PRACE NAUKOWE GIG
GÓRNICTWO I ŚRODOWISKO
Kwartalnik

RESEARCH REPORTS
MINING AND ENVIRONMENT
Quarterly 1/2011

Alina Rejman-Burzyńska[*], *Anna Śliwińska*[*], *Eugeniusz Jędrysik*[*]

CONSTRUCTION OF THE INTEGRATED MONETARY-PHYSICAL SUPPLY AND USE TABLES FOR POLAND

Abstract

This paper presents a methodology of construction of the integrated Monetary-Physical Supply and Use Tables (MPSUTs) for Poland. The elaboration of these tables for Poland (2003) was a pioneering work, since, to the best our knowledge, such tables have never been produced before. This research was done within FORWAST project – 6th EU Framework Programme (RTD). The integrated MPSUTs provide a framework in which all physical flows associated with all monetary flows in the economy can be recorded. This paper describes this framework with monetary and physical matrices for supply and use as well as matrices of the resources and emissions. The categories of products/activities and data sources are mentioned. The matrices were compiled using data from various sources: production statistics, foreign trade statistics, energy accounts, emissions inventory, recycling data, etc. Thus the elaborated MPSUTs can be served as an integration of framework for different data sources and various specific sector production and use accounts such as agriculture, forestry, fishery, metals and mineral extraction and energy. Such tables are a valuable tool for integrated environmental-economic accounting and modelling. Starting point of creation MPSUTs for Poland was the Monetary Supply and Use Tables (MSUTs), elaborated by CSO (Central Statistical Office – Poland) according to ESA'95 (European System of Accounts). For the construction of PSUTs (59 59), the quantities (mass) of the products related to given categories were determined on the basis of statistical data. Distribution of mass flows into industry activities in PSUTs was proportionally with the relevant monetary values in MSUTs and was delivered from monetary values and price. For a better determination of the flows of the system, disaggregations of the primary data of the monetary and physical SUTs (59 products x 59 activities) were performed in order to trace out and map all the internal flows of the whole economy (117 products · 117 activities). The methodology of data mining, data processing and validation, as well as tools used for construction of the tables (MPSUTs) for Poland are discussed. The information covered in matrices included in these tables are illustrated using numerical examples.

Opracowanie zintegrowanych tablic międzygałęziowych przepływów pieniężnych i masowych dla produkcji i wykorzystania wyrobów i usług w Polsce

Streszczenie

W niniejszym artykule opisano metodykę konstruowania zintegrowanych tablic bilansowych przepływów pieniężnych i fizycznych dla podaży i wykorzystania wyrobów i usług (MPSUTs). Stworzenie tablic przepływów międzygałęziowych finansowych i fizycznych dla Polski było pracą pionierską, gdyż jak wiadomo autorom, takie tablice dotąd nie zostały opracowane. Praca została wykonana w ramach projektu FORWAST – 6. Program Ramowy Unii Europejskiej (Badania i Rozwój Technologii). Zintegrowane tablice produkcji i wykorzystania (MPSUTs) stanowią strukturę zbioru macierzy, w której mogą być zapisane i powiązane wszystkie strumienie przepływów fizycznych (masowych) z przepływami pieniężnymi w gospodarce narodowej. Tablice te obejmują: macierze przepływów pieniężnych i fizycznych dla podaży i wykorzystania oraz macierze surowców i emisji zanieczyszczeń gazowych do powietrza. Przy modelowaniu przepływów pieniężnych i fizycznych dla macierzy (SUTs) wykorzystano rachunek przepływów materiałowych (MFA), macierze rachunków narodowych, macierze przepływów surow-

[*] Główny Instytut Górnictwa

ców i emisji. Dlatego też tablice te mogą być wykorzystywane do integracji struktury różnych danych oraz rachunków produkcji i wykorzystania dla różnych sektorów przemysłu, takich jak: rolnictwo, leśnictwo, rybołówstwo, wydobycie rud metali i minerałów czy energetyka. Tablice stanowią cenne narzędzie do modelowania środowiskowego i ekonomicznego. Mogą one zostać przekształcone w tablice wejście-wyjście (IOTs), które są wykorzystywane w rachunkach środowiskowych. Tablice te służyły w projekcie FORWAST jako dane wejściowe do modelowania i prognozowania odpadów i zasobów materiałowych i do określania wpływów środowiskowych dla różnych scenariuszy zapobiegania powstawaniu odpadów, recyklingu i przekształcania odpadów w Unii Europejskiej (UE-27). Punktem wyjścia do stworzenia tablic MPSUTs były tablice rachunków narodowych (Rachunek podaży i wykorzystania wyrobów i usług w 2003 r.) opracowane przez GUS, zgodne z ESA '95 (*European System of Accounts*) i zawierające 60 produktów/aktywności według klasyfikacji CPA/NACE. W celu lepszego określenia systemu przepływów przeprowadzono dalszą dezagregację danych, aby prześledzić i ująć wszystkie istotne wewnętrzne przepływy w gospodarce (117 produktów × 117 aktywności). W artykule omówiono metodykę eksploracji danych, ich przetwarzania i walidacji oraz narzędzia stosowane do tworzenia tablic MPSUTs dla Polski. Informacje zawarte w tych tablicach zostały zilustrowane na przykładach.

INTRODUCTION

Generally, flows between different activities in the technosphere are determined using information on monetary flows in the economy. Detailed, consistent information on monetary flows in the economy is provided in the Supply and Use Tables (SUTs), e.g. see Eurostat (2008a). Supply and use tables can be established in monetary as well as in physical units (Hoekstra, Bergh 2005) by using physical statistics. Modelling all monetary and physical flows for SUTs employs: economy-wide Material Flow Accounting (MFA), national accounting matrices, resource accounts and emission accounts.

The integrated Monetary and Physical SUTs developed for Poland have two important features. Firstly, the tables are balanced, so that use balances with supply. This ensures that the system modelling is consistent and provides the possibility for establishing equations using the balancing principle for the whole economy. Secondly, the SUTs can be converted into analytical Input Output Tables (IOTs) which can be used for different environmental accounts e.g. determination of environmental impacts, Life Cycle Inventory (LCI), etc. In the context of FORWAST project such SUTs were constructed for Poland as well as for nine other EU countries (Denmark, France, Germany, Austria, Spain, UK, Ireland, Sweden and Greece). These tables served as input data, firstly for modelling and forecasting for the next 25 years, the expected amounts of waste generated, per material category and secondly, to determine life-cycle environmental impacts from different scenarios of waste prevention, recycling and waste treatment in the EU-27.

This paper describes as follows: Chapter 1 Basic and FORWAST frameworks of SUTs, Chapters 2 and 3 methodology of data mining and creation of MSUTs and PSUTs for Poland, Chapters 4 Resources matrix, and Chapter 5 Emissions matrix. Chapter 6 concerns data checking and validation. In Chapter 7 the statistical data availability is discussed.

1. SUPPLY AND USE TABLES – BASIC AND FORWAST FRAMEWORKS

Monetary Supply and Use Tables (MSUTs) are created by most national statistics. The concept of supply and use tables has been introduced in the European System of Acounts in 1995 (ESA'95). The tables present for the total economy, by product groups, the resources and uses of goods and services in monetary units.

The Supply Table (Table 1) gives information in monetary units (e.g. EUR, kEUR or MEUR) about supply of goods and services. In the rows, the various types of products (60) are presented according to the Classification of Products by Activity (CPA). In the columns, are described the activities (industries and services) and imports (intra EU and extra EU).

For each activity (columns) the total supply and use are balanced. For each product (rows) total supply should be balanced with total use.

The general format of the physical supply and use tables (Table 2) is equal to the format of a monetary supply table. The only differences are that the physical supply and use tables are given in physical units (e.g. kg, Mg or Gg) instead of monetary units (e.g. EUR, kEUR or MEUR). As we can see in tables 1 and 2, the physical tables are a mirror of the monetary tables, and both tables are related via price relationships.

Table 1. A Supply Table at basic prices

	Activities (NACE[2])	∑	Imports	Total supply at basic prices
Products (CPA[1]) of activities	Output by product and by activity			
∑	Total output by activity			

CPA[1] – The Classification of Products by Activity is used by the European Union in national and regional accounts, NACE[2] – NACE codes represent the statistical classification of economic activities within the European Union which serves as a basis for compiling statistics on the production, factors of production (labour, raw materials, energy, etc.)

Table 2. A Supply Table in physical units

	Activities (NACE[2])	∑	Imports	Total supply in physical units
Products (CPA[1]) of activities	Output by product and by activity			
∑	Total output by activity			

The Use Table (Table 3) gives information about the different uses. The same classification of products as in the Supply Table is used in the rows. The columns show the different uses, namely a matrix of Intermediate Consumption by activities (industries and services) and the final uses: Exports, Final Consumption on expenditures: by households, by non-profit institutions serving households, by government, gross fixed capital formation, changes in inventories and valuables, and exports (intra EU and extra EU).

Physical Supply and Use Tables can be established either directly from physical information or by combining the monetary supply and use tables and the price matrix. Prices of products are described in a product by activity matrix having monetary units per mass unit.

Table 3. A Use Table at purchaser's prices

	Input of activites		Final uses				
	Activities (NACE)	∑	Final con-sumption	Gross capital formation	Exports	∑	Total use at purchaser's prices
Products (CPA)	Intermediate consumption by product and by activity						
∑	Total intermediate consumption by activity		Total final uses by type				Total use
Compensation of employees Other net taxes Consumption of fixed capital Operating surplus, net	Components of value added by industry						
∑	Value added by activity						
∑	Input at basic prices by industry						

Table 4. A Physical Use Table in physical units

	Input of activites		Final uses				
	Activities (NACE)	∑	Final con-sumption	Gross capital formation	Exports	∑	Total use
Products (CPA)	Intermediate consumption by product and by activity						
∑	Total intermediate consumption by activity		Total final uses by type				Total use
∑	Input by activity						

The Supply and Use Tables developed within FORWAST project present the extended PSUTs framework in comparison with basic SUTs framework. FORWAST SUTs specify the 117 included product groups and activities defined in the FORWAST model (see Table 5). The Table 5 also specifies the NACE/CPA classification numbers relating to each product group and activities.

The FORWAST SUTs contains four different types of products:

- Physical products, i.e. products that have a physical weight (mass unit, dry weight) or products being electricity/heat (energy unit),
- Service products, i.e. products that are measured in monetary units,
- Waste treatment services, i.e. services to treat or recycle waste. These may be intermediate treatments (e.g. incineration that supplies ash and slag as waste) or final (e.g. landfill),
- Household uses, i.e. groups of final uses.

The dissagregation of the primary data of the Eurostat SUT (59 × 59) into (117 × 117) was performed in order to trace out and map all the significant internal flows of the whole economy. Moreover, the physical SUTs framework was extended. These extended PSUTs include the matrices of the resources, emissions, generated residuals and stock changes.

For each product (rows) in monetary tables as well as in physical tables, total supply should be balanced with total use. The basic equation is:

Output + Imports (Total Supply) = Intermediate Consumption + Exports + Gross Capital Formation + Final Consumption (1).

For each activity (columns) in monetary tables the total supply and use is balanced.

$$\text{Total Supply} = \text{Total Use} \quad (2)$$

The balance for each activity in physical tables requires inclusion of resource inputs, generated residuals and emissions, and addition of stock changes.

The balance per activity and per product respectively in the SUTs according to FORWAST format based on the following equations:

$$\text{Supply} + \text{Waste} + \text{Stock Changes} + \text{Emissions} = \text{Use} + \text{Waste Use} + \text{Resources} \quad (3)$$

$$\text{Supply} + \text{Import} = \text{Use} + \text{Export} \quad (4)$$

The Figure 1 shows balance of physical supply and use tables (PSUTs).

Supply matrix (V)	Import		Total supply	
Total output from supply		Export		Total use
Use matrix (U)				
Stock changes (-ΔS)				
Supply of residuals (-W_V)				
Use of residuals (W_U)				
Resources (R)				
Emissions (-B)				

Fig. 1. Balance physical supply and use tables (PSUTs) (Schmidt, Weidema, Suh 2010)

Rys. 1. Bilans przepływów fizycznych dla produkcji i wykorzystania (Schmidt, Weidema, Suh 2010)

It is important to take notice of the fact that the figure is onl in balance when the correct units of measurement of mass are used:

- Water is excluded and only dry matter weight is accounted for,
- Only oxygen contained in products is included, oxygen in emissions is always excluded.

2. MONETARY SUPPLY AND USE TABLES

For construction of SUTs, the format of the data collection platform: Supply and Use Tables MASTER 11 (Excel sheets) was provided by Schmidt and others 2010. The methodology of data mining was described by Rejman-Burzyńska, Śliwińska, and Jędrysik (2009). The scheme of the procedure used to develop the MSUTs is shown in Figure 2.

For Poland Monetary Supply and Use Tables (MSUTs) standardised at the level of 60 products/industries are created by Central Statistical Office of Poland and published five yearly. The MSUTs (2003) for Poland are available from EUROSTAT – Economy and Finance (Eurostat 2008a).

To obtain both monetary tables in basic prices, the Use Table was converted from purchase prices into basic prices. For this purpose "Basic price converter release" tool was used (Schmidt, Weidema, Suh 2010).

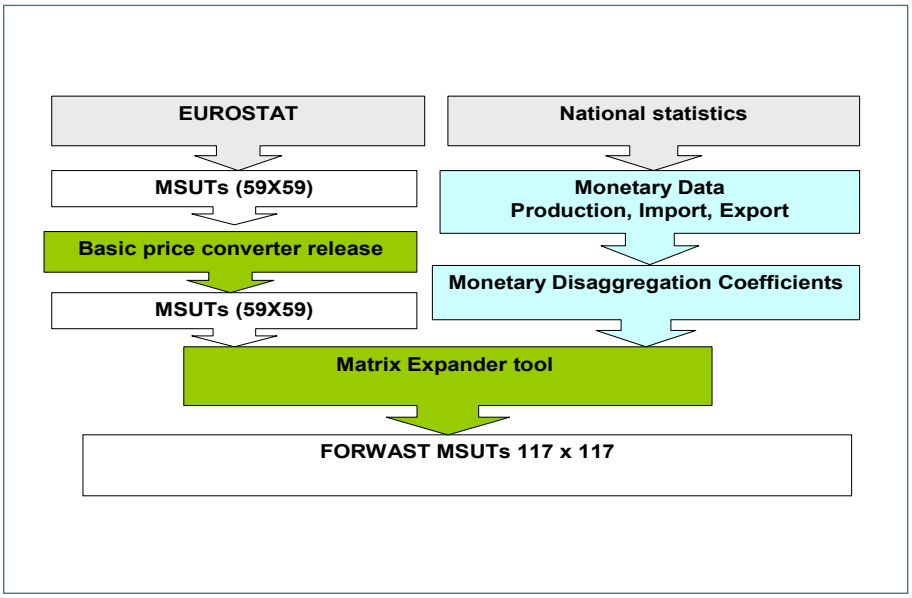

Fig. 2. Construction of Monetary Supply and Use Tables

Rys. 2. Konstrukcja tablic międzygałęziowych przepływów pieniężnych dla produkcji i wykorzystania

For confidentiality reasons Statistics of Poland has merged some products and activities. Industries and products with numbers 11–14: exploration of crude petroleum and natural gas, mining of uranium and thorium ores, mining of metals ores and other mining and quarrying, were added up and the sum was shown for industry and product number 13 – metal ores. The services such as: water transport 61 and air transport 62 were also added up, and the result is placed at service and product 62. For all industries mentioned above the monetary flows have been estimated using physical data and prices.

To obtain MSUTs for FORWAST 117 × 117 categories of activities and products (defined by Daxbeck and others 2008b), the monetary flows and disaggregation coefficients have been determined. The categories of products and activities as well as sources of data for compilation of SUTs for Poland are specified in Table 5.

For the most cases the monetary data, available from national statistics or EUROSTAT (PRODCOM 2007) were used. In some cases the monetary flows have been estimated basing on physical data and prices. The processing of collected data included usually aggregation of data for Supply, Import, Export intra EU-27 and extra EU-27. Use was calculated from balance (Use = Supply + Import – Export).

The processing of monetary data for each category of products for monetary matrices: Supply (V) including Import intra EU-27 and extra EU-27 and Use (U_O),

Export intra EU-27 and extra EU-27 has been described in details by Rejman-Burzyńska and others (2010a).

For the generation MSUTs (117 × 117) Matrix Expander tool (Schmidt, Weidema, Suh 2010) has been applied. Inputs were MSUTs (59 × 59) and estimated disaggregation coefficients.

Table 5. The categories of products/activities and data sources for Poland (2003)

FORWAST code	Products/Industries (CPA/NACE code)	Data sources
01–06	Products of Agriculture, hunting and related service activities **(01)** *01.Bovine meat and milk* *02. Pigs* *03. Poultry and animals n.e.c.* *04. Grain crops* *05. Crops n.e.c* *06. Agriculture services*	**SUPPLY, USE:** GUS 2004a, GUS 2007a, GUS 2007d, GUS 2005a 2005, GUS 2007c. **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b, GUS 2007b
07–08	Products of forestry, logging and related service activities **(02)** *07. Forest products* *08. Recycling of waste wood*	**SUPPLY, USE**: GUS 2005b **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
09	Fish and other fishing products; services incidental of fishing **(05)**	**SUPPLY, USE**: GUS 2004a **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b, GUS 2007b
10	Coal and lignite; peat **(10)**	**SUPPLY, USE:** GUS 2003, GUS 2004c **EXPORT AND IMPORT (intra EU-27 and extra EU-27):** GUS 2004b
11	Crude petroleum and natural gas; services incidental to oil and gas extraction excluding surveying **(11)**	**SUPPLY, USE:** GUS 2004c **EXPORT AND IMPORT (intra EU-27 and extra EU-27):** GUS 2004b
12–15	Metal ores **(13)** *12. Iron ores from mine* *13. Bauxite from mine* *14. Copper from mine* *15. Metals from mine n.e.c.*	**SUPPLY, USE:** PAN 2004, PGI 2008, PAN 2006, KGHM 2003 **EXPORT AND IMPORT (intra EU-27 and extra EU-27):** PAN 2006
16–18	Other mining and quarrying products **(14)** *16. Sand, gravel and stone from quarry* *17. Clay and soil from quarry* *18. Minerals from mine n.e.c.*	**SUPPLY, USE**: Eurostat MSUTs 2003, PAN 2004, PGI 2008, USGS 2003, GUS 2003 2004, GUS 2004b **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b, PAN 2006
19–27	Food products and beverages **(15)** *19. Meat and fish products* *20. Dairy products* *21. Fruits and vegetables, processed* *22. Vegetable and animal oils and fats* *23. Flour* *24. Sugar* *25. Animal feeds* *26. Food preparations n.e.c.* *27. Beverages*	**SUPPLY, USE**: GUS 2003, GUS 2007b, PRODCOM 2007 **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b, GUS 2007b
28	Tobacco products **(16)**	**SUPPLY, USE**: GUS 2004a. **EXPORT AND IMPORT (intra EU-27 and extra EU-27:** GUS 2004b
29	Textiles**(17)**	**SUPPLY, USE**: GUS 2003, EUROSTAT 2008b **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
30	Wearing apparel; furs **(18)**	**SUPPLY, USE**: GUS 2003, EUROSTAT 2008b **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b

31	Leather and leather products **(19)**	**SUPPLY, USE**: GUS 2003, EUROSTAT 2008b **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
32	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials **(20)**	**SUPPLY, USE**: GUS 2005b **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
33–35	Pulp, paper and paper products **(21)** *33. Pulp, virgin* *34. Recycling of waste paper* *35. Paper and paper products*	**SUPPLY, USE**: CEPI 2003, UN 2003, GUS 2004b **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
36	Printed matter and recorded media **(22)**	**SUPPLY, USE**: UN 2003 **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: **GUS 2004b**
37–38	Coke, refined petroleum products and nuclear fuels **(23)** *37. Coke, refined petroleum products* *38. Recycling of waste oil*	**SUPPLY, USE:** GUS 2004c, GUS 2004d **EXPORT AND IMPORT (intra EU-27 and extra EU-27):** GUS 2004b
39–43	Chemicals, chemical products and man-made fibres **(24)** *39. Fertiliser, N* *40. Fertiliser, other than N* *41. Plastics basic, virgin* *42. Recycling of plastics basic* *43. Chemicals, n.e.c.*	**SUPPLY, USE**: GUS 2003, NPWM 2002, NPWM 2006 **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
44	Rubber and plastic products **(25)**	**SUPPLY, USE**: GUS 2003 **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
45–52	Other non-metallic mineral products **(26)** *45. Glass, mineral wool and ceramic goods, virgin* *46. Recycling of glass, mineral wool and ceramic goods* *47. Cement, virgin* *48. Recycling of cement* *49. Concrete, asphalt and other mineral products, virgin* *50. Recycling of concrete, asphalt and other mineral products* *51. Bricks* *52. Recycling of bricks*	**SUPPLY, USE**: GUS 2003, GUS 2004b, GUS 2004d **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
53–64	Basic metals **(27)** *53. Iron basic, virgin* *54. Recycling of iron basic* *55. Aluminium basic, virgin* *56. Recycling of aluminium basic* *57. Copper basic, virgin* *58. Recycling of copper, basic* *59. Metals basic, n.e.c., virgin* *60. Recycling of metals basic, n.e.c.* *61. Iron, after first processing* *62. Aluminium, after first processing* *63. Copper, after first processing* *64. Metals n.e.c., after first processing*	**SUPPLY, USE**: GUS 2003, PAN 2004, HIPH 2003, GUS 2004d, GUS 2003, GUS 2004b, BGS 2007, USGS 2003, Metal Trade 2003, GUS 2004d **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
65	Fabricated metal products, except machinery and equipment **(28)**	**SUPPLY, USE**: GUS 2003 **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
66	Machinery and equipment n.e.c. **(29)**	**SUPPLY, USE**: GUS 2003 **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
67	Office machinery and computers **(30)**	**SUPPLY, USE**: GUS 2004a, GUS 2003 **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b

68	Electrical machinery and apparatus n.e.c. **(31)**	**SUPPLY, USE**: GUS 2003 **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
69	Radio, television and communication equipment and apparatus **(32)**	**SUPPLY, USE**: GUS 2003, UN 2003 **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
70	Medical, precision and optical instruments, watches and clocks **(33)**	**SUPPLY, USE:** GUS 2003, UN 2003 **EXPORT AND IMPORT (intra EU-27 and extra EU-27):** GUS 2004b
71	Motor vehicles, trailers and semi-trailers **(34)**	No physical flow included
72	Other transport equipment **(35)**	**SUPPLY, USE, EXPORT AND IMPORT (intra EU-27 and extra EU-27):** GUS 2003, GUS 2004b
73	Furniture; other manufactured goods n.e.c. **(36)**	**SUPPLY, USE**: GUS 2003 **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b
74	Secondary raw materials **(37)**	No physical flow
75–76	Electrical energy, gas, steam and hot water **(40)** *75. Electricity, steam and hot water* *76. Gas*	**SUPPLY, USE**: GUS 2003, GUS 2004c **EXPORT AND IMPORT (intra EU-27 and extra EU-27)**: GUS 2004b, GUS 2004c
77–117	Services **(41, 45, 50, 55, 60–67, 70–75, 80, 85, 90–95)**	No physical flows

A numerical example of two selected products/activities: *crude petroleum and natural gas,* and *refined petroleum products and fuels included* in MSUTs – Poland (2003) are shown in Tables 6 (Supply matrix) and Table 7 (Use matrix). Other activities are aggregated into three groups: industries 1–10, industries 12–36 and activities (industries and services) 38–117 (see Table 5).

Table 6 presents domestic production and imports and describes economic flows for the supply from industries. Total supply, **q** is total value of products (e.g. *crude petroleum and natural gas,* and *refined petroleum products and fuels)* supplied by industries and import and **g** is total value of products supplied from industries (e.g. *crude petroleum and natural gas,* and *refined petroleum products and fuels)* by products.

Table 7 describes economic flows for the use of products (e.g. *crude petroleum and natural gas,* and *refined petroleum products and fuels)* by industries and services (i.e. intermediate consumption), final consumption (i.e. mainly household consumption), gross capital formation (i.e. investments) and export. The value of **q** is total value of products (e.g. *crude petroleum and natural gas,* and *refined petroleum products and fuels)* used by industries and services as well as by final demand categories (final consumption, capital formation and export). The value of **g** is total input by industries, i.e. the sum of intermediate inputs of products from industries and primary inputs. Primary inputs include the value added (labour and profit) and the use of fixed capital by industries.

The corresponding physical matrices: PSUTs, resources matrix and emissions matrix are provided respectively in Tables 8 –10.

3. PHYSICAL SUPPLY AND USE TABLES FOR POLAND

Physical Supply and Use Tables (PSUTs) for Poland have never been produced before. For creation of PSUTs in FORWAST format 117 × 117 categories

activities/products, Supply and Use Tables MASTER 11 (Excel sheets), elaborated by Schmidt and others 2010, was applied. The methodology of data mining and tools used for construction of PSUTs were described by Rejman-Burzyńska, Śliwińska, and Jędrysik (2009). The procedure used to develop the PSUTs for Poland is shown in Figure 3.

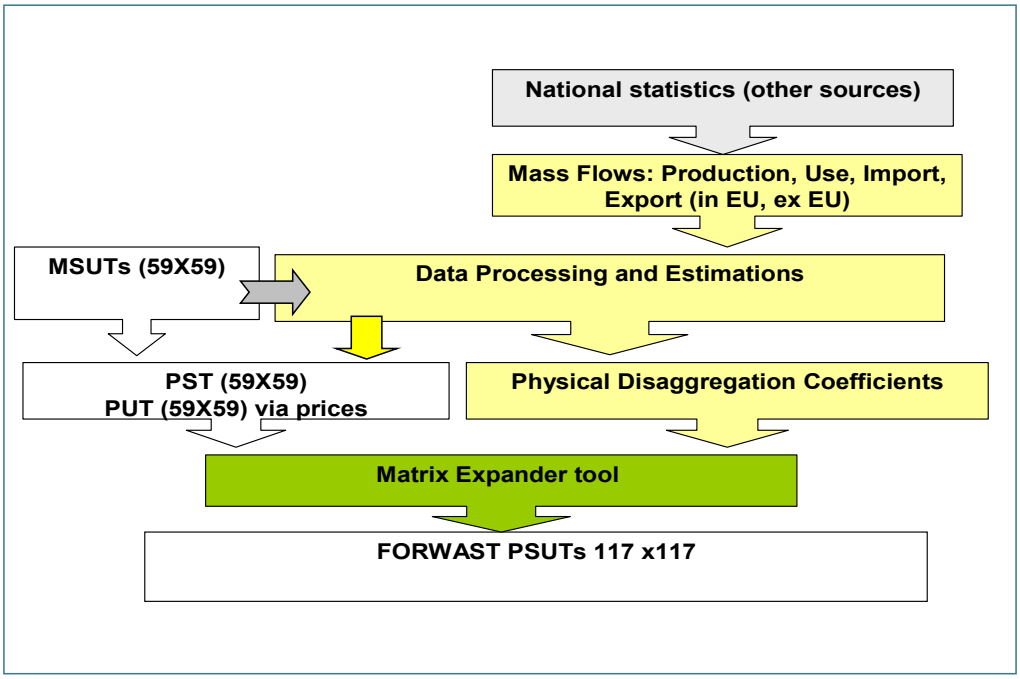

Fig. 3. Construction of Physical Supply and Use Tables

Rys. 3. Konstrukcja tablic międzygałęziowych przepływów fizycznych dla produkcji i wykorzystania

For the construction of PSUTs in format 59 × 59 for Poland, the quantity (mass) of the products related to given category was determined on the basis of statistical data. In most cases it was done directly from the basic physical data available from production and trade statistics or indirectly by estimation from available data e.g. monetary data and price information. Distribution of mass flows into industry activities in PSUTs was proportionally with the relevant monetary values in MSUTs and was delivered from monetary values and price.

For elaboration of PSUTs in FORWAST format 117 × 117, the mass flows and disaggregation coefficients (from 59 × 59 to 117 × 117) have been determined. For the generation PSUTs (117 × 117) Matrix Expander tool (elaborated by Schmidt and others 2010) has been used.

Table 6. Monetary Supply Table – Poland 2003 (million PLN)

	Activity No.	1–10	11	12–36	37	38–117	1–117			
Product No.	Activities / Products	Activities 1–10	Crude petroleum and natural gas	Activities 12–36	Refined petroleum products and fuels	Activities 38–117	Total	Import Intra EU	Import Extra EU	Total Supply (q)
1–10	Products 1–10	93819,41	5,64	477,46	0,05	429,77	94732,33	3810,18	2868,90	101411,41
11	Crude petroleum and natural gas	10,26	978,45	1,83	0,03	1244,61	2235,18	283,97	18221,76	20740,92
12–36	Products 12–36	1393,66	0,86	173043,37	2,94	20519,09	194959,92	28299,04	15334,54	238593,50
37	Refined petroleum products and fuels	0,29	0,00	0,00	20550,01	443,41	20993,71	1582,28	3876,74	26452,73
38–117	Products 38–117	2275,40	1876,44	13589,19	4201,40	1309025,68	1330968,11	151447,51	69772,22	1552187,84
	Total Output from Supply (g)	97499,02	2861,39	187111,85	24754,42	1331662,56				

Table 7. Monetary Use Table – Poland 2003 (million PLN)

	Activity No.	1–10	11	12–36	37	38–117	1–117					
Product No.	Activities / Products	Activities 1–10	11.Crude petroleum and natural gas	Activities 12–36	37. Refined petroleum products and fuels	Activities 38–117	Total intermediate consumption of products	Final consumption	Gross Capital Formation	Export Intra EU	Export Extra EU	Total Use (q)
1–10	Products 1–10	15698,29	8,77	29613,40	1630,89	14296,61	61247,96	35510,44	–1225,01	4113,61	1764,39	101411,41
11	Crude petroleum and natural gas	50,54	63,94	105,96	9886,68	9864,30	19971,42	124,38	277,09	220,82	147,21	20740,92
12–36	Products 12–36	6799,00	19,91	41417,45	2633,06	46877,83	97747,25	96306,87	2030,19	31496,39	10827,96	238408,66
37	Refined petroleum products and fuels	1819,23	37,63	828,04	648,02	14592,16	17925,08	6235,62	162,23	1301,47	828,33	26452,73
38–117	Products 38–117	25482,34	1209,19	59495,67	5349,99	570880,94	662418,13	530455,55	151184,76	145503,19	62100,53	1551662,17
	Total intermediate consumption by activity	49849,41	1339,44	131460,52	20148,65	656511,82						
	Compensation of employees	17206,40	820,55	26971,06	1055,88	275568,72						
	Other net taxes	4260,02	181,67	7032,12	812,30	41729,09						
	Consumption of fixed capital	0,00	0,00	0,00	0,00	0,00						
	Net operating surplus	26183,20	519,73	21648,15	2737,60	357852,93						
	Total value added	47649,62	1521,95	55651,33	4605,77	675150,74						
	Total output from use table (g)	97499,02	2861,39	187111,85	24754,42	1331662,56						

Table 8. Physical Supply Table – Poland 2003 (Gg)

	Activity No.	1–10	11	12–36	37	38–117	1–117			
Product No.	Activities / Products	Activities 1–10	Crude petroleum and natural gas	Activities 12–36	Refined petroleum products and fuels	Activities 38–117	Total	Import Intra EU	Import Extra EU	Total Supply (q)
1–10	Products 1–10	181528,16	0,00	343,96	0,00	24,79	181896,91	662,25	2316,06	184875,22
11	Crude petroleum and natural gas	0,00	4605,29	0,00	0,00	0,00	4605,29	486,51	23240,49	28332,29
12–36	Products 12–36	501,13	36,28	158706,86	0,42	2340,60	161585,29	5521,21	13460,74	180567,24
37	Refined petroleum products and fuels	0,00	0,00	0,00	26519,11	398,51	26917,62	2349,16	1679,84	30946,62
38–117	Products 38–117	354,32	0,00	498,66	1734,62	108557,14	111144,74	13870,74	11736,80	136752,28
	Total Output from Supply (g)	182383,61	4641,56	159549,48	28254,15	111321,04	486149,85	22889,88	52433,93	561473,65

Table 9. Physical Use Table – Poland 2003 (Gg)

	Activity No.	1–10	11	12–36	37	38–117	1–117					
Product No.	Activities / Products	Activities 1–10	11.Crude petroleum and natural gas	Activities 12–36	37. Refined petroleum products and fuels	Activities 38–117	Total intermediate consumption of products	Final consumption	Gross Capital Formation	Export Intra EU	Export Extra EU	Total Use (q)
1–10	Products 1–10	17884,07	0,39	27204,99	11461,77	99206,33	155757,56	13792,87	–875,96	13916,14	2303,66	184894,27
11	Crude petroleum and natural gas	0,00	0,00	0,00	24209,66	3930,00	28139,66	0,00	0,00	193,00	0,00	28332,66
12–36	Products 12–36	1954,31	50,02	18006,24	9,37	141636,17	161656,10	11009,21	921,94	5069,17	2057,50	168782,77
37	Refined petroleum products and fuels	2155,90	0,00	707,64	2362,47	18669,14	23895,15	0,00	30,90	5713,96	1497,04	31106,15
38–117	Products 38–117	1989,56	25,80	6246,22	277,07	91791,31	100329,97	13135,78	1609,77	12889,52	8685,47	121904,95
	Total intermediate consumption by activity	23983,84	76,21	52165,09	38320,34	355232,96	469778,43	37937,85	1686,66	37781,79	14543,67	535020,80
	Total value added	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	Total output from use table	23983,84	76,21	52165,09	38320,34	355232,96	469778,43	37937,85	1686,66	37781,79	14543,67	535020,80

The categories of products and activities as well as data sources for compilation of PSUTs for Poland are specified in Table 5. The collection and processing of physical data for each category of products for physical matrices: Supply including Import intra EU-27 and extra EU-27 and Use, Export intra EU-27 and extra EU-27 have been described by Rejman-Burzyńska and others (2010a).

A numerical example of PSUTs corresponding to MSUTs, for two selected products/activities: *crude petroleum and natural gas,* and *refined petroleum products and fuels* is shown in Tables 8 and 9. Table 8 presents domestic production and imports and describes mass flows for the supply from industries. Table 9 describes mass flows for the use of products (e.g. *crude petroleum and natural gas,* and *refined petroleum products and fuels)* by industries and services (i.e. intermediate consumption), final consumption (i.e. mainly household consumption), gross capital formation (i.e. investments) and export. The statistical data (mass of products) are provided in wet weight. They were transformed for PSUTs into dry weight according to water content in individual products (Hafner 2010).

Total supply, **q** is total mass value of products (e.g. *crude petroleum and natural gas,* and *refined petroleum products and fuels)* supplied by industries and import and **g** is total mass value of products supplied from industries (e.g. *crude petroleum and natural gas,* and *refined petroleum products and fuels)* by products. For each product (rows) total supply (**q**) is balanced with total use (**q**). The mass balance for each activity (columns) requires addition of mass flows of resource inputs, generated residuals, emissions, and stock changes.

4. RESOURCES MATRIX

Matrix of Resources (R) includes input of resources and was defined in Supply and Use Tables Master 11 (Schmidt, Weidema, Suh 2010; Daxbeck and others 2008b). The Matrix (R) operates with 13 different materials which sum up to the total mass of the resources:

1. Aluminium
2. Fibre carbon
3. Food carbon, including tobacco
4. Coal carbon
5. Crude oil and natural gas carbon
6. Carbonate carbon
7. Copper
8. Iron
9. Metals, n.e.c.
10. Minerals and other balancing element, n.e.c., including nitrogen and hydrogen
11. Oxygen in oxidized products
12. Clay and soil
13. Sand, gravel and stone

The matrix was created basing on national resource statistics. The statistical data are provided in wet weight. Therefore they were transformed into dry weight. The water content was specified in product material composition matrix (Hafner and others 2010). Determination of mass flows and composition of resources for matrix Resources have been described by Rejman-Burzyńska and others (2010a).

An example of description of input of resources, which are extracted from environment, in matrix (R) for *crude petroleum and natural gas* is shown in Figure 10. *Refined petroleum products and fuels* are not resources, thus they are not included in this matrix.

Table 10. Matrix of Resources – Crude petroleum and natural gas, Poland (2003)

Material No.	Material	Crude petroleum and natural gas	Refined petroleum products and fuels
1	Aluminium		
2	Fibre carbon		
3	Food carbon, (including tobacco)		
4	Coal carbon		
5	Crude oil and natural gas carbon	3799,05	
6	Carbonate carbon		
7	Copper		
8	Iron		
9	Metals, n.e.c.		
10	Minerals, n.e.c. (including nitrogen)	775,35	
11	Oxygen (only in products, but not in H_2O)	30,6	
12	Clay and soil		
13	Sand, gravel and stone		
14	Total material (T)	4605	

5. EMISSIONS MATRIX

The starting point for elaboration of matrix B was the review and collection of data presenting results of national emission inventory of greenhouse gases (GHGs) in Poland in year 2003. The sources of data (2003) were: National Inventory Report

(NIR 2005) and National Inventory Report under *European Monitoring and Evaluation Programme* (EMEP 2005). The national inventory and accompanying tables of Common Reporting Format (CRF), have been prepared in accordance with the UN FCCC Reporting Guidelines on Annual Inventories.

To create the matrix B, and in the next step matrices G, the calculations of emissions for 117 activities have been done using, for this purpose prepared, own Excel sheet. The input data were: statistical data related to consumption of fuels (solid, liquid and gaseous) by activities, pollutant specific emission factors as well as emissions to air from industrial processes (NIR 2005). The classification of categories of activities: SNAPs and NFR (UNFCCC) used in inventory reports: NIR 2005 and EMEP 2005 are different from NACE activities as well as categories defined in FORWAST format 117 × 117 and emissions have to be split into several activities. For transformation of data available in inventory reports into FORWAST activities 117 × 117, the converters "SNAP to FORWAST" and "UNFCCC (CRF) to SNAP to NACE" scheme, described by Daxbeck and others (2010a), were applied. Distribution of emissions related to given category of fuels was done according to physical data in Use matrix. For determination of human respiratory emissions as well as animals respiratory emissions Excel sheet "DM and C-balances" provided by **(**Schmidt, Weidema, Suh 2010) was used.

The emissions included in the matrix B for Poland cover the following pollutants: ammonia, carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), dinitrogen monoxide (N_2O), nitrogen dioxide (NO_2), NMVOC, PAH, particles (< 10 um), sulphur dioxide (SO_2) and heavy metals: arsenic, cadmium, chromium, lead, mercury, nickel and zinc.

Table 11 presents Emissions matrix (B) describing for example emissions from two industries: *crude petroleum and natural gas* and *refined petroleum products and fuels*.

Table 11. Emissions Matrix (B) – crude petroleum and natural gas; refined petroleum products and fuel, Poland (2003)

Compartment	Emission No.	Emission	11. Crude petroleum and natural gas	37. Refined petroleum products and fuels
Air	1	Ammonia	0	0
Air	2	Arsenic	0	0,000808
Air	3	Cadmium	0	0,000808
Air	4	Carbon dioxide, fibre carbon	0	0
Air	5	Carbon dioxide, food carbon	0	2,346571
Air	6	Carbon dioxide, coal carbon	0	0,9
Air	7	Carbon dioxide, crude oil and natural gas carbon	211,18	5190,6
Air	8	Carbon dioxide, carbonate	0	0
Air	9	Carbon monoxide	0	1,317043
Air	10	Chromium	0	0,000978
Air	11	Copper	0	0,002291
Air	12	Dinitrogen monoxide	0	0,067
Air	13	Hydrogen chloride	0	0
Air	14	Hydrogen fluoride	0	0

Air	15	Lead	0	0,001032
Air	16	Mercury	0	8,12E-08
Air	17	Methane	16,543	0,213
Air	18	Nickel	0	0,022006
Air	19	Nitric acid	0	0
Air	20	Nitrogen dioxide	0	7,884674
Air	21	NMVOC	0,0765	0,305311
Air	22	ODP	0	0
Air	23	PAH, measured as Benzo(a)pyrene	0	0,000928
Air	24	Particulates, < 10 um	0	1,062777
Air	25	Phosphorus	0	0
Air	26	Selenium	0	0
Air	27	Sulfur dioxide	0	4,941388
Air	28	Vanadium	0	0
Air	29	Zinc	0	0,000815
		Total	74,21405	1421,15

6. DATA VALIDATION

In the process of development of Supply and Use Tables for Poland, the validation process was carried on two levels: creation of MPSUTs and correction of consistency PSUTs.

On the first level, the validation procedure comprised examination of collected statistical data and estimated data for creation of PSUTs in format 59 × 59 as well as data (monetary and physical) for disaggregation the Eurostat MSUTs (59 × 59) into MPSUTs in FORWAST format 117 × 117. The processing of data involved the determination of monetary and physical disaggregation coefficients and carrying out disaggregation of products/activities.

Three main steps (checks) of validation process can be distinguished. The first check was to control if the data monetary and physical available in national statistics refer to the given category of products according to classification industries NACE/products CPA and definitions of FORWAST system described by Daxbeck and others (2008a). At this stage the ways of data processing: aggregation and/or disaggregation of statistical data, or own estimation of required data (e.g. mass data, conversion factors and prices) were established. Simultaneously, the level of harmonisation of Polish classification with NACE has been checked.

The second check was targeted to know whether the collected data cover the whole considered category of products and to identify the under – or over-estimations. The data were then compared with related data from other sources and, next integrated. In the case of monetary data for Poland it was done usually by comparison of monetary values obtained from national statistics to monetary values of supply, export and import in Eurostat MSUTs. Physical data from national statistics were compared with related data from international sources (e.g. EUROSTAT or UN Production Statistics) or to results of estimation of these data from monetary data and price information. In the case if it was impossible the rough check was done and

examined data were compared to the relevant data available for other countries with the same population level and GDP.

In the third check the rough balances of supply and use flows, for products/activities from the same tree such as: forestry products (2), wood products (20), pulp and paper (21) and furniture (37); crude petroleum and natural gas (11) and coke, refined products, have been done and analyzed. The examination of these balances allowed to find quickly hard errors and to make necessary corrections. The balances were done for data in PSUTs in format as well as in PSUTs in format 117 × 117 after disaggregation process.

On the second level the validation procedure was targeted to identify inconsistency in SUTs MASTER 117 × 117 and to adjust data for obtaining the required level of consistency. On this level the validation involved the series of balance checks: for monetary SUT products, monetary SUT activities, physical SUT products and physical SUT activities.

7. DATA AVAILABILITY

The availability of statistical data differed from one matrix to another. The statistics provided necessary data related to production of the most of products, but for uses of products by different activities in the economy, data availability and quality are generally poor.

The availability and quality of physical data as well as data processing related to supply, use, import and export, varied significantly between categories of products/industry. There are categories of products/industry where statistics was able to provide the sufficient mass data and data processing comprises only aggregation and/or disaggregation of data (e.g. energy resources and fuels). In many cases statistical data are indicated in different units from mass units and only rough estimation of mass could be done (e.g. 31–35 electrical machinery; radio and TV; medical, optical and precision instruments; motor vehicles; other transport equipment). Mass of some heterogeneous flows of products/commodities are difficult for estimation (e.g. category of chemicals (24): in this category medicines are included, the monetary value of medicines gives 50% of total monetary flows for the category (24), but mass data are not available). Import and export data in some cases (products) are incomplete or physical data are not available (e.g. categories 17–20 textiles, wearing apparel, furs, leather, wood, furniture). The physical data for USE table were available only for energy resources and fuels: coal and lignite, peat (NACE 10), crude oil and natural gas (11) and coke, refined petroleum products (23). The use of products is therefore to some extent determined on the basis of monetary use (as obtained from use table), which implies potentially uncertainties.

In monetary SUTs, for confidentiality reasons some products and industries have been merged (NACE 11–14, 61–62) and added up, the sum was shown for industry/product 13 and 62 respectively. Polish system of classification industries/products is not completely harmonized with NACE/CPA system what caused in some cases difficulties during data collection and processing.

The coverage of statistical data concerning air pollutant emissions were not sufficient, thus the completion of Emission matrix B, was done on the basis of emissions data obtained from national inventory submissions under the UNFCCC.

The availability of data and consistent information on mass flows of recycled materials utilised in different industries are poor. The gaps of data on recycled materials were filled by own estimations and/or assumptions on the basis of expert knowledge.

CONCLUSIONS

The aim of this paper was to provide a brief overview of the methodology for the construction of Monetary Physical Supply and Use Tables developed within FORWAST project. As a result of the work based on the methodology described in this paper, the integrated MPSUTs for Poland for year 2003 have been obtained. The compilation of these tables was a pioneering work, such tables did not exist before for Poland.

This research work was done on the basis of data obtained from national sector statistics, national emission inventory of greenhouse gases and other documents related to material flows in economy sectors. In some cases the international databases were used. The process of bringing the primary data into harmonized SUTs MASTER format required various transformation and harmonization steps, for instance dealing with confidential data, harmonizing activity and product classification, estimating mass of product from other units and conversions factors, etc.

Statistics office provides detailed data related to production, import and export, but for uses of products by different activities in the economy, data availability and quality are generally poor. The use of products is therefore to some extent determined on the basis of monetary use (as obtained from use table), which implies potentially uncertainties. After data entry into SUTs inconsistencies were detected and corrected. To achieve required level of data consistency extensive knowledge of process engineering, mass balances for technological processes used in different industrial activities were needed.

The MPSUTs demonstrate an integration of economic accounts (SUT), emissions account (national inventory submissions under the UNFCCC), and various sector specific production and use accounts. Such tables are a valuable tool for environmental-economic accounting.

ACKNOWLEDGEMENTS

This study was performed within project (Specific Targeted Research Project) entitled: Overall mapping of physical flows and stocks of resources to forecast waste quantities in Europe and identify life-cycle environmental stakes of waste prevention and recycling – FORWAST. The project was co-funded by the European Commission 6th Framework Program (contract number: 0044409). The project duration was from March 2007 to December 2009. Project homepage: http://forwast.brgm.fr/.

ABBREVIATIONS

CPA	Classification of Products by Activity
CFR	Common Reporting Format
EMEP	European Monitoring and Evaluation Programme
ESA	European System of Accounts
EUROSTAT	European Union Statistics
GHGs	Greenhouse gases
IOT	Input – Output Table
LCA	Life Cycle Analysis
MFA	Material Flow Analysis
MSUTs	Monetary Supply and Use Tables
NACE	Statistical Classification of Economic Activities
NFR	Nomenclature for Reporting
NIR	National Inventory Report
PSUTs	Physical Supply and Use Tables
SNAP	Standardized nomenclature for Air Pollutants
SUTs	Supply and Use Tables
UNFCCC	United Nations Framework Convention on Climate Changes
UN	United Nations Production Statistics (Database)

References

1. BGS (2007): British Geological Survey; European Mineral Statistics 2001–2005; Nottingham: http://www.mineralsuk.com/britmin/ems.pdf.
2. CEPI (2003): European Pulp and Paper Industry, Annual Statistics.
3. Daxbeck H., Brandt B., Buschmann H. & Neumayer S. (2008a): Definition of the system and first estimates of transfer coefficients as well as emission factors and conversion factors, FORWAST Deliverable no 2–2, RMA.
4. Daxbeck H., Buschmann H., Brandt B., Neumayer S. (2008b): Data collection guidelines and forms for WP3 and WP4, FORWAST Deliverable no 2–4, RMA.
5. Hafner G., Escalante N., Daxbeck H., Buschmann H., Brandt B. (2010): Data Processing and Validation for Austria, Denmark, France and Germany, FORWAST Deliverable no 3–1, RMA.
6. EMEP (2005): Inventory of emissons to air SO_2, NO_2, CO, dust, heavy metals, NMVOCs and POPs in Poland for year 2003 (Inwentaryzacja emisji do powietrza SO_2, NO_2, CO, pyłów, metali ciężkich, NMLZO i TZO w Polsce za rok 2003). National Emission Centre (Krajowe Centrum Inwentaryzacji Emisji), Warsaw 2005.
7. EUROSTAT (2008a): EUROSTAT ESA 95 Supply, Use and Input-Output Tables: http://epp.eurostat.ec.europa.eu/portal/page?_pageid=2474,54156821,2474_54764840&_dad=portal&_schema=PORTAL (Accessed January 2008).
8. EUROSTAT (2008b): Eurostat: Textiles, clothing, leather and footwear (publication) (accessed May 2008).
9. GUS (2003): Production of Industry for years 2003–2005 (Produkcja wyrobów przemysłowych Archiwum 2003-2005): http://www.stat.gov.pl/gus/45_1076_PLK_HTML.htm.
10. GUS (2004a): Rocznik statystyczny Polski (Statistical Yearbook of Poland 2003). Warszawa, GUS.
11. GUS (2004b): Turnover by Main Commodities January – December 2003 (Obroty towarowe handlu zagranicznego styczeń - grudzień 2003 r.), Central Statistical Office,

Warszawa, GUS: http://www.stat.gov.pl/gus/45_975_PLK_HTML.htm?action=show_archive.
12. GUS (2004c): Fuels and Energy Statistics 2002, 2003 (Gospodarka paliwo-energetyczna w latach 2002, 2003), Central Statistical Office. Warszawa, GUS.
13. GUS (2004d): Materials Management 2003 (Gospodarka Materiałowa 2003), Central Statistical Office. Warszawa, GUS.
14. GUS (2004e): Environment 2004 (Ochrona środowiska), Central Statistical Office. Warszawa, GUS.
15. GUS (2005a): Means of production in agriculture (Środki produkcji w rolnictwie w 2004 r.), Central Statistical Office. Warszawa, GUS.
16. GUS (2005b): Forestry 2005 (Leśnictwo 2005), Central Statistical Office. Warszawa, GUS.
17. GUS (2007a): Statistical Yearbook of Agriculture and Rural Areas 2007 (Rocznik statystyczny rolnictwa i obszarów wiejskich 2007), Central Statistical Office. Warszawa, GUS.
18. GUS (2007b): Production and foreign trade of agricultural products in 2006 (Produkcja i handel zagraniczny produktami rolnymi w 2006 r.), Central Statistical Office. Warszawa, GUS.
19. GUS (2007c): Land use, sown area and livestock in 2007 (Użytkowanie gruntów, powierzchnia zasiewów i pogłowie zwierząt gospodarskich w 2007 r.), Central Statistical Office. Warszawa, GUS.
20. GUS (2007d): Livestock (Zwierzęta gospodarskie), Central Statistical Office. Warszawa, GUS.
21. HIPH (2003): The Polish Steel Industry (Polski Przemysł Stalowy), The Metallurgical Chamber of Industry and Commerce (Hutnicza Izba Przemysłowo Handlowa:http://www.hiph.com.pl/ANALIZY_RAPORTY/pliki/pps2003.pdf (Accessed: November 2009)
22. Hoekstra R., Bergh J.(2005): Constructing physical input-output tables for environmental modeling and accounting: Framework and illustrations:http://www.aseanenvironment. info/Abstract/41014939.pdf (Accessed March 2010).
23. KGHM (2008): KGHM Company: http://www.kghm.pl/.
24. MT (2003): Metal Trade.
25. NPWM (2002): Program of Waste Management: National Program of Waste Management (Krajowy Plan Gospodarki Odpadami), Ministry of Environment, Warszawa, Ministerstwo Środowiska.
26. NPWM (2006): Program of Waste Management: National Program of Waste Management 2010 (Krajowy Plan Gospodarki Odpadami), Ministry of Environment, Warszawa, Ministerstwo Środowiska.
27. NIR (2005): Poland's National Inventory Report (Krajowa inwentaryzacja emisji gazów cieplarnianych i ich prekursorów), National Emission Centre. Warszawa, Krajowe Centrum Inwentaryzacji Emisji.
28. PAN (2004): Minerals Yearbook of Poland 1999–2003, Polish Academy of Sciences, Mineral and Energy Economy Research Institute, Department of Mineral Policy, Kraków, PAN.
29. PAN (2006): Bilans gospodarki surowcami mineralnymi Polski i świata 2000–2004), Ministerstwo Środowiska, PAN, Instytut Gospodarki Surowcami Mineralnymi i Energią. Kraków, PAN.
30. PIG (2008): Mineral Resources of Poland, Polish Geological Institute Department of Economical Geology: http://www.pgi.gov.pl/mineral_resources (Accessed February 2008).

31. Rejman-Burzyńska A., Śliwińska A., Jędrysik E. (2009): Data Mining in EU-27. Methodology, Final Workshop, Copenhagen, November 25: http://forwast.brgm.fr/ Documents/ Workshop/Forwast_Alina_WP4-Metodology.pdf (Accessed October 2010).
32. Rejman-Burzyńska A., Śliwińska A., Jędrysik E. and others (2010a): Report Describing Data Processing and Validation, Poland, FORWAST Deliverable no. 4-1. Katowice, GIG.
33. Rejman-Burzyńska A. (2010b): Report on needs for development of national statistics related to resources and wastes, FORWAST Deliverable no 4-3. Katowice, GIG.
34. PRODCOM (2007): EUROSTAT Industry Trade and Services, Statistics on the Production of Manufactured Goods Value Annual 2003: http://epp.eurostat.ec.europa.eu/portal/page/ portal/prodcom/data/database (Accessed November 2007).
35. Schmidt J., Weidema B., Suh S. (2010): Documentation of the final model used for the scenario analyses, FORWAST Deliverable no 6-4, 2.0 LCA Consultants.
36. UN (2003): Database: United Nations Production Statistics 1950–2004.
37. USGS (2003): U.S. Geological Survey Minerals Yearbook 2004–2003: The Mineral Industries of Central Europe Czech Republic, Hungary, Poland, and Slovakia: http://minerals.usgs.gov/minerals/pubs/country/2003/ezhupllomyb03.pdf.

Recenzent: prof. dr hab. inż. Krzysztof Stańczyk