

PROJECT N. 037033

EXIOPOL

A NEW ENVIRONMENTAL ACCOUNTING FRAMEWORK USING EXTERNALITY DATA AND INPUT-OUTPUT TOOLS FOR POLICY ANALYSIS

TECHNICALREPORTONSPECIFICATIONS OF THE DATABASE INVIEW OF THE DESIRE TO LINK IT WITHEXISTING MODELS
[Scoping WP III.4.c]

Report of the EXIOPOL project

Title	Technical report on specifications of the database in view of the desire to link it with existing models
Purpose	WP III.1.a: Scope refining, alignment and meeting in Cluster III, with respect to scoping of Workpackage III.4.c: Interfaces with existing models
Filename	Scoping Report _DIII_1_a_4.doc
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Document history	
Current version.	
Changes to previous version.	
Date	26.07.2007
Status	Final Draft
Target readership	EXIOPOL Cluster III
General readership	no
Dissemination level	Cluster III

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Jun-07

Prepared under contract from the European Commission

Contract no 037033-2 Integrated Project in PRIORITY 6.3 Global Change and Ecosystems in the 6th EU framework programme

Deliverable title:	Report on specifications of the database in view of the desire to link it with existing models
Deliverable no. :	D III.1.a.4
Due date of deliverable:	Month n 4
Period covered:	from 1 st March 2007 to 30 th July 2007
Actual submission date:	20.07.2007
Start of the project:	01.04.2007
Duration:	4 months
Start date of project:	
Project coordinator:	
Project coordinator organisation:	FEEM

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1 Introduction

1.1 General Objectives

Environmentally-extended IO tables are an important building block of a variety of socio-economic models and other tools in use for sustainability impact assessment, in particular input-output (IO) models and computable general equilibrium (CGE) models. The two overall goals of WPIII.4.c in terms of data compilation and model extensions are:

1) To ensure that the environmentally-extended IO database meets the needs of different types of models, especially: (i) the World Trade Model (WTM), a multiregional IO model with endogenous, bi-lateral determination of imports and exports; (ii) the CEPAM-GEM-E3 CGE model. The possibility to create further links to additional models, such as NEMESIS, will be also investigated.

2) The WTM will be extended to accommodate a new approach to calculating resources and pollutants embodied in both production and consumption and evaluation of resource scarcity rents associated with different consumption patterns. In addition, the CEPAM-GEM-E3 model will be extended by operational algorithms for integrating the bottom-up estimates on abatement cost functions. Since actions can be taken to reduce emissions per unit of activity for many pollutants, these algorithms allow the feed back of abatement costs into the economy-wide CGE modelling framework.

Additionally, the Work Package will ensure a wide applicability of the data generated in the overall project for by the European Commission with mathematical models and other quantitative tools.

JRC-IPTS has various models in use that should be easily linked with the EE I-O database developed. JRC-IPTS will transform this in a list of some essential design specifications for the database structure.

Finally, the detailed elaboration of this topic will take place in the WP III_4_c, whereas this report is concerned with scoping the type of demands that are posed.



2 Outline of the EXIOPOL database

2.1 General considerations regarding the data structure

One of the main objectives of the EXIOPOL project is to set up a detailed environmentally extended (EE) Input-Output (I-O) database, with links to other socio-economic models, in which as many of the external cost valuations compiled in Cluster II as possible are included. Such a comprehensive EE I-O data set for the EU 25/27 has the ambition be a major advancement to the state of the art of data availability for the target field of application.

The EXIOPOL database will comprise a set of economic accounts (SIOTs or SUTs) representing each EU country (and ~15 major trade partners) individually, linked by bilateral trade accounts (again there are two main different choices available for the level of detail of trade accounts) and extended by satellite accounts for emissions, other environmental interventions (e.g. resource extraction) and valuation of external costs. Additional modules representing consumers' activities and waste management will also be included.

Time series will not be produced by the project: all data will be related to one single base year. The choice of this base year has some consequences in terms of attractiveness for external modellers to use EXIOPOL data. The effort cost of updating a model with new data is often significant enough to prompt modellers to undertake the endeavour only when the benefit is large enough. It is unlikely that a researcher would spend time to update old data with other old data, but she would probably do it if the new data were attractively recent.

2.2 Level of detail of the database

Most existing multi-sectoral economic models have a level of sectoral detail that is far inferior to the ~100 sectors envisaged for EXIOPOL. This suggests that the linkage to those models would be straightforward as far as sectoral detail is concerned. However, some commodities (in particular those that are much traded, such as for instance agricultural products) are often represented in great detail in economic models.

Also, the ambition to model the EU economy embedded in the global context may entail that the level of detail implemented *also for trade partners* should meet minimum requirements that may turn out to be quite demanding in the areas of agricultural commodities and resources.

As regards the classification to be adopted, the general consensus is to use the "new NACE" classification for industries (NACE Rev. 2) at 2-digit level by default, with additional detail at 3 and 4 digit level. The corresponding CPA revision is still in draft phase and should be published in 2008. It should be noted however that the level of detail of the 4-digit NACE scheme may not suffice in some cases (CPA is much more detailed, as it reaches down to the 6-digit level). This could be the case, for instance, for agro-food commodities



(NACE 4-digit still does not distinguish sugar beet from potato) or refinery products. Additionally, in some cases (prevalently related to technologies) there is apparently no existing classification that distinguishes between, for instance, electricity produced by coal from nuclear or wind power. This may have consequences when deciding where to put this information, in new IO sectors or in the satellite accounts.



3 Demands posed by the models considered

The following sub-sections present an overview of the geographical, sectoral, technological/environmental and institutional/economic information contained in each of the models considered.

However, different strategies to link the EXIOPOL data to those models can be envisaged.

Possibly the most economical approach would be to merely complement the information of model X with the additional information not already covered (which would mainly be in the field of emissions and externality valuations).

The most comprehensive approach, on the other hand, would be to produce a complete new set of data covering all economic, environmental, trade and social aspects. Especially when having in mind extremely complex models such as GEM-E3, which contain a wealth of data often outside the boundaries of what is per-se relevant to the EXIOPOL project, this approach could turn out to be extremely demanding.

Compromises between the two extreme approaches are possible and we should strive for the attainment of the best compromise; it should be kept in mind that the more data is delivered to a modeller, the more effort it will require also for them to incorporate the data in their model. Efforts to produce very timeconsuming data updates should therefore be concentrated on very few models for which cooperation with the modeller is secure and possibly on the data topics on which EXIOPOL can provide the most added value.

For instance, this would also imply that the estimations of *behavioural* parameters (such as elasticities) would be out of scope. Note in fact that the econometric estimation of substitution elasticities between inputs of a production function requires the availability of *temporal series* of prices and quantities.

3.1 Models considered

IPTS has a number of models in use; the necessity for linking these models with EXIOPOL goes beyond the mere wish to update their background information with more recent data: policy analysis often relies on the combination of different models, and the comparability of the results generated by these models is made difficult whenever the underlying data lack the necessary common denominator.

Models considered in this brief survey are Computable General Equilibrium (CGE) models, partial models, Input-output models. For all these models a linkage with EXIOPOL would generate added value; however, this linkage may very well be of different nature for different types of models.

CGE models have in fact a (series of) Input-output table(s) at the core of their data structure, and a hard link with EXIOPOL can be easily envisaged, that



would first of all imply the substitution of the IO core of the model with data generated by EXIOPOL.

Partial models, on the contrary, do not include IO data. However, recent experience (*inter alia* at IPTS, see for instance Neuwahl & Löschel 2007) demonstrates the interest in building hybrid modelling frameworks that link the output of partial simulations to IO models, thereby allowing for capturing the economy-wide implications of sectoral policies, while at the same time keeping the high level of detail necessary for a serious analysis in the key affected sector. However, a necessary condition is that the sectoral resolution achieved in the IO model is sufficient to capture the main results of the partial model. The IPTS has developed several ad-hoc IO models that could use the EXIOPOL database and could be linked to partial models. These models are quite standard and coded in a flexible, undemanding way. This means that the data requirements are determined solely by the partial model linked.

Furthermore, EXIOPOL will contribute to the World Trade Model (WTM) developed by Faye Duchin. The WTM is a static IO model. In this respect it requires a standard, consistent IO database. However, the WTM has been conceived to include mixed units. This means it can work in all monetary values as a least-effort choice, but we should not rule out the possibility to supply it with the required mixed-units data. It should be possible to do the conversion with enough information on unit prices of selected commodities (such as resources, fuels, transportation services, key products (cars, computers...))

3.2 Demands with regard to interfaces

The requirements indicated in this report are more related to the information content of the EXIOPOL database than to the generation of interfaces that allow transforming automatically data in the format useable by a different model. This last requirement at the moment is not considered a relevant priority in this scoping phase.

Further requirements for the information content of the EXIOPOL database are expected to come from discussion with the "demand side" target group in the EC.

This is relevant also in the context pertinent to the present report because strong demands from the policymakers' side may entail the requirement from the one hand to cover some specific sectors or stressors in the data collection phase, from the other hand to choose or extend specific models able to correctly represent the questions related to those specific data.

Preliminary indications from the EC policymakers (DG ENTR, DG ENV) suggest that further detail, in addition to the specifications summarised in Annex I -Tables 9 and 10-, would be considered necessary for the chemicals sector and for the description of economy-environment interactions, thereby including expenditures for environmental protection as a well as the environment /or the *quality* of the environment/ providing valuable inputs to the economy (recreational values, ecotourism, etc.)



3.2.1 Introduction

The following sections go in some detail introducing the specific requirements that are posed by different kinds of models and by some selected individual models. However, there are also a number of common requirements of several model types that should be satisfied.

In fact some sort of representation of factor inputs, factor prices, and factor endowments would be required for an economic model of the world economy because they are central to any theory of international trade. And when it comes to empirical implementation, the transport of goods cannot be ignored.

Furthermore, consistency considerations and practical needs suggest that the economic accounts should be sufficiently complete to allow calculating a whole set of macro variable, such as: GDP both from the value added and from the consumption side, household budget and expenditure including taxes, government budget.

Some further general considerations:

- Different models may have different ways to represent trade flows; whenever a full update of the target model's database is envisioned, care should be taken such that traded data is delivered in the applicable form.
- Most existing models use SIOT-based databanks. In case the EXIOPOL database should be based on SUTs, two evident possible approaches are: 1) to transform SUTs into SIOTs (at the relatively high level of aggregation of most CGE models, for example, this would probably have very limited consequences); 2) to extend the CGE model in order to accommodate the SUTs. This could in principle be done by for instance implementing appropriate CET (Constant Elasticity of Transformation) functions, but it is evidently much more demanding than 1).
- Linking to existing models is not necessarily restricted to updating and expanding the data information in the target model (hard link). Inputoutput frameworks can also provide the macroeconomic (economy-wide) backdrop against which to interpret the results of sector-specific simulations (soft link).

Below, a schematic list of formal requirements for different types of models:

For the World Trade Model (WTM):

- transport sectors (included in IO tables)
- selected unit prices
- selected factor inputs and factor prices (including by extension externalities and any fees associated with them)
- selected stocks and factor endowments
- geographic information (transport distances)
- for goods-producing sectors, mass of product and common mode of transport

For CGE models:



Chapter 3: Demands posed by the models considered

- Sectoral aggregation routines (matrices)
- sufficient information on institutional accounts, factor inputs
- abatement cost curves for key pollutants
- selected externality data
- possibly: information on several types of elasticities
- a consistent geographical breakdown

CGE models considered:

- GEM-E3
- CEPAM
- Globe
- Worldscan

For partial models:

- sufficient sectoral detail in EXIOPOL to allow constructing soft links with selected partial models
- selected externality data
- a consistent geographical breakdown

Partial models considered:

- Poles
- CAPRI
- TREMOVE and other transportation models

For Econometrically estimated models:

• Only *multisectoral* econometrically estimated models are considered here, as otherwise too much information would be foregone by aggregation. The requirements, in general, are therefore similar to those entailed by CGE and other multisectoral models.

Econometrically estimated models considered:

- The contract foresees that the EXIOPOL database be linked to NEMESIS
- Additionally, the participation in the consortium of GWS Osnabrück opens the opportunity to link to the model GINFORS

In the following sections some of the models (in particular those for which limited effort is envisaged) have been pooled together. This is done also, for instance, for all CGE models that use the GTAP database.

3.2.2 Demands World Trade Model

As in a static EE-IO database, for each region: A matrix, y vector of final demand (with detail for subsequent policy scenarios distinguishing household consumption, govt spending, investment, and exports and imports; the latter 2 will become endogenous), F matrix of factor inputs per unit of output (including as factors the resources we want to distinguish in the study, measured in physical units), vector of factor prices per unit of factor (for example average



annual wage rate for the factor of labor, royalty rate for oil in the ground, etc.) There should also be a matrix, E, of emissions and wastes generated per unit of output in each industry. This matrix can be accompanied by a vector of costs placed on these discharges, such as a carbon tax. Let us call the vector of factor prices pi and the vector of costs (which can be zero in some scenarios) for discharges mu.

For each region, the vector f of factor endowments (such that $Fx \leq f$). This vector serves as the constraint on more production in a given region. An example is the size of the labor force or the amount of capital stock in place. A resource-related example is the maximum amount of oil that can be pumped in any given year. We can also set a similarly-represented constraint on the allowable quantity of pollutant emissions and waste discharges as policy measures: for example a cap on carbon emissions. The exact definition for endowments of each kind will require discussion that needs to take place: the limits set by factor constraints are a central part of the economic theory of comparative advantage.

To obtain a solution with bilateral trade endogenous, we need to represent in the IO matrices one or more industries that move product among trade partners. Most international freight is carried by sea, but within the EU truck and rail must be of dominant importance. Distances among trade partners for each mode are needed as well as the mass of the product moved, assuming that the output of the transport sectors will be measured in ton-kilometres

3.2.3 Demands GEM-E3

GEM-E3 is an applied general equilibrium model, simultaneously representing World regions or European countries, linked through endogenous bilateral trade and environmental flows. The European model covers the EU countries, Switzerland and four Accession countries and it is being extended towards the other associated countries.

The model has been developed as a multinational collaboration project, partly funded by the European Commission, DG Research, 5th Framework programme and by national authorities, and further developments are continuously under way. Applications of the model have been (or are currently being) carried out for several Directorate Generals of the European Commission (economic affairs, competition, environment, taxation, research) and for national authorities.

GEM-E3 is maintained primarily by the University of Leuven, Belgium (Denise van Regemorten); in the EC, JRC-IPTS runs and maintains the model in-house.

The model has the following general features:

• Its scope is general in two terms: it includes all simultaneously interrelated markets and represents the system at the appropriate level with respect to geography, the sub-system (energy, environment, economy) and the dynamic mechanisms of agent's behaviour.



- It formulates separately the supply or demand behaviour of the economic agents which are considered to optimise individually their objective while market derived prices guarantee global equilibrium
- It considers explicitly the market clearing mechanism and the related price formation in the energy, environment and economy markets: prices are computed by the model as a result of supply and demand interactions in the markets and different market clearing mechanisms, in addition to perfect competition, are allowed
- The model is simultaneously multinational (for the EU or the World) and specific for each country/region; appropriate markets clear European/World wide, while country/region-specific policies and distributional analysis are supported
- Although global, the model exhibits a sufficient degree of disaggregation concerning sectors. structural features of energy/environment and policy-oriented instruments (e.g. taxation). The model formulates production technologies in an endogenous manner allowing for price-driven derivation of all intermediate consumption and the services from capital and labour. In the electricity sector, the choice of production factors can be based on the explicit modelling of technologies. For the demand-side the model formulates consumer behaviour and distinguishes between durable (equipment) and consumable goods and services.
- The model is dynamic, recursive over time, driven by accumulation of capital and equipment. Technology progress is explicitly represented in the production function, either exogenous or endogenous, depending on R&D expenditure by private and public sector and taking into account spillover effects.
- The model formulates pollution permits for atmospheric pollutants and flexible instruments allowing for a variety options, including: allocation (grandfathering, auctioneering, etc.), user-defined bubbles for traders, various systems of exemptions, various systems for revenue recycling, etc.

The GEM-E3 model is built in a modular way around its central CGE core. It supports defining several alternative regimes and closure rules without having to re-specify or re-calibrate the model. The most important of these options are:

- Capital mobility across sectors and/or countries
- Flexible or fixed current account (with respect to the foreign sector)
- Flexible or fixed labour supply
- Market for pollution permits national/international, environmental constraints
- Fixed or flexible public deficit
- Perfect competition or Nash-Cournot competition assumptions for market regimes



Every CGE model has a Social Accounting Matrix (SAM) at the core of its data. In GEM-E3 the SAM is based on an IO matrix with 18 sectors. The linkage to the GEM-E3 classification should not pose any significant problems and could be made with a simple bridge matrix. The GEM-E3 classification is reported in Annex I, Table I.

On the consumption side, 13 consumption categories are distinguished (see Annex I, Table 2), implemented in the model by bridge matrices for all countries.

Factor inputs

- Labour and capital rents, SSC

Full investment matrices

- Government, Household, Private

Taxes and social sec. contributions

- in GEM-E3: direct and indirect taxes, VAT, subsidies, duties and social security contributions

Institutional accounts

- GEM-E3 is based on a full SAM
- inter-institutional accounts are filled

Additional satellite accounts

- Employment figures (in '000 full time job equivalents)

Environmental module:

Generally speaking, In a CGE model there are three ways to reduce pollutant emissions from the sectors:

- 1. To reduce activity. Data-wise, this is easy. All the information required is already in the EE-IO package
- 2. To abate emissions. Data-wise, this is done parametrising marginal abatement cost functions. It has been already done for GEM-E3 for a few air pollutants (see below). It would be very interesting to extend the approach to some new pollutants, good candidates being some water emissions and/or water inputs (water policy).
- 3. To substitute inputs. Data-wise, this is done by identifying the substitutabilities and estimating the substitution elasticities. This is difficult, in the absence of specific data.

- Pollutants covered in GEM-E3: CO2, NOX, PM10, SO2, VOC, NIT, SUL, O3



Externalities

- ExternE estimates have been integrated in GEM-E3 for cost-benefit analysis of air emissions abatement policies

Substitution elasticities. In principle it is possible to conduct econometric estimates of a number of elasticities of substitution from time series of inputoutput tables. Since EXIOPOL in principle will not produce time series but only data for one base year, it could make sense to drop ambitions to derive elasticities of substitution, unless some partners, for instance ZEW, show interest to pursue the task in this framework.

Abatement cost functions for selected pollutants: Since there are no end-of-pipetechnologies for reducing greenhouse gases at reasonable costs, the end-of-pipe abatement technologies considered in GEM-E3 are limited to the primary pollutants SO_2 , NO_x , VOC and particulates. The estimation of these cost functions is based on data of a survey undertaken by the Institute for Energy Economics and the Rational Use of Energy (IER, Stuttgart) in 1985 for the German state Baden-Württemberg. Its objective was to calculate the minimal costs of abatement in the year 2000 under varying technical, political and economic assumptions. Therefore the emission structure of 1985 was projected up to the year 2000 without any additional environmental regulations (i.e. no change in the rate of abatement in this matter up to the year 2000).

Five aggregated groups of emitters were taken into consideration, i.e. (1) power stations, (2) combustion systems requiring official approval (without refineries), (3) refineries, (4) combustion systems that do not require official approval and (5) traffic. The abatement data of these five groups of emitters do not fit exactly in type and size to the classification of the sectors of GEM-E3. In GEM-E3 twenty emission relevant sectors (firms) or uses (households) are distinguished: agriculture/fishery/forestry, coal, crude oil/oil products, natural gas, electricity, ferrous/non-ferrous/metal products, chemical products, other energy intensive industries, electrical goods, transport equipment, other equipment goods, consumer goods, building/construction, telecommunication services, transport services, services of credit and insurance institutions, other market services, non-market services, heating systems of households and private traffic. The consistency of data was kept by aggregating some GEM-E3 industries (see Annex I, table 3).

3.2.4 Demands GTAP-based models (CEPAM, Globe, Worldscan)

A large number of mainstream CGE models (and not only CGE models) use the GTAP database as their main database.

The GTAP-6 database has 57 sectors defined with a focus on international trade. The sectors are pretty standard, without much resolution on services, except for a remarkable detail in the agro-food sectors. The 57 sectors are reported in Annex I, Table 4.



GTAP comprises 87 regions including all EU27 countries individually. It is likely that any reasonable EXIOPOL country definition will turn out to be a subset of the GTAP regions (see Annex I, Table 5)

Trade and trade-related data include, for each region, the following trade flows:

- total exports from each sector to each other region (not resolved by sector)
- total imports to each sector from each other region (not resolved by sector)

GTAP (since the release of the GTAP-E extension of the GTAP4 database) furthermore contains some energy satellites (in physical units)

To be noted that the EXIOPOL project does not have the ambition to submit an update to the GTAP consortium. However, it can be expected that in the next future, probably already form the GTAP 7 release in 2008, a more consistent integration of EUROSTAT tables in GTAP will be achieved.

There is a specific interest for the WorldScan model which is used by DG ENTR, to analyze in more detail energy-intensive industries (similar to POLES subsectors: Iron & Steel, Aluminium, Pulp & Paper, Glass, Cement, Brick). A further disaggregation of the GTAP database with respect to energy-intensive industries would allow analysing the impact of energy/environmental policies on international competitiveness for the most-affected sectors in the economy.

Additionally, ZEW will work specifically for the integration of abatement cost functions in the CEPAM model. Note that by CEPAM we refer here to the MPSGE formulation of GEM E-3 developed by the CEPAM project for the EC/IPTS. The CEPAM model will be extended by operational algorithms for integrating the bottom-up estimates on abatement cost functions. The CGE model will be extended in order to take into account pollution control options. Since actions can be taken to reduce emissions per unit of activity for several pollutants in the database, these pollutants should not be in fixed proportions to activities in the sectors that produce them. The associated abatement cost functions require detailed bottom-up analysis which subsequently needs to be fed back into the economy-wide CGE modelling framework. Within the work package, we will come up with operational algorithms for integrating these bottom-up estimates on abatement costs in the CGE model. In addition to this more general methodological contribution, we aim at demonstrating the policy usefulness of the developed methodology along a specific large-scale policy application. The primary scope of this task will be however to integrate existing data on abatement costs (of as many pollutants as possible by data availability) in the model, not to carry out novel bottom-up data collection.

Note that DG Environment is currently carrying out a study (conducted by VITO et al.) focussing on the costs of environmental policy to some main industrial sectors. Closer to their delivery date (early 2008?), it will be interesting to check if that study provides enough technological data to produce some new abatement cost functions.



3.2.5 Demands POLES model

POLES (Prospective Outlook on Long-term Energy Systems) is a partial equilibrium model for the world energy system up to 2050. Market equilibrium is (recursively) simulated by matching energy supply and demand which reply to changes in the international prices with a certain time lag. A feedback loop derives endogenous price changes from the supply and demand balance in the previous period. Thereby consistent long term energy-scenarios are simulated on a year-by-year basis and respective abatement policies can be economically assessed.

The model is designed by interconnected submodels at the international, regional and national level. In each region four submodels deal with (i) final energy demand by sector, (ii) new and renewable energy technologies, (iii) conventional energy and transformation system, now including Hydrogen and CO2 sequestration options, (iv) primary energy supply.

Since the model is disaggregated with respect to the regional as well as the sectoral structure, it is suitable to analyse national and international energy markets as well as inter-technology and inter-fuel substitution, in particular in the case of GHG emission constraints.

The POLES model contains and produces detailed information on the following sectors:

- Iron & Steel
- Pulp & Paper
- Non-metallic mineral products
 - o Glass
 - o Cement
 - o Brick
- Coal
- Oil
- Gas
- Electricity
 - large number (>15) of different power generation technologies including generation from waste and biomass:
 - large size Hydroelectricity; Conventional Light Water nuclear Reactor; New Nuclear Design; Pulverised Fuel Super Critical Coal; Integrated Coal gasification with combined cycle; Advanced Thermodynamic Cycle (coal powered); lignite Powered Conventional Thermal; Coal-Powered Conventional Thermal; Oil-Powered conventional thermal; Oil-Powered Gas turbine in Combined Cycle; Gas-Powered Gas turbine in Combined Cycle
- New and renewable Energy technologies diffusion module (current model incorporates 12 technologies)
 - Combined Heat and Power (small co-generation); Small Hydro Power plants (<10 MWe); Wind; Solar Thermal; Decentralized Building integrated PV systems; PV systems for Decentralized rural electrification in DCs; Low temperature Solar systems in residential sector; Biofuels (3 conventional technologies);



Biomass Gasification for electricity production in GT; Proton exchange fuel Cells (Vehicles); Proton exchange fuel Cells (stationary); Solid Oxide Fuel Cells (cogeneration)

- Transportation
 - o Road
 - o Rail (note that it is separated from Road tsp)
 - o Air
 - o Other Transport (Mainly water transport).
 - Discerning Passenger and Freight transport (in EXIOPOL, this distinction may be in part intrinsically taken care of by the IO structure of the database)
 - o Discerning different fuel use
- Residential demand
 - Including different types of dwellings

A reasonable linkage to POLES would be achieved by adopting an energy carrier resolution similar to the Belgian NAMEA compiled by Gilis, Jansen and Vandille in 2006 (see Annex 1, Table 6), and a sufficient breakdown of energy production technologies (energy production side) and of energy intensive industry (energy demand side). It is however reasonable to foresee a level of detail somewhat inferior to the full information contained in POLES.

The geographical coverage of POLES is reported in Annex I, Table 7.

3.2.6 Demands CAPRI Model

CAPRI is an economic modelling system developed to assist in analysing impacts of the Common Agricultural Policy (CAP), of European agrienvironmental measures or of agricultural trade policies from regional to global scale. It combines the representation of regional agricultural policies and production with political and economic conditions on regional, Member State, EU and global agricultural commodity markets. An activity based approach allows the direct implementation of relevant CAP policy measures and the technological definition of appropriate environmental indicators related to the agricultural production activities. Product and activity coverage are in line with the Economic Accounts for Agriculture (EAA) by a combined top down / bottom up approach.

The model is split up into a supply and a market component. An iterative process between the supply and the market component establishes a comparative static equilibrium and returns market clearing prices for tradable agricultural products and young animals.

The CAPRI model (Common Agricultural Policy Regional Impacts) is widely used in the EC and includes a database (COCO) based mainly on EUROSTAT data for production and FAOSTAT for trade. It contains a large number of agricultural commodities (ca. 70 marketable, plus intermediates). The geographical resolution of CAPRI is NUTS lev.2 (~300 regions)



A data transformation process is currently underway at IPTS-AGRILIFE and aims to reach a level of ca. 50 agro-food sectors (MAC classification, see Annex I, Table 8), that can be easily mapped onto GTAP 6 (total 22 agri and food sectors). This work aims at the generation of Social Accounting Matrices (SAMs) for the 27 EU MS.

While the original CAPRI classification is certainly too detailed for EXIOPOL (it includes for instance 6 different types of animal fodder), the agricultural detail adopted by the MAC or by its further re-aggregation to the GTAP classification may be an option.

The first release of MAC SAMs is foreseen for end of calendar year 2007. This database should be freely accessible to the general public, therefore freely available to EXIOPOL.

3.2.7 Demands TREMOVE and other transportation models

TREMOVE is a modelling tool developed with the participation of the European Commission to analyse transportation activities in detail. It is a partial equilibrium model that evaluates the effects of policy measures adopted in the transportation sector. TREMOVE calculates: demand for transportation split in different modes (i.e. road, rail, air and maritime with an ad-hoc module), vehicle fleet, emissions of air pollutants, energy consumption and welfare impacts under different policy scenarios (e.g. incentive mechanisms or emission standards). TREMOVE covers the period 1995-2020 and covers the EU27 countries plus Switzerland, Norway, Croatia and Turkey.

The model is composed of three inter-linked modules:

- 1. **transport demand module**: with a nested structure based on Constant Elasticity of Substitution functions, it describes how households and firms choose first between other goods or inputs and transport, and then among different transportation options or modes (respectively, to maximize utility or minimize costs of production);
- 2. **vehicle stock module**: it calculates the optimum stock of vehicles that is needed to fulfil the transport demand by firms and households; the difference between optimum stock and existing stock represents the overall sales of new vehicles that is then split up in the purchase of different types of cars by applying a discrete choice model based on vehicles' price, other vehicles' characteristics and consumers' preferences;
- 3. **environmental module**: it includes Well to Wheel emissions (i.e. CO2, CO, CH4, NMVOC, NOx, PM, SO2, N2O, C6H6 and Tropospheric Ozone Formation Potential) and fuel consumption.

A welfare cost module is also part of the tool and calculate the costs for the society of different policy scenarios including externalities for pollution and traffic congestion.

TREMOVE is however a partial equilibrium model; as such, it neglects the interaction of the transportation sectors with the rest of the economy; hence a link with an environmental IO framework such as Exiopol would broaden the potential of the tool. Diverse ways of integrating TREMOVE into the Exiopol framework can be envisaged, with different levels of technical complexity. At a limited level of complexity, it can be envisaged to link the final demand vector



and the IO structure of Exiopol to model the household demand for transport and the firms' purchase of transportation service respectively. In particular, the sales of new vehicles, the fuel consumption and the consumption of transportation services by households could be used to reshape the final demand structure such as to reflect changing household consumption patterns under different policy scenarios. The transport demand by firms computed with the transport demand module could further be integrated by modifying the sales structure of the transportation sectors in to the IO matrix.

Splitting the transportation sectors as in the NACE A59 classification to a slightly more detailed level, as indicated in Annex II Table10, is a minimum requirement for a meaningful linkage of TREMOVE to EXIOPOL.

3.2.8 Demands NEMESIS model

NEMESIS (New Econometric Model for Environmental and Sustainable development and Implementation Strategies) is a macrosectoral econometric model aimed at developing tools for decision making in the fields of energy, environment and economic policies.

The underlying database is multi-country, multi-sector and includes final consumption activities and an energy-environmental module.

The main specifications, necessary for defining a data transformation protocol that would eventually serve the aim to make the EXIOPOL data available to NEMESIS, are reported below. A refinement of this description and of the requirements will be provided after establishing contacts with the NEMESIS team.

Geographical coverage:

- The 27 EU countries
- Other countries from Western Europe
- China
- Eastern Europe
- OPEC
- Japan
- New industrialised countries
- Former USSR
- Other countries belonging to OECD
- NAFTA
- Rest of the world

Sectoral coverage (30 production branches):

- Agriculture
- Foods, Beverages and Tobacco
- Coal and coke
- Clothing and Footwear
- Oil and Gas Distribution
- Paper and Printing products
- Gas distribution
- Rubber Plastic



- Refined oil
- Other Manufactured Goods
- Electricity
- Construction
- Water supply
- Distribution
- Ferrous and Non Metals (ores?)
- Lodging and Catering
- Non Metal Mineral Products
- Inland Transports
- Chemicals
- Sea and Air Transports
- Metal Products
- Others Transports
- Agri. And industrial Machines
- Communication
- Offices Machines
- Bank, Finance & Insurance
- Electrical Goods
- Other Market Services
- Transport Equipment
- Non Market Services

Consumption sectors (27 activities):

- Food
- Domestic services
- Beverages
- Medical care and health expenses
- Tobacco
- Personal transport equipment
- Clothing and footwear
- Operation of personal transport equipment
- Gross rent and water charges
- Rail transport
- Power
- Inland transports
- Gas
- Air transport
- Petroleum products
- Other transport
- Other petroleum products
- Communication
- Furniture
- Equipment and repair
- Textiles
- Recreation
- Major appliances
- Expenditures in restaurants, cafés and hotels
- Household utensils (???)



- Household operations
- Miscellaneous

Energy-environmental variables:

The ee-module applies a detailed description of energy demand and supply from the EU 15, with a special care given to the electricity sector.

The pollutants coverage is:

• CO2, SO2, NOX, CH4, N2O, CF6, HFC, PFC

As regards energy demand, each sector owns a technological substitution specification. The different kinds of demand considered by the module are the following ones:

- Industry : Iron, Non ferrous metals, Non metallic metals (???), Mines, Chemical industry, Printing products, Food, tobacco and drinks, Textile, Leather and Clothing, others industries;
- Tertiary-Domestic : services, household and agriculture;
- Passenger transport : cars, buses, rail, air-international, inland navigation;

Freight transport: road, rail and inland navigation.

3.2.9 Demands GINFORS model

The model GINFORS (Global INterindustry FORecasting System) has been developed to allow for a global analysis of the economic-environmental interdependencies as a tool for concrete policy planning. It has been used as the simulation engine in the MOSUS project (www.mosus.net), which analysed as part of 5^{th} frame program of the EU commission the impact of European resource strategies on the economic development and resource extractions in the world and all European countries (Giljum et al. 2007, Meyer et al. 2007). Current applications include the analysis of future climate regimes.

The model combines econometric-statistical analysis with input-output analysis embedded in a complete macroeconomic framework. The link between the economic development in the countries is given by international trade, which is the result of global competition in deep sectoral disaggregation. Nearly all parameters of GINFORS are estimated econometrically using international time series data sets from the OECD, the IEA and the IMF.

The main sectoral data sources are OECD Input-Output tables (48 sectors), OECD Bilateral Trade database (BTD, 25 sectors plus services) and IEA Energy Balances and related Carbon emissions. GINFORS always uses the sector breakdown of these official sources. 50 countries and two regions (OPEC and Rest of World) are explicitly modelled. Country model for all EU-27 countries, all OECD countries and their major trading partners including China, India, Russia and Brazil are included.





3.3 Pitfalls and problems for use of the EE I-O database developed in the project

Some of the original ambitions of EXIOPOL in regard to linking existing models may have to be reviewed. For instance, since EXIOPOL will not produce time series, the background data necessary for econometrical estimates of elasticities and behavioural parameters in general will not be available.

Some of the data required (marginal abatement cost functions, for instance) lies slightly outside the boundaries of the core work envisaged for cluster III. A sensible division of work for these tasks must therefore be devised.

The base year. If the chosen base year is not sufficiently recent, it may turn out that updating external model information would not be considered attractive beyond the addition of variables not already covered. More in general, in certain spheres the credibility of the project would be hampered by the production of data already old at birth.

The EXIOPOL classification should be at the same time broad and detailed enough to provide added value to different domains of modelling. In particular, we feel it is important to reach a sufficient level of detail in energy and energy intensive industries and agriculture, since these are possibly the most widespread areas of application of sectoral simulations. (energy intensive industries should be added as well as these are the sectors most-effected by energy/environmental policies and important to look at in our intersectoral approach) Not reaching a satisfactory level of detail in these areas would seriously limit the possibilities of linking to sectoral models.

Another important aspect is that the economic accounts should be produced in a form that is consistent and complete. If some of the factor inputs, taxes or investment accounts were missing, the data would maybe still serve the purpose of an engineering model but would effectively become useless to any socioeconomic model.

3.4 Review of key choices, opportunities and threats

Choices must be made in relation to several aspects; in some cases they are decisions that only affect the specific workpackage, in other cases they are decisions that would be taken primarily of other reasons, but that originate consequences of importance to the WP:

- How many models we intend to link to EXIOPOL (concentrate solely on the key ones, WTM and CEPAM/ GEM-E3 or extend the list, and to what level, exactly).
- For each model, up to what level do we want to go in funnelling new data: Environmental and Externality data is the minimum, whereas how much to go further may have to be decided case by case, also in relation to demand and willingness to cooperate from the modellers (for instance the NEMESIS case).
- How to approach marginality in external costs. In those models that include marginal abatement cost functions, the marginality of externalities could in principle be reflected too.



- The base year. If the chosen base year is not sufficiently recent, it may turn out that updating external model information would not be considered attractive beyond the addition of variables not already covered.
- Marginal abatement cost curves: for which pollutants, and what division of work.
- The chosen trade data structure may be more or less compatible with other models. However, the models that feature full-information bilateral trade data are not abundant, so that any of the two proposed schemes would do.

3.5 Proposed approach

The proposal is to take actions on three themes (with strongly decreasing effort required):

- 1. The EXIOPOL data will be substantially exploited by 2-3 core models, the WTM and CEPAM/ GEM-E3. This will include the effort to generate some additional data; for the WTM:
 - selected unit prices
 - selected factor inputs and factor prices (including by extension externalities and any fees associated with them)
 - selected stocks and factor endowments
 - geographic information (transport distances)
 - for goods-producing sectors, mass of product and common mode of transport

For the CGE models, mainly marginal abatement cost functions for selected pollutants. It is proposed here to focus on water pollutants and possibly waste.

- 2. Simple aggregation routines to make EXIOPOL data easily compatible with additional models. Here we propose to focus on:
 - NEMESIS, by establishing contacts with the research team and testing their interest in the project
 - GTAP, by including all the GTAP sectors in the EXIOPOL classification.
- 3. To make sure that the EXIOPOL classification is sufficiently detailed in the energy and agro-food domains to be utilisable in conjunction with sectoral simulations in those two fields. Transportation would make an interesting third field, although data availability on e.g. transport modes in third countries could turn out in a serious bottleneck.

In the light of the considerations discussed in this paper, the IPTS proposes the inclusion of the following sectors in the EXIOPOL classification (this information only relates to the endeavour covered by this scoping report, i.e. the linkage with existing models; further sectoral detail in e.g. waste, resources and basic metals is equally important but is not of concern for the present document):



- All the GTAP sectors. Two concordance tables between the 57 GTAP sectors (GSC) and standard classifications exist for two subsets of sectors, 1) GSC2 CPC, and 2) GSC2 ISIC Rev. 3 (see Annex I, Tables 9.1 and 9.2)
- Limited additional detail in land transport (separation of rail from freight and other road transport)
- Limited additional detail in power and utilities (separation of electricity from water and heat distribution). Additionally, Power generation by different energy carriers: Gas, coal, (oil), nuclear, hydro, wind, biomass, other. This information is important. As far as we know there is no sector classification whatsoever that distinguishes between different sectors here. We may want to think whether to split the sector or have the information only in the satellites.
- Additional detail in refinery products and distinction between refinery products from coke and nuclear fuel (this distinction is only available at CPA 5- and 6-digit level)
- Possibly, splitting of agro-food sectors further than in GTAP. Inclusion of this additional sectoral detail would be conditional to the availability of the IPTS-AGRILIFE work (see Annex I, Table 8). Table 10 summarises the non-GTAP additional sectoral splitting proposed.



4 Overall conclusions and recommendations

4.1 Conclusions on the degree of integration

Incorporating new data in existing models is always possible but almost never cost-free. Priority should be given to integrating those elements that do generate real added value.

In most cases, some information will be lost by aggregation when linking EXIOPOL data to an existing model. This is to say that the updating of economic accounts of a standard CGE model, for instance, may not be justified if this does not bring about a significant improvement in the base year.

The inclusion of environmental and externality data, on the contrary, will certainly provide a wealth of new data to all the models considered in this report.

4.2 Recommendations on the division of efforts

Efforts should be concentrated on two models: the WTM and CEPAM/GEM-E3. Additionally, there are some additional actions that could be taken to increase the applicability of the database; first and foremost is probably to ensure compatibility with the GTAP classification, as this database is used by a very large number of models. Then EXIOPOL has a commitment to take into consideration NEMESIS. Finally, provisions have been outlined that would make EXIOPOL useful in conjunction with sectoral simulations; since this would not require the establishment of hard links with models, it would not entail any additional dedicated efforts other than an appropriate specification of the sectoral detail.



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Annex I: Classification schemes of the models considered

No	Sector Name	Status	NACE-CLIO R25/R59
1	Agriculture	PC	010
2	Solid fuels	PC	060/031+033+050
3	Liquid fuels	PC	060/071+073
4	Natural Gas	PC	060/075+098
5	Electricity	PC	060/097+110+099
6	Ferrous And Non Ferrous Ore And Metals	IC	130
7	Chemical Products	IC	170
8	Other Energy- Intensive Industries	IC	150+190+470
9	Electrical Goods	IC	250
10	Transport Equipment	IC	280
11	Other Equipment Goods Industries	IC	210+230
12	Consumer Goods Industries	PC	360+420+490+480
13	Building and Construction	PC	530
14	Telecommunication Services	IC	670
15	Transports	PC	610+630+650
16	Services of Credit and Insurance	IC	690
17	Other Market Services	PC	560+590+740
18	Non-Market Services	PC	860

Table 1: GEM-E3's sector classification

No	Purpose Name	Status	EUROSTAT
1	Food, Beverages and Tobacco	ND	1
2	Clothing and Footwear	ND	2
3	Housing and Water	ND	31
4	Fuels and Power	ND	32
5	Housing Furniture and Operation	ND	41+42+44+45+46
6	Heating and Cooking Appliances	D	43
7	Medical Care and Health Expenses	ND	5
8	Transport Equipment	D	61
9	Operation of Transport Equipment	ND	62
10	Purchased Transport	ND	63
11	Telecommunicatio n services	ND	64
12	Recreation, Entertainment, Culture, etc.	ND	7
13	Other Services	ND	8

Table 2: the 13 household consumption categories in GEM-E3:



group of emitters	GEM-E3 industries
1	electric power
2a	ferrous/non-ferrous/metal products, chemical products, other energy intensive industries,
2b	coal, electrical goods, transport equipment, other equipment goods
3	crude oil/oil products (refineries)
4a	natural gas, consumer goods, building and construction, agriculture/fishery/forestry
4b	telecommunication services, services of credit and insurance institutions, other market services, non-market services, heating systems of the households
5	transport and private traffic (households)

Table 3: aggregated groups of emitters in the environmental module of GEM-E3:



Table 4: GTAP sector classification:

- 1 PDR Paddy rice
- $2\ {\rm WHT}$ Wheat
- 3 GRO Cereal grains nec
- $4~V_F$ Vegetables, fruit, nuts
- $5\ \mathrm{OSD}$ Oil seeds
- $6\ {\rm C_B}$ Sugar cane, sugar beet
- 7 PFB Plant-based fibers
- 8 OCR Crops nec
- 9 CTL Bovine cattle, sheep and goats, horses
- 10 OAP Animal products nec
- 11 RMK Raw milk
- $12 \ {\rm WOL}$ Wool, silk-worm cocoons
- 13 FRS Forestry
- 14 FSH Fishing
- 15 COA Coal
- 16 OIL Oil
- 17 GAS Gas
- 18 OMN Minerals nec
- 19 CMT Bovine meat products
- $20 \; \mathrm{OMT}$ Meat products nec
- 21 VOL Vegetable oils and fats
- 22 MIL Dairy products
- 23 PCR Processed rice
- $24 \ \mathrm{SGR} \ \mathrm{Sugar}$
- $25 \; \mathrm{OFD}$ Food products nec
- 26 B_T Beverages and to bacco products
- 27 TEX Textiles
- 28 WAP Wearing apparel
- 29 LEA Leather products
- 30 LUM Wood products
- 31 PPP Paper products, publishing
- $32 P_C$ Petroleum, coal products



- 33 CRP Chemical, rubber, plastic products
- 34 NMM Mineral products nec
- $35 I_S$ Ferrous metals
- 36 NFM Metals nec
- 37 FMP Metal products
- 38 MVH Motor vehicles and parts
- 39 OTN Transport equipment nec
- 40 ELE Electronic equipment
- 41 OME Machinery and equipment nec
- $42 \ {\rm OMF}$ Manufactures nec
- 43 ELY Electricity
- $44\ {\rm GDT}\ {\rm Gas}$ manufacture, distribution
- $45 \ \mathrm{WTR} \ \mathrm{Water}$
- 46 CNS Construction
- 47 TRD Trade
- 48 OTP Transport nec
- 49 WTP Water transport
- 50 ATP Air transport
- 51 CMN Communication
- $52 \; \mathrm{OFI}$ Financial services nec
- 53 ISR Insurance
- $54 \ \mathrm{OBS}$ Business services nec
- 55 ROS Recreational and other services
- 56 OSG Public Administration, Defense, Education, Health
- 57 DWE Dwellings



Table 5: GTAP country coverage:

1 AUS Australia 2 NZL New Zealand 3 XOC Rest of Oceania 4 CHN China 5 HKG Hong Kong 6 JPN Japan 7 KOR Korea 8 TWN Taiwan 9 XEA Rest of East Asia 10 IDN Indonesia 11 MYS Malaysia 12 PHL Philippines 13 SGP Singapore 14 THA Thailand, 5 VNM Vietnam 16 XSE Rest of Southeast Asia 17 BGD Bangladesh 18 IND India 19 LKA Sri Lanka 20 XSA Rest of South Asia 21 CAN Canada 22 USA United States of America 23 MEX Mexico 24 XNA Rest of North America 25 COL Colombia 26 PER Peru 27 VEN Venezuela 28 XAP Rest of Andean Pact 29 ARG Argentina 30 BRA Brazil 31 CHL Chile 32 URY Uruguay 33 XSM Rest of South America 34 XCA Central America 35 XFA Rest of Free Trade Area of the Americas 36 XCB Rest of the Caribbean 37 AUT Austria 38 BEL Belgium 39 DNK Denmark 40 FIN Finland 41 FRA France 42 DEU Germany 43 GBR United Kingdom 44 GRC Greece 45 IRL Ireland 46 ITA Italy 47 LUX Luxembourg 48 NLD Netherlands 49 PRT Portugal 50 ESP Spain 51 SWE Sweden 52 CHE Switzerland 53 XEF Rest of EFTA 54 XER Rest of Europe 55 ALB Albania 56 BGR Bulgaria 57 HRV Croatia 58 CYP Cyprus 59 CZE Czech Republic 60 HUN Hungary 61 MLT Malta 62 POL Poland 63 ROM Romania 64 SVK Slovakia 65 SVN Slovenia 66 EST Estonia 67 LVA Latvia 68 LTU Lithuania 69 RUS Russian Federation 70 XSU Rest of Former Soviet Union 71 TUR Turkey 72 XME Rest of Middle East 73 MAR Morocco 74 TUN Tunisia 75 XNF Rest of North Africa 76 BWA Botswana 77 ZAF South Africa 78 XSC Rest of South African Customs Union 79 MWI Malawi 80 MOZ Mozambique 81 TZA Tanzania 82 ZMB Zambia 83 ZWE Zimbabwe 84 XSD Rest of Southern African Development Community 85 MDG Madagascar 86 UGA Uganda 87 XSS Rest of Sub-Saharan Africa



Table 6: Energy carriers disaggregation (excluding nuclear fuel) in Gilis, Jansen and Vandille 2006

1	Lignite	
2	Coal	
3	Natural gas	
4	Biofuels	Wood
5		Other bio-fuels
6	Peat and other	
7	Waste	
8	Coal coke	
9	Coke gas and other gases	
	Petroleum products	Total
10		Fuel oil
11		Diesel oil
12		Motor gasoline
13		LPG
14		Jet fuel and kerosene
15		Other petrolum products



Table 7:Geographical coverage in POLES:

- The 27 EU countries
- USA United States
- CAN Canada
- MEX Mexico
- RCAM Rest of Central America
- BRA Brazil
- RSAM Rest of South America
- TUR Turkey
- ROWE Other Western Europe
- RCEU Rest of Central Europe
- RUS Russia
- UKR Ukraine
- FSUN Former Soviet Union
- NOAP Alg, Libya
- NOAN Marocco, Tunisia
- EGY Egypt
- MEME Medit. Countries
- GOLF Gulf Countries
- SSAF South of Sahara Africa
- NDEIndia
- RSAS Rest of South Asia
- COR Korea
- RSEA Rest of South East Asia
- CHN China
- JPN Japan
- RJAN Australasia



Table 8: Modified Agro-industry Classification (MAC) under development at IPTS- AGRILIFE. Agri sectors are shaded in green, food sectors in orange.

1	DWHE	Durum wheat	40	OMIN	Other mining and quarrying	79	OMAC	Machinery and equipment, n.e.c.
2	OWHE	Other wheat	41	BFVL	Meat of bovine animals	80	OFMA	office machinery and computers
3	BARL	Barley	42	PORK	Meat of swine	81	ELMA	electrical machinery n.e.c.
4	MAIZ	Grain maize	43	SGMT	Meat of sheep	82	COEQ	radio, tv and comm apparatus
5	PARI	Paddy rice	44	POUM	Poultry meat	83	MEIN	medical, precision instruments
6	OCER	Other cereals	45	OTMT	Meat and meat products n.e.c.	84	мото	motor vehicles
7	ΡΟΤΑ	Potatoes	46	FSHP	Fish and fish products	85	TREQ	other transport equipment
8	STPR	Other starch and protein plants	47	PRFV	Fruit and vegetables	86	FURN	furniture; manufacturing n.e.c.
9	SOYA	Soya seed	48	AOIL	Animal oils and fats	87	RECY	Recycling
10	RAPE	Rape seed	49	VOIL	Vegetable oils and fats	88	ELEC	electricity
11	SUNF	Sunflower seed	50	VCAK	Oil-cake and other solid residues	89	DSGS	gas
12	OOIL	Other oil plants	51	MPWD	Milk powder	90	STEA	Steam and hot water supply
13	SUGB	Sugar beet	52	FMIP	Fresh milk products	91	WATR	Coll. Pur. Distrib. of water
14	SUOT	Other sugar plants	53	PMIP	Processed milk products	92	CONS	Construction
15	FODD	Fodder crops	54	RICE	Processed rice	93	SMOT	Sale of motor vehicles
16	FIBR	Fibre plants	55	MCER	Grain mill products, except rice	94	WTRD	Wholesale trade
17	OTCR	Other crops	56	STAR	Starches and starch products	95	RTRD	Retail trade
18	FVEG	Fresh vegetables	57	ANFD	Prepared animal feeds	96	HORE	Hotels and restaurants
19	LPLT	Live plants	58	SUGA	Processed sugar	97	TRLD	Land transport
20	GRPS	Grapes	59	OFOD	Other food products	98	TRWA	Water transport
21	OFRT	Other plant products	60	BEVR	Beverages	99	TRAR	Air transport
22	LCAT	Live cattle	61	TOBA	Tobacco products	100	TROT	Supporting transport activities
23	СОМІ	Cow milk	62	TEXT	Textiles	101	TECO	Post and telecommunications
24	LSGE	Live sheep, goats, and equines	63	GARM	Wearing apparel	102	FINA	Financial intermediation
25	SGMI	Sheep and goat milk	64	LETH	Tanning, dressing of leather	103	INSU	Insurance and pension funding
26	ANHR	Wool and animal hair	65	WOOD	Wood and of products of wood	104	FIAX	Activities auxiliary to financial
27	PIGF	Pig farming	66	PULP	Pulp, paper and paper products	105	ESTA	Real estate activities
28	PLTR	Live poultry	67	MDIA	Publishing, printing	106	MARE	Renting of machinery
29	EGGS	Eggs	68	RPET	Coke, petroleum products	107	COMP	Computer and related activities
30	SLKW	Silkworm cocoons	69	FERT	Fertilizers	108	RESC	Research and development
31	OANM	Other animal products	70	PLAP	Pesticides	109	OTBS	Other business activities
32	AGSV	Agricultural services	71	IPHA	Pharmaceuticals for agriculture	110	PUAD	Public administration
33	FORE	Forestry, logging	72	OCHM	Chemicals n.e.c.	111	EDUC	Education
34	FISH	Fishing	73	PLST	Rubber and plastic products	112	HESO	Health and social work
35	COAL	Mining of coal and lignite	74	NMMP	Other non-metal mineral products	113	SANI	Sewage and refuse disposal
36	COIL	Extraction of crude petroleum	75	FRMT	Ferrous metals	114	ORGA	Membership organization
37	NGAS	Extraction of natural gas	76	NFRM	Basic metals nec	115	CULT	Recreational activities
38	URAN	Mining of uranium and thorium	77	FAME	Fabricated metal products	116	OTSV	Other service activities
39	MEOR	Mining of metal ores	78	MAGR	Agricultural machinery	117	PRHH	Private hh with employees

Number	Code	Code	Description
1	pdr	113	Rice, not husked
	P +	114	Husked rice
2	wht	111	Wheat and meslin
2	aro	110	Wheat and mesimi Maiza (see)
3	gio	112	
		115	Dalley
		116	Rye, oats
		119	Other cereals
4	v_t	12	Vegetables
		13	Fruit and nuts
5	osd	14	Oil seeds and oleaginous fruit
6	c_b	18	Plants used for sugar manufacturing
7	pfb	192	Raw vegetable materials used in textiles
8	ocr	15	Live plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds
		16	Beverage and spice crops
		17	Unmanufactured tobacco
		191	Cereal straw and husks unprepared whether or not chopped, ground, pressed or in the form of pellets:
			swedes manapolds folder roots hav lucerne (alfalfa) clover sainfolin forage kale lunines vertices and
		103	Plants and parts of plants used primarily in performance in pharmacy, or for insecticidal functional and an article insection of the section
		193	Finance and parts of plants used primarily in pertainery, in priarmacy, of for insecticidal, fullycidal of similar
		194	Sugar beet seed and seeds of forage plants
		199	Uner raw vegetable materials
9	CTI	211	Bovine cattle, sheep and goats, norses, asses, mules, and ninnies, live
		299	Bovine semen
10	oap	212	Swine, poultry and other animals, live
		292	Eggs, in shell, fresh, preserved or cooked
		293	Natural honey
		294	Snails, live, fresh, chilled, frozen, dried, salted or in brine, except sea snails; frogs' legs, fresh, chilled or
		295	Edible products of animal origin n.e.c.
		297	Hides, skins and furskins, raw
		298	Insect waxes and spermaceti, whether or not refined or coloured
11	rmk	291	Raw milk
12	wol	296	Raw animal materials used in textile
13	for	3	Forestry, logging and related service activities
19	cmt	21111	Meat of bovine animals, fresh or chilled
		21112	Meat of bovine animals, frozen
		21112	Maat of shapp fresh or chilled
		21115	Most of shoop, frozon
		21110	Meet of Snots, firsh, chilled or frozen
		21117	Magt of goals, response mulas of rozen
		21110	The advances as a set of the set
		21113	Lable of all of bowine animals, swine, sheep, goals, noises, asses, males of nimites, itesh, chilled of nozen
20	omt	2101	And of ouring animals, sheep, goals, pigs and poulity, raw of rendered, woor grease
20	onn	21113	Med of swine, rest of chiled
		21114	Interation Swinte, nozen
		2112	Interact and euloie on al, mesh, chilled or hozer, n.e.c.
		2113	Freserves and preparations of meat, meat offail or blood
		2114	Flouis, means and penets of mean of mean of all interference greaters
04	vol	2102	Animiral one and rate, clude and remined, except rates of bowine antimitals, sheep, goals, pigs and pollity
21	VOI	2103	being and the second state of the second state
		2164	Paim, coconut, paim kernei, babassu and linseed oli, crude
		2165	Soya-bean, ground-nut, olive, suntiower-seed, sattiower, cotton-seed, rape, coiza and mustard oil and their
			fractions, refined but not chemically modified; other oils obtained solely from olives and sesame oil, and their
		2166	Naize (corn) oil and its fractions, not chemically modified
		2167	Palm, coconut, palm kernel, babassu and linseed oil and their fractions, refined but not chemically modified;
			castor, tung and jojoba oil and fixed vegetable fats and oils (except maize oil) and their fractions n.e.c.,
		2168	Margarine and similar preparations
		2169	Animal or vegetable fats and oils and their fractions, partly or wholly hydrogenated, inter-esterified, re-
			esterified or elaidinised, whether or not refined, but not further prepared
		217	Cotton linters
			Oil-cake and other solid residues resulting from the extraction of vegetable fats or oils; flours and meals of oil
		218	seeds or oleaginous fruits, except those of mustard; vegetable waxes, except triglycerides; degras; residues
22	mil	22	Dairy products
23	pcr	2316	Rice, semi- or wholly milled
24	sgr	235	Sugar
25	ofd	212	Prepared and preserved fish
		213	Prepared and preserved vegetables
		214	Fruit juices and vegetable juices
		215	Prepared and preserved fruit and nuts
		2311	Wheat or meslin flour
		2312	Cereal flours other than of wheat or meslin
		2312	Groats meal and pellets of wheat
		2313	Cereal groats, meal and pellets n e c
		2314	Other creat area in products (including con flakes)
		2313	Other venetable flours and meals
		2017	Nives and double for the preparation of bakers' wares

Table 9.1: GSC2 Sectors Defined by Reference to the CPC

Number	Code	Code	Description
14	fsh	15	Hunting, trapping and game propagation including related service activities
		5	Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing
15	col	101	Mining and agglomeration of hard coal
		102	Mining and agglomeration of lignite
		103	Mining and applomeration of peat
16	oil	111	Extraction of crude petroleum and natural gas (part)
	-	112	Service activities incidental to oil and gas extraction excluding surveying (part)
17	gas	111	Extraction of crude petroleum and natural gas (part)
	3	112	Service activities incidental to oil and das extraction excluding surveying (part)
18	omn	12	Mining of uranium and thorium ores
		13	Mining of metal ores
		14	Other mining and guarrying
27	tex	17	Manufacture of textiles
	tox	243	Manufacture of man-made fibres
28	wap	18	Manufacture of waring apparel: dressing and dveing of fur
29	lea	19	Tan and dressing of leather: manufacture of luggage handbags saddlery harpess and footwear
30	lum	20	Manufacture of wood and of products of wood and cork excent furniture manufacture of articles of straw and
31	nnn	20	Manufacture of paper and paper products
01	PPP	22	Publishing printing and reproduction of record media
32	n c	221	Manufacture of coke over products
52	P_0	231	Manufacture of rofic over products
		232	Manuacture of refine perforem products
22	orn	233	Processing of nuclear nucl
	orp	241	Manufacture of other chemical products
		242	Manufacture of other filled products
24		20	Manufacture of rubber and plastics products
34		20	Manufacture of one informedation interal products
30	1_5	271	
20	- 6	2/31	
30	ntm	272	Manufacture of basic precious and non-refrous metals
07	(2732	Casting of non-ferrous metals
37	tmp	28	Manufacture of fabricated metal products, except machinery and equipment
38	mvh	34	Manufacture of motor vehicles, trailers and semi-trailers
39	otn	35	Manufacture of other transport equipment
40	ele	30	Manufacture of office, accounting and computing machinery
		32	Manufacture of radio, television and communication equipment and apparatus
41	ome	29	Manufacture of machinery and equipment n.e.c.
		31	Manufacture of electrical machinery and apparatus n.e.c.
		33	Manufacture of medical, precision and optical instruments, watches and clocks
42	omf	36	Manufacturing n.e.c.
		37	Recycling
43	ely	401	Production, collection and distribution of electricity
44	gdt	402	Manufacture of gas; distribution of gaseous fuels through mains
		403	Steam and hot water supply
45	wtr	41	Collection, purification and distribution of water
46	cns	45	Construction
47	trd	50	Sales, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
		51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
		521	Non-specialized retail trade in stores
		522	Retail sale of food, beverages and tobacco in specialized stores
		523	Other retail trade of new goods in specialized stores
		524	Retail sale of second-hand goods in stores
		525	Retail trade not in stores
		526	Repair of personal and household goods
		55	Hotels and restaurants
48	otp	60	Land transport; transport via pipelines
		63	Supporting and auxiliary transport activities; activities of travel agencies
49	wtp	61	Water transport
50	atp	62	Air transport
51	cmn	64	Post and telecommunications
52	ofi	65	Financial intermediation, except insurance and pension funding
		67	Activities auxiliary to financial intermediation
53	isr	66	Insurance and pension funding, except compulsory social security
54	obs	К	Real estate, renting and business activities
55	ros	92	Recreational, cultural and sporting activities
		93	Other service activities
		95	Private households with employed persons
56	osg	75	Public administration and defense; compulsory social security
		80	Education
		85	Health and social work
		90	Sewage and refuse disposal, sanitation and similar activities
		91	Activities of membership organizations n.e.c.
		99	Extra-territorial organizations and bodies
57	dwe	n.a.	n.a.

Table 9.2: GSC2 Sectors Defined by Reference to the ISIC, Rev.3 $\,$

Table 10: Additional non-GTAP sector splitting proposed

	Land transport (NACE rev.2):
49.1+49.2	rail transport
49.3	Other passenger land transport
49.4	Freight transport by road
49.5	Transport via pipeline
	1
	Power and utilities (NACE rev.2):
35.1	Electric power generation, transmission and distribution (different tehenologies?)
35.2	Manufacture of gas: distribution of gaseous fuels through mains
35.3	Steam and air conditioning supply
	le come and an constructional existent
	COKE. REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL (CPA2002)
23.1	Coke oven products
23.20.11	Motor spirit (gasoline)
23.20.14	Kerosene, including kerosene type jet fuel
23.20.15	Gas oils
23.20.17	Fuel oils n.e.c.
23.20.2	Petroleum gases and other gaseous hydrocarbons, except natural gas
23.20.2 23.20.3+4	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products
23.20.2 23.20.3+4 23.3	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel
23.20.2 23.20.3+4 23.3 23	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products <i>other than 23.1 and 23.5</i>
23.20.2 23.20.3+4 23.3 23 23 23.1	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products <i>other than 23.1 and 23.5</i> Manufacture of glass and glass products
23.20.2 23.20.3+4 23.3 23 23.1 23.5	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products <i>other than 23.1 and 23.5</i> Manufacture of glass and glass products Manufacture of cement, lime and plaster
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products <i>other than 23.1 and 23.5</i> Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals <i>other than 24.1 and 24.4</i>
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products <i>other than 23.1 and 23.5</i> Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals <i>other than 24.1 and 24.4</i> Manufacture of basic iron and steel and of ferro-alloys
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products other than 23.1 and 23.5 Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals other than 24.1 and 24.4 Manufacture of basic iron and steel and of ferro-alloys Manufacture of basic precious and non-ferrous metals other than 24.42
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4 24.42	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products other than 23.1 and 23.5 Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals other than 24.1 and 24.4 Manufacture of basic iron and steel and of ferro-alloys Manufacture of basic precious and non-ferrous metals other than 24.42 Aluminium production
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4 24.42 25	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products other than 23.1 and 23.5 Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals other than 24.1 and 24.4 Manufacture of basic precious and non-ferrous metals other than 24.42 Aluminium production Manufacture of fabricated metal products, except machinery and equipment
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4 24.42 25	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products other than 23.1 and 23.5 Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals other than 24.1 and 24.4 Manufacture of basic precious and non-ferrous metals other than 24.42 Aluminium production Manufacture of fabricated metal products, except machinery and equipment
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4 24.42 25	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products other than 23.1 and 23.5 Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals other than 24.1 and 24.4 Manufacture of basic iron and steel and of ferro-alloys Manufacture of basic precious and non-ferrous metals other than 24.42 Aluminium production Manufacture of fabricated metal products, except machinery and equipment Agri and food:
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4 24.42 25	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products other than 23.1 and 23.5 Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals other than 24.1 and 24.4 Manufacture of basic iron and steel and of ferro-alloys Manufacture of basic precious and non-ferrous metals other than 24.42 Aluminium production Manufacture of fabricated metal products, except machinery and equipment Agri and food: Concerning agricultural primary production, it could be important to important to
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4 24.42 25	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products other than 23.1 and 23.5 Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals other than 24.1 and 24.4 Manufacture of basic iron and steel and of ferro-alloys Manufacture of basic precious and non-ferrous metals other than 24.42 Aluminium production Manufacture of fabricated metal products, except machinery and equipment Agri and food: Concerning agricultural primary production, it could be important to important to have barley, animal feed cereals, fodder, rape and sunflower seed, swine, and poultry
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4 24.42 25	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products other than 23.1 and 23.5 Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals other than 24.1 and 24.4 Manufacture of basic iron and steel and of ferro-alloys Manufacture of basic precious and non-ferrous metals other than 24.42 Aluminium production Manufacture of fabricated metal products, except machinery and equipment Agri and food: Concerning agricultural primary production, it could be important to important to have barley, animal feed cereals, fodder, rape and sunflower seed, swine, and poultras individual sectors/commodities. This can become useful when one wants to follow
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4 24.42 25	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products other than 23.1 and 23.5 Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals other than 24.1 and 24.4 Manufacture of basic precious and non-ferrous metals other than 24.42 Aluminium production Manufacture of fabricated metal products, except machinery and equipment Agri and food: Concerning agricultural primary production, it could be important to important to have barley, animal feed cereals, fodder, rape and sunflower seed, swine, and poultr as individual sectors/commodities. This can become useful when one wants to follow the food value-added chains, analyse certain policies related to cattle/pig rearing, or
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4 24.42 25	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products other than 23.1 and 23.5 Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals other than 24.1 and 24.4 Manufacture of basic precious and non-ferrous metals other than 24.42 Aluminium production Manufacture of fabricated metal products, except machinery and equipment Agri and food: Concerning agricultural primary production, it could be important to important to have barley, animal feed cereals, fodder, rape and sunflower seed, swine, and poultr as individual sectors/commodities. This can become useful when one wants to follow the food value-added chains, analyse certain policies related to cattle/pig rearing, or link the commodities flexibly to different farm-types. Food industry is more or less
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4 24.42 25	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products <i>other than 23.1 and 23.5</i> Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals <i>other than 24.1 and 24.4</i> Manufacture of basic iron and steel and of ferro-alloys Manufacture of basic precious and non-ferrous metals <i>other than 24.42</i> Aluminium production Manufacture of fabricated metal products, except machinery and equipment Agri and food: Concerning agricultural primary production, it could be important to important to have barley, animal feed cereals, fodder, rape and sunflower seed, swine, and poultry as individual sectors/commodities. This can become useful when one wants to follow the food value-added chains, analyse certain policies related to cattle/pig rearing, or link the commodities flexibly to different farm-types. Food industry is more or less okay in GTAP, but at least animal feed should be separated. Pork and poultry meat
23.20.2 23.20.3+4 23.3 23 23.1 23.5 24 24.1 24.4 24.42 25	Petroleum gases and other gaseous hydrocarbons, except natural gas Other petroleum products Nuclear fuel Energy intensive sectors (NACE rev.2): Manufacture of other non-metallic mineral products other than 23.1 and 23.5 Manufacture of glass and glass products Manufacture of cement, lime and plaster Manufacture of basic metals other than 24.1 and 24.4 Manufacture of basic precious and non-ferrous metals other than 24.42 Aluminium production Manufacture of fabricated metal products, except machinery and equipment Agri and food: Concerning agricultural primary production, it could be important to important to have barley, animal feed cereals, fodder, rape and sunflower seed, swine, and poultry as individual sectors/commodities. This can become useful when one wants to follow the food value-added chains, analyse certain policies related to cattle/pig rearing, or link the commodities flexibly to different farm-types. Food industry is more or less okay in GTAP, but at least animal feed should be separated. Pork and poultry meat should also not be merged into one sector.

Note: Preliminary discussions with EC services (chiefly ENTR and ENV) already indicated that further detail would be considered necessary for the chemicals sector and for the description of economy-environment interactions, thereby including expenditures for environmental protection as a well as the environment /or the quality of the environment/ providing valuable inputs to the economy (recreational values, ecotourism, etc.)



Annex II: Contributors to the report

This report is the result of discussions between all partners in the EXIOPOL consortium. It has been edited by Frederik Neuwahl. The different chapters were written by the following persons:

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