CO_2 emissions to the different production sectors, an increase of the sectors that pay more incomes for labour to households would be expected. Comparing the results from Table 10 with those from Table7, it is those sectors that bear a heavy weight in the regional economy, "Metallurgy and manufacture of metal products", "Construction" and the service sector, which see a more significant increase.

Methane accounts for 0.24% of the total gas emissions in Asturias, much lower than the Spanish figure (10.5%) and the European one (9.3%), both estimates for the time period 1990-2000 (IHOBE, 2002). The agricultural sector, with 57% of the total direct emissions and coal mining with 42.5% are responsible for the emissions in this region (see Table 4). When these are compared with direct and indirect CH_4 emissions as seen in Table 7, it can be observed the share of these two sectors in the total emissions is considerably reduced. Once more the reason lies in the fact that their output is used as an input in other production sectors. "Other manufacturing industries", the heading under which the regional food and agricultural industry is found, leads in first place with 24.5%. It is followed by electricity generation with 23%, using basically regional coal and, at a greater distance, "Metallurgy and manufacture of metal products" (7.2%), also a coal-consumer, and "Other services" (7.9%). The inclusion in the last

sector of hotel and catering, which is a consumer of primary sector products, could lie behind the increase. When the results of the direct, indirect and induced emissions are analysed (see Table 10) and compared with the previous ones, it is clear that the share of services, construction and metallurgy activities in the total emissions of CH_4 increases.

The emissions of nitrous oxide account for 0.009% of the total emissions in Asturias, an insignificant percentage, especially when compared to the 8.3% and 9.1% of Spain and the EU, respectively, in the period 1999-2000 (IHOBE, 2002) .The main direct emitters of N_2O are the primary sector (67.2%) and the chemical fertilizer industry (30.3%). Again, when the results corresponding to the direct and indirect emissions are analysed (see Table 7), a decrease in these two sectors can be noticed (32% and 24.4%) as well as a sharp increase in "Other manufacturing industries" (28.2%). The explanation for the observed changes, both in the direct and indirect effects and the direct, indirect and induced ones, is similar to that offered in the case of methane.

The emissions of the remaining gases (HFC/PFC) are virtually insignificant. Their quantity is even lower than that of N_2O and they correspond basically to the aluminium industry included in the branch "Metallurgy and manufacture of metal products" (99.6%). The weight of this branch is reduced to 91.7%, when direct and indirect emissions are under consideration, and the share of others, notably construction, rises. These changes would arise from the use of aluminium as an input in other production sectors, with the remainder being exported from the region.

FOOTNOTES

[1] This work has been financed by the I+D+I regional Plan of Asturias 2001-2004 under the section for grants to carry out agreed research projects. File no. PC-CIS01-21. Resolution of 26th September 2002.

[2] This task has been carried out by Beatriz Miranda, contracted as a researcher for the project financed by the I+D+I Regional Plan of Asturias 2001-2004, no. PC-CIS01-21.

[3] The quality of this type of coal and, therefore its carbon content will vary according to the country of origin. Finding an emission factor is, therefore, very complicated. The coal emission factor, recommended by the EPA (Environmental Protection Agency, 1999), was used.

[4] Aeroplane consumption of kerosene is the origin of the emissions from the burning of this fuel. The emission factor used has been taken from McGregor et al. (2001)

[5] The emission factor used by natural gas was the one recommended by the IV Conference on Air Quality of Spain (Ministerio de Medio Ambiente ,2000).

[6] The 60 branches of the Asturian Input Output Table are aggregated as follows: Agriculture, forestry and fishing (81+2+3); Coal mining (4); Other Mining activities (5+6+7+8); Coke and petroleum refineries (17); Chemical industry (18); Other non metallic mineral products (20); Metallurgy and manufacture of metal products (21+22); Other manufacturing industries (9+10+11+12+13+14+15+16+19+23+24+25+26+27+28+29+30+31); Electricity, gas steam and hot water (32);Construction(34); Transport (39+40+41+42); Other services (33+35+36+37+38+43+44+44bis+45+46+47+48+49+50+51+52+53+54+55+56+57+58 +59+60).

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www.princast.es	Gobierno del Principado de Asturias
www.nalonchem.com	Industrial Química del Nalón, S.A.
www.ine.es	Instituto Nacional de Estadística
www.ipcc.ch	Intergovernmental Panel on Climate Change (IPCC)
www.mma.es	Ministerio de Medio Ambiente de España
www.sadei.es	SADEI
www.unfccc.int	United Framework Convention on Climate Change

TABLE 1. FUEL CONSUMPTION BY SECTORS (in tonnes), 1995

	Domestic Coal	Imported Coal	Petrol	Diesel	Fuel oil	Natural Gas*	Natural Gas **	PLG
Agriculture, forestry and fishing	5411	0	313	31051	0	208	572	575
Coal Mining	0	0	22	1115	0	0	0	0
Other Mining Activities	0	0	5	118	224	0	0	0
Coke and Petroleum Refineries	7516	4844851	0	0	0	0	0	0
Chemical Industry	1704	260055	0	158	7624	53548	147257	0
Other Non Metallic Mineral Products	431	42345	1	361	73428	201689	554645	3033
Metallurgy and Manufacture of Metal Products	3760	0	17	4759	28525	59841	164563	6264
Other Manufacturing Industries	220	0	11	566	177074	114044	313621	22307
Electricity, Gas Steam and Hot Water	4591223	1061754	0	3520	119091	1853	5096	0
Construction	0	0	32	337	0	2925	8044	0
Transport	18	0	3158	15525	0	0	0	42
Other Services	40376	0	0	24320	0	52359	143987	3307
Households Consumption	106522	46654	180719	301116	0	143355	394226	65677
TOTAL	**4857181**	**6255659**	**184278**	**382946**	**405966**	**629822**	**1732011**	**101205**

* In thousands of therms; ** thousands of m^3 ; the rest of the Table is in tonnes.

SOURCE: Gonsales Chaves, S. (1996), SADEI (2002) and own calculations

TABLE 2. NITROGEN EXCRETED BY EACH TYPE OF LIVESTOCK ACCORDING TO THE MANURE MANAGEMENT SYSTEM (kg N_{ex}/head).

	Liquid Type System	Daily Fertilizer	Solid Storage	Meadows and Pastures	Other Systems
Dairy herd	38.5	0	1.4	23.1	6.3
Other cattle	46	24	21	8	1
Sheep	0	0	0.4	17.4	2.2
Pigs	15.4	0	4.6	0	0
Goats, horses, mules and donkeys	0	0	0	24	1

SOURCE: IPCC (1997) and own calculations.

TABLE 3. INPUT OUTPUT TABLE OF ASTURIAS, 1995 (In thousands of Euros)

INTERMEDIATE DEMAND MATRIX		Agriculture, forestry and fishing	Coal mining	Other Mining activities vas	Coke and petroleum refineries	Chemical industry	Other non metallic mineral products	Metallurgy and manufacture of metal products	Other manufacturing industries	Electricity, gas steam and hot water	Construction	Transport	Other services	**Intermediate Outputs**
Agriculture, forestry and fishing	**Asturias**	**120256**	**6342**	**192**	**2**	**656**	**2**	**42**	**203935**	**1**	**28**	**1**	**9619**	**341077**
	R. of Spain	6497	8379	0	0	437	0	0	209402	0	161	3	16966	241844
	R. of World	273	0	0	0	1093	0	0	42619	0	5	0	553	44544
	TOTAL	**127026**	**14721**	**192**	**2**	**2187**	**2**	**42**	**455956**	**1**	**195**	**4**	**27138**	**627465**
Coal mining	**Asturias**	**162**	**0**	**0**	**482**	**117**	**30**	**257**	**15**	**314004**	**0**	**1**	**9530**	**324598**
	R. of Spain	208	0	0	32	0	0	0	0	0	0	0	70	310
	R. of World	0	0	0	161256	8656	1409	0	0	35339	0	0	0	206661
	TOTAL	**370**	**0**	**0**	**161770**	**8772**	**1439**	**257**	**15**	**349343**	**0**	**1**	**9601**	**531569**
Other Mining activities	**Asturias**	**0**	**55**	**0**	**0**	**389**	**34244**	**5715**	**278**	**0**	**14058**	**20**	**156**	**54915**
	R. of Spain	16	1043	0	0	2767	13471	57873	467	0	11710	0	28	87376
	R. of World	0	0	0	0	4182	20314	185032	222	0	1433	0	0	211183
	TOTAL	**16**	**1098**	**0**	**0**	**7338**	**68029**	**248620**	**968**	**0**	**27201**	**20**	**184**	**353473**
Coke and petroleum refineries	**Asturias**	**0**	**0**	**0**	**0**	**6086**	**0**	**191571**	**0**	**51101**	**0**	**0**	**0**	**248757**
	R. of Spain	8975	2103	1644	651	1252	9538	26518	11174	10514	18441	80270	50121	221200
	R. of World	1090	559	0	196	10386	4213	1925	377	68809	2185	15581	5093	110413
	TOTAL	**10065**	**2662**	**1644**	**846**	**17724**	**13751**	**220014**	**11551**	**130424**	**20626**	**95851**	**55214**	**580370**
Chemical industry	**Asturias**	**1288**	**5699**	**2467**	**93**	**2296**	**513**	**26793**	**2880**	**82**	**6414**	**10**	**1595**	**50130**
	R. of Spain	6655	2688	1213	200	16363	11240	13454	27918	1088	12223	592	44076	137711
	R. of World	1036	1399	0	0	42193	8086	935	7023	102	239	88	9566	70668
	TOTAL	**8979**	**9786**	**3680**	**293**	**60853**	**19839**	**41182**	**37822**	**1273**	**18876**	**690**	**55237**	**258509**
Other non metallic mineral products	**Asturias**	**66**	**722**	**1**	**320**	**0**	**22132**	**45792**	**2060**	**103**	**107311**	**137**	**2583**	**181228**
	R. of Spain	73	18	0	0	0	5434	15167	14855	95	69906	42	6485	112074
	R. of World	0	0	0	0	0	1880	0	4361	0	7542	0	270	14053
	TOTAL	**139**	**740**	**1**	**320**	**0**	**29446**	**60959**	**21276**	**198**	**184759**	**178**	**9338**	**307355**
Metallurgy and manufacture of metal products	**Asturias**	**442**	**10978**	**251**	**516**	**231**	**3250**	**218745**	**44068**	**54946**	**90940**	**1488**	**2806**	**428662**
	R. of Spain	2598	2125	302	198	125	4352	267260	53753	1741	30789	1243	5023	369509
	R. of World	21	749	0	0	287	386	151163	23965	134	2359	0	330	179394
	TOTAL	**3062**	**13853**	**553**	**715**	**644**	**7989**	**637168**	**121785**	**56821**	**124087**	**2731**	**8158**	**977565**
Other manufacturing industries	**Asturias**	**44674**	**13451**	**2027**	**3424**	**3818**	**9541**	**58914**	**104580**	**6708**	**48061**	**11203**	**143315**	**449718**
	R. of Spain	34793	8419	1622	1964	5912	8674	46288	321164	12174	62877	48461	211453	763802
	R. of World	596	2270	0	8	3372	1921	7788	61392	2672	10910	6829	58391	156150
	TOTAL	**80063**	**24141**	**3650**	**5396**	**13102**	**20137**	**112990**	**487137**	**21554**	**121847**	**66494**	**413159**	**1369670**
Electricity, gas steam and hot water	**Asturias**	**5857**	**27397**	**3084**	**30707**	**15375**	**22541**	**202798**	**30047**	**72673**	**4091**	**11157**	**128430**	**554157**
	R. of Spain	0	0	0	0	0	0	0	0	77130	0	3	0	77133
	R. of World	0	0	0	0	0	0	0	0	10089	0	0	0	10089
	TOTAL	**5857**	**27397**	**3084**	**30707**	**15375**	**22541**	**202798**	**30047**	**159892**	**4091**	**11160**	**128430**	**641379**
Construction	**Asturias**	**2215**	**45443**	**6931**	**1644**	**612**	**984**	**21060**	**3373**	**3612**	**625**	**15002**	**141112**	**242612**
	R. of Spain	0	0	0	0	0	0	0	0	0	0	0	0	0
	R. of World	0	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	**2215**	**45443**	**6931**	**1644**	**612**	**984**	**21060**	**3373**	**3612**	**625**	**15002**	**141112**	**242612**
Transport	**Asturias**	**3941**	**15290**	**1578**	**14796**	**7712**	**12578**	**79132**	**62344**	**15210**	**43941**	**24576**	**40461**	**321559**
	R. of Spain	797	589	140	435	1228	3634	14840	11787	1607	7617	11375	19022	73073
	R. of World	0	23	0	0	5	0	2189	220	0	0	1389	0	3826
	TOTAL	**4738**	**15903**	**1718**	**15231**	**8945**	**16212**	**96161**	**74351**	**16817**	**51558**	**37340**	**59483**	**398457**
Other services	**Asturias**	**33362**	**21317**	**3685**	**9447**	**12847**	**21171**	**89276**	**132107**	**30264**	**146023**	**126912**	**1451070**	**2077482**
	R. of Spain	4927	4864	429	1041	3025	3119	34918	56536	4680	20720	16321	208386	358967
	R. of World	0	0	0	18	2538	1023	2265	4905	11	0	11	4543	15314
	TOTAL	**38289**	**26181**	**4114**	**10507**	**18410**	**25313**	**126459**	**193549**	**34955**	**166744**	**143244**	**1663999**	**2451763**
Intermediate Inputs	**Asturias**	**212264**	**146694**	**20217**	**61431**	**50138**	**126986**	**940096**	**585689**	**548703**	**461491**	**190508**	**1930679**	**5274896**
	R. of Spain	65539	30228	5350	4521	31110	59463	476319	707055	109030	234446	158310	561628	2442998
	R. of World	3016	5001	0	161478	72713	39232	351295	145085	117157	24672	23898	78746	1022294
	TOTAL	**280819**	**181924**	**25567**	**227430**	**153961**	**225682**	**1767710**	**1437829**	**774890**	**720609**	**372715**	**2571053**	**8740188**

SOURCE: SADEI (1998)

TABLE 3 (cont.)

FINAL DEMAND MATRIX		Household Consumption	Public Consumption	Total Final Consumption	GDFCF	Stocks Changes	Total GDCF	Domestic Final Demand	Exports to the Rest of Spain	Exports to the Rest of the World	Total Exports	Demand Final	Resources Uses
Agriculture, forestry and fishing	**Asturias**	**81136**	**0**	**81136**	**-3616**	**551**	**-3065**	**78071**	**115774**	**2256**	**118030**	**196101**	**537178**
	R. of Spain	108708	0	108708	0	0	0	108708	0	0	0	108708	350552
	R. of World	15914	0	15914	0	0	0	15914	0	0	0	15914	60458
	TOTAL	**205758**	**0**	**205758**	**-3616**	**551**	**-3065**	**202693**	**115774**	**2256**	**118030**	**320723**	**948188**
Coal mining	**Asturias**	**7285**	**0**	**7285**	**0**	**84**	**84**	**7369**	**52920**	**0**	**52920**	**60290**	**384888**
	R. of Spain	0	0	0	0	0	0	0	0	0	0	0	310
	R. of World	1553	0	1553	0	0	0	1553	0	0	0	1553	208214
	TOTAL	**8838**	**0**	**8838**	**0**	**84**	**84**	**8922**	**52920**	**0**	**52920**	**61842**	**593411**
Other Mining activities	**Asturias**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6695**	**3324**	**10019**	**10019**	**64933**
	R. of Spain	176	0	176	0	0	0	176	0	0	0	176	87552
	R. of World	0	0	0	0	0	0	0	0	0	0	0	211183
	TOTAL	**176**	**0**	**176**	**0**	**0**	**0**	**176**	**6695**	**3324**	**10019**	**10195**	**363668**
Coke and petroleum refineries	**Asturias**	**0**	**0**	**0**	**0**	**7279**	**7279**	**7279**	**15351**	**8284**	**23636**	**30915**	**279672**
	R. of Spain	232838	0	232838	0	0	0	232838	0	0	0	232838	454038
	R. of World	2630	0	2630	0	0	0	2630	0	0	0	2630	113043
	TOTAL	**235468**	**0**	**235468**	**0**	**7279**	**7279**	**242747**	**15351**	**8284**	**23636**	**266383**	**846753**
Chemical industry	**Asturias**	**1120**	**0**	**1120**	**0**	**395**	**395**	**1515**	**96466**	**90926**	**187392**	**188907**	**239037**
	R. of Spain	117585	0	117585	0	0	0	117585	0	0	0	117585	255296
	R. of World	20040	0	20040	0	0	0	20040	0	0	0	20040	90708
	TOTAL	**138745**	**0**	**138745**	**0**	**395**	**395**	**139141**	**96466**	**90926**	**187392**	**326532**	**585041**
Other non metallic mineral products	**Asturias**	**964**	**0**	**964**	**2673**	**4828**	**7501**	**8465**	**186681**	**22210**	**208891**	**217356**	**398584**
	R. of Spain	4246	0	4246	3420	0	3420	7665	0	0	0	7665	119740
	R. of World	3469	0	3469	2040	0	2040	5508	0	0	0	5508	19561
	TOTAL	**8678**	**0**	**8678**	**8132**	**4828**	**12961**	**21639**	**186681**	**22210**	**208891**	**230530**	**537885**
Metallurgy and manufacture of metal products	**Asturias**	**498**	**0**	**498**	**69540**	**132524**	**202064**	**202562**	**1410859**	**627140**	**2037999**	**2240561**	**2669223**
	R. of Spain	18303	0	18303	23123	0	23123	41426	0	0	0	41426	410935
	R. of World	6019	0	6019	13873	0	13873	19892	0	0	0	19892	199286
	TOTAL	**24820**	**0**	**24820**	**106537**	**132524**	**239060**	**263880**	**1410859**	**627140**	**2037999**	**2301879**	**3279444**
Other manufacturing industries	**Asturias**	**432829**	**0**	**432829**	**64749**	**58900**	**123649**	**556478**	**917996**	**232758**	**1150754**	**1707232**	**2156951**
	R. of Spain	1079191	0	1079191	290845	0	290845	1370036	0	0	0	1370036	2133839
	R. of World	296879	0	296879	149991	0	149991	446869	0	0	0	446869	603019
	TOTAL	**1808898**	**0**	**1808898**	**505585**	**58900**	**564485**	**2373384**	**917996**	**232758**	**1150754**	**3524138**	**4893808**
Electricity, gas steam and hot water	**Asturias**	**152259**	**0**	**152259**	**0**	**-59**	**-59**	**152200**	**644190**	**0**	**644190**	**796390**	**1350547**
	R. of Spain	0	0	0	0	0	0	0	0	0	0	0	77133
	R. of World	0	0	0	0	0	0	0	0	0	0	0	10089
	TOTAL	**152259**	**0**	**152259**	**0**	**-59**	**-59**	**152200**	**644190**	**0**	**644190**	**796390**	**1437769**
Construction	**Asturias**	**63273**	**0**	**63273**	**1278258**	**0**	**1278258**	**1341531**	**0**	**0**	**0**	**1341531**	**1584144**
	R. of Spain	0	0	0	0	0	0	0	0	0	0	0	0
	R. of World	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL	**63273**	**0**	**63273**	**1278258**	**0**	**1278258**	**1341531**	**0**	**0**	**0**	**1341531**	**1584144**
Transport	**Asturias**	**228151**	**0**	**228151**	**8171**	**0**	**8171**	**236323**	**278328**	**57844**	**336173**	**572495**	**894054**
	R. of Spain	35509	0	35509	4565	0	4565	40074	0	0	0	40074	113147
	R. of World	0	0	0	0	0	0	0	0	0	0	0	3826
	TOTAL	**263660**	**0**	**263660**	**12737**	**0**	**12737**	**276397**	**278328**	**57844**	**336173**	**612569**	**1011026**
Other services	**Asturias**	**3875514**	**1559502**	**5435016**	**196662**	**228**	**196890**	**5631907**	**306379**	**58491**	**364871**	**5996778**	**8074259**
	R. of Spain	101726	0	101726	15937	0	15937	117662	0	0	0	117662	476630
	R. of World	0	0	0	0	0	0	0	0	0	0	0	15314
	TOTAL	**3977240**	**1559502**	**5536742**	**212599**	**228**	**212827**	**5749569**	**306379**	**58491**	**364871**	**6114440**	**8566203**
Intermediate Inputs	**Asturias**	**4843030**	**1559502**	**6402532**	**1616438**	**204731**	**1821168**	**8223700**	**4031640**	**1103234**	**5134874**	**13358574**	**18633470**
	R. of Spain	1698282	0	1698282	337890	0	337890	2036172	0	0	0	2036172	4479171
	R. of World	346503	0	346503	165904	0	165904	512406	0	0	0	512406	1534700
	TOTAL	**6887814**	**1559502**	**8447316**	**2120232**	**204731**	**2324962**	**10772279**	**4031640**	**1103234**	**5134874**	**15907153**	**24647341**

SOURCE: SADEI (1998)

TABLE 3 (cont.)

PRIMARY INPUTS MATRIX		Agriculture, forestry and fishing	Coal mining	Other Mining activities vas	Coke and petroleum refineries	Chemical industry	Other non metallic mineral products	Metallurgy and manufacture of metal products	Other manufacturing industries	Electricity, gas steam and hot water	Construction	Transport	Other services	**Intermediate Outputs**
Gross wages		25503	304088	6693	17906	36387	64941	293744	305054	85085	359694	168639	2075146	**3742879**
Employers´ contribution to social security		6552	168535	2708	9798	11808	24800	134190	101853	45283	115142	59021	653378	**1333068**
Compensation of employees		32055	472622	9401	27704	48195	89741	427934	406908	130367	474836	227660	2728523	**5075947**
Gross operating surplus		276979	67704	29072	11817	29162	90487	516387	302096	416715	217066	334073	2329663	**4621220**
Gross value added at factor costs		309034	540326	38473	39521	77357	180228	944321	709004	547082	691902	561732	5058186	**9697167**
Value of commodities at production prices		589853	722250	64040	266951	231318	405910	2712031	2146833	1321972	1412511	934448	7629239	**18437355**
Fixed capital consumption		40750	61259	8869	11652	11493	18976	118862	56174	114695	33576	100252	569168	**1145725**
Net operating surplus		236229	6445	20203	165	17669	71511	397525	245923	302020	183490	233820	1760495	**3475495**
Production taxes		2300	4868	202	550	872	1517	10851	9890	12764	27831	5333	188072	**265051**
Operating subsidies		44813	331362	0	0	34	852	723	7914	59	2064	53487	60719	**502027**
Gross value added at market prices		266521	213832	38675	40071	78195	180894	954449	710980	559787	717670	513578	5185539	**9460192**
Production value at producer prices		547340	395756	64242	267501	232156	406575	2722159	2148809	1334677	1438279	886294	7756592	**18200380**
Sales to final demand		-13578	-11967	681	12171	6689	-8173	-53519	-21749	-8991	48008	-7333	57763	**0**
Distributed domestic production		533762	383789	64923	279672	238845	398402	2668640	2127060	1325686	1486286	878961	7814355	**18200380**
Imports from rest of Spain		346571	310	87531	424815	243137	119080	408370	2026764	77133	0	110171	463742	**4307624**
Imports from rest of World		59728	208028	211183	112573	88583	19141	198377	567088	10089	0	3826	15052	**1493667**
Total imports		406299	208338	298714	537388	331720	138222	606747	2593852	87222	0	113996	478794	**5801291**
VAT on commodities	**Asturias**	**3416**	**1099**	**11**	**0**	**193**	**182**	**583**	**29891**	**24861**	**97858**	**15093**	**259904**	**433090**
	Rest of Spain	3981	0	21	29223	12159	659	2565	107075	0	0	2976	12888	171546
	Rest of World	730	186	0	470	2125	420	909	35931	0	0	0	262	41033
	TOTAL	**8127**	**1285**	**32**	**29693**	**14477**	**1261**	**4057**	**172897**	**24861**	**97858**	**18069**	**273054**	**645670**
Available resources at producer prices	**Asturias**	**537178**	**384888**	**64933**	**279672**	**239037**	**398584**	**2669223**	**2156951**	**1350547**	**1584144**	**894054**	**8074259**	**18633470**
	Rest of Spain	350552	310	87552	454038	255296	119740	410935	2133839	77133	0	113147	476630	4479171
	Rest of World	60458	208214	211183	113043	90708	19561	199286	603019	10089	0	3826	15314	1534700
	TOTAL	**948188**	**593411**	**363668**	**846753**	**585041**	**537885**	**3279444**	**4893808**	**1437769**	**1584144**	**1011026**	**8566203**	**24647341**

SOURCE: SADEI (1998)

TABLE 4. TOTAL DIRECT EMISSIONS BY PRODUCTION SECTOR AND HOUSEHOLD CONSUMPTION, 1995

	CO_2		CH_4		N_2O		HFC / PFC	
	Emissions (t)	**% / TOTAL**	**Emissions (t)**	**% / TOTAL**	**Emissions (t)**	**% / TOTAL**	**Emissions (t)**	**% / TOTAL**
Agriculture, forestry and fishing	114168.9810	0.3329	47457.3170	56.7989	2102.4900	67.2480	0.0000	0.0000
Coal Mining	3646.3450	0.0106	35558.5560	42.5580	0.0000	0.0000	0.0000	0.0000
Other Mining Activities	1113.0030	0.0032	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Coke and Petroleum Refineries	13328584.8400	38.8659	58.0040	0.0694	0.0000	0.0000	0.0000	0.0000
Chemical Industry	1022777.4260	2.9824	0.0000	0.0000	950.0000	30.3857	0.0000	0.0000
Other Non Metallic Mineral Products	2019418.9350	5.8886	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Metallurgy and Manufacture of Metal Products	596525.0370	1.7395	0.0000	0.0000	0.0000	0.0000	88.0000	99.6520
Other Manufacturing Industries	1232962.1430	3.5953	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Electricity, Gas Steam and Hot Water	12443600.7920	36.2853	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Construction	16464.7930	0.0480	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Transport	61846.4090	0.1803	7.0580	0.0084	2.5010	0.0800	0.0120	0.0136
Other Services	640413.0800	1.8674	274.6740	0.3287	0.0000	0.0000	0.0000	0.0000
Households Consumption	2812287.3130	8.2006	197.6260	0.2365	71.4800	2.2863	0.2953	0.3344
TOTAL	**34293809.0970**	**100.0000**	**83553.2350**	**100.0000**	**3126.4710**	**100.0000**	**88.3073**	**100.0000**

SOURCE: SADEI (1998), SADEI (2002) and own calculations.

TABLE 5. MATRIX OF OUTPUT-POLLUTION COEFFICIENTS (Mx) AND OF CONSUMPTION-POLLUTION COEFFICIENTS (Mc). DIRECT EMISSIONS BY UNIT OF PRODUCTION AND CONSUMPTION.

	Agriculture, forestry and fishing	Coal mining	Other Mining activities vas	Coke and petroleum refineries	Chemical industry	Other non metallic mineral products	Metallurgy and manufacture of metal products	Other manufacturing industries	Electricity, gas steam and hot water	Construction	Transport	Other services	Household Consumption
CO_2	0.2125	0.0095	0.0171	47.6579	4.2787	5.0665	0.2235	0.5716	9.2137	0.0104	0.0692	0.0793	0.408298935
CH_4	0.0883	0.0924	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000028692
N_20	0.0039	0.0000	0.0000	0.0000	0.0040	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000010378
HFC/PFC	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000032968	0.000000000	0.000000000	0.000000000	0.000000013	0.000000000	0.000000043

TABLE 6. MATRIX OF TYPE I OUTPUT-POLLUTION MULTIPLIERS (Mx_1)

	Agriculture, forestry and fishing	Coal mining	Other Mining activities vas	Coke and petroleum refineries	Chemical industry	O. non metallic mineral products	Metallurgy and manufacture of metal products	Other manufacturing industries	Electricity, gas steam and hot water	Construction	Transport	Other services
CO_2	0.6202	1.3276	1.0234	49.0752	6.4385	6.3081	5.3433	1.0085	12.2779	0.8869	0.3236	0.3866
CH_4	0.1156	0.0967	0.0021	0.0033	0.0023	0.0021	0.0027	0.0120	0.0241	0.0009	0.0007	0.0011
N_20	0.0051	0.0002	0.0002	0.0000	0.0040	0.0000	0.0001	0.0005	0.0001	0.0000	0.0000	0.0000
HFC/PFC	0.000000180	0.000001475	0.000000509	0.000000319	0.000000203	0.000000515	0.000036159	0.000000840	0.000001945	0.000002163	0.000000167	0.000000121

TABLE 7. TOTAL DIRECT PLUS INDIRECT EMISSIONS BY PRODUCTION SECTOR AND HOUSEHOLD CONSUMPTION, 1995

	CO_2		CH_4		N_2O		HFC / PFC	
	Emissions (t)	**% / TOTAL**	**Emissions (t)**	**% / TOTAL**	**Emissions (t)**	**% / TOTAL**	**Emissions (t)**	**% / TOTAL**
Agriculture, forestry and fishing	121617.2844	0.3546	22669.0237	27.1312	1002.8255	32.0753	0.035248293	0.0399
Coal Mining	80040.7859	0.2334	5831.9504	6.9799	10.5257	0.3367	0.088921655	0.1007
Other Mining Activities	10253.2080	0.0299	21.3509	0.0256	1.9404	0.0621	0.00509477	0.0058
Coke and Petroleum Refineries	1517138.4711	4.4239	100.6070	0.1204	0.4772	0.0153	0.009875908	0.0112
Chemical Industry	1216283.8952	3.5467	434.5902	0.5201	763.4165	24.4178	0.038359961	0.0434
Other Non Metallic Mineral Products	1371098.0743	3.9981	448.2864	0.5365	9.0590	0.2898	0.111860714	0.1267
Metallurgy and Manufacture of Metal Products	11972000.5106	34.9101	6022.6442	7.2082	145.5398	4.6551	81.016639	91.7440
Other Manufacturing Industries	1721820.9482	5.0208	20479.4889	24.5107	884.2114	28.2815	1.4341034	1.6240
Electricity, Gas Steam and Hot Water	9777996.8372	28.5124	19204.7424	22.9850	39.9037	1.2763	1.549287935	1.7544
Construction	1189763.5331	3.4693	1167.7224	1.3976	57.6830	1.8450	2.90184741	3.2861
Transport	185283.5523	0.5403	373.9098	0.4475	8.1901	0.2620	0.09534657	0.1080
Other Services	2318224.6837	6.7599	6601.2927	7.9007	131.2187	4.1970	0.725414383	0.8215
Households Consumption	2812287.3130	8.2006	197.6260	0.2365	71.4800	2.2863	0.2953	0.3344
TOTAL	**34293809.0970**	**100.0000**	**83553.2350**	**100.0000**	**3126.4710**	**100.0000**	**88.3073**	**100.0000**

SOURCE: SADEI (1998), SADEI (2002) and own calculations.

TABLE 8. TOTAL DIRECT PLUS INDIRECT EMISSIONS DESAGREGATED BY FINAL DEMAND SECTORS

	Household consumption		Public consumption		Gross Domestic Fixed Capital Formation		Stocks changes		Exports to the Rest of Spain		Exports to the Rest of the World		Total direct plus indirect emissions	
	Emissions (t)	%	Emissions (t)	%	Emissions (t)	%	Emissions (t)	%	Emissions (t)	%	Emissions (t)	%	Emissions (t)	%
CO_2	4010034.865	12.74	602869.7968	1.91	1663813.354	5.29	1157555.329	3.68	19283278.49	61.25	4763969.949	15.13	**31481521.7840**	**100**
CH_4	23423.8949	28.10	1716.710215	2.06	1885.62887	2.26	1167.980113	1.40	50031.51949	60.02	5129.875416	6.15	**83355.6090**	**100**
N_20	743.3739378	24.33	34.12429923	1.12	79.05496578	2.59	43.85821868	1.44	1610.498706	52.72	544.0808722	17.81	**3054.9910**	**100**
HFC/PFC	1.347519993	1.53	0.18864885	0.21	5.359754945	6.09	4.846436674	5.51	53.34594846	60.61	22.92369108	26.05	**88.01**	**100**

SOURCE: SADEI (1998), SADEI (2002) and own calculations.

TABLE 9. MATRIZ OF TYPE II OUTPUT-POLLUTION MULTIPLIERS (Mx_2)

	Agriculture, forestry and fishing	Coal mining	Other Mining activities vas	Coke and petroleum refineries	Chemical industry	Other non metallic mineral products	Metallurgy and manufacture of metal products	Other manufacturing industries	Electricity, gas steam and hot water	Construction	Transport	Other services	Household Consumption
CO_2	0.8367	3.2505	1.3936	49.3462	6.8333	6.7816	5.7305	1.3824	12.9448	1.4497	0.8045	1.0035	1.4017
CH_4	0.1163	0.1034	0.0034	0.0042	0.0037	0.0037	0.0040	0.0133	0.0264	0.0028	0.0023	0.0032	0.0049
N_20	0.0051	0.0004	0.0002	0.0000	0.0041	0.0001	0.0001	0.0006	0.0001	0.0001	0.0001	0.0001	0.0002
HFC/PFC	0.000000232	0.000001938	0.000000598	0.000000385	0.000000298	0.000000629	0.000036252	0.000000930	0.000002106	0.000002299	0.000000282	0.000000270	0.000000338

TABLE 10. TOTAL DIRECT PLUS INDIRECT PLUS INDUCED EMISSIONS PER PRODUCTION SECTOR AND HOUSEHOLD CONSUMPTION, 1995

	CO_2		CH_4		N_2O		HFC / PFC	
	Emissions (t)	**% / TOTAL**	**Emissions (t)**	**% / TOTAL**	**Emissions (t)**	**% / TOTAL**	**Emissions (t)**	**% / TOTAL**
Agriculture, forestry and fishing	114056.1206	0.3326	15859.6831	18.9815	700.6003	22.4087	0.0316	0.0358
Coal Mining	178519.9590	0.5206	5678.2907	6.7960	22.2020	0.7101	0.1064	0.1205
Other Mining Activities	13962.2222	0.0407	34.1929	0.0409	2.3834	0.0762	0.0060	0.0068
Coke and Petroleum Refineries	1525514.6950	4.4484	129.6087	0.1551	1.4776	0.0473	0.0119	0.0135
Chemical Industry	1285221.4843	3.7477	689.7842	0.8256	768.9488	24.5948	0.0561	0.0635
Other Non Metallic Mineral Products	1469197.9435	4.2841	801.9977	0.9599	21.2816	0.6807	0.1362	0.1542
Metallurgy and Manufacture of Metal Products	12837493.3388	37.4339	9025.1185	10.8016	249.1241	7.9682	81.2123	91.9655
Other Manufacturing Industries	1919135.3925	5.5962	18450.3844	22.0822	781.0078	24.9805	1.2912	1.4621
Electricity, Gas Steam and Hot Water	8856732.3794	25.8260	18078.9989	21.6377	88.7830	2.8397	1.4409	1.6317
Construction	1877227.6197	5.4740	3650.5783	4.3692	142.7274	4.5651	2.9765	3.3706
Transport	325333.8228	0.9487	937.4081	1.1219	29.0114	0.9279	0.1142	0.1293
Other Services	3151945.3645	9.1910	10166.7315	12.1680	300.1701	9.6009	0.8466	0.9586
Households Consumption	739468.7546	2.1563	50.4580	0.0604	18.7534	0.5998	0.0776	0.0879
TOTAL	**34293809.0970**	**100.0000**	**83553.2350**	**100.0000**	**3126.4710**	**100.0000**	**88.3073**	**100.0000**

SOURCE: SADEI (1998), SADEI (2002) and own calculations.

TABLE 11. DIRECT PLUS INDIRECT PLUS INDUCED EMISSIONS DESAGREGATED BY FINAL DEMAND SECTORS.

	Exogenous Household Consumption		Public Consumption		GDFCF		Stocks Changes		Exports to the Rest of Spain		Exports to the Rest of the World		Total of direct and indirect emissions	
	Emissions (t)	**%**	**Emissions (t)**	**%**	**Emissions (t)**	**%**	**Emissions (t)**	**%**	**Emissions (t)**	**%**	**Emissions (t)**	**%**	**Emissions (t)**	**%**
CO_2	1799532.4865	5.36	1564980.6778	4.66	2560132.2121	7.63	1235687.5168	3.68	21185216.8847	63.14	5208106.3317	15.52	**33553656.1095**	**100**
CH_4	8739.5934	10.47	5047.9106	6.05	4989.0318	5.97	1438.5040	1.72	56616.7666	67.81	6667.6475	7.99	**83499.4540**	**100**
N_20	284.4769	9.154	149.0382	4.80	186.1107	5.99	53.1903	1.71	1837.6651	59.13	597.1282	19.22	**3107.6095**	**100**
HFC/PFC	0.5338	0.61	0.4203	0.48	5.5756	6.32	4.8653	5.51	53.8039	60.98	23.0306	26.10	**88.2295**	**100**

SOURCE: SADEI (1998), SADEI (2002) and own calculations