

CARBON STORED IN MATERIALS AND PRODUCTS IN CASE OF NON-ENERGY USE OF FOSSIL FUELS: PROBLEMS AND APPROACHES TO ASSESSMENT OF RELATED CO₂ EMISSIONS

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INTRODUCTION

Current growth of manufacturing of synthetic materials and chemical products with the corresponding growth of the non-energy use of fossil fuels – coal(coke), natural gas, oil and petrochemical products -- as feedstocks changes energy balances in the majority of industrialized countries substantially. As it is likely that this tendency will be continued greater attention should be paid to inventories of non-energy use of fossil fuels in reporting national energy related CO₂ emissions. To do it accurately a number of methodological and statistical problems must be analyzed and resolved.

The NEU-CO₂ project (Non-Energy Use and CO₂ emissions), funded by the Environment and Climate ENRICH programme of the European Commission (NEU-CO₂, 2000) was launched in 1999 to study the problems and to develop efficient and reliable instruments for estimating CO₂ emissions related to the non-energy use of fossil fuels. The paper presents the results of the study of these problems for Russia as a part of the NEU-CO₂ project.

Special features of the oil and petrochemical industries in Russia important for non-energy use were described. Statistical information on different non-energy uses of fossil fuel as feedstocks for the manufacture of synthetic materials and chemical products in Russia was studied with the use of a detailed questionnaire.

Default conversion factors (carbon and calorific content, etc.) proposed in the IPCC manuals were compared with country-specific factors determined in accordance with the characteristics of particular fossil fuels and petroleum products in Russia.

Statistical definition of non-energy use in the energy balance of Russia was analyzed and compared with that one used in other countries to improve compatibility of national energy statistics and CO₂ emission estimates.

A detailed analysis of technologies and material and product structure made it possible to develop a flow material and processes diagram for petrochemical industries in Russia. Suggestions for improving a quality of statistical information on non-energy use of fossil fuels to use it as an input to a general spreadsheet model NEAT (Non-Energy use Emission Accounting Tables) (Gielen, D., Patel, M. 1999), developed and tested under the NEU-CO₂ project, can be derived from the study.

FEATURES OF THE OIL AND PETROCHEMICAL INDUSTRIES IN RUSSIA IMPORTANT FOR UNDERSTANDING NON-ENERGY USE

Russia is one of the greatest world energy producers and consumers and hence a big emitter of greenhouse gas (GHG) emissions. Russia plays a significant role in the world production of natural gas and oil, and exports of natural gas, oil and petroleum products is a major source of revenue for the national economy.

About 98% of Russia's CO₂ emission is energy related. Energy intensity of the Russian economy was 2-3 times greater than that in the USA or Western Europe at the beginning of the 1990s. During the last decade energy intensity of GDP raised up by more than 30% (RF Ministry of Fuel and Energy, 1998). For these reasons energy and fuel supply is a main purpose of production of oil and natural gas in Russia.

Non-energy use in 1996 constituted:

- ✓ only 2.7% (1078.6PJ) of the total production of primary energy, excluding losses;
- ✓ 4.3% of the total consumption of primary energy resources, in particular:
 - 2.6% of oil and petroleum products including LPG;
 - 3.5% of natural gas;
 - 0.4% of coal (IEA/OECD, 1998).

To adequately understand the non-energy use of petrochemical products in Russia, one needs to consider the production chain starting from the stabilization of crude products (NG and oil) as a first stage.

The greater part of the oil and natural gas fields are situated in the remote parts of the country far from the regions where most of the consumers are so only some preliminary treatment (stabilization, stripping, etc.) takes place close to fields. The largest refineries and petrochemical facilities are placed close to consumers.

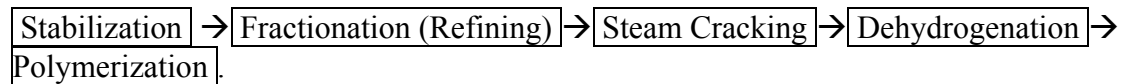
Among other important features needed for a better understanding of the non-energy use of petrochemical products and related carbon storage is the impact of the general economic crisis in Russia during the last decade when there were no investments in new technologies and products. This has resulted in an outdated product structure compared to the product structure of the petrochemical industry in Western Europe.

In contrast to the situation in European petrochemical industry NG and petroleum products (measured in energy units) play comparable roles as feedstock for chemical production, with 621,000 TJ of Natural gas and 216,000 TJ of petroleum products being used for this purpose in 1996 (IEA, 1998).

FLOW MATERIAL AND PROCESSES DIAGRAM

A detailed analysis of technologies and feedstock and product structure for petrochemical sector made it possible to develop a flow material and processes diagram (Fig. 1) for Russia. The diagram covers all the stages of oil and natural gas treatment for chemical purposes and shows output used for fuel production that is marked with a different coloring at the diagram. All the significant chemical products are shown at the diagram starting from the unstable crude oil and natural gas, basic chemicals, then intermediates and finalizing with most important polymers such as polyethylene, polypropylene, etc.

The processes showed in the diagram include:



The diagram looks complicated enough because, at some stages of the chain, products derived from natural gas and oil come through different processes and at other stages through the same processes like steam cracking, etc.

Among the significant products and processes used which are typical mainly for Russia it should be mentioned:

- WCLH – a wide cut fraction of light hydrocarbons. It is derived at many plants from natural gas, associated oil gas, stabilized oil, refineries refluxes, and includes: methane(less than 0.1%), ethane(1.1-2.4%), propane(25-39%), butane(25-40%), isobutane(13.5-16.3%), pentane(4.9-8.5%), isopentane(6.6-7.5%), hexane(0.8-10%). So the content of WCLH from particular plants varies greatly, and the share of the WCLH used as a fuel and a content of the output from steam cracking process could vary significantly too. It makes accounting of carbon stored in the products more complicated and less accurate.

- GFU is a gas fractioning process used to divide WCLH and to get a wide range of products which are used then as inputs for steam cracking and dehydrogenation (see the flow diagram).

Amounts of the products used as inputs and derived from the processes give more or less full product balance for NEAT model of the petrochemical sector in Russia.

OTHER PROBLEMS RELATED TO THE APPLICATION OF THE NEAT MODEL TO THE RUSSIAN PETROCHEMICAL SECTOR

Some other problems related to the application of the NEAT model to the Russian petrochemical industry were studied.

NEU statistics in the energy balance of Russia

There are different approaches in accounting the energy and non-energy use of feedstocks for petrochemical processes in national statistics. An analysis of the instructions for filling-in the NEU line in the energy balance of Russia and discussion of this problem with the experts from the Statistical Committee and from the industry leads us to conclusion the formula used in Russia is as follows:

$$Q_{NEU, i} = Q_{TF, i} - Q_{F, i} - Q_{E, int., i}$$

It means that all energy and fuels produced by technological process as by-products and used for combustion at the plant or sold as fuels for combustion outside basic chemical production are subtracted from the amount of feedstock used in the process.

Conversion factors of energy statistics into mass flows

To improve the accuracy of national estimates for carbon stored in products of the petrochemical industry, the default conversion factors recommended by the IPCC Guidelines should be replaced by the country specific values. So conversion factors (lower heating value, LHV) to transform data on mass flows through petrochemical industry to energy units used in NEAT model were compared with their values used in Russian energy and chemical manuals. Different values were observed for some fuels and feedstocks (see Table 1 where different LHV used in Russia are in brackets). These discrepancies could result from the different standards for fuels and products (humidity, percentage of particular substances, etc.) used in the countries. LHV for some more products used in significant amounts in Russia were added to the list (marked with +).

Product	LHV, PJ/Mt
Ethane	46,30(47,52)
Propane	45,60(46,40)
Butane	45,30(45,68)
Pentane	40,60(45,41)
Gas-, diesel-, fuel oil	43,00(41,36-42,62)
Heavy fuel oils(mazut)	42,00(39,78-41,32)
+Butylene	45,35
+Acetylene	47,77
+Kerosene	42,96
+Gasoline	43.75

Long life versus short life products division

For correct accounting of carbon stored in products they should be divided in two groups: short living and long living ones. Some products are used in both time frames so their shares should be estimated. As a result of discussion of the problem a corrected list of long and short life products and their proportions for Russia was developed (Table 2).

<i>PRODUCTS</i>	<i>Long life, %</i>	<i>Short life, %</i>
	<i>Consumption</i>	
Acetylene, Benzene, Ethylene, Methanol	50	50
Bitumen, Butadiene, Butene, Carbon black, Pitch, Acrylic acid, Acrylonitrile, Bisphenol A, Dimethylterephthalate, Styrene, Terephthalic acid TPA, Vinylchloride monomer VCM, Epoxy resin, Melamineformaldehyde resin, Phenolic resin, Polyacrylates, Polyacrylonitrile, Polyamide 6,66, Polycarbonate, Polyethylene PE, Polyethyleneterephthalate PET, Polypropylene PP, Polystyrene PS, Polyurethane PUR, Polyvinylacetate, Polyvinylchloride PVC, Saturated polyester, SBR	100	0

Lubricants, Petroleum coke, Toluene, Waxes, paraffins, Xylenes (o-, m-, p-, mixed xylene), Acetic acid, Acetone, Cumene, Cyclohexane, Cyclohexanone, Ethanol, Ethylene glycol, Ethylene oxide, Formaldehyde, I-Propanol, Phenol, Phthalic anhydride PSA, Propylene oxide, Solvents	0	100
Propylene	20	80
Aniline	80	20

CONCLUSION

Dramatic changes of ownership within the industrial sectors, of governmental administration of the national economy and the general economic crisis in Russia resulted in great gaps and fluctuations, lower accuracy and less details of production and consumption data for related to non-energy use industries. The availability and reliability of statistical information on different non-energy uses of fossil fuel as feedstocks for the manufacture of synthetic materials and chemical products in Russia was studied in view of current transition processes in the economy.

Substantial advance was gained in understanding of the non-energy use and applicability of NEAT model to petrochemical industry in Russia. Flow material and processes diagram was developed which could be used for construction and adjusting the NEAT model. Other factors and formulas were studied and corrected. All this opens an opportunity for testing the NEAT model as an instrument to analyze non-energy use in Russia at the next stage of the NEU-CO₂ project.

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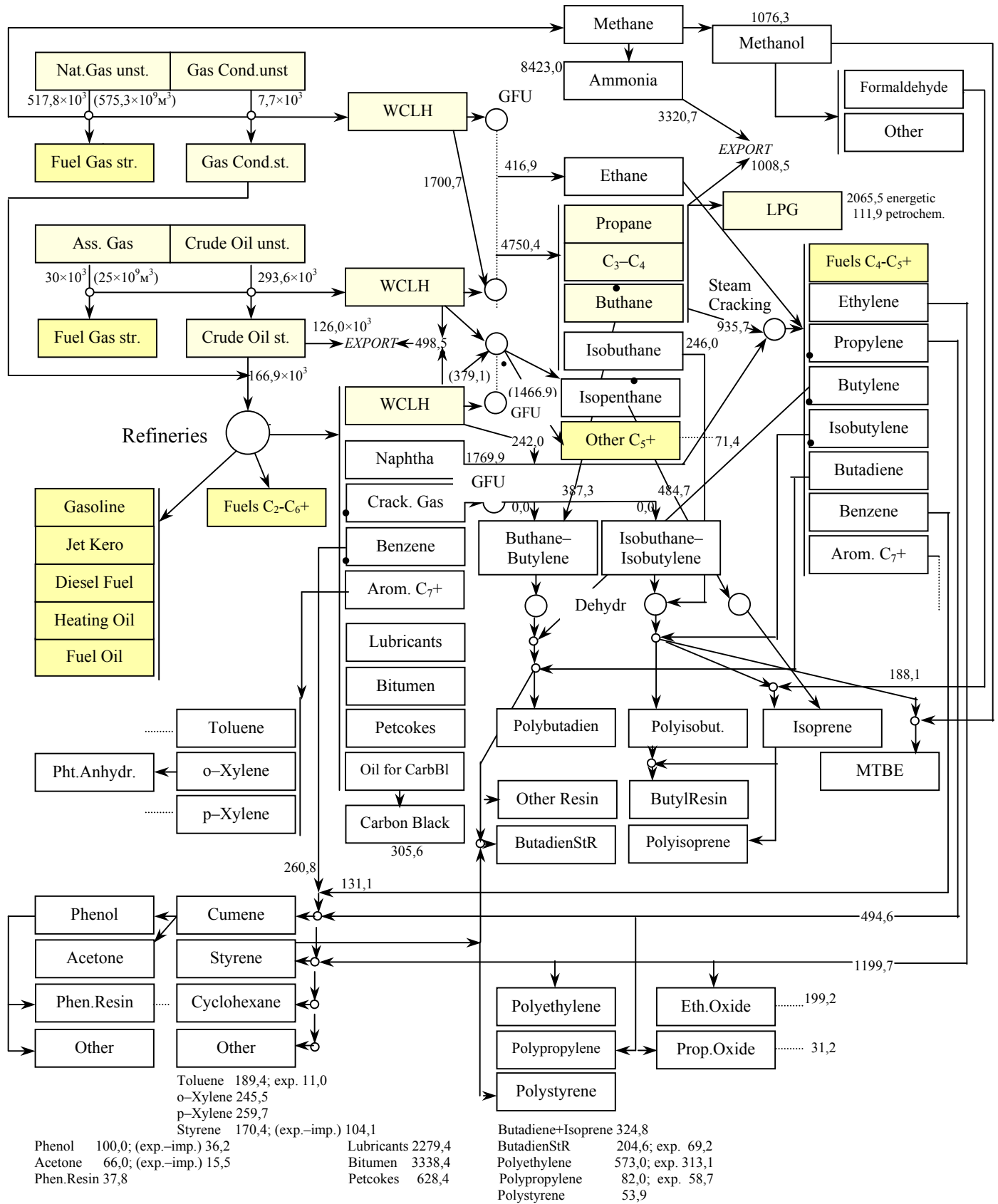
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Figure 1. Flow material and processes diagram for the year 1996



WCLH – Wide cut light hydrocarbons
 GFU – Gas fraction's unit, C – central
 LPG – liquid petroleum gas
 st – stable, unst – unstable
 str – stripped
 ass – associated
 Data for the year 1996, in thou. tonne

