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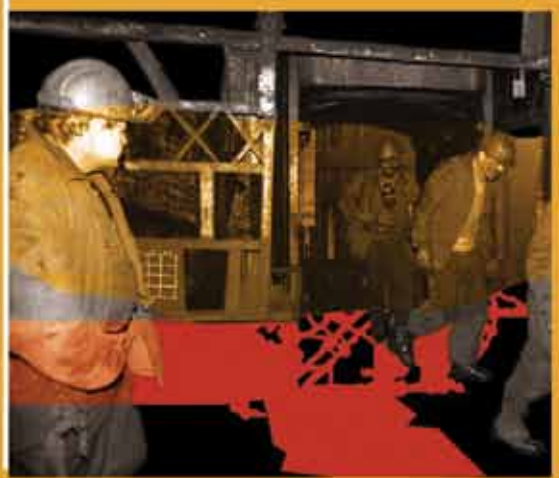
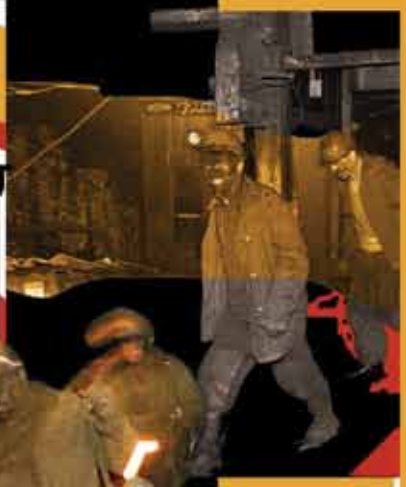
PROBLEMS OF UKRAINE'S COAL SECTOR AND GREENHOUSE GAS EMISSIONS FROM COAL MINING AND CONSUMPTION





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REPORT

PROBLEMS OF UKRAINE'S COAL SECTOR AND GREENHOUSE GAS EMISSIONS FROM COAL MINING AND CONSUMPTION

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This document has been prepared with the financial support
of the Swedish NGO Air Pollution & Climate Secretariat
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The original report is published in Ukrainian.
This translated version might differ insignificantly from the original.

REPORT

PROBLEMS OF UKRAINE'S COAL SECTOR AND GREENHOUSE GAS EMISSIONS FROM COAL MINING AND CONSUMPTION

KYIV-2010

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Abbreviations

CPP — cogeneration power plant

FEC — fuel and energy complex

FER — fuel and energy resources

GHG — greenhouse gases

HPP — heating power plant

IEA — International Energy Agency

IPCC — Intergovernmental Panel on Climate Change

Minvugleprom — Ministry of the Coal Industry of Ukraine

PPP — purchasing power parity

RES — renewable energy sources

TPES — total primary energy supply

WEC — World Energy Council

Introduction

The aim of this report is to analyze negative social, economic and environmental impacts of coal mining and combustion. Special attention is given to the problem of greenhouse gas emissions and emissions reduction policies and technologies.

Section 1 contains a general overview of Ukraine's coal industry including information about coal mining and combustion, export and import, ownership structure of coal-mining companies, and information about technical condition and accident risk at mines. Section 2 describes economic aspects of coal sector with focus on coal prime cost and price ratio, sector unprofitability and governmental backing. Section 3 outlines social and environmental problems in coal-mining areas. Section 4 provides calculations of greenhouse gas emissions caused by coal mining and combustion and indicative estimates of expected growth of these emissions due to the increase of coal share in the energy balance of Ukraine pursuant to the base scenario of the Energy Strategy by 2030. Section 5 explains the need to remove the sector financing and lists key policy approaches to reduce greenhouse gas emissions, including CO_2 emissions tax and emissions trading scheme. The report also contains recommendations for improvement of energy policy and strategic development of the coal industry. Hopefully, relevant government authorities will take our suggestions into consideration. This report might also be useful for public organizations.

First of all, we would like to thank experts for interviews and consultations, in particular, to O. M. Dudnik (Institute of Coal Energy Technologies, senior scientific specialist); V.G. Krasnik (Ministry of the Coal Industry of Ukraine, Department of Perspective Development and Coordination of Preparatory Operations, Director); O. F. Lyashenko (Council for Studies on Productive Forces of Ukraine, Fuel and Energy Complex Department, leading scientific officer); V. L. Saprykin (Razumkov Centre, Energy Program Director). However, the opinion expressed in the report may differ from the opinion of the experts.

We are very grateful to Swedish NGO Secretariat on Acid Rain for providing financial support for this report. We also would like to thank S. Puri and A. Demidenko (Coal Sector Policy Support Programme) for cooperation. Special thanks to O. Pasyuk, I. Stavchuk and Y. Urbansky for helpful comments and suggestions, and to Pip Erken who provided photos.

Summary

Problems of the Coal Sector and Suggested Solutions

One of the key problems of crisis in the coal sector is that coal prices do not cover even operational costs, let alone repair and maintenance costs and capital investment. Average prime cost of coal is significantly higher than its price, and this gap is growing. The price was equal to 80% of the prime cost in 2004 and dropped down to 75% in 2008 [11]. The IEA experts believe that coal prices are distorted due to subsidization of the coal sector, governmental interventions in fuel allocation and influence of private monopoly buyers [37].

Understated coal prices result in considerable losses that continue to grow. Since 2004, losses have grown from UAH 1,500 mn [15] to UAH 4,276.5 mn in 2008 [10]. It means that in 2008 1 ton of product brought losses of UAH 152. Ukraine's coal industry is traditionally unprofitable and requires significant financial support from the government. In 2008, coal sector received funding of UAH 7,475.68 mn. [10], which is approximately 3% of Ukraine's annual budget. However, the largest share of funding is used to cover the prime cost. In 2008, approximately 60% of all money provided to support the sector was used to offset losses.

Local people are highly dependent on the coal industry. This is particularly so for small towns and villages, where most people work at coal-mining companies. Soviet-time practice on establishment of 'mono-industry' cities and villages today creates significant social problems because with time and due to various reasons, companies are closed down and many people are left without jobs. Unfavorable social conditions, unemployment and poverty caused a high level of crime, increase of drug addition and HIV in the main coal-mining regions of Ukraine.

Coal sector causes a range of serious environmental problems, including air pollution and alteration of geological, hydrologic and hydrochemical conditions in the areas where coal-mining companies are located.

In view of the number of problems existing in Ukraine's coal sector, it obviously requires restructuring and review of the Energy Strategy in the particular sector. First of all, it is necessary to conduct an in-depth analysis of economic expediency of coal mining and increase of coal combustion. Secondly, the Energy Strategy should be revised to include the sector's environmental impact, especially its climate impact.

Energy security is of crucial importance for the independent country but decrease of the gas consumption at the expense of coal is not the best approach. First of all, energy security should be addressed through reduced energy consumption. We recommend that priority should be given to energy-saving measures and potential of renewable energy sources. This is a strategically sound solution since it minimizes negative environmental impact of the energy production and contributes to the significant saving of the budget funds.

In order to solve current problems of the coal sector, it is essential to improve its profitability, i.e., shutdown unprofitable mines and privatize commercial and promising ones; set the market price of coal and reduce its prime cost, which is a precondition for the reduction of energy subsidies, and, hence, of the national budget burden. Accident rate is another critical issue. Number of accidents and occupational injuries could be reduced by stricter compliance with safety rules and regu-

lations and installation of required safety equipment. It is also expedient to initiate widespread use of methane-catching technologies, e.g. under the joint implementation mechanism of the Kyoto Protocol. Mines where coal production would remain dangerous even with the introduction of all possible safety measures should be closed. To solve social problems and develop the former 'one company' villages and towns, it is necessary to gradually re-orient the economy of coal-mining regions.

Greenhouse Gas Emissions Caused by Coal Mining and Combustion

Ukraine is a party to the UN Framework Convention on Climate Change and the Kyoto Protocol and, therefore, has to take certain steps to cut its greenhouse gas emissions. However, the country's energy policy might result in the opposite. The Energy Strategy plans to increase the percentage of coal in the energy balance from 22% (43.5 mn tons of equivalent fuel) in 2005 to 33% (101 mn of equivalent fuel) by 2030 according to the base scenario. Coal is the most carbon-intensive fuel. Hence, its increased use will almost double greenhouse gas emissions by 2030 (to 350 mn tons of CO_2 equivalent). This growth is mainly explained by the increased combustion of coal as a fuel by power stations. In view of this, percentage of emissions from coal mining and combustion (from total amount of greenhouse gas emissions) can rise from 39% (162 mn tons) as of 2005 to 53% (346 mn tons) in 2030.

1. Overview of the Coal Sector

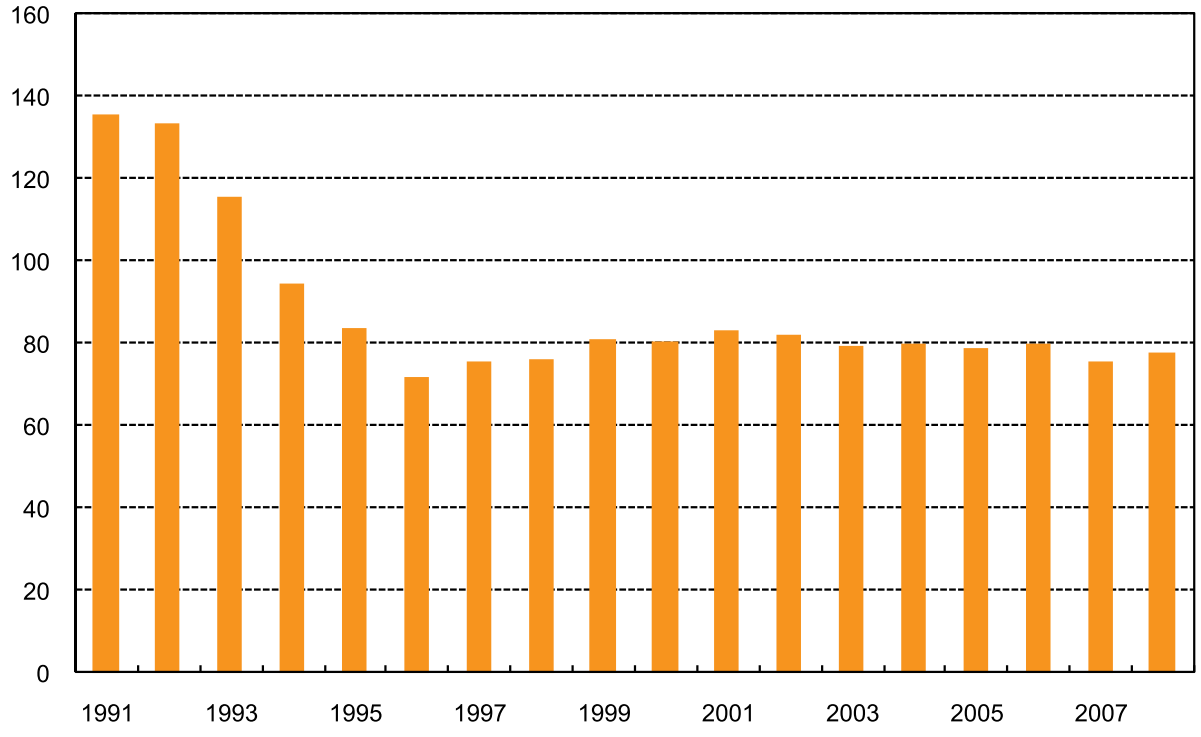
1.1. Coal Mining and Consumption

Ukraine's coal deposits are concentrated mostly in the Donetsk and Lviv-Volyn anthracite basins and the Dnieper brown coal basin. The richest deposits are found in the Donetsk, Lugansk and Dnipropetrovsk regions (up to 95%) [37] (see Figure 1). Coal reserves of operating mines are estimated of 8.7 billion tons (including 6.5 million tons of industrial coal), with 54% of power-generating coal. However, approximately 15% of coal is lost in the production process, which is the result of complicated mining and geological conditions and deficient technologies [22]. Ukraine's Government estimates that coal reserves of operating mines will last from 40 to 90 years. An average mine is of 700 m deep, and about 20% of mines are from 1,000 to 1,400 m. Moreover, coal seams are thin (85% are 1.2 m thick) and tend to be very steep, which complicates the production process, worsens operating conditions, and increases the cost price of coal [37].

Ukraine's Government has estimated that the total coal reserves at 117.5 billion tons, with explored reserves (where coal mining is profitable) estimated at 56.7 billion tons [22]. However, the World Energy Council (WEC) estimated the total coal reserves at 52 billion tons and explored reserves at 34.2 billion tons [37]. The data provided by the Government suggest that explored reserves will last for about 700 years if the annual rate of coal mining is 80 million tons. In case the data of World Energy Council is taken as the basis coal reserves are sufficient only for 430 years.

Figure1. Ukraine's coal basins [42]

Figure 2. Coal mining in Ukraine (million tons)[1]



1 The figure is based on the data from Ukraine's Energy Strategy by 2030 (data for 1991 to 2004) [22], National Inventories of Anthropogenic Greenhouse Gas Emissions (2005 to 2006) [24,25] and Minvugleprom (2007-2008) [10].

To date, Ukraine's coal sector is no longer playing the role it used to have at the Soviet time. From 1945 to 1970-ies, coal mining in Ukraine was among the largest in the world.

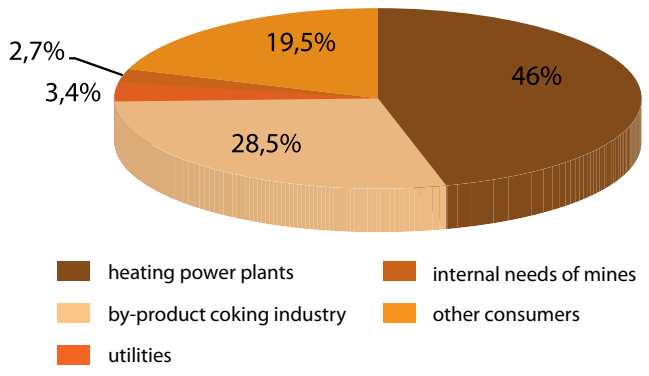
Since then, coal extraction has started to decline due to depletion of easily accessible coal seams which has directly influenced the prime cost of coal, and also due to intensive development of coal sector in Russia [37].

Since 1991, coal mining has dropped by 57.8 million tons or 42.6% and reached 77.8 million tons in 2008 (see Figure 2). Hence, the number of coal mines dropped, as well. In 2005, Ukraine had only 167 mines compared to 283 in 1991 [22].

Quality of Ukraine's coal is low and is constantly decreasing due to depletion of coal seams. Ash content of coal produced for domestic needs has increased from 29.8% in 1991 to 37.9% in 2005, while in exported coal it has increased from 18.3% to 25.5%. At the same time, sulphur content is very high, 2.5% on the average. Therefore, pre-processing is required to improve the quality of coal which significantly reduces the competitiveness of the domestically-produced coal at the international market [37].

The largest consumers of coal are heating power plants (27.4 million tons or 46%) and by-product coke plants (17 million tons or 28.5%), followed by utility companies, (2 million tons) and mines (1.6 million tons) [22]. Figure 3 shows coal consumption structure as of 2005.

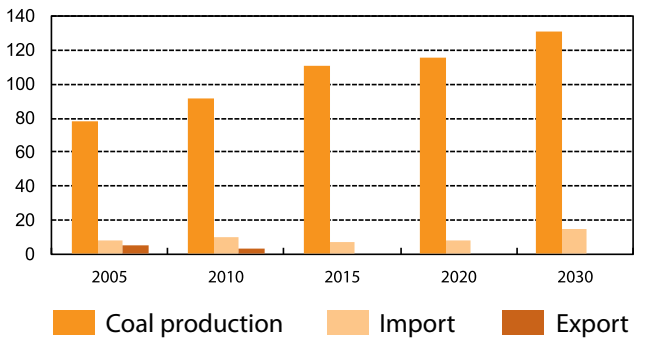
Figure 3. Coal consumption structure[1]



1.2. Coal Export and Import

In 1991, Ukraine has gradually become a coal importer rather than exporter due to decrease of coal quality (increase of sulphur content) [37]. To date, Ukraine imports coal due to the insufficient production of coal of the gas group (for HPPs) and coking coal (for metallurgy), and low quality of the latter due to the high content of sulphur. The largest suppliers are Russia (about 97%) and Kazakhstan. In 2005, Ukraine imported 7.7 million tons of coal and exported only 5 million tons. It is planned to increase imports (of coking coal mainly) up to 14.6 million tons and halt exports (see Figure 4) by 2030 according to Energy Strategy [22].

Figure 4. Projections of coal production, import and export[2]



1.3. Ownership Structure

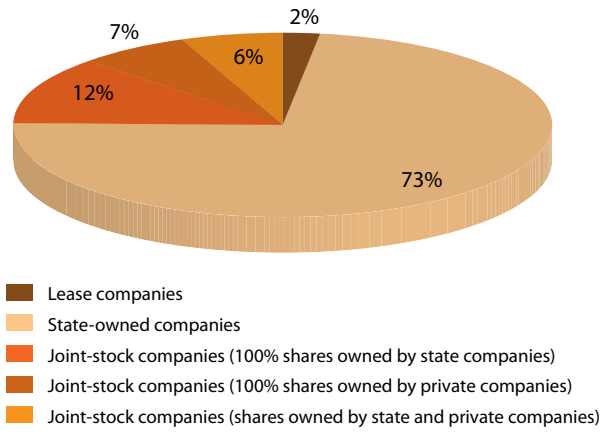
Although ownership structure of coal companies has been changing gradually in the last few years, denationalization is happening very slow due to low investment value of mines and inconsistent state policy. The majority (93%) of 167 coal companies are state-owned and regulated by Ministry of Coal Industry. In particular, 122 mines (73% of all operating mines) are state-owned, and 20 mines belong to joint-stock companies with 100% of shares are owned by the state. Mixed joint-stock companies own 10 mines (one mine belongs to OJSC "Komsomolets Donbasu" and 9 mines

1 The diagram is based on the Ukraine's Energy Strategy to 2030 (data for 1991 to 2004) [22], National Cadastres of Anthropogenic Greenhouse Gas Emissions (2005 to 2006) [24,25] and Coal Ministry (2007-2008) [10].

2 The figure is prepared based on the data of the Energy Strategy of Ukraine [22].

to OJSC "Krasnodonvugillya"). Private companies own 11 mines, mostly coking coal mines (Coal Company (BAT) Shakhta Krasnoarmiyska-Zahidna No.1, and 10 mines of OJSC "Pavlogradvugillya"). In addition, 4 mines are leased, in particular, O.F.Zasyadko mine and open-pit mines Morozovskiy, Konstantynovskiy, and Protopolivskiy. Although, in 2005, only 7% of mines were private, they produced about 40% of the country's annual coal output [37]. Figure 5 shows the ownership structure as of 2005 [22]. It is planned to continue the privatization of state coal-mining companies since private mines operate more efficiently even in complicated conditions [22].

Figure 5. Ownership structure of coal-mining companies as of 2005 [1]



1.4. Labor Efficiency

As the result of the decrease in coal mining and shutdown of mines, the number of workers employed by sector has decreased considerably. In 1991, the industry provided jobs for about 870 thousand people with 511 thousand working in coal production while in 2003 the number of jobs has reduced to 230 and 160 thousand, respectively (see Figure 6). Although labor efficiency increased from 22.1 in 1991 to 29.4 in 2007, this index is much lower than global average [39]. For example, average labor efficiency is 2 times higher in Poland, 5 times higher in Western Europe and even 20 times higher in the USA. However, labor

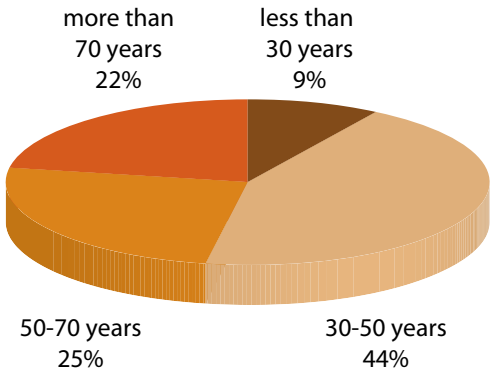
Figure 6. Number of workers in coal sector and labor efficiency[2]

efficiency depends on a number of factors including ownership type and location. In Donetsk region, one miner produce on the average around 1 ton of coal per month, while at the Krasnoarmiyska-Zahidna labor productivity was at the level of 95 tons per month. In 2005, this index was 23.3 tons per month at state mines, and 57 tons per month at private mines [37].

1.5. Overview of Ukraine's Mines

Ukraine's mines are the oldest in the Commonwealth of Independent States (CIS); an average mine is about 40 years old [37]. More than 96% of mines has not been upgraded in the last 20 years; two thirds of mining equipment is outdated and needs urgent replacement (see Figure 7) [22].

Figure 7. Breakdown of mines by terms of operation[3]



1 The figure is prepared based on the data of the Energy Strategy of Ukraine [22].

2 The figure is prepared based on the data provided by Dzerkalo Tygnya [39].

3 The figure is prepared based on the data of the Energy Strategy of Ukraine [22].

As the result of slow restructuring of coal sector, small unprofitable mines are still in operation [22]. An average annual output of one mine is less than 800 thousand tons, which is unusually low compared to other neighboring countries [37].

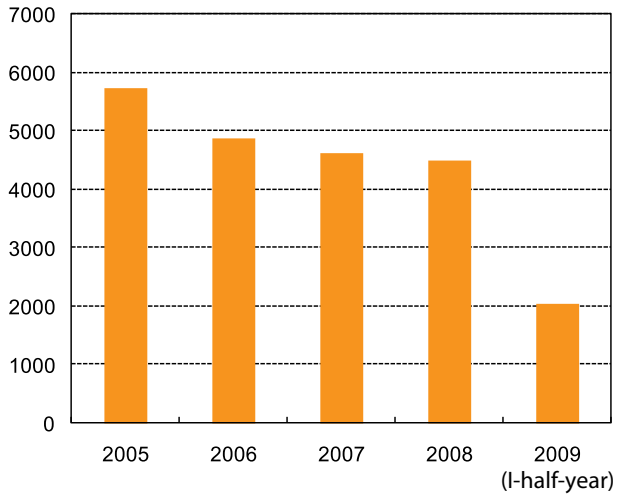
1.6. Accident Rate and Labor Safety

Complicated mining conditions and outdated equipment result in an unusually high accident and injury rate at mines in Ukraine. From time to time, Ukraine's media report tragic accidents. In 2008, large accidents have happened at the Karl Marx mine in Yenakiyevo as a result of which 1 miner died and 12 workers have disappeared [44]. At the same year, 11 miners have died at the Krasnolymanska mine [18]. In total, 43 accidents and 17 emergency situations has happened only at state mines regulated by the Ministry of Coal Industry [10].

According to the State Committee for Industrial Safety, coal sector is the most dangerous industrial sector accounting for 15.6% of the total fatal accidents in all production sectors. Thus, every sixth person who has died due to production accident is miner [4]. Over the last 10 years, more than 3 thousand miners have died [37]. Annually, several thousand of miners are injured at work. In 2006, 6,751 accidents have happened (comparing to 7,768 in 2005) 168 of which are fatal [4]. In 2008, 4,490 injuries were registered at the mines subordinate to the Ministry of Coal Industry alone (see Figure 8). Although, over the past decade, the level of occupational injuries has significantly dropped from 4.7 accidents in 1998 to 2.7 accidents in 2008, this level is still exceptionally high comparing to international standards and is one of the highest in the world. The situation is much better in other coal mining countries like USA, India and Russia [37].

Such high level of occupational injuries is caused by poor discipline of miners; insufficient control of operational conditions by engineers and technical staff; undue health inspections; poor professional level of specialists and chiefs

Figure 8. Occupational injuries at mines of the Ministry of the Coal Industry of Ukraine[1]

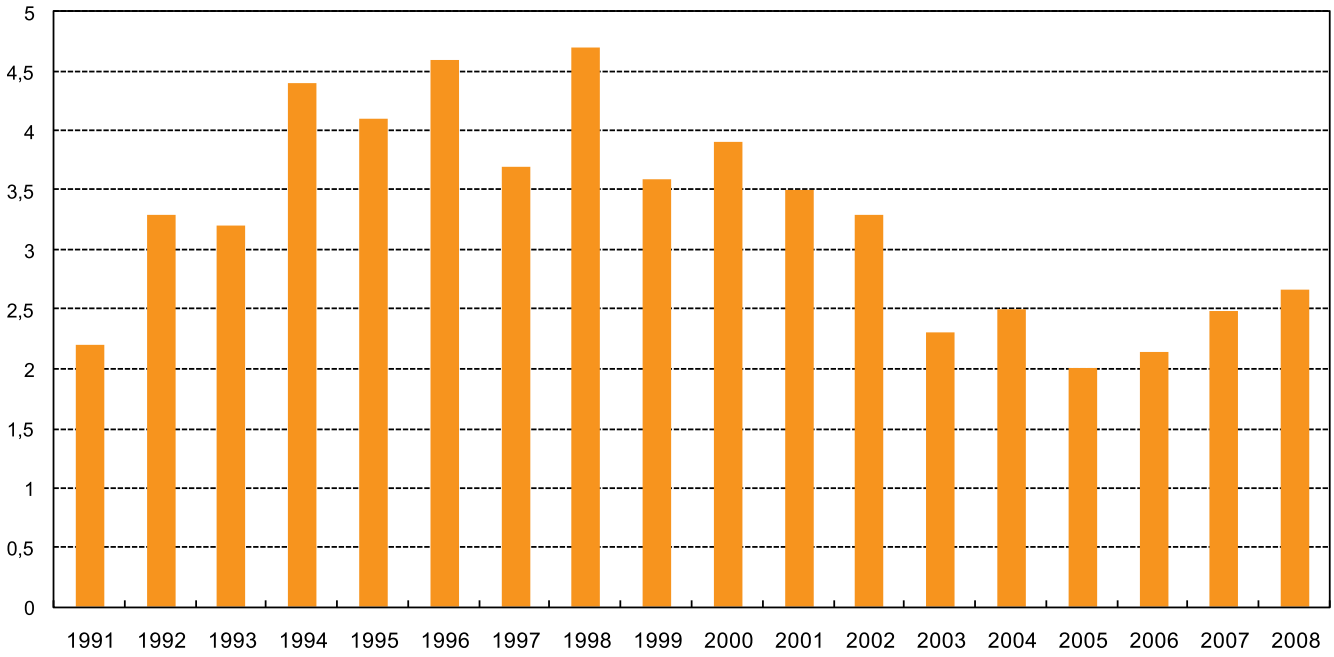


of mines and sites; improper operation of mining and electromechanical machinery; low level of mechanization of ancillary operations, etc. In 2003, Razumkov Centre carried out public opinion poll and found out that the key reasons of accidents are as follows: outdated coal mining equipment — 71.4%, equipment insufficiency for safe operational conditions — 55.4%, failure to meet all occupational safety requirements — 46.5% (respondents were able choose three main options) [42]. These reasons are entirely subjective and, therefore, the level of occupational injuries could be decreased significantly if these factors are removed.

The number of accidents and injuries is also influenced by the existing coal shadow market. The market accounts from 70% to 30-40% (different estimates) of the official coal mining [44]. Unauthorized coal mining takes place at either previously closed mines (with some coal left in such mines) or even in open coal pits at illegally occupied sites. Occupational safety rules are not observed in the above cases. On November 23, 2007, five miners died as the result of unauthorized coal mining operations at the 12th Zakhidna mine that was shut down in 2001 [33]. Moreover, there is evidence of unauthorized resumption of operations at some mines despite prohibitions of dis-

1 The figure is prepared based on the data provided by the Ministry of Coal Industry [14,15,11,10].

Figure.9. Index of fatal occupational injuries[1] (number of accidents per 1 mn tons)



trict offices of the State Committee for Industrial Safety, Labor Protection and Mining Supervision. The authorities had banned mining operations at Karl Marx mine and sealed the machinery, but the mine continued operations which resulted in the accident the following day. The same violation took place at the Chaikino mine that belongs to the state association Makiyivvugillya [44].

The attitude towards occupational safety changed only in 1998 after several serious accidents when it was revealed that the key reason of the miners' death was insufficiency of personal and collective protective equipment. Since then, a number of state regulations and programs have been approved to improve safety at mines. In 2002, UAH 80 mn has been transferred from budget to address these problems. In the same year, State Committee on Labor Protection Supervisio has been established with 24 state and 7 specialized inspections at the regions [42]. In 2004, UAH 105 million has been allocated within the Program of Safety Improvement at Coal Mines. Most of the money has been used to purchase degassing and communication equipment [37].

In 2006, the Program of Safety Improvement at Coal Mines and Mine-Building Companies has been approved for 4 years. However, according to Ukraine's State Committee for Industrial Safety (as of 04.07.08), less than a half of 112 planned measures were introduced (most measures were planned for implementation within 2007-2008). Degassation of seams has not been fully completed; schedules of emergency action training are not followed; miners are not provided with all required personal protection equipment; shaft radio communication systems are not commissioned; measures necessary to control temperature in mines more than 1,000 m deep have been undertaken terribly slow; etc [38].

1 On the figure is prepared based on data provided by the Razumkov Centre (for 1991-2002) [42] Ministry of Coal Industry (for 2003, 2006-2008) [6,7,17] and Ukraine's State Committee for Industrial Safety, Labor Protection and Mining Supervision (for 2004-2005) [3]

2. Economic Aspects of Coal Sector

2.1. Prime Cost and Price of Coal in Ukraine

Among the key reasons of crisis in the sector is that coal prices do not reimburse operating expenses, not to mention repair and maintenance costs and capital investments. As shown on Figure 10 that compares prices of various energy resources, the worst situation is in the coal sector and in heating sector [37]. Figure 11 shows that average net cost of coal is much higher than its price. In 2004, net cost amounted to UAH 214.18 while the price was only UAH 171.71 [15], and UAH 605.84 and UAH 453.88 in 2008, respectively [10]. There is a tendency towards the increase of this gap. In 2004, price constituted 80% of net cost, in 2008 the price was equal only to 75% of the average production cost, and in 2009 to only 64% [11].

However, net cost may vary depending on the producer and could reach UAH 10 thousand per ton of coal in some cases. The cheapest coal is produced at Rovenkiantrotsyt mine and Sverdlovantrotsyt mine, UAH 267 and UAH 218 per ton, respectively [43]. One of the reasons why coal price is much lower than its net cost is a significant disparity of prices of coal and mining equipment. This could be explained because private producers and suppliers are, in fact, monopolists on the market of mining equipment (own about 90% of the market) and able to set exceptionally high prices. Due to this fact, private companies obtain super-profits, while mines and

Figure 10. Energy prices and tariffs compared to prime cost, June 2006 [37].

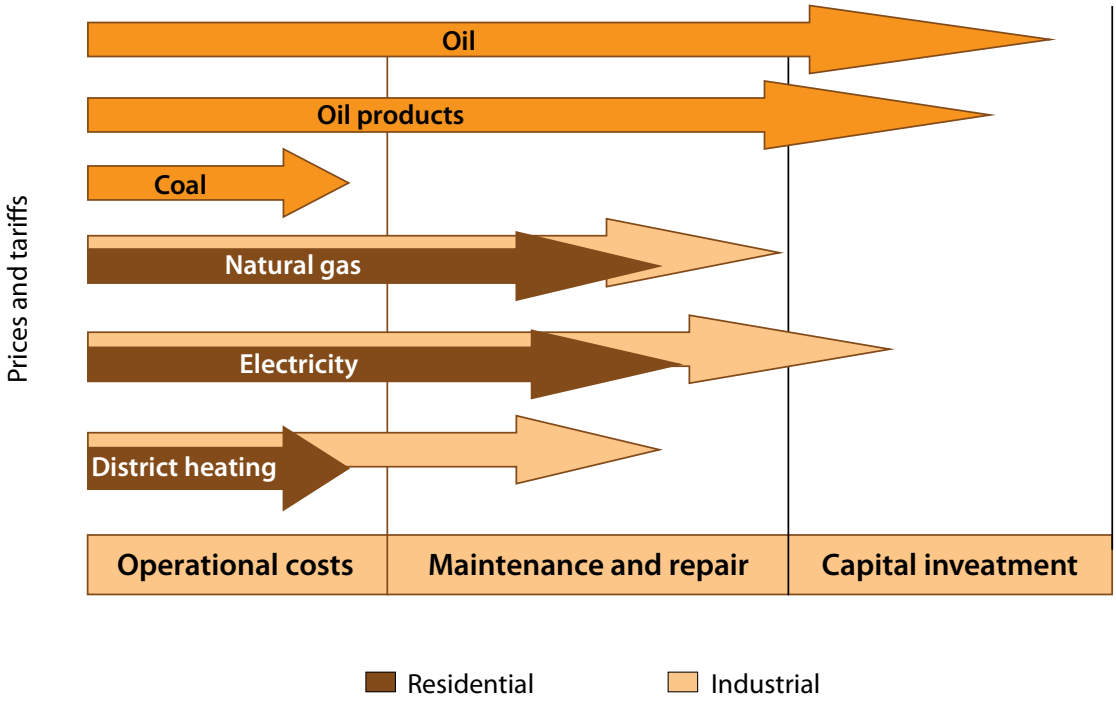
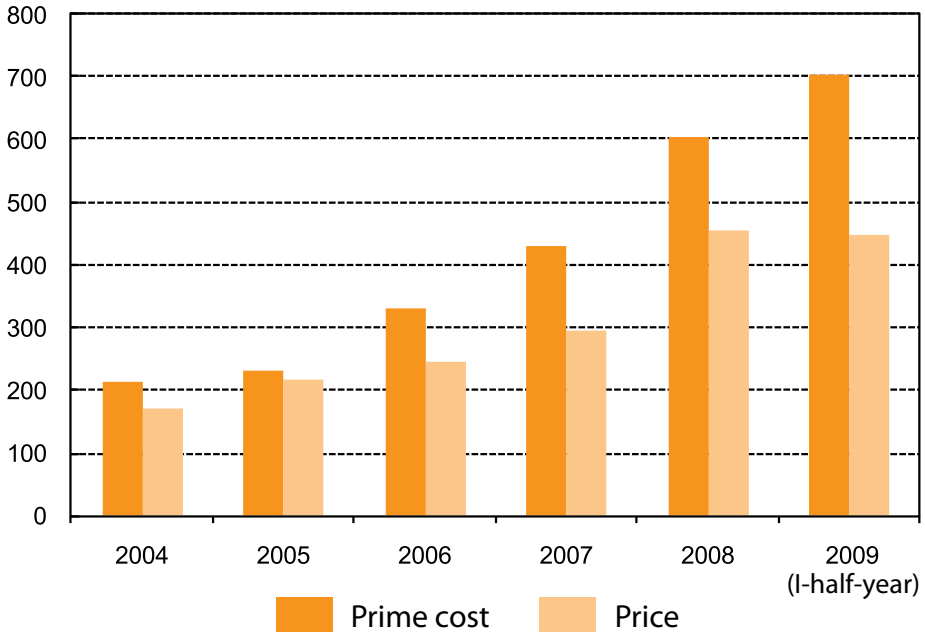


Figure. 11. Comparison between coal net cost and price in Ukraine (UAH)[1]



1 The figure is prepared based on the data provided by the Ministry of Coal Industry [14,15,11,10].

open pits suffer substantial losses. According to Ministry of Coal Industry, in 2005, prices of basic mining equipment and materials were much higher (UAH 223.4 for metal-roll; UAH 229.2 for 1 LT800 conveyor belt; UAH 211.3 for a section of motorized fastener 3KD90; UAH 223.7 for 1K101U coal cutter-loader) than the coal price of UAH 149.3 [22].

The IEA experts believe that coal prices are distorted due to subsidization of the coal sector, state interventions in fuel allocation and influence of private monopoly buyers [37]. In 2003, experts of the Razumkov Centre concluded carried a study and came to the conclusion that private intermediary companies with the help of state executive authorities monopolized both coal sale market and market of mining equipment and materials which resulted in bankruptcy of many mines. Intersectoral commodity and money flows are shown in Figure 12 [42]. Setting market price of coal is a prerequisite to meet the crisis in the sector. However, analysts conducted by the Razumkov Centre suggests that "a possibility to obtain super-profits that are available to powerful private companies associated with state authorities, is a key reason of inefficiency of efforts to introduce transparent market mechanisms into the coal sector as well as intersectoral relations, and is a barrier to legal privatization" [42].

Current financial imbalance in the coal sector is aggravated by the deterioration of the market conjuncture (impact of global economic crisis), continued increase of prices of mining equipment and electricity, gradual increase of salaries (increase of minimum salary), and a necessity to maintain social institutions in case of absence of budget funding [10].

2.2. Sector Profitability and State Subsidies

Reports by the Ministry of Coal Industry have mentioned several times that "coal sector is traditionally unprofitable" [15]. Ukraine's Government annually provides significant subsidies to maintain unprofitable sector of the economy (see Figure 13). Figure 13 shows the dynamics of the state funding of the sector from 2004 to the first half of 2009. In 2008, coal sector has received support of UAH 7,475.68 million. [10], (approximately 3% of Ukraine's annual budget[1]), and UAH 5,217.8 million during the first half of 2008 [11]. Taking into account that in 2008 state companies produced 45,381.7 tons of coal [10], every ton of coal received approximately UAH 165 (UAH 266 in terms of salable coal) from the state budget. Financing from the

Figure 12. Intersectoral commodity and monetary flows [42]

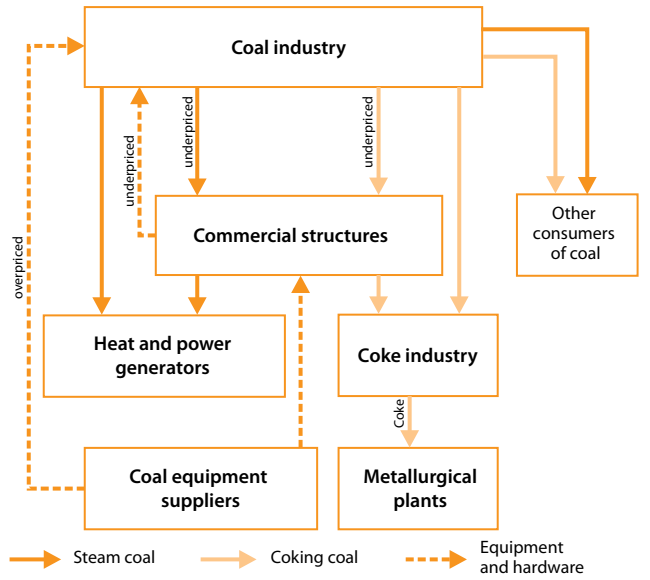
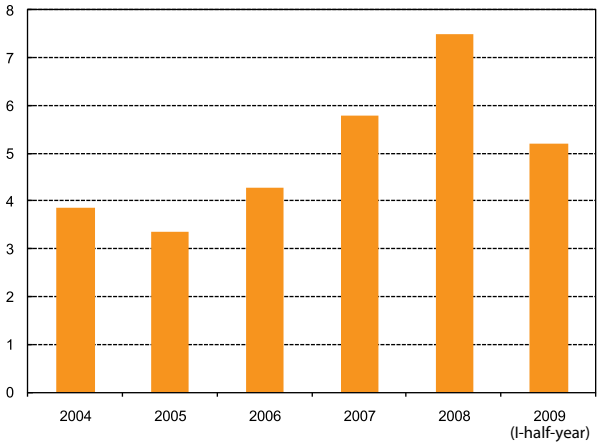


Figure 13. Sector funding by the state budget (UAH bn)[2]



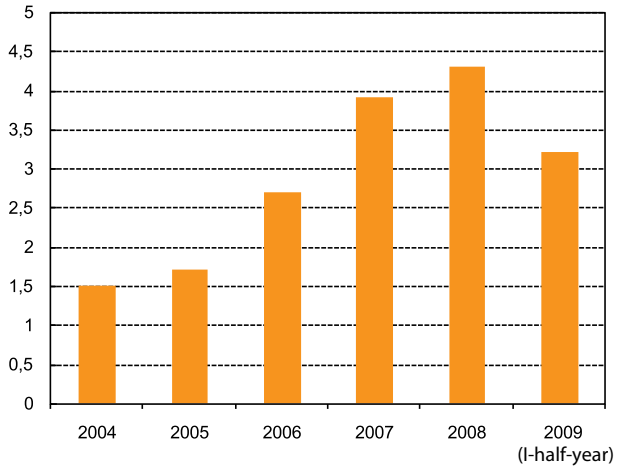
1 In 2008, Ukraine's annual budget was UAH 231,931,966.7 thousand [1].

2 The figure is based on the data provided by the Minvugleprom [14, 15, 11, 10]. In US dollars equivalent, coal sector received state budget support of $ 726.9 mn in 2004, $655.4 mn in 2005, $853.2 in 2006, $1,156 mn in 2007, $1,410.5 mn in 2008, and $677.6 mn in first half-year of 2009.

general fund of the state budget is provided for maintenance of Ministry of Coal Industry, application-oriented scientific and technical developments, rescue operations, labor protection and safety improvements, pensions, emergency operations, coverage of product net cost. State programs are financed from the special fund [1]. However, the largest share of funding is used to cover net cost of coal. In 2008, government provided UAH 42,766.5 million [10], which approximately equals to 60% of all money provided for the sector support.

Understated coal prices result in considerable losses that grow every year (see Figure 14). Since 2004, losses have grown from UAH 1500 million [15] to UAH 4276.5 million in 2008 [10]. It means that in 2008 losses per 1 ton of product amounted to UAH 152. The majority of the production costs are covered with the state budget. For example, in 2008 state coal mining companies received 93% compensation. Uncompensated losses cause accumulation of companies' debts, "which is often done intentionally to declare such company a bankrupt and privatize it for its debts or at a liquidation price" [42], believe analysts at the Razumkov Centre. If to take into account terribly difficult financial situation of many mines and unprofitability of the coal sector in general, it is obvious that the industry requires significant funding. Authors of the Energy Strategy to 2030 have estimated that the sector requires about 222 billion [22].

Figure 14. Losses from coal mining (UAH bn)[1]



1 The figure is based on data provided by the Minvugleprom [14,15,11,10]. In US dollars equivalent, losses from coal mining amounted to $283 mn in 2004, $335.4 mn in 2005, $540 mn in 2006, $780 mn in 2007, $806.9 mn in 2008, $416.1 mn in first half-year of 2009.

3. Social and Environmental Problems Associated with the Coal Sector

3.1. Social Problems in the Coal-Mining Regions

Soviet-time practice on the establishment of 'one company' cities and villages today creates significant social problems, because with time and due to various reasons, companies are closed down and many people are left without jobs. This problem is particularly critical for mining towns in Eastern Ukraine. In particular, 63 of 142 mono-industrial settlements in Ukraine are located in the Lugansk region [31].

Local people are highly dependent on the coal industry which is especially important for small towns and villages, where most people work at coal-mining companies. Public opinion poll conducted by the Razumkov Centre in 2003 has shown that 20.5% of respondents' families are almost fully dependent on the coal industry, 17.1% are highly dependent, and 17.4% are partially dependent. Every fifth respondent wanted to move to another region of Ukraine, but most people did not have enough money or were afraid not to find a job there [42].

Re-structuring of the coal sector and closure of unprofitable mines started in 1996, when Ukraine's President issued a decree on re-structuring of the coal industry. In 2001, authorities approved program "Coal of Ukraine" which provided decentralization, restructuring of mines into open companies and auction sale of mines to investors. About 122 mines were planned to be closed in 2001, and half of them was closed by 2005 [37]. In 2005, the

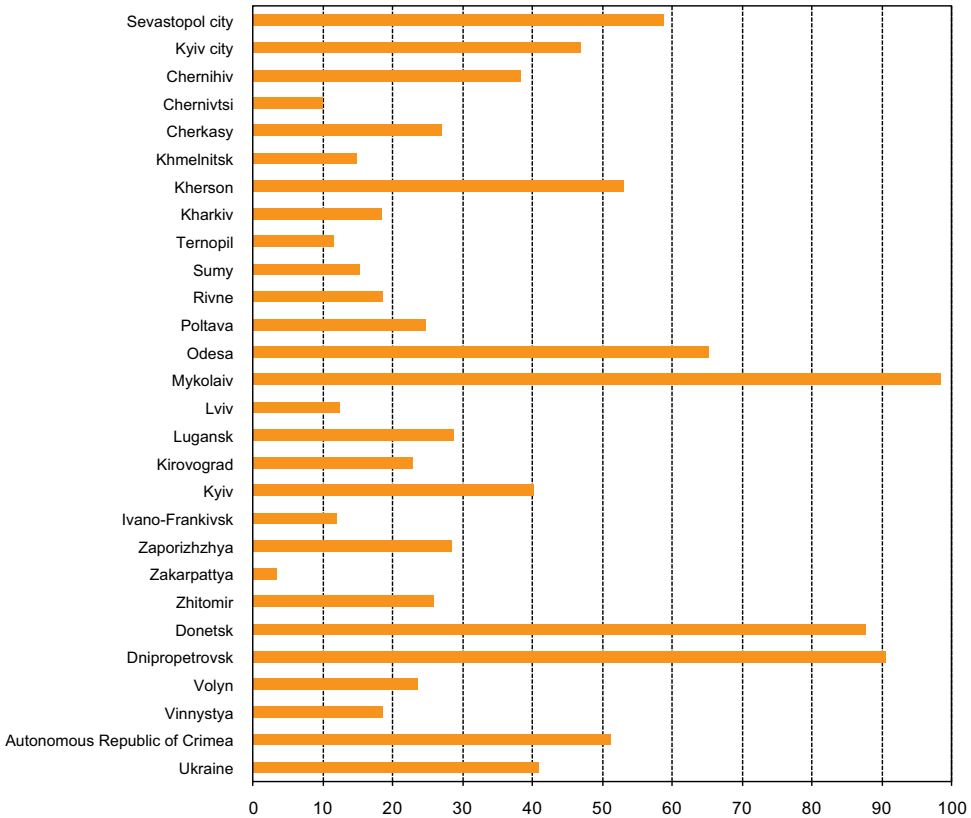
Concept of the Development of the Coal Sector was approved that outlined the principles of the further re-structuring of the sector up to 2030 [2]. Ukraine's Government made some steps to solve current social problems and create jobs by allocating significant funds from the state budget and taking the loan from the World Bank. However, due to insufficient funding and poor management most social problems related to unemployment of miners have not been solved [37].

Official information certainly does not show the real situation related to the unemployment of miners. According to analysis of human resources in Lugansk region (conducted as a part of TACIS project by the Scientific and Research Institute of Social and Labor Relations), level of unemployment in coal-mining regions was several times higher. Main problems related to job placement include unofficial employment, migration, high level of unemployment; increase of share of unqualified personnel and ageing of employees, especially at unprofitable mines; personnel turnover at mines which are planned to be closed down (many employees leave before official closure); unemployment is constantly growing [31].

Unfavorable social conditions, unemployment and poverty cause a high level of crime in coal-mining regions of Ukraine. According to materials of the website "Criminal Ukraine", the highest number of crimes per 10 thousand people (56.6) is recorded in Lugansk as of 2009. The highest rate of alcohol-related crime (2.0) and robbery (0.99) was registered in Donetsk region [40]. According to Ukraine's Ministry of Emergency Affairs, Donetsk, Lugansk and Dnipropetrovsk regions have the highest rate of drug-related crime — 5,542, 4,863 and 5,007, respectively, as of 2008 [19].

Drug addiction is a particularly serious problem in the region. According to the Donetsk Regional State Administration, 9,952 of drug-

Figure 15. HIV infection in Ukraine in 2008 (per 100,000)[1]



1 The figure is prepared based on the data provided by the Ministry of Health [20].

addicted people (0.21% of the total population) were registered in the region as of 2008 [5]. However, Ministry of Emergency Affairs states that the number of drug addicts was even higher (19.9 thousand in Donetsk region, 20.8 thousand in Dnipropetrovsk region, and 15.7 thousand in Lugansk region) [41] in 2007. However, experts believe that the real figures may be ten times higher [29]. High rate of spreading of drug addiction in Eastern and Southern Ukraine causes quick dissemination of HIV in these regions since injection drugs are one of the main ways of HIV transmission. Figure 15 shows that Donetsk and Dnipropetrovsk regions are among the regions with the largest HIV-infected population per 100 thousand people. In Lugansk district, this figure is much lower.

3.2. Environmental Problems

Coal sector causes a range of serious environmental problems, including air pollution and deterioration of geological, hydrologic and hydrochemical conditions of the areas where coal-mining companies are located.

Subsidence of earth surface is one of such problems. The report by Donetsk Information and Analytical Centre on Main Problems of Development of Coal sector and Donbass Region [31] indicates that earth subsidence above the mines is more than 20% for a 50-150 m deep mine, and 5-7% for more than a 1,000 m deep mine. Annual rate of earth subsidence is about 1,000 square meters. In Western Donbass, land subsidence has reached 5 m and is accompanied by underflooding and damage of buildings and communication facilities by underground water, and change of mesophytic vegetation to mire vegetation. Within Donetsk alone, impounded areas cover about 31% (5,180 hectares) of the city, and 42% (1,690 hectares) in Makiyivka. In many other cities of the region the situation is the same [31].

It is also important to mention increased mineralization of aquifers, soils and rivers by pit water that contains a large amount of soluble chemicals (up to 4 g per liter) including dangerous chemicals. Contamination of aquifers with this water leads to considerable salification of aquifers which makes them unsuitable for use. The same problem is related to 22 storage ponds where pit and waste water is collected from concentration factories. Basins of these ponds are not dampproofed and contaminated water penetrates to aquifers and soils and causes salification [31].

Direct discharge of the pit water into the river system that represents the main part of the river flow is equally damaging. It changes hydrologic and hydro-chemical conditions of the rivers. In the rivers Lugan and Velyka Kamyanka, water mineralization is two times higher than normal and is 2.2 to 2.6 g per liter. Together with soluble chemicals, pit water brings a large amount of solid particles (20 to 70 g per liter) which results in the riverbed silting (Kazennyi Torets, Kalmius, Krynka) and creates an additional necessity to clear and straighten such riverbeds [31].

At the same time, dry areas of several thousand kilometers wide and up to 50 m deep are appeared above industrial areas where coal is still produced as a result of intense drainage. Drainage of aquiferous stratum resulted in dewatering of hundreds of wells, natural springs and watercourses in gullies and rivers. Hydrological situation in the region is also deteriorated by ongoing bailing of underground water from mines since dewatering is almost twice higher than the water resources available in nature. This is caused water shortage in most basins of the rivers Lugan, Krynka, Bulavinka, etc [31]. In view of the general aridization of climate of Southern and Eastern Ukraine, such devastation of aquiferous system can soon turn arid lands into desert.

Accumulation and storage of solid coal waste is also a serious problem. As of 2002, nearly 1.3 billion tons of rocks are accumulated in dumps (7,190 hectares) and sludge banks (4,010 hectares) in Donbass region. This amount is annually growing by 60 million tons. Production of 1 mn ton of coal is estimated to pollute and ruin 4 hec-

tares of land, and operations of an average mine are estimated to spoil 83 hectares of land. It is important to note that utilization of mining waste for other economic needs or filling in of mined-out pits is unusually low and in total is not more than 17% of annual extraction [31].

Moreover, the waste often ignites spontaneously and emits more than 500 thousand tons of dangerous substances into the air. According to the Scientific Research Institute of Makiyivka, one combusting dump emits on the average 150 tons of carbon dioxide, 1.5 tons of sulphur dioxide, 0.4 tons of hydrogen sulfide, and 0.1 tons of nitric oxide per day. Waste bank dust also contains many toxic substances [31].

Mine ventilation also contributes to air pollution. Approximately 5.6 billion m3 are emitted annually, including 172.5 million m3 in Dnipropetrovsk region, 3.7 billion m3 in Donetsk region, and 1.8 billion m3 in Lugansk region. Air is the most polluted in Donesk, Makiyivka, Alchevsk, Yenakiyevo, Lysychansk and Horlivka [31]. Methane is a powerful greenhouse gas (impact of 1 ton of methane on climate change is equal to the impact of 25 tons of CO2 [54]). Estimation of greenhouse gas emissions from coal mining and consumption is described in the next section.

Not only intense operations of coal-mining companies, but also closure of mines constitute a threat. On the one hand, it reduces coal mining operations and, therefore, decreases environmental pressure. On the other hand, administrative closure of mines without consideration the situation in complex also creates environmental problems [27].

Donetsk coal basin is an enormous anthropogenic and geological system where most mines that can reach one kilometer in depth are aerodynamically and hydraulically connected. Hence, a closure of a mine results in filling in underground hollows with water [27].

A typical example is town Bryanka in Lugansk region. Development of coal mining resulted in dewatering of underground aquifers on the land which was swampy previously. Settlements have been established on the drained land and agriculture has been introduced. New hydrogeological conditions were maintained only due to the ongoing dewatering of mines with powerful pumps. However, six of Bryanka's eight mines have been closed. In 2001, Ukraine's Ministry of Fuel and Energy issued a decree No. 22 of 17.04.2000 to close down one of Bryanka's mines, the Krasnopilska mine. The mine closure project has been developed by the Luganskdiproshakht Institute. However, negligent attitude towards project development caused unanticipated environmental effects [27] including increased earth subsidence which has damaged the town's buildings and communication facilities. 24 hectares have been already impounded, and the impounded area is expected to reach 146 hectares. Railway station, cemeteries, and refining facilities are situated within the potential flood area which constitutes additional threat. Moreover, the Lozova river has been silted as a result of continued dewatering of underground hollows and water discharge into the river. Underground water has been also polluted with pit water, which makes water in wells unsuitable for drinking [31].

4. The Role of Coal in Greenhouse Gas Emissions

4.1. Greenhouse Gas Emissions from Coal Mining and Consumption

Coal is traditionally one of the major sources of greenhouse emissions since it plays an important role in the global production of heat and energy. In 2006, 41% of global energy was produced from coal [53]. Carbon content of coal is higher than that of other fossil fuels. That is why coal combustion produces larger amount of CO_2 than oil and gas combustion. The IEA reports that 42% of the global GHG emissions was produced by coal combustion as of 2008 [53].

In Ukraine, coal is responsible for a significant share of domestic greenhouse gas emissions of Ukraine. To estimate the amount of GHG emissions from coal mining and consumption, the following categories of emission sources have been marked out in the National Inventory of Anthropogenic GHG Emissions [26]:

- **Production of cast iron and steel.** Coke is used as a fuel and reducer in the production process leading to high CO_2 emissions.

- **Stationary combustion of solid fuel**[1] **.**This category includes emissions from stationary combustion, in particular, energy production and transfer, fuel processing; produc-

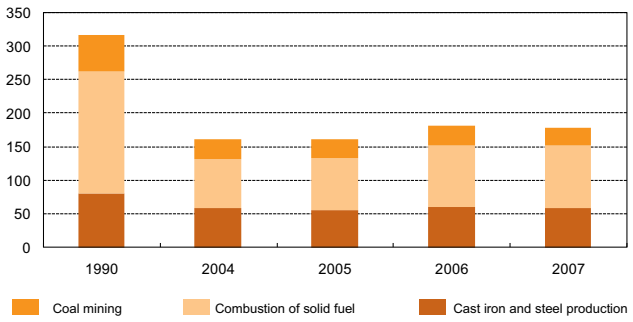
1 According to the National Inventory of Anthropogenic Emissions, 'solid fuel' category includes black coal, lignite, slate coal, peat, coke, and coke gas [26].

tion of non-energy materials; in industry and construction; for house heating and water heating in private households, agricultural activities, etc.

- **Coal mining and use.** This category includes emissions related to release of methane in production, preparation, transportation, storage and use of fossil fuels.

Figure 16 shows dynamics of greenhouse gas emissions by particular categories.

Figure 16. Dynamics of greenhouse gas emissions from coal mining and combustion (equivalent to mn tons of CO_2)[1]

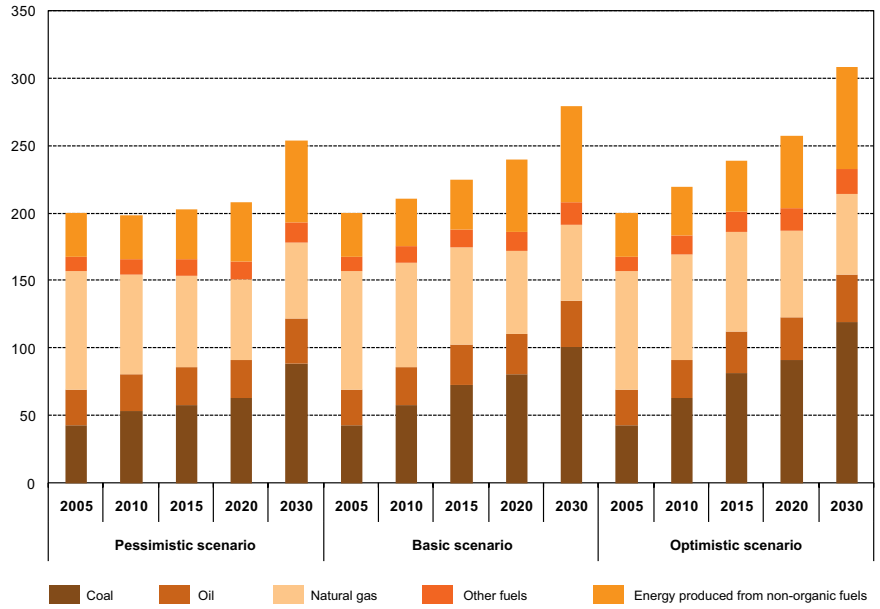


In 1990, greenhouse gas emissions from coal mining and consumption were at the level of 318 million tons of CO_2 equivalent and amounted to 34% of Ukraine's total emissions. Emissions from solid fuel combustion constituted the largest share of total emissions (approximately 60%). After the collapse of the Soviet Union, coal mining and consumption has dropped significantly (from 135.6 million tons in 1990 [22] to 77.8 million tons in 2008 [10]) due to economic recession. Thus, greenhouse emissions decreased almost twice and as of 2004 amounted to 162 million tons of CO_2 equivalent. Since then, emissions are gradually growing. As of 2007, greenhouse gas emissions from coal mining and consumption amounted to nearly 40% of the country's overall emissions (approximately 180 million tons of CO_2 equivalent).

4.2. Projections of Coal Consumption up to 2030

It is planned to increase considerably the share of coal in the country's overall fuel and energy balance, from 22% (43.5 million tons of

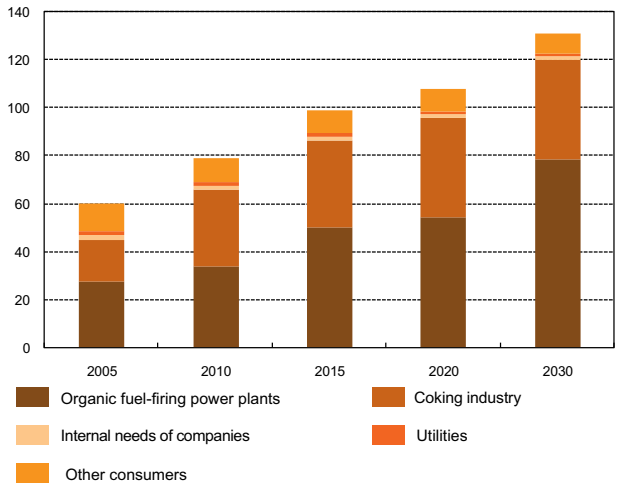
Figure 17. Projections of fuel and energy balance (use part) up to 2030 (mn tons of equivalent fuel)[2]



1 The figure is prepared based on the data of the National Inventories of Anthropogenic Emissions [24,26,25,23] and calculations described in Appendix A.

2 The figure is prepared based on the data of Energy Strategy of Ukraine [22].

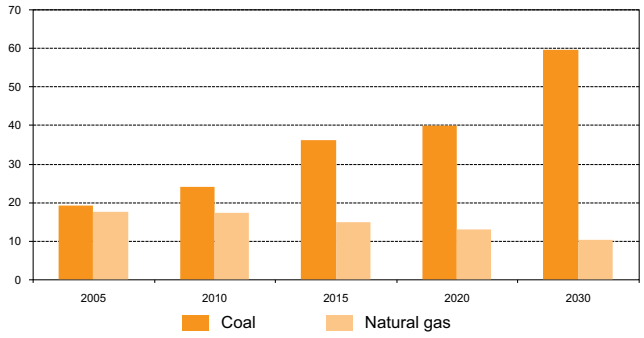
Figure 18. Forecasted fuel consumption up to 2030 under basic scenario (mn tons)[1]



fuel equivalent) in 2005 to 33% (101 million tons of fuel equivalent) in 2030 according to the basic scenario [22] of the Energy Strategy of Ukraine (see Figure 17). Figure 18 shows projections of the coal consumption by various sectors of economy up to 2030.

Coal combustion is expected to increase considerably by the coking industry and power stations. Coal use by coking industry would increase almost twice from 2005 to 2010, and then gradually by 2030. The highest growth of coal consumption is expected for power stations that use organic fuel. This could be explained by strategic decision of the Ukrainian Government to replace gradually gas with coal in order to decrease the importance of Russian gas for Ukraine's economy and improve energy security [22]. Figure 19 shows projections of coal consumption by heating power plants and isolated generating plants up to 2030 (basic scenario).

Figure 19. Expected fuel consumption by heating power plans and isolated power plants up to 2030 under basic scenario (mn tons)[1]



1 Diagram based on data of the Ukraine's Energy Strategy [22].

4.3. Projections of GHG Emissions from Coal mining and Consumption up to 2030

Increase of greenhouse gas emissions was estimated based on the expected volumes of coal mining and consumption specified in the Energy Strategy of Ukraine up to 2030 (under basic scenario)[2] (see Figure 20).

Figure 20. Expected emissions from coal mining and consumption under basic scenario[3]

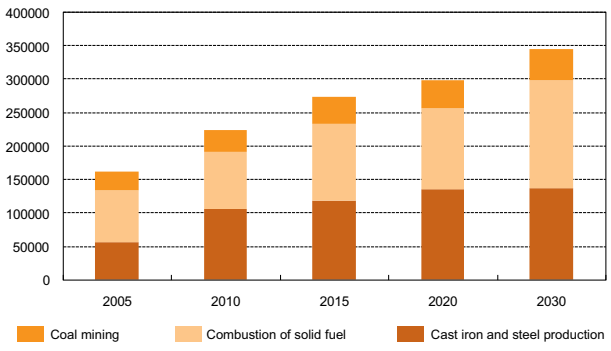
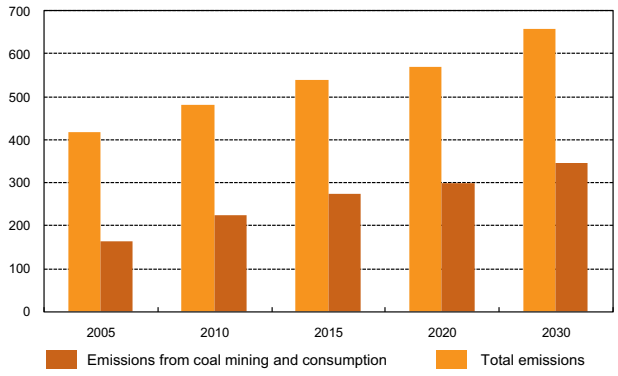


Figure 20 clearly demonstrates that greenhouse gas emissions would increase more than twice from 2005 to 2030 amounting to 350 million tons of carbon equivalent. This growth is mainly explained by the expected increase of coal use by power stations. Due to this fact, emissions from coal mining and consumption (of the overall level of greenhouse emissions) could rise from 39% (162 million tons) to 53% (346 million tons) in 2030 (see Figure 21).

2 Calculations are based on the Energy Strategy of coal mining and consumption up to 2030 [22], and the National Inventory of Anthropogenic Emissions [24], 2005 is taken as the baseline. Detailed calculations are described in Appendices B and C.

3 The figure is based on the data of the Second National Communication of Ukraine on Climate Change [32] and calculations described in Appendix C.

Figure 21. Expected GHG emissions in Ukraine according to basic scenario of Energy Strategy and share of GHG emissions from coal mining and consumption (mn tons in carbon equivalent)[1]



4.4. Key Shortcomings of the Energy Strategy

Ukraine's Cabinet of Ministers approved the Energy Strategy of Ukraine up to 2030 in March 2006. Since then, the Strategy has been repeatedly criticized by scientists, media, international institutions and nongovernmental organizations of Ukraine. Environmental organizations have prepared a critical analysis of fundamental principles of the Energy Strategy [30] and the Concept of "non-nuclear" development of energy complex of Ukraine [28]. The strategy contains a number of questionable provisions, but this report is focused on the issues that are directly related to the coal industry.

One of the key shortcomings of the Strategy is, first of all, the priority of political interests. In particular, the IEA experts argue that *"its projections seem to be based not on detailed statistical data and models, but rather on political objectives without economic analysis of whether these objectives are feasible"* [37]. Experts also believe that the strategy is too focused on energy supply issues, instead energy efficiency improvements should be the key element of energy policy of Ukraine [37].

Would the strategy improve energy security?

The economy of Ukraine is highly dependent on the import of energy resources (up to 60.7% of total needs in 2005) [22]. Russia and Turkmenistan are the main suppliers. Therefore, energy security issue is crucially important for Ukraine and should be seriously addressed. According to the Energy Strategy, it is planned to improve energy security by development of nuclear power industry (22 new nuclear power units are planned to be constructed) and gradual increase of coal share in the country's fuel and energy balance (replacement of gas by coal). However, these approaches are far from being optimal since they cause a range of other problems and risks, including environmental ones. It is important to note that nuclear energy development could create a new threat for energy security since nuclear fuel (Ukraine has only 30% of required nuclear fuel) and machinery for nuclear power plants is supplied by Russia. This can result in nuclear dependence, which would not improve the overall situation with energy security [30]. Risks of nuclear pathway of energy development are described in detail in critical documents prepared by nongovernmental organizations [30, 28]. At the same time, increased consumption of the national coal creates financial burden on Ukraine's budget since coal sector devours enormous financial resources and is still unprofitable. In 2008, nearly UAH 7 billion was allocated to the sector from the country's budget. Secondly, strategic planning should also account for negative environmental impacts caused by coal mining and consumption. Coal is one of the most "dirty" energy sources. If the strategy is implemented, the share of greenhouse gas emissions caused by coal mining and consumption will amount to 53% of the country's overall emissions in 2030 (see section 4.3).

Instead, energy security of Ukraine can be improved, first of all, by the decreased use of energy resources, which could be achieved through intensive implementation of energy efficiency technologies, and development of renewable energy sources (see Appendix E). IEA experts argue that *"energy efficiency is less expensive and has a bigger impact on reducing imports than*

1 The figure is based on the data of the Second National Communication of Ukraine on Climate Change [32] and calculations described in Appendix C.

projected new domestic supply" [37]. Energy efficiency improvements would also stimulate the country's economic growth [30]. Public experts think that the share of RES in Ukraine's energy balance could be increased up to 11% (33.7 million tons of equivalent fuel of 302.7 million tons equivalent fuel required) by 2030 [30]. Thus, Ukraine can not only reach more energy independence, but also gain a number of economic and environmental benefits since proposed approached is more economically efficient and environmentally friendly.

Is it really necessary to increase the consumption of fuel and energy resources?

The strategy projects that the consumption of primary energy resources would reach 302.7 million tons of equivalent fuel (according to the basic scenario) by 2030 [22]. Projections for development of fuel and energy complex are based on the expected increase of gross domestic product by 3.1 times, which means 4.9% of annual GDP growth. Public experts believe that this figure is too optimistic and could result in overestimated projections for energy consumption. Experts also argue that too high energy-intensity index is used in the strategy in 2030. In 2005, energy-intensity was at the level of 0.89 kg of equivalent fuel / USD (PPP — purchasing power parity). It has been estimated (taking into account GDP growth and expected consumption of primary energy sources) that energy-efficiency would drop by only 2.05 amounting to 0.43 kg of equivalent fuel / USD of PPP, while global average level was of 0.34 kg in 2003. Public experts point out that *"exceptionally low energy intensity index is used in the Strategy that preserves lagging development of energy-efficient technologies for the nearest decades"* [30]. If Ukraine could decrease energy-intensity of the economy to 0.34 kg of equivalent fuel/USD (PPP) in 2030, energy consumption would be 237.5 million tons of equivalent fuel by 2030, which is 65.2 million tons less than projected by the strategy. Moreover, structural changes of the economy are not considered in the strategy [30].

Is it feasible to increase the amount of coal production?

According to the Energy Strategy up to 2030, it is projected to increase coal extraction by 130 million tons according to the basic scenario, and to 121.5 million tons according to the pessimistic scenario. Quality of Ukraine's coal is decreasing due to depletion of seams. However, the Strategy plans to decrease the ash contents of the produced coal from 38.1% as of 2005 to 28.1% in 2030 [22]. There are technologies that considerably improve the quality of coal, but this requires additional investment.

In order to achieving the objectives of the strategy, not only reconstruction of operating mines is essential but also 10 new ones should be established which in total would require. UAH 222 billion (based on prices effective in 2005) of investment [22]. It is essential to note that most of the funding would have to be allocated from the country's budget since the majority of mines are not attractive for investors. However, due to economic recession, Ukraine is not likely to raise required finances for development of the coal industry. Therefore, the increase of coal mining to 121.5 million tons even according to the pessimistic scenario is questionable.

It was initially planned to increase coal mining almost by 13 million tons from 2005 to 2010, but the economic crisis decreased the demand for coal, and in 2008 coal mining was at the level of 77.8 million tons, which is even less than in 2005. It is quite obvious that the objective would not be reached by 2010.

Experts have different opinions regarding the feasibility of long-term projections of coal mining up to 2030. O. F. Lyashenko believes that *"it is realistic to increase production not only to 130 mn tons (according to the basic scenario), but even to 146.3 mn tons (according to the ambitious scenario). Projections of coal production are based on the analysis of potential of each operating coal-producing plant and available resources*

(the potential is almost unlimited here). However, the potential of operating mines could be utilized only if mines are technologically re-equipped and renovated"[1]. At the same time, V. G. Krasnik argues that projected production increase to 130 million tons is not feasible considering the current situation in the economy since significant investments are required[2]. Moreover, V. L. Saprykin believes that coal production could be increased to maximum 100 million tons considering the current situation[3].

What would be the demand for domestically produced coal?

IEA experts argue that the Strategy fails to account for trends of changing demand for energy; instead, it is assumed that demand would respond to the dynamics of energy supply [37]. According to the Strategy, both coal mining and consumption would amount to 130 mn tons. This approach is risky since in reality demand for energy is likely to differ from the expected volumes of supply. Evolution of the demand structure would clearly impact the energy consumption and gradual replacement of energy sources with alternative ones. Therefore, in-depth demand analysis should underpin the Energy Strategy [37].

To date, energy prices do not cover long-term production costs. In Ukraine, the price of coal is considerably lower than its prime cost, and the difference is covered directly by the state budget. As a result, consumption is partially stimulated by uneconomic incentives, hence, *"demand is higher than is economically e cient"* [37]. Demand would obviously decrease if the energy prices go up, and demand for coal would drop, respectively (the share of coal in energy production is projected to increase considerably). Moreover, domestic coal is not competitive since the quality is low and the cost is high.

Due to economic recession, nearly 5 million tons of coal are accumulated in reserve storehouses of power plants, and storehouses of mines are full as well2.

Energy demand and supply projection for transition countries (including Ukraine, but excluding Russia) differs significantly from the projections provided by official strategy of Ukraine. It is planned to decrease the share of coal in total primary energy supply (TPES) from 21% to 16% [37].

Hence, whether and how large would be the demand for domestic coal would depend on a number of factors, including general economic situation in Ukraine, demand for heating and energy, prime cost and quality of salable coal, etc. It is quite possible that demand would be much lower than projected by the Energy Strategy.

What would be the impact of coal sector on the environment?

Fuel and energy complex of Ukraine is among the biggest sources of environmental pollution, which, in turn, affects human health. However, the Energy Strategy does not pay sufficient attention to the environmental problems. Although it describes some facts, there is no comprehensive assessment of the impact the FEC on the environment. The Strategy sets goals to decrease negative environmental impact of the FEC, but it is not always clear how these objectives would be reached.

Some statements of the section describing environmental problems contradict with the general principles of the Strategy. It is noted in the section VIII that *"it is planned to optimize the structure of the energy sector based on the use of less carbon-intensive energy sources, including a gradual transition to renewable and alternative energy sources"* [22]. At the same time, it is projected to increase the share of coal (which is the most carbon-intensive fuel) from 22% (2005) to 33% in 2030 according to the basic scenario, and the share of renewable energy sources would only be increased to 4%.

1 According to the interview with O. F. Lyashenko (leading scientific officer, Fuel and Energy Complex Department of Council for Studies of Productive Forces of Ukraine).
2 According to the interview with V.G. Krasnik (Director, Department of Perspective Development and Coordination of Preparatory Operations, Minvugleprom).
3 According to the interview with V.L. Saprykin (Energy Programs Director, Razumkov Centre).

Moreover, the Strategy does not address climate change issues and Ukraine's commitment to cut greenhouse gas emissions under the Kyoto Protocol. World's leading scientists came to the conclusion that global greenhouse gas emissions must be reduced by 50-85% by 2050 (from 2000 levels) to limit the increase of global average temperature by 2-2.4 °C. If this level is exceeded, this would result in irreversible environmental, social and economic consequences [55]. According to Energy Strategy of Ukraine, it is projected to increase the consumption of primary energy resources up to 302.7 million of equivalent fuel by 2030 (according to the basic scenario) [22], which would increase the country's CO_2 emissions by 64% compared to the 2005 levels (482.3 million tons of carbon equivalent in 2010, 539.9 in 2015, 571.3 in 2020, and 658.2 in 2030 [32]). It has been estimated (based on data of the Energy Strategy of Ukraine and the National Inventory of Anthropogenic Greenhouse Gas Emissions) that greenhouse gas emissions would reach 345.8 million tons of CO_2 equivalent, which equals to 53% of the projected emissions of Ukraine in 2030 (see Appendix C), if coal mining and consumption is increased to 130 million tons, . Such increase of emissions is inadmissible since Ukraine is also responsible for climate change and has to make certain efforts to reduce greenhouse gas emissions. The problem of climate change is of immense importance for Ukraine and should be taken into account in the development of energy and environmental policy of the country (see Appendix E).

5. Energy Policiy on the Coal Production and Consumption

5.1. The Rational for Gradual Reduction of Financial Support for the Coal Sector

Introduction of subsidies could be justified only if it improves the overall social welfare. In practice, most subsidies which were introduced for social reasons (for example, control of fuel prices for households, support of coal mining to secure jobs) result in significant financial, and environmental losses, and sometimes bring limited benefits for the targeted social groups. Therefore, governments should seek for more efficient ways to solve social problems than energy subsidies and find options to avoid or minimize environmental damage [59].

According to the IEA, indirect energy subsidies are equal to 18% of the GDP of Ukraine as of 2005. This figure is among the highest in the world and is even higher than in countries that are richer in energy resources. For example, energy subsidies in Iran are equal to 17% of the, while in Russia are only 5% [56]. This leads to economic distortions and development of energy-intensive industries which would otherwise be unprofitable. It is not surprising that, energy consumption per GDP unit in Ukraine is among the highest in the world.

It is also essential to take into account negative environmental impacts of energy subsidies. Subsidies provided to the coal sector are the most dam-

aging for the environment, especially, in terms of greenhouse gas emissions, since coal is the most carbon-intensive source of energy and subsidies create incentives for coal consumption. A study by M.Shlapak suggests that reduction of subsidies in the coal sector would considerably abate adverse impact on the environment [45].

Ukraine joined the WTO in 2008; hence, subsidies provided to the coal sector must be consistent with its rules and regulations. According to the WTO classification, subsidies in the coal of Ukraine's coal sector are labeled as so called "yellow subsidies" which are not prohibited but to which compensation sanctions may be applied [13]. O. Amosha believes that "Ukraine's WTO entry does not create any new problems for the coal industry. It only intensifies the existing problems which must be solved irrespective of the country's membership in the organization" [34]. It is important to note that Ukraine's Government is already taking certain steps in this direction. In particular, the Concept on the Coal Sector Reforms outlines the necessity to adopt subsidization in the coal sector to the WTO and EU requirements, including but not limited to the reconciliation of the state support with the level of prices, prohibition of the export of coal and gradual reduction of state subsidies [2]. The Ministry of Coal Industry has also prepared a draft Law of Ukraine on the state support (subsidization) of the coal sector taking into an account WTO requirements [16]. We can only hope that declared measures will be taken in time.

Thus, gradual decrease of energy subsidies, in particular, for the coal industry, would bring a number of positive economic and environmental consequences, including but not limited to improved energy efficiency; incentives for reduction of the prime cost of coal; abatement of negative environmental impacts, particularly GHG emissions. However, subsidy reform in the coal sector should be undertaken simultaneously with the revision of the energy pricing policy in the coal sector. In addition, it is necessary to take into account not only economic and social criteria, but environmental as well [45].

5.2. "Clean Coal" Technology

"There is no such thing as 'clean coal' for climate change. The description is a marketing triumph for the coal industry, like 'safe cigarettes' for the tobacco industry [55, 60]".

The term "clean coal" is used more and more often by officials and energy companies throughout the world. However, how could the coal be "clean"? Coal is the one of the dirtiest energy sources since it causes much more CO_2 emissions per energy unit comparing to natural gas and oil. Therefore, coal is the most responsible for climate change. Coal pollutes the environment at every stage of the production cycle, from mining to combustion. If to consider fresh water pollution, particles of mercury and other toxic substances (emitted in the combustion process) that damage human health, coal sector is obviously a dirty business [52]. There is a number of technologies that can reduce but not eliminate completely emissions from coal combustion.

The term "clean coal" refers to technologies that help decrease negative environmental impact from coal combustion. Some of these technologies enable purification of coal from impurities prior to combustion, e.g. washing out unwanted minerals by mixing the grinded coal with liquid and subsequent separation of impurities using one of the existing methods. Other approaches regulate coal combustion to minimize sulphur and nitrogen oxide emissions using wet scrubbers (flue gas desulfurization systems). Lower class coal (e.g. brown coal) is dewatered to increase calorie content and efficiency of energy production. Another method is coal gasification (Integrated Gasification Combined Cycle). A mixture of carbon mono-oxide and hydrogen (syngas) is created and then purified and combusted in a gas turbine to produce energy. The methods described above are used to decrease sulphur and mercury oxide emissions [48]. However, the most disputable method is

CO_2 capture and storage the limitations of which are described in the section below.

Pioneering "clean coal" programs were launched in 1980 as a response to concerns with acid rains. The programs were focused on the reduction of sulphur and nitrogen oxide emissions that are the main cause of acid rains. Nowadays, these technologies are used to promote coal as an energy source. However, "clean coal" technologies are hugely expensive and do not help to mitigate negative environmental impacts caused by coal mining or climate change [46]. Energy companies are spending a large amount of money to promote "clean coal", but it is obvious that it is much better to invest in energy-saving technologies and renewable energy sources than to spend money on making the dirty coal business look a bit more attractive.

Although some technologies do reduce the amount of harmful emissions caused by coal sector, "clean coal" is a deceptive term since it contains mutually exclusive notions. In addition, the term is not accurate since coal could not be clean a priori.

5.3. CO_2 Capture and Storage Technology

If CCS is ever able to deliver at all, it will be too little, too late [51].

Carbon Capture and Storage technology is an integrated process that combines three main stages: capture => transportation => storage (including measuring, monitoring and verification). The technology is designed to generate a concentrated flow of CO_2 which then can be compressed, transported, and stored. It is likely that the largest share of captured CO_2 will be transported to storage places locations is most likely to be via pipelines. It is expected that most CO_2 would be injected in geological formations on land or under the seabed. It has been also proposed to dispose captured CO_2 in the ocean but this method has been largely disregarded since CO_2 would have considerable impacts on the ocean ecosystem. In addition, legal system does not allow it. CCS is often used as an excuse by power companies and utilities to proceed with plans on the establishment of new coal-burning power plants. However, the technology will not help solve the problem of climate change for a number of reasons [51].

- **First of all, CCS cannot deliver in time to stop climate change.** In order to avoid the worst impacts of climate change, global greenhouse gas emissions have to peak and start falling after 2015. The urgency of the climate crisis means solutions must be available for extensive use as soon as possible. To date, there are no large coal-burning power plants in the world equipped to capture carbon or any that are retrofitted with storage operations. According to the IPCC, it is not likely that CCS will become commercially feasible until at least 2050. Even then, plants responsible for 40-70% of the electricity sector CO_2 emissions will not be technically suitable for carbon capture [51].

- **CCS is energy wasting.** It is estimated that 10-40% of a power station's capacity is required for capturing and storing carbon. This means that more coal is needed to produce the same amount of energy as the power station generated without CCS. CCS will also use more costly resources. In particular, 90% more freshwater will be utilized by power stations with CCS than those without. This will exacerbate water shortages, already aggravated by climate change. Overall, large-scale application of CCS is likely to eliminate the efficiency savings of the last 50 years, and increase in resource consumption by more than 30% [51].

- **Storing carbon underground is not safe.** The IEA estimates that for CCS to provide any meaningful climate mitigation effects by 2050, 6000 projects each injecting a million tons of CO_2 per year into the ground would be required. To date, it is not clear whether it will be technically possible to capture and store so much carbon. In particular, there are might be not enough storage locations, or that

they will be situated not too far from power plants. Transportation of CO_2 for distances of more than 100 kilometers is likely to be prohibitively expensive. It does not make any sense to capture CO_2 if there is not enough space available to bury it for a long time. Even if it is possible to store a huge amount of CO_2 there is no assurance that storage sites will be properly designed and maintained over the time periods required. There is a risk of leakage as long as CO_2 is in geological formations. Although it is not possible at the moment to estimate the exact risks, release of CO_2 could potentially affect the nearby environment. Even low leakage of about 1% could negate climate mitigation efforts [51].

- **CCS is an extremely expensive technology.** Although cost estimates for CCS differ significantly, one thing is certain – it is extremely expensive. CCS will require significant funding to establish the power station and appropriate infrastructure for transportation and storage of carbon. The US Department of Energy (US DOE) has estimated that retrofitting with carbon capture will increase plant costs in about two times. This will lead to energy price hikes of 21 to 91%. Providing the considerable levels of support required to start up CCS, the technology comes at the expense of real solutions. Current research shows that electricity generated from coal-fired power stations retrofitted with CCS will be more expensive than other renewable energy sources, such as wind power and various types of biomass. Recently, the share of coal in research and development budgets in countries targeting CCS has expanded. At the same time, funding for energy-efficiency and renewable technologies has remained the same or declined. Spending money on CSS diverts urgent funding away from more sustainable solutions for the climate crisis. Even assuming that at some point carbon capture becomes technically feasible, commercially viable, capable of long-term storage and environmentally safe, it would still only have a minimal effect and would come at a high cost. In contrast, Greenpeace's Future Investment report shows that investment in a renewable energy would save US$180 billion every year and reduce CO_2 emissions twice by 2050 [51].

- **CCS and legal/financial accountability: risky business.** Large-scale implementation of CCS constitute considerable liability risks, including adverse health effects and deterioration of ecosystems, contamination of groundwater including pollution of drinking water, and potential increase of CO_2 due to leakage of CO_2. There is no valid method for estimating the likelihood or severity of these risks. Industry views accountability as a constraint to wider application of CCS and does not want to invest in CCS without a system that protects it from long-term liability. Potential operators are urging that they only take legal responsibility for permanently stored carbon for ten years. Thus, the society will be responsible for CCS-associated risks [51].

Energy and power companies are concealing all risks and problems related to CCS to promote it and use as an excuse to build coal-burning power stations, so called "capture-ready" plants. According to the definition of IEA, a capture ready plant is the one which can be reconstructed to incorporate CO_2 capture when the required regulatory or economic instruments are introduced. This is broad enough to enable any installation to be capture ready theoretically. However, a real threat is that such power plants provide no assurance that CCS will ever installed since retrofitting is hugely expensive and the plant can become unprofitable. Even if the installation is technically suitable for CCS, there is no guarantee that it has an appropriate place to store carbon [51]. Therefore, the technology of carbon capture and storage cannot be considered as an instrument neither for Ukraine, nor for any other country.

6. GHG Emissions Reduction Policies

Caron tax and emissions trade systems are primary economic instruments used to cut greenhouse gas emissions. In case the tax is introduced, the polluting company pays for every ton of carbon emissions and can opt either to pay a tax or to reduce emissions, depending on the tax levels and the cost of emissions reduction. If emissions trading is implemented, the government distributes emission quotes between installations. The companies then choose whether to reduce emissions or buy permits from other companies.

- **Carbon tax**
  In 1920, Arthur Pigou expressed the idea of imposing taxes on environmentally harmful activities to reduce production volumes and, hence, pollution levels. The economist developed the theory of externalities[1] and suggested imposing taxes on harmful emissions at the level required to remove environmental damage caused. This way polluters will take responsibility for all the consequences of their activities [46]. Thus, the main objective of environmental taxes is internalization of externalities i.e., compensation of damage. Environmental taxes implementation of the "polluter pays principle"; create incentives for a transition from environmentally damaging technologies to more environmentally friendly ones; help reduce emissions in a more economically efficient way than regulatory

1 Externality is the impact of activity or behavior of one person on another person, where the former does not take responsibility for. Externalities may be both positive and negative, but environmental economics is focused on the latter, e.g. environmental pollution [46].

mechanisms, e.g. standards. Moreover, environmental taxes bring income to the country which can be used either to solve environmental problems or to cut other taxes [50].

- **Emissions trading scheme**
  Introduction of tradable emissions permits as a pollution control instrument was first suggested in 1968 by John Dales, and the first emissions trading programs were implemented in the United States under the Clean Air Act in 1997 [58]. The implementation of the emissions trading scheme resulted in reduction of sulphur oxide emissions (IV) that cause acid rains, and also brought significant savings compared to expenses that would be incurred if regulatory instruments were used. Later, USA adopted a number of other emissions trading schemes. In the United Kingdom, permits trading is used for municipal waste management while in Denmark and Italy it is established for renewable energy sources [46]. In 1997, the Kyoto Protocol was adopted, and emissions trading became an instrument for global GHG emissions reduction [58].

In October 2003, an EC Directive [47] was approved to create a legal framework for emissions trading. The Directive sets the rules for calculation of quotes, their allocation and monitoring. In 2005, the trading system was officially launched for a two-year pilot period ending in 2007. At the first stage, the system has covered carbon emissions only of large installations (nearly 11,500 companies that collectively emitted 2190.8 million tons of carbon). Information shortage about the real permit deficit at the market resulted in significant price fluctuations. The supply of permits significantly exceeded the demand. In particular, EU countries collectively issued 44 million of excessive CO_2 certificates. As a result, the emissions trading system was absolutely not effective during the first period. The second stage has started in 2008 and will end in 2012. The European Commission considered mistakes of the first period, revised the rules on approval of the total number of European Union Allowances (EUAs) for each country and approved stricter rules for EUAs allocation [49].

Main advantages of the tax are that it guarantees a defined and stable cost of emissions reduction, could maintain a fiscal function (raise income for the government), is easy to implement and does not require significant legal and institutional changes. Administrative expenses for the tax implementation will not be very high since Ukraine has a functioning tax system and these mechanisms are well established. At the same time, the principal limitation is a difficulty to estimate appropriate tax rate to ensure desired emissions reductions. In contrast, the emissions trading system guarantees emissions reduction at a certain level due to allocation of a defined number of permits. However, the price of emissions reduction permits could vary significantly, which complicates making decision-making on technologies implementation that will bring emissions reductions in a log-term perspective. Moreover, implementation of emissions trading system requires considerable institutional and legal changes and high administrative costs.

It is important to note that Ukraine has preconditions to implement both instruments. The draft of the Tax Code of Ukraine [21] has provisions for implementation of the carbon tax with a tax rate of UAH 0.20 per ton (which is unusually low compared to other countries, e.g., $150 per ton in Sweden [57]) that obviously would not result in emission reductions[1]. In addition, domestic emissions trading system is being developed. Although first steps in using economic instruments of climate protection in Ukraine might be ineffective, it is essential to introduce more strict rules to reduce greenhouse gas emissions.

Since coal is the most carbon-intensive fuel, it is obvious that companies that use coal as a fuel would have to either pay higher tax or invest more in emissions reduction. This fact also gives the reasons to think once again whether it makes sense increasing the share of coal in the energy balance as suggested by the energy strategy.

1 Combustion of one ton of coal releases 1.8 ton of CO_2 (according to the Energy Strategy [22] and the National Inventory of Anthropogenic Greenhouse Gas Emissions [26]). If a tax is implemented with a rate of UAH 0.2 for a ton of CO_2, companies will pay UAH 0.36 for combustion of one ton of fuel. As of 2008, one ton of coal costs UAH 446. Therefore, such tax is unlikely to stimulate the reduction of coal combustion and CO_2 emissions.

Conclusions

Coal sector of Ukraine no longer plays the role it had in the Soviet Union times, coal mining has dropped significantly, and the quality of coal decreased due to depletion of seams. Instead, the country has inherited a totally unprofitable economy sector that requires constant investments. The sector also causes a number of social and environmental problems, which are aggravate with time, but the state has neither political will nor financial resources to solve them.

Current subsidization from the state budget is not a solution. First of all, it does not reduce the prime cost, and, secondly, it is a weighty burden for the budget. It is essential to create favorable conditions to attract investments from non-governmental sources. Although Ministry of Coal Industry is taking certain steps in this direction (e.g., a decree of Coal Ministry No. 484 of 22.09.2008 on investments to the coal sector), coal sector would not be attractive for investors unless coal price becomes higher than its prime cost. Thus, it is essential to set a market price of coal and close down unprofitable mines. This would increase profitability of the sector and would help to reduce gradually state subsidies and raise non-governmental investments.

Mining regions are facing a number of social problems related to unemployment, crime and drug addition that should be solved simultaneously with the efficient restructuring of coal sector.

It is obvious that first of all it is necessary to solve current problems of the sector and after this consider possible increase of coal production, if this is economically and environmentally reasonable. However, it is projected to increase the share of coal in the country's energy balance from 22% (43.5 mn of equivalent fuel) in 2005 to 33% (101 mn tons of equivalent fuel) in 2030 (according to the basic scenario). Whether and for how much coal production would be increased by 2030 depends on many factors such as economic and political situation in the country. However, Ukraine might not need to increase significantly coal production to cover domestic energy needs if to consider potential of energy-saving technologies and renewable energy sources, and reduction of energy demand due to economic recession. In addition, it would be a heavy burden for the economy of the country to maintain the fuel and energy complex at the required level and provide funding suggested by the Strategy. Thus, implementation of energy efficiency technologies and development of renewable energy sources is of immense importance today since it would reduce significantly consumption of the primary energy resources, improve the energy security of Ukraine and save budget money.

Moreover, it is important to emphasize that development of fuel and energy complex, particularly coal sector, should be planned to take into account negative impacts on environment (in particular, climate change) and human health. Hence, appropriate state programs should be developed and funded.

Recommendations

Regarding energy policy in the coal sector:

- To take more active steps to increase the profitability of the coal sector (close down unprofitable mines and privatization of profitable and promising ones).
- To set a market price for coal and reduce its prime cost.
- To develop a program of gradual reduction of energy subsidies in Ukraine, particularly, decrease the compensation of prime cost of coal and capital investments from the country's budget.
- To take measures for urgent termination of shadow coal market. In particular, introduce strict punishment for unauthorized coal mining in closed mines and open-pit coal extraction in the places that are not approved for such operations.
- To improve safety level at mines through better compliance with safety requirements, and installation of equipment required to prevent emergency situations. It is recommend to close mines where coal mining is extremely dangerous even if all possible safety measures are introduced.
- To prepare and gradually implement a program of economic restructuring of the coal-mining areas. This is essential precondition to solve social problems and develop former "one-company" towns and villages.
- To promote implementation of technologies to catch and utilize methane from mines, in particular, within the joint implementation mechanism under the Kyoto Protocol.
- To launch a large-scale national program for land re-cultivation and environmental restoration of mining lands.

Regarding Energy Strategy in the coal sector:

- To conduct an in-depth assessment of economic expediency of coal mining and an increase of coal consumption.
- Energy security problem should be solved through reduction of the energy consumption rather than the substitution of gas with coal.
- Prior to increasing of coal production, it is essential to explore fully the potential of energy saving and the renewable energy technologies. It is strategically beneficial decision since it not only mitigates negative environmental impact of the energy industry but would also help to reach considerable budget savings.
- To revise Energy Strategy of Ukraine taking into an account the impact of coal mining and consumption on the environment, particularly climate change aspect.

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Appendix A

Estimation of Greenhouse Gas Emissions from Coal mining and Consumption

Estimation of GHG emissions from coal mining and consumption is based on the data provided by the National Inventories of Anthropogenic Greenhouse Gas Emissions [24,26,25,23]. GHG emissions from coal mining and consumption are reflected in the three categories of GHG emissions sources described in the Inventories (see Table A.1).

Table A.1

Categories of GHG emissions sources	carbon equiv., mn tons	Year				
		1990	2004	2005	2006	2007
2.C.1 Cast iron and steel production	CO_2	80	58	56	61	59
1.A.1, 1.A.2, 1.A.4, 1.A.5 Stationery combustion of solid fuel[1]	CO_2	182	74	78	92	93
1.B.1.a Coal mining and use	CH_4	55	29	28	29	28
Total		318	162	162	182	179

1 1.A.1 Energy sectors; .A.2 Industry and construction;1.A.4 Other sectors (private households, commercial sector, agriculture etc); 1.A.5 Other (sectors that are not included into the above categories).

Appendix B

Projections of Coal mining and Consumption

Tables B.1 and B.2 illustrate projections of coal mining and consumption according to Ukraine's Energy Strategy [22].

Table B.1

	2005	2010	2015	2020	2030
Coal mining, mn tons	78	90,9	110,3	115	130

Table B.2

Economy sector	2005	2010	2015	2020	2030
Coking industry	17	32	36,2	41,2	41,5
Power plants on organic fuel	27,5	33,4	49,6	54	78,1
Internal needs of companies	2	1,9	1,8	1,7	1,6
Utilities	1,6	1,5	1,4	1,3	1,1
Other consumers	11,6	10,1	9,7	9,4	8

Appendix C

Projections of Greenhouse Gas Emissions from Coal Mining and Consumption

To estimate approximate levels of emissions, the data on projected amount of coal mining (see Table B.1) and consumption (see Table B.2) according to Ukraine's Energy Strategy up to 2030 [22] and greenhouse gas emissions data for 2005 indicated in the Inventory (see Table A.1) is used, 2005 is taken as the baseline.
The following assumptions have been made to simplify the estimates:

- Methane emissions will grow proportionally to the amount of coal extracted.
- Possible renovation of mines and implementation of methane catching technologies by 2030 is taken into account.
- Emissions from coal consumption by power stations for domestic needs of companies and utilities and other consumers are given in the Inventory for 2005 in (categories on stationary combustion of solid fuel: 1.A.1, 1.A.2, 1.A.4, 1.A.5).
- All coke produced by coking industry will be used in cast iron and steel production. Therefore, emissions are given in the Inventory under the category "2.C.1 Cast iron and steel production".
- Emissions given in Table A.1 will grow in proportion to increase of coal mining and consumption.

Estimated results are given in Table C.1.

Table C.1

Categories of GHG emissions sources	2005	2010	2015	2020	2030
2.C.1 Cast iron and steel production	56	105	119	136	136
1.A.1, 1.A.2, 1.A.4, 1.A.5 Stationery combustion of solid fuel	78	85	114	121	161
1.B.1.a Coal mining and management	28	33	40	42	47
Total	162	224	273	298	346

Appendix D

Climate Change Problem in Ukraine

Many politicians do say that Ukraine should primarily focus on economic development and then solve its environmental problems; climate change is a secondary problem for Ukraine.. However, this is just an excuse for not doing anything to cut greenhouse gas emissions. The country is facing global climate change problem just like all other countries do. Though negative climate change impacts in Ukraine will not be as severe as in island countries, Ukraine may also suffer from the increase of abnormal natural phenomena, e.g. droughts, floods, spread of malaria and other infection diseases typical for warmer areas. Southern regions may become deserts while coastal areas would be drowned. A likely consequence is a massive immigration from southern countries where living conditions will become intolerable [35].

It is important to note that many countries are seriously intended to cut emissions and demand that other countries make certain efforts as well. International pressure on the countries that plan to increase their emissions is growing. Hence, Ukraine's position for 20% emission reductions by 2020 from 1990 level is not politically acceptable since, in fact, it means emissions growth [36]. Sooner or later, Ukraine will have to take serious commitment. And the sooner we do this, the more time we will have to adapt the national economy.

Moreover, there are a number of economic leverages which can be used, for example, by the European Union against the countries that do not take steps to reduce carbon emissions in order to protect its own companies from import of carbon intensive (and therefore cheaper) products from other countries. Victor Skarshevskiy[1] believes that a real threat for domestic export-oriented economy will be a potential "ban on import into EU of carbon-intensive products – I mean metallurgical products, maybe cement, or aluminum. It's not something that is far future, and it's not a Conference with 192 participating countries, it's The European Commission that sometimes makes decisions very quickly. After December 2009, when details of the post-Kyoto agreement will be disclosed, the European Commission will be able to make relevant decisions — maybe, on carbon tax, or maybe environmental damping. Another thing is how it will be implemented". To make domestic companies competitive on the international market, a nation-wide policy to reduce carbon intensity of production should be initiated as soon as possible.

Therefore, a conclusion could be made that the sooner Ukraine will take steps to cut its greenhouse gas emissions, the better environmental, political and economic results it will achieve.

1 Source: shorthand record of Youth Parliament Hearings on Climate Change of June 22, 2009.

Appendix E

Potential of Alternative Energy Sources

Some politicians believe that Ukraine does not have enough alternative energy sources that can fully provide the country with energy. This idea favors the owners of industrial companies who make profits from the increased use of traditional energy sources, which are often used inefficiently and are the primary sources of environmental pollution. However, there are alternatives ways of development of the energy sector. In particular, many countries effectively explore the potential of renewable energy sources. In 2001, the share of renewable energy in Norway was 45%, in Sweden 29.1%, in New Zealand 25.8%, in Finland 23%, in Austria 21.5%, in Canada 15.6%, and 10.4% in Denmark. Most countries are going to increase RES. Ukraine has also a good potential to develop alternative energy sources. Estimates of environmental organizations described in the critical analysis of principal provisions of Ukraine's Energy Strategy show that the share of RES in 2030 may amount to 33.7 million tons of equivalent fuel, or 11% of the overall consumption of fuel and energy in 2030 (with 302.7 million tons of equivalent fuel required), or 14.2% (with 237.5 million tons of equivalent fuel required, if Ukraine will intensively implement energy-saving measures) (see Table E.1) [30]. Obviously, Ukraine will not be able to cover 100% of its energy needs with renewable energy sources. Therefore, it is necessary to reduce energy consumption using energy efficiency technologies and fully explore the potential of RES.

Table E.1.
Potential of Alternative and Renewable Energy Sources in 2030, million tons of equivalent fuel per year [30].

Total off-balance energy sources	22,20
Including mine methane	0,93
Renewable energy sources, total, including	33,7
Bioenergetics	20,0
Solar thermal energy	2,0
Solar electrical energy	0,7
Small hydro	1,3
Geothermal energy	1,1
Wind energy	8,6
Total	55,9

Appendix F

Emissions from energy generating companies and power stations, which belong to statutory fund of the National Stock Company (NSC) «Energy Company of Ukraine»

As of 1.01.2009 (based on the latest data , 2008)

	Emissions, thousand of tons			
	CO_2	SO_2	NO_x	Solid particles
Heat power plants of NCS «ESU», total	**62304,3**	**811,0**	**113,8**	**196,5**
including:				
Energy generating thermal power plants, total	**55690,2**	**810,7**	**106,6**	**196,4**
including:				
OSC "Dniproenergo"	**15984,2**	**224,0**	**41,7**	**42,0**
Kryvorizka TPP	*6566,8*	*114,05*	*12,87*	*18,19*
Prydniprovska TPP	*4011,5*	*52,46*	*14,48*	*16,87*
Zaporizka TPP	*5405,9*	*57,46*	*14,35*	*6,96*
OSC "Donbasenergo"	**7322,2**	**67,0**	**14,3**	**52,2**
Starobeshivska TPP	*4755,3*	*41,87*	*9,34*	*46,18*
Slavanska TPP	*2567,0*	*25,17*	*5,0*	*6,06*
OSC "Zahidenergo"	**1417,1**	**313,9**	**19,7**	**46,7**
Burshtynska TPP	*8889,0*	*179,55*	*11,72*	*25,69*
Dobrotvirska TPP	*2064,5*	*42,32*	*3,32*	*13,39*
Ladyzhynska TPP	*3763,6*	*92,03*	*4,69*	*7,63*
OSC "Centrenergo"	**17666,7**	**205,7**	**30,8**	**55,4**
Vulegirska TPP	*4450,7*	*85,19*	*8,62*	*5,68*
Trypilska TPP	*6883,3*	*46,36*	*14,49*	*17,75*
Zmiivska TPP	*6332,7*	*74,19*	*7,72*	*32,01*
Heat and power plants	**6614,1**	**0,4**	**7,2**	**0,1**
OSC Dniprodzerzhynska HPP	*101,7*	*0,00*	*0,14*	*0,00*
OSC Mykolaivska HPP	*122,1*	*0,00*	*0,11*	*0,00*
OSC Khersonska HPP	*191,3*	*0,00*	*0,10*	*0,00*
OSC Odesska HPP	*150,3*	*0,00*	*0,12*	*0,00*
OSC Kharkivska OSC	*898,6*	*0,27*	*0,87*	*0,01*
SC HPP "Kievenergo"	*5150,1*	*0,10*	*5,83*	*0,10*

Information on energy generating companies and power stations, which belong to statutory fund of the National Stock Company (NSC) "Energy Company of Ukraine")

(According to information request of National Ecological Centre of Ukraine to the Ministry of Energy and Fuel Resources of Ukraine)

As of 1.01.2009 (based of latest data of 2008)

	Installed capacity	Operating ratio	Fuel (%)			Prime price	
	MWt	%	coal	gas	mazut	electricity (UAH cents/ kWth)	heat (UAH/Tcal)
Energy generating companies of NSC «ECU», total	**25059,6**	**27,4**	**76,28**	**23,51**	**0,22**	**31,76**	**177,82**
Thermal power plants, total	**23140**	**26,5**	**90,74**	**9,06**	**0,20**	**32,01**	**183,19**
including:							
OSC "Dniproenergo"	**8185**	**22,3**	**93,42**	**6,40**	**0,18**	**30,85**	**218,94**
Kryvorizka TPP	*2820*	*25,6*	*97,27*	*2,41*	*0,32*		
Prydniprovska TPP	*1765*	*26,2*	*88,49*	*11,43*	*0,08*		
Zaporizka TPP	*3600*	*17,9*	*93,28*	*6,61*	*0,12*		
OSC "Donbasenergo"	**2680**	**30,6**	**92,31**	**7,02**	**0,67**	**31,10**	**144,95**
СтаробешівStarobeshivska TPP	*1800*	*30,5*	*90,30*	*8,95*	*0,75*		
Slavanska TPP	*880*	*30,8*	*96,34*	*8,15*	*0,51*		
OSC "Zahidenergo"	**4700**	**36,2**	**93,47**	**6,45**	**0,09**	**34,43**	**163,67**
Burshtynska TPP	*2300*	*44,2*	*95,67*	*4,30*	*0,03*		
Dobrotvirska TPP	*600*	*38,4*	*97,33*	*2,58*	*0,09*		
Ladyzhynska TPP	*1800*	*25,3*	*86,11*	*14,68*	*0,21*		
OSC "Centrenergo"	**7575**	**23,6**	**84,59**	**15,28**	**0,13**	**31,31**	**140,27**
Vulegirska TPP	*3600*	*16,2*	*77,68*	*22,24*	*0,07*		
Trypilska TPP	*1800*	*28,4*	*84,24*	*15,57*	*0,20*		
Zmiivska TPP	*2175*	*31,9*	*90,60*	*9,28*	*0,12*		
Heat and power plants	**1919,6**	**38,3**	**0,00**	**99,72**	**0,28**	**29,62**	**177,34**
OSC Dniprodzerzhynska HPP	*61,6*	*13,7*	*0,00*	*100,00*	*0,00*	*36,28*	*86,29**
OSC Mykolaivska HPP	*40*	*25,8*	*0,00*	*100,00*	*0,00*	*39,65*	*190,85*
OSC Khersonska HPP	*80*	*16,8*	*0,00*	*100,00*	*0,00*	*36,12*	*319,91*
OSC Odesska HPP	*68*	*14,1*	*0,00*	*100,00*	*0,00*	*46,78*	*42,19**
OSC Kharkivska OSC	*470*	*34,5*	*0,00*	*98,36*	*1,64*	*32,26*	*49,60**
SC HPP "Kievenergo"	*1200*	*44,2*	*0,00*	*99,96*	*0,04*	*28,07*	*196,95*

* These heat and power plants use provided fuel to produce heat, which explains the substantially lower level of prime price of the produced heat in comparison to other HPPS.

"According to the base scenario of the Energy Strategy it is planned to increase the share of coal in the energy balance from 22% (43.5 mn tons of equivalent fuel) in 2005 to 33% (101 mn of equivalent fuel) by 2030. Since coal is the most carbon-intensive fuel, increased consumption of it will more than double greenhouse gas emissions by 2030 (to 350 mn tons of CO_2 equivalent)."

"Energy security is of crucial importance for the independent country but reduction of the gas consumption at the expense of coal is not the best approach. First of all, energy security should be addressed through reduced energy consumption. We recommend that priority should be given to energy-saving measures and renewable energy sources. This is a strategically sound solution since it minimizes negative environmental impact of the energy production and contributes to the significant saving of the budget funds."

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