UNDP Blue Ribbon Analytical and Advisory Centre
Energy Policy Team

COMPARATIVE ANALYSIS

EU and Ukraine Security of Energy Supply

September 2007

TABLE OF CONTENTS

This report was prepared in the framework of the UNDP Blue Ribbon Analytical and Advisory Centre financed by the European Union Tacis Programme for the Ministry of Fuel and Energy of Ukraine and represents the authors' views on energy facts, figures and projections.

Authors: Iñigo Arencibia González and Yevgeniy Bobrov.

INTRODUCTION

Sources

The main sources of data for this paper have relied upon publicly available reports. For the establishment of baseline information (2004) from both Ukraine and the European Union, most information has been provided by the International Energy Agency (IEA).

The information on developing scenarios is based on those developed for Ukraine's Energy Strategy until the year 2030 and the scenarios on energy which are part of the "European Energy & Transport Outlook, trends to 2030" as updated in 2005.

When other sources have been used, references have been inserted.

Except for the chapter dealing with a common energy security, figures for both EU and Ukraine taking account only of total primary energy needs less any exports of energy resources.

Conversion from tons of coal equivalent (tce, Ukrainian standard) into oil equivalent (toe, IEA standard) has been done at the factor 1 tce = 0.7 toe.

Conversion from million barrels per day (Mbpd) to million tonnes of oil equivalent (Mtoe) is undertaken here at the standard rate of 50 Mtoe per Mbpd.

Establishment of a baseline

The consultant has reviewed existing information on energy demand for Ukraine and the EU searching for a baseline year where public and comprehensive statistics were available for both cases. The choice was made for 2004, the last year for which comparable set of data on Ukraine and EU was publicly available.

When analysing the horizon over which to make the analysis, the availability of the EU Green Paper "A European Strategy for Sustainable, Competitive and Secure Energy" looking at the period 2030 and the "Ukraine Energy Strategy until 2030" made the case for setting comparison in the timeframe 2004-2030.

Demographic and macroeconomic assumptions

Population, EU-25

(million)

2004	2010	2020	2030
459.5	464.1	469.3	469.4

Population, Ukraine

(million)

2004	2010	2020	2030
47.4	45.2	41.7	38.1

Sources: *Eurostat and World Population Prospects: The 2006 Revision* and *World Urbanization Prospects. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat*

Gross Domestic Product

EU-25 (in billion 2000 euro)				***Ukraine (in billion 2005 UAH / EUR)*** [1]			
2004	**2010**	**2020**	**2030**	**2004**	**2010**	**2020**	**2030**
9 897.6	10 946.8	13 656.3	16 051.4	327.4 53.2	523.7 85.2	852.4 138.6	1 286.2 209.2
Yearly GDP growth							
04-10	***10-20***	***20-30***	***04-30***	***04-10***	***10-20***	***20-30***	***04-30***
1.69%	2.24%	1.63%	1.88%	8.14%	4.99%	4.20%	5.40%

[1] IMF-based exchange rate €1 = 6.1481 UAH.

Main assumptions

The scenario assumes that all current policies and those in the process of being implemented at the end of 2004 will continue in the future. However, it is not assumed that the indicative targets, as set out in various EC Directives (renewables electricity Directive 2001/77, Directive 2003/30 on renewable energy in transport will be necessarily met. This approach allows the Baseline scenario to be considered as the benchmark against which a number of alternative policies can be judged, assisting in the evaluation of alternative measures.

The scenario takes into account:

- Technological progress, induced both by economic growth and by modernisation of installations in all sectors of the economy, thereby improving the efficiency of the energy system.
- The restructuring of the sectoral pattern of economic growth
- The effects from restructuring of markets through the liberalisation of electricity and gas in the EU; liberalisation is assumed to be fully implemented in the period to 2010.
- Power and steam generation continue their restructuring, enabled by gas power generation technologies that are efficient, involve low capital costs and are flexible.
- Changes in primary energy production patterns, which is expected to continue to some extent over the next few decades.
- Differences in current policies of EU-25 Member States as regards nuclear capacity, taking into account policy decisions as regards nuclear phase out in Belgium, Germany and Sweden; and plans concerning nuclear plant refurbishment/closure in new Member States.
- The effects arising from the voluntary agreement reached between the European Commission and the European automobile industry on specific CO2 emissions from new cars (followed by similar agreements with Korean and Japanese car manufacturers).

Concerning the use of biofuels in transportation, it was assumed that all countries would follow EU rules. The impact of blending gasoline and diesel with biofuels on final consumer prices was assumed to be negligible, since higher fuel production costs will probably be offset by tax reductions scheduled to be implemented on these fuel blends.

The discount rate is a crucial element in the determination of investment decisions. Three (real) rates are currently used within the model. The first, used mostly for large utilities, is set at 8%; the second, for large industrial and commercial entities, is set at 12%; the third, used for households in determining their spending on transportation and household equipment, is set at 17.5%.

For the scenario in Ukraine, the main assumption lays in the progressive reduction of energy intensity in its economy. Specifically, the target is to achieve intensity of 0.34 kilograms of oil equivalent per thousand $ of GDP (at constant 2000 prices)[i]. This is a very ambitious target in view that energy intensity in 2004 was 3.19 kgoe / th.$. When measuring GDP on a power purchase parity basis, energy intensity in 2004 amounts to 0.50 kgoe / th.$ against an objective of 0.29 kgoe / th.$.

PRIMARY ENERGY NEEDS AND DEMAND PROJECTIONS

Primary energy consumption

Having peaked around the year 2000, indigenous primary energy production in the EU is continuing its decline. The decline primarily concerns the production of fossil fuels. Coal extraction has declined under pressure from cheaper and cleaner coals available in the world market. In the meantime, production of natural gas and oil is declining due to the exhaustion of currently exploited reserves.

In the meantime, energy demand has not experienced much growth in the last years within the EU25. Higher demand in the “old” Member States was offset by the shift in the economy activity of “new” members, the massive closure of old energy-inefficient activities and the progressive alignment of energy prices to the world market.

Ukraine economic growth which took off during the first half of this decade has reversed the declining trend in energy consumption, which as a result, is showing moderate growth, which is expected to average 0.9 percent yearly between 2004 and 2010.

As a result of economic growth, indigenous production of primary fuels is increasing. On the one hand, coal extraction is on the rise, while oil and gas reserves are slowly coming online. These should be the subject of appraisal given that preliminary data points to important oil & gas reserves the extraction of which, given current market prices, could be economically viable.

The table below provides a snapshot of primary energy demand in the EU25 and Ukraine.

Primary Energy Supply in the EU25 and Ukraine in 2004[iiiii]
(in Mtoe)

EU-25				Ukraine		
Production	**Net imports**	**Total supply**		**Production**	**Net imports**	**Total supply**
895.4	861.8	1 757.2	**All fuels**	76.3	64.0	140.3
192.1	119.1	311.9	**Coal**	30.8	2.3	33.2
139.0	516.5	655.5	**Liquid fuels**	4.3	13.5	17.8
192.2	226.2	418.4	**Gas**	17.2	48.7	65.9
257.1	-	257.1	**Nuclear**	22.6	-0.5*	22.2
115.0	-	115.0	**Renewables**	1.2	-	1.2

(*) adjustment for electricity exports from Ukraine.

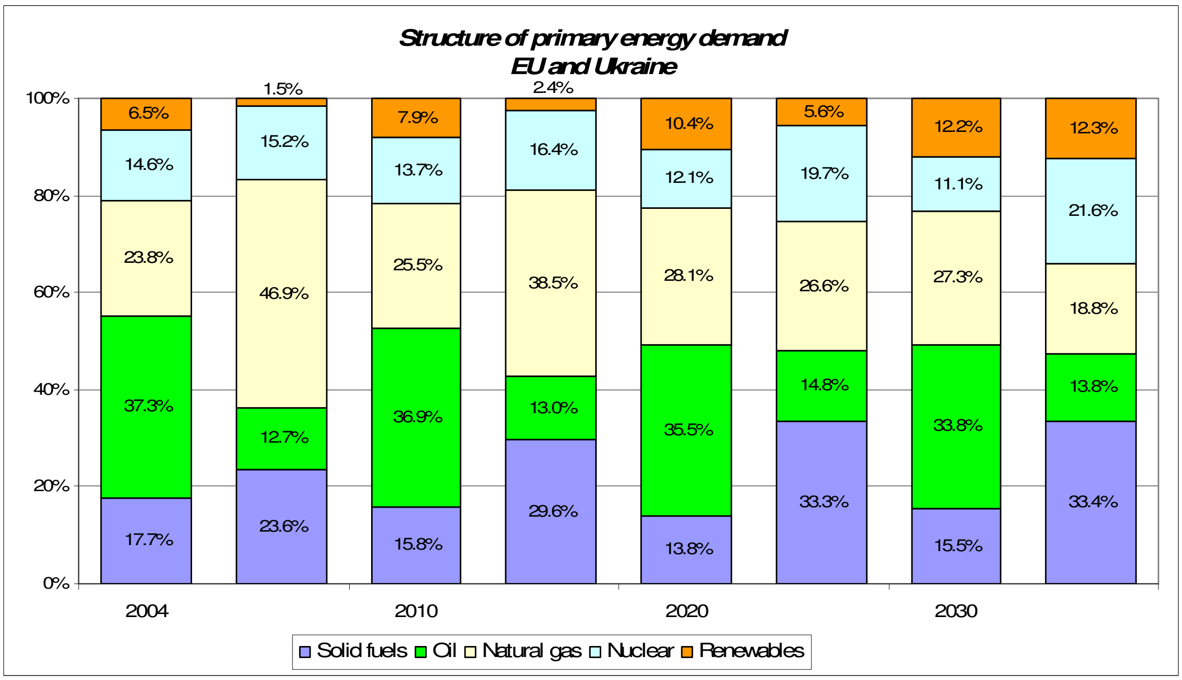
Primary energy demand until 2030

In the projections for EU demand of primary energy, this is set to grow by 8.9% in the period 2004-2030. The increase in primary energy needs is more pronounced in the short term (until 2010) as sluggish economic growth in recent years limits the scope for energy intensity improvements. In the long run consumption virtually stabilises reflecting a more service oriented economy, low economic growth, saturation effects in the demand side and stagnating population.

in Mtoe	**2004**		**2010**		**2020**		**2030**	
All fuels	1,757.2	140.3	1,812.5	148.1	1,885.3	171.2	1,895.2	211.7
% annual growth	0.5%	0.9%	0.4%	1.5%	0.1%	2.1%	0.3%	1.6%
Solid fuels	311.2	33.2	286.8	43.8	259.5	57.0	293.1	70.7
% annual growth	-1.4%	4.8%	-1.0%	2.7%	1.2%	2.2%	-0.2%	3.0%
Oil	655.5	17.8	668.7	19.3	669.9	25.3	640.5	29.3
% annual growth	0.3%	1.3%	0.0%	2.7%	-0.4%	1.5%	-0.1%	1.9%
Natural gas	418.4	65.9	462.2	57.0	529.7	45.6	517.8	39.8
% annual growth	1.7%	-2.4%	1.4%	-2.2%	-0.2%	-1.3%	0.8%	-1.9%
Nuclear	257.1	21.3	248.8	24.3	228.6	33.8	210.8	45.8
% annual growth	-0.5%	2.2%	-0.8%	3.4%	-0.8%	3.1%	-0.8%	3.0%
Renewables	115.0	2.2	143.8	3.6	195.5	9.5	230.8	26.1
% annual growth	3.8%	8.7%	3.1%	10.3%	1.7%	10.6%	2.7%	10.0%

Natural gas and renewable energy forms are projected to be the fastest growing fuels in the EU-25 energy system, growing at rates several times faster than overall growth of total energy needs. Primary energy demand for liquid fuels remains stable over the projection period. Solid fuels, after a strong decline to 2020, are projected to regain some market share in the EU-25 energy system beyond 2025 as a result of the increasing competitiveness of imported coal and also nuclear plant decommissioning. By 2030, primary energy demand for solid fuels is projected to come close to that observed in 2004. Overall, the share of fossil fuels is projected to reach 76.6% of primary energy demand in the EU-25 energy system by 2030 compared to 78.9% in 2004.

As regards non fossil fuels, nuclear energy accounts for 11.1% of primary energy demand in 2030 (compared to 14.6% in 2004) following the political decisions on nuclear-phase out in certain Member States and the closure of plants with safety concerns in some new Member States, and the decommissioning of old nuclear power plants at the end of their lifetimes (40 years in this model). The share of renewable energy forms increases significantly from 6.5% of primary energy demand in 2000 to reach 12.2% in 2030.



In Ukraine's case, demand for primary energy sources is set to grow by 54.9% in the period 2004-2030. These projections ought to be regularly monitored to take account of real economic growth, sector contributions to the economy as well as demographic considerations.

Natural gas is the one fuel which is set to have a substantial decline over the period, 39.5%. This is a response to recent hikes in gas prices which are set to approximate to world gas prices. Hence it may be deemed as a declaration of intentions, but no policy guidelines have been enacted in this respect. In a scenario of substantial growth of energy needs, substitution of natural gas is based upon the growth in use of solid fuels, nuclear power and renewables. Accordingly, natural gas will make 18.8% of primary energy needs by the year 2030 down from its 46.9% share in 2004.

Demand for solid fuels is expected to grow by 113% by 2030, mainly through the commercial development of Ukraine significant coal reserves. As a result, coal will make over 33% of primary energy needs. Nuclear power will also increase in the period 2010-2020. This is due to the commissioning of new capacities from 2010 onwards. Accordingly, the contributions of nuclear power will more than double, representing 21.6% of primary energy needs in 2030 from a 15.2% share in 2004.

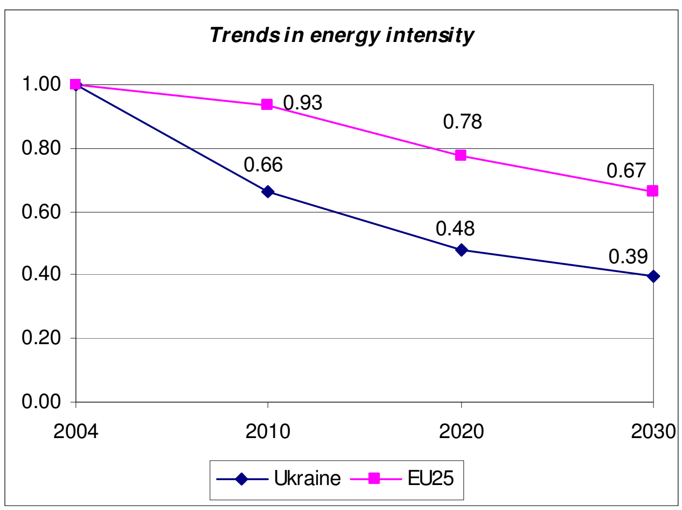
By and large, renewable energy sources (RES) are expected to be the fastest growing source in Ukraine primary energy needs. Overall, the growth of RES is set to be more than six times the growth rate of overall energy needs in the period at hand. As a result, the share of RES is set to increase to over 12% of primary energy needs by 2030.

As regards fossil fuels, their contribution to primary energy needs will grow by almost 20% as a result of increasing use of coal and oil. Nonetheless, when offset against steep reduction in natural gas, their contribution to Ukraine total energy needs will come down from 83.3% in 2004 to 66.1% in 2030.

ENERGY INTENSITY

In the EU25, the 9% increase of energy consumption by 2030 is much lower than the growth of GDP over the same period (69%) so that energy intensity (= ratio between energy consumption and GDP) improves by 1.5 % pa up to 2030. This is an improvement over the recent years, where there has been a slowing down of energy intensity improvements in recent years following sluggish economic growth with lower capital turn-over towards energy efficient equipment.

In Ukraine, where GDP measured at constant prices is expected growth almost threefold, the 55% increase in primary energy consumption provides for unusually large improvement in energy intensity. According to IEA and WB estimates, when adjusted for differences in power purchase parity, the energy intensity of Ukraine of Ukraine's economy in 2004 was 3-3.5 times higher than in the EU.



By 2030 Ukraine's energy intensity is set to reduce by to less than half its 2004 value. But this is a result of natural changes in consumption with limited impact from active measures to improve energy savings and efficiency.

Even when adjusted to PPP, Ukraine's intensity by 2030 will still be 15 to 20 percent higher than that of the EU25 in 2004, which still accounts for energy-intensive industries undergoing restructuring.

SECURITY OF SUPPLY

Import dependency is one of the main criteria when considering security of supply. Before we proceed further, we must note that nuclear energy will hereby be considered as an indigenous energy source both for Ukraine and the EU. Nevertheless, it must be noted that Ukraine, while having uranium reserves and capacities to produce "yellow cake", relies on imports for all its nuclear fuel needs.

Both EU and Ukraine are net importers of energy in large amounts. In 2004, the EU imported over 50% of its primary energy needs, while Ukraine did so for 62% of them. In the long term however, the trends are intended to diverge. By 2030, the EU will have to import almost 64% of its primary energy needs, or 1.2 billion tons of oil equivalent (toe). At the same time, Ukraine's dependency on import will amount to about 21% of primary demand, or as little as 54.6 Mtoe.

Import dependency (in %)

EU-25					*Ukraine*			
All fuels	**Coal**	**Oil**	**Gas**		**All fuels**	**Coal**	**Oil**	**Gas**
50.5%	38.2%	80.2%	54.5%	**2004**	62.3%	7.4%	83.3%	73.9%
53.9%	46.1%	82.5%	62.7%	**2010**	33.9%	7.9%	73.6%	60.3%
62.5%	49.5%	92.1%	81.4%	**2020**	24.4%	6.9%	78.7%	43.9%
63.9%	59.0%	93.2%	84.6%	**2030**	20.8%	11.2%	81.6%	33.4%

Sources: Eurostat and IEA

The main reason for this difference lies in Ukraine's intention to reduce the contribution of natural gas from its 2004 levels. In absolute terms, this would imply that by 2030, natural gas needs will be 40 percent less than in 2004. This dramatic drop in gas contribution towards primary energy demand will be offset through: 1) increased use of indigenous coal, 2) the commissioning of additional nuclear power plants and, 3) the introduction of renewables.

On the other hand, while demand is not set to grow as much as in Ukraine, the exhaustion of indigenous oil and gas reserves will play a key role in the increased reliance on imports of primary energy. Transport use of oil and the increased use of gas will account for 85% of imported primary energy sources by 2030. This trend is also brought upon by the declared policy to phase out nuclear power in several EU Member States.

Energy security is not solely based on dependency on imports. A solid economy with diversified sources of primary energy will be well placed to absorb disturbances brought upon by price shocks in world markets. Other important criteria ensuring security of supply is the reliability and capacity of the energy infrastructure to deal with temporary disruptions along the supply chain.

The reliability of energy networks can only be ensured by: 1) the availability of comprehensive, properly-funded refurbishment plans overseen or approved by national regulators and, 2) the availability of interconnection capacities with neighbouring energy networks with specific assistance obligations. In this respect, the EU-25 has long-existing technical and procedural mechanisms in its electricity, oil and gas transportation networks, covering the eventuality of supply disruptions. The increasing demand of natural gas has led to the implementation of an extensive programme for increasing and diversifying the infrastructure for gas supplies by building pipelines, terminals for liquefied natural gas and storage capacities

The capacity to deal with temporary disruptions is particularly obvious in respect of protecting the economy from disruptions in the supply of oil & gas. In this respect, the EU has in place a system for holding of oil stocks equal to 90 days of domestic consumption. The system is currently under review with the aim of increasing it to 120 days. Gas storage obligations are also being developed.

The third (and last) issue when looking at "how secure" energy supplies is directly related to the energy intensity of any given economy. On the one hand, it is a criterion difficult to quantify insofar as the intensity of any given economy is closely related to the underlying structure. Hence, comparisons are not possible between a service-based economy and a heavily industrialised one.

As discussed earlier, in a situation where Ukraine's economy is set to maintain a significant share of heavy industry as well as to extensively develop its extractive industries, it is unlikely that energy intensity will align itself with that of the EU25. However, given the current intensity of its economy, Ukraine has substantial untapped potential to reduce intensity at little or low cost, particularly in the period between 2004 and 2020, where alongside fast GDP growth it can offset obsolete and unnecessary facilities and infrastructure.

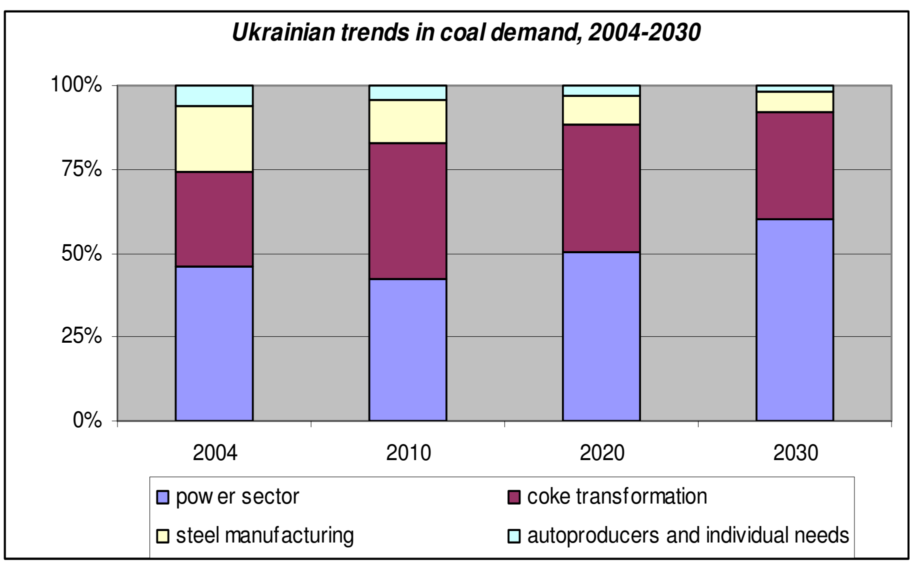
COAL

Overview of balance and forecast demand

In 2004, primary consumption of coal both in Ukraine and the EU25 amounted respectively, to 24 and 18 percent of their total primary energy supply. In Ukraine, the two main uses for coal are heat & electricity production, coke transformation and steel production. In the EU, coal is primarily used for electricity and heat production, making up almost thirty percent of total electricity generation in 2004.

Given the steady increase in electricity demand throughout the EU until 2030, it is expected that coal contribution to TPES will remain at 15 to 17 percent within the period. The actual contribution of coal to the energy mix will require monitoring and updating, given that the coal consumption patterns in the EU will be closely related to decisions made by Member States in respect of nuclear generation capacities, and to the penetration of RES in electricity generation.

Given the importance of its steel industry for the country's economy, the unstoppable increase in the price of natural gas and its significant coal reserves (proven reserves in Ukraine are estimated 56.7 billion tons), Ukraine's obvious choice lies in maximizing the role of coal in the energy mix.



Such an option has been laid out in the Energy Strategy until 2030, where the role of coal is set to increase from a contribution of 23.7 percent in 2004 to a little over 33 percent by 2030. This document foresees that coal consumption for transformation purposes (coking) will increase by about 140 percent in the period 2004-2020, reflecting the steady growth in the steel sector. From 2020 onwards, coking coal consumption stabilises throughout 2030. For electricity & heat generation, the Ukrainian authorities foresee a strong growth of coal use, from about 24 million tons in 2005 to over 69 in 2030, or about 4% yearly growth.

Cost

Both EU and Ukraine coal extraction industries have costs higher than world market prices. In the EU, supporting the restructuring of the coal industry to the concerned Member States was the first joint action that laid the basis for the European Union. Currently, regulated state aid to the coal industry in the EU is allowed until 2010 for the restructuring of the hard coal industry, taking into account the social and regional aspects of the restructuring as well as the need to maintain, as a precautionary measure, a minimum quantity of indigenous production to guarantee access to reserves. In particular, the Czech Republic, France, Germany, Hungary, Poland, Slovakia, Spain and the United Kingdom continue to assist their industries.

The main sources of imported coal for the EU are: South Africa, Australia, Colombia, Russia, the US and Indonesia. With over sixty percent of coal consumption met by imports, the price of coal is set in the international market. Moreover, it is closely monitored since price dumping is a key condition for the release of EU aid to coal producers.

Due to difficult mining conditions, the cost of Ukrainian coal is well above “international” prices. The situation is aggravated by higher than average sulphur contents. This has led to the development of a costly state-aid system which, unlike the EU one, subsidises coal output rather than industry restructuring. The pricing of Ukrainian coal will become more sensitive when, after joining the World Trade Organization, Ukraine will have to lift the protective measures currently in place fending coal imports into the country.

Security of supply

In view of the substantial coal reserves, Ukraine has a clear incentive to support domestic coal extraction and maximize its use in the electricity production and transformation industries (coking).

The important role to be played by coal in Ukraine’s energy mix is reflected in its Energy Strategy. According to it, by 2030, coal should make thirty-four percent of TPES with some imports mainly for the transformation industry. In absolute terms, this implies that coal consumption will more than double during the period 2005-2030.

In the EU, proven coal reserves are already earmarked for extraction and these will be declining steadily to 120 Mtoe in to 2030 from 154 Mtoe in 2004. Nevertheless, the current commitment to phase out nuclear energy in some Member States, in a scenario of strong growth of demand for electricity will imply the commissioning and revamping of coal-fired power plants. Accordingly, coal consumption in the EU will slightly increase to 293 Mtoe by 2030 from 287 Mtoe. As a result, the EU dependency on coal imports shall rise from 46 to 59 percent.

Considerations on security of supply

Maximizing Ukraine and EU potential use of coal is feasible by increasing the use of coal for electricity and heat production. Coal use for transformation purposes shows a steady pattern in both Ukraine and the EU, particularly after 2010, when Ukraine is set to achieve almost full use in the capacity of its steel industry.

In both cases, upholding commitments as regards international trade means that restructuring of domestic coal industries has to leap forward so as to avoid consumers from relying primarily on imported coal. This is of particular importance to Ukraine, which is about to join the WTO.

Potential for demand-side management

We have established that electricity and heat producers are the driving force behind strengthening the role of domestic coal in total primary energy consumption in Ukraine. As we will see later, environmental considerations will be important criteria in the upgrading/revamping of fossil-fired power plants. Therefore, the technical specifications for the power plants are to be based on the characteristics of the coal which they will use as primary fuels. As a result, it becomes apparent that coal-fired power plants will be driving the demand for specific types of coal.

CO_2 emissions

The use of coal for electricity generation requires substantial investments in developing technologies enabling clean and efficient burning and, ideally, carbon sequestration methods.

- Clean Coal - The coal industry uses the term "clean coal" to describe technologies designed to enhance both the efficiency and the environmental acceptability of coal extraction, preparation and use, with no specific quantitative limits on any emissions, but taking into account less efficient technologies.

- Carbon sequestration (Carbon capture and storage, CO2 sequestration) is the term describing processes that remove carbon dioxide from the atmosphere. To help mitigate global warming, a variety of means of artificially capturing and storing carbon (while releasing oxygen) — as well as of enhancing natural sequestration processes – are being explored.

<u>EU-25</u>

In the period 2000-2010, CO_2 emissions for EU-25 are projected to grow by 5.7%, exceeding the 1990 level by +2.8%. The strong short term increase to 2010 is due to high price increases for oil and particularly gas that encourage coal use in power stations, as well as the limited investment in energy efficient equipment, both in the demand and the supply side, caused by the slowdown of economic growth in the EU-25 that occurred in the recent past. Between 2002 and 2003, emissions of greenhouse gases from coal in the EU-25 increased by 37.5 million tonnes between 2002 and 2003.[iv]

Beyond 2010, CO_2 emissions are projected to rise at a much slower pace (+1.2 in 2010-2020, +0.7% in 2020-2030), with the demand side being the main driver for emissions growth in 2010-2020 and the power generation sector becoming the main driver for this increase in 2020-2030 due to the massive decommissioning of nuclear power plants and increasing competitiveness of coal in the power sector.

<u>Ukraine</u>

CO_2 emission in Ukraine reduce comparative to 1990. In 2003 key sources for CO_2 emission from coal was 125.02 Mt of CO_2 (producing electricity and heat – 54.68, manufacturing industries – 51.32, unallocated autoproducers– 10.99, residential – 8.03).
In perspective CO_2 emission will be increased. Opportunity for reducing CO_2 emission is using new technologies deep mining, methane from coal mines, clean coal technology.

OIL

Overview of balance and forecast demand

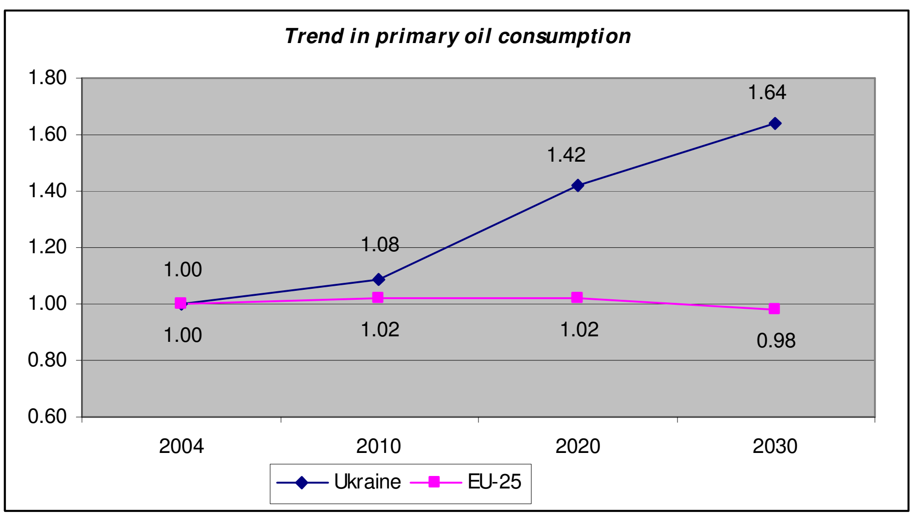
EU25 oil consumption amounted in 2004 to about 650 million tons of oil equivalent (Mtoe). After a period of solid increase in consumption in the 1990es (1.5% per year between 1994 and 1998 reflecting high growth in private road transport in the new Member States), consumption has been almost constant (0.1% per year average) since 1998.

On a per capita basis, oil consumption in the EU25 was of 1.41 toe per citizen. 60 kgoe were consumed per euro of 2004 GDP.

Ukraine's oil consumption for the same period totalled 18.0 (Mtoe) or 0.38 toe per capita. When measuring primary demand for oil against GDP, oil consumption per each of euro of GDP reached 280 kgoe in the case of Ukraine.

Several factors explain the differences above: lower oil consumption per capita in Ukraine reflects the lower use of private transport, which is the key driver for oil consumption in the EU25. The much higher use of oil per unit of GDP in Ukraine is explained, firstly, by the significant refining capacities in operation in the country (6 refineries with the capacity to distil 51 Mtoe per year) operating equipment which does not allow for obtaining high-value oil products. Secondly, oil consumption has until recently played a role outside the transport sector in, for example, electricity, industry and domestic heating.

For the purpose of this review, we shall assume that oil consumption patterns in Ukraine and the EU will tend to converge, i.e. that the transport sector and petrochemical industry will become the main consumers of oil and oil products. For this reason, energy consumption in the transport sector ought to be regularly monitored to ensure that forecasted demand remains realistic.



In the EU25, with somewhat stronger economic growth (2.3% per year) in the future than in recent years an average 0.2% increase per year to 2020 is foreseen in the 2005 baseline scenario. This would be followed by a small decline thereafter reflecting stagnating EU population and low economic growth, so that EU oil consumption would come back to current levels in 2030.

For Ukraine, her Energy Strategy foresees a steady 2.2% per year growth in the period 2004-2020. This would be followed by a slower growth (1.5% per year) between 2020 and 2030.

When compared about forecasted GDP growth for the same periods (4.9% and 4.2% respectively) the growth in oil consumption looks conservative unless it is accompanied by demand-side dampening measures.

In 2004, both Ukraine and the EU25 imported about 80 percent of their crude oil needs. However, from this point onwards oil imports begin to differ. In the case of Ukraine, it is foreseen that domestic oil extraction will increase until 2030, thus enabling to meet up to 25 percent of domestic demand for crude oil.

In the EU25, depleted proven oil reserves will continue their decline, thus making the EU25 dependent on imports for over 90 percent of crude oil demand.

Cost

Crude oil prices for both Ukraine and the EU are set by world market prices. In the case of Ukraine, prices follow the price of internationally quoted “Urals”, which is cheaper than lighter crudes such as Brent or Saudi.

Therefore, the global character of the oil market (and relatively small price differences between different parts of the world) and the fact that oil is predominantly used as a transport fuel implies that oil prices have only marginal impact on competitiveness.

It therefore seems more relevant to assess the additional cost of a $20 or €20 increase in the price of crude oil in a tight world market. With a 90 percent dependency on imports, EU25 would stand to face an additional cost of €90 billion in the year 2020.

Accordingly, with 79 percent of imported crude oil, a $20 increase per barrel would cost Ukraine $2.8 billion or an additional 1.1 percent of the forecasted GDP for 2020.

Security of supply

Net imports of crude oil, feedstocks and petroleum products contribute to EU25 consumption during 2004 in the following way:

- Russia 27%
- Middle East 19%
- Norway 16%
- North Africa 12%
- Other regions 5%

The implication of this is that EU security of oil supply, whether seen as protection against disruption of supplies or against excessive prices, has to be measured against the global market.

<u>*Ukraine*</u>

Due to the configuration of her refineries and the layout of her crude oil transport infrastructure, Ukraine only imports crude of the “Urals” type from the Russian Federation (a small amount of same crude is imported from Kazakhstan). Therefore, Ukraine relies on both a single type and a single source of crude oil, thus increasing her exposure to potential disruptions of supplies.

Considerations on security of supply

With an ever increasing dependence on oil imports, increasing to 90% of domestic needs by 2030, EU energy policy focuses on limiting any difficulties, even temporary, which may have the effect of reducing supplies of crude oil and/or oil products, or significantly increasing the price thereof on international markets and could cause serious disturbances in the economic activity of the Member States. Two instruments are in place for strengthening security of oil supplies:

1) A mandatory holding of crude and oil products equivalent to no less than 90-days of the yearly consumption of each Member State. In practice, stockholding is closer to 125 days, but because new Member States have been granted transitional periods (1-2 years) for building strategic reserves, the average throughout the EU was 85 days in 2007. Stocks maintained in accordance with EU legislation shall be fully at the disposal of EU Member States should difficulties arise in obtaining oil supplies.

2) Increasing the number of sources of oil imports into the EU. Although the oil market operates globally, it is an overriding concern to improve the conditions for European companies seeking access to oil resources. This is achieved by promoting partnerships with oil producers, transit countries and major actors such as OPEC, the Gulf Cooperation Council and the Russian Federation.

In the past year, Ukraine has announced the intention to implement a system of strategic oil stocks following along the lines of those in place within the EU. A decision has yet to be made on the legal, institutional and financial framework for implementing such a system.

As mentioned earlier, Ukraine oil transportation and processing infrastructure is closely linked to the "Urals" type crude mainly transported by the pipeline system linking Ukraine and Russia.

Potential for demand-side management

Oil consumption in the EU occurs almost entirely in the transport sector and in the petrochemical industry as feedstock. A limited amount is still used for heating purposes (gas oil). The forecast consumption by sector shows that this trend will remain until the year 2030.

Substitution of oil and oil products outside the transport sector is continuing and is encouraged at policy level (*e.g. biomass, natural gas and waste heat from power production*). However, the achievement of significant impact on oil demand has to concentrate on the transport sector. The EU has three main initiatives at policy level in this respect:

1) Taxation of oil products for transport:

Two types of tax are applied to the sale of automotive petrol and diesel, Value Added Tax (VAT) and Excise Duties. For the purpose of our study, VAT is a generic tax which we will not take into account.

Excise duty on automotive oil products is regularly revised and updated by Member State Governments. On 2006, with average prices for petrol and diesel for the final consumer at €1,305 and €1,029 per 1,000 litres, EU governments applied a minimum excise duty of €359 and €352 or around 30 percent of the final price at the pump.

2) Development of inter-modal transportation:

This policy seeks to shift primarily freight & passenger transportation from the road to more efficient means of transportation. Modal shift, particular freight transport from road to rail or waterborne transport offers some potential. However, it appears to be a long and difficult process to make this potential materialise.

3) Alternative fuels and increased fuel efficiency:

First steps in this direction have been taken at EU level. The "ACEA-agreement" on reduced CO_2 emissions from passenger cars is de facto a fuel efficiency agreement. However the achievement of the 2008 target will require significant further efforts by the car industry and it is not clear yet what should be “post 2008” targets. The biofuels directive (2003) stipulates 5.75% substitution of motor fuels by 2010, another target still hanging in the balance.

A policy targeting fuel efficiency in the transport sector and alternative motor fuels offers a potential at the global level as well as at EU level. On the basis of experience and analysis at EU level, there is reason to believe that a progressive policy on fuel efficiency and alternative fuels specifically focusing on the transport sector at the global level could reduce transport oil demand by 20% compared to what would otherwise be the case. With transport energy consumption worldwide of some 60 mpbd in 2025 to 2030, this corresponds to an oil saving of 12 mbpd.

If assumed that half of the reduction would be due to fuel efficiency and the other half equally split between biofuels and natural gas, one could expect a net saving on the fuel bill corresponding to 10% from energy efficiency and 2.5% from natural gas (prices at roughly half of diesel/gasoline) leading to savings of over $150 bill. at an oil price of $60/bbl
Biofuels might add to the fuel cost, depending on oil prices and on where and how biofuel is produced. Whether the fuel expenditure saving would be sufficient to pay for the cost of all the measures depends on how it is achieved.

CO_2 emissions

EU25

The EU25 trend in oil consumption (foreseen to be 640 Mtoe by 2030) is not consistent with the expectations to meet the objective of long-term stabilisation of greenhouse gas emissions. Between 2002 and 2003[v], greenhouse gas emissions in the EU-25 increased by 21.6 Mt.

While it might be possible to achieve significant reductions through measures aiming at emissions from coal and more use of natural gas, the scarcity of oil resources compared to other fossil fuels and its higher cost offers both moral and cost-effective justifications in favour of policies that will reduce oil demand.

Ukraine

CO_2 emissions in Ukraine have reduced compared to 1990. In 2003, oil-related CO2 emissions from oil totalled 27.44 Mt of CO_2 (road transport – 12.51, manufacturing industries – 7.65, other sectors – 7.28). In perspective CO_2 emissions will be on the rise. Obvious opportunities for reducing CO_2 emissions are the modernisation of refineries and the introduction of biofuels for transport.

GAS

Overview of balance and forecast demand

Natural gas consumption has grown steadily in the EU during the last decades, offering both environmental and economic benefits. In 2004, gas consumption amounted to about 420 Mtoe. Its share of total primary energy needs increased from 16.7 to 24 % over the period 1990-2004.

Natural gas is mainly used by households and power generation (29 % each), the industrial sector uses another 25 percent with other final users taking up the rest (13%). Natural gas plays only a minor role in transport).

Due to the large North Sea gas deposits, EU production has been stable over the last 10 years, but UK production has already peaked. Norwegian production shows so far a strong increase, but for the purpose of this document, Norwegian gas is considered an import. The depleting UK reserves make a fifty percent reduction in production quite likely within the next twenty years.

Energy consumption patterns in the EU-25 show increasing reliance in natural gas. Its share in primary energy needs is due to increase from 23.8% to 27.3% (or 517.8 Mtoe) in 2030. While primary energy demand in the EU25 is projected to increase at an annual rate of 0.3 percent in the period 2004-2030 against an annual GDP growth rate of 2.0%, natural gas demand will grow by 0.8 percent in the same period. Therefore, natural gas is projected to have the fastest growth amongst fossil fuels, growing at a rate three times faster than overall energy needs. In the meantime, CO_2 emissions are foreseen to grow, but at lower rates than those for primary energy demand.

In Ukraine natural gas consumption has gone down during the last 15 years to 76 billion cubic meters (bcm) in 2004 or 65.9 Mtoe. In that year, natural gas made almost 64 percent of Ukraine's primary energy needs. Natural gas is mainly used in electricity & heat generation - 39% and the industrial sector - 26%, with household consumption accounting for 20 percent.

In 2004, domestic production of natural gas reached 20.5 bcm (17.9 Mtoe). Some raw data points to the availability of substantial on- and off-shore gas deposits, but methodical and detailed exploration work only recently got underway.

Ukraine's Energy Strategy has set the ambitious target to reduce natural gas consumption both in absolute terms as well as a share of her primary energy needs. The objective is to reduce consumption to 49.5 bcm (42.9 Mtoe) to 18.8 percent of primary energy needs. Our analysis of this objective points to an optimistic scenario where gas in the heating sector is largely substituted by electricity. We could not find substantiation about the economic rationale for the choice of such an alternative.

Cost/Competitiveness

While gas prices continue to be linked to oil prices, a difference in oil prices will affect the overall EU25 gas bill, the latter amount increasing with expected increased imports over time.

Whereas the cost impact of gas prices is relatively modest, the potential impact on competitiveness is big. This has several reasons:

– Differences between gas prices amongst world regions can be huge, ranging from almost zero to more than €300 per thousand cubic meters.
– Gas is used as a fuel in many energy-intensive industries.
– Gas prices have a spill-over effect on electricity prices.

In the last 15 years due to low gas prices (50-80 $/1000 cubic meters) in Ukraine some industries such as ammonia or methanol production began more competitive that ones in EU. Similarly, growth in electricity demand in the EU was met by commissioning gas-fired power plants, the construction of which is comparatively cheap and fast.

Once the fuel costs are input, electricity produced from natural gas becomes the most expensive type of electricity. Therefore, in a period when electricity demand is strong, electricity prices reflect to a large extent the cost of gas-powered generation capacities.

The conclusion is that gas prices are extremely important for industrial competitiveness. In this connexion, the link between oil prices and gas prices is unfortunate.

Considerations on security of supply

The current supply situation in EU25 is relatively comfortable: 46 % is covered by domestic production mainly from United Kingdom, Netherlands, Germany, Italy and Denmark.

During 2004, imports of natural gas contributed to the EU25 total consumption in the following way:

- Russia – 25 %
- Norway – 15 %
- North Africa, Nigeria – 14 %
- Middle East – less than 1 %

About 6 to 8 percent was imported as liquefied natural gas (LNG) from Africa and the Middle East.

The perspectives for the EU gas supply looks stable in the coming years. Besides the Russian resources, Norway, North Africa, Nigeria, Middle East and the Caspian Basin hold large reserves in development or waiting to be commercialised. The increase in gas prices will only make the commercial extraction of these reserves more attractive. The one problem lies in the development of the infrastructure necessary to make that gas available for European consumers.

This stability is based on the sources being in a position to continue stable supplies to the EU while meeting their domestic needs and/or their obligations to third parties.

A number of projects already decided or in an advanced stage of planning are likely to help meet the necessary additional import capacity over the coming 5-10 period:

- The Baltic pipeline, scheduled to start up in 2010, with an initial capacity 27.5 bcm/year.
- A number of LNG terminals in Italy, Spain, the UK and possibly other Member States bringing the total LNG capacity of the EU close to 140 bcm/year by 2010.
- The Nabucco project linking Caspian gas resources to the European market with a capacity of up to 31 bcm by 2020.
- A Trans-Caspian gas pipeline to bring Central Asian gas supplies to the EU, and possibly to Ukraine.

<u>Ukraine</u>

Ukraine is a significant gas producer with output of 20,5 bcm per year with the potential to increase domestic production. On the other hand, Ukraine is the second gas consumer among the countries of the former Soviet Union. While it meets 26 percent of consumption through domestic production, it imports the rest from Russia (30-33 percent) and Turkmenistan (41-44 percent). The existing infrastructure only allows for gas imports to arrive via the gas pipeline system of “Gazprom”.

The Ukrainian mid-term perspective for gas imports looks bleak: import contracts are negotiated on a yearly basis.

The Ukrainian gas transport network makes it the most important transit country for Russian gas (137 bcm/year)[vi] and a one of the largest in the world; it features 37,800 km of pipelines, with an annual design input capacity of 280 bcm and an output capacity of 175 bcm. The system has 13 storage fees for gas (21 % volume storage in Europe) with an actual capacity of 32 bcm. The transport network is currently the main route for the transit of Russian gas to Europe, providing transit for about eighty percent of Russian gas exports to the EU.

The transport network is technically reliable, and its capacity is expanding slowly, but major investments are required for refurbishing the system, reducing losses and meeting environmental standards. One estimate put the cost at $ 5 billion A decision on this issue continues to be postponed, thus creating unnecessary concerns about the reliability of gas supplies to Ukraine and Europe.

CO_2 emissions

The evolution of the EU25 energy system in the last decade has been characterised by a strong decoupling of energy demand from economic growth and, in addition, by a decoupling between energy demand and CO_2 emissions growth.

The impact of greenhouse gas emissions of increased natural gas consumption is totally dependent on whether the increase represents a general increase in energy consumption or whether it reflects a substitution of other energy sources.

The EU25 trend in gas consumption is in 2004 – 24 % and foreseen is 27.3 % for 2030). Greenhouse gases emissions (GHG) from natural gas in the EU25 increased by 53.4 million tonnes between 2002 and 2003.[vii]

Ukraine

CO_2 emissions in Ukraine have reduced from 1990. In 2003, key sources for CO_2 emission from gas was 129.41 Mt of CO_2 (main activity with producing electricity and heat – 60.71, residential – 28.14, manufacturing industries – 24.85, non-specified other sectors – 15.71).
In perspective CO_2 emission from gas will be reduce. Opportunity for reducing CO2 emission is modernisation gas transport system, increasing energy efficiency and saving in energy sector, using renewable sources.

ELECTRICITY

Overview of balance and forecast demand

European Union

EU electricity production has shown a steady increase since the early days of electricity production and stood at around 3178 TWh (billion kilowatt-hours) in 2004. With very little exchange with neighbours (net imports from Norway, Ukraine, Russia, etc accounting for only 2% of consumption) and no possibility to store electricity, production is virtually equal to consumption plus power plant own use as well as transmission and distribution losses (slightly above 10%).

The national mix of energy sources in electricity generation within the European Union varies within wide ranges. Solid fuels maintain a strong base in several Member States. Hydropower has a high or significant share of the Nordic, Alpine and Iberian Mountains. Nuclear power covers half or more of national consumption in several old and new Member States and contributes significantly in Germany, Spain and the United Kingdom. Natural Gas, originally mainly used in the Netherlands and later in the United Kingdom has made a strong showing as the fuel of choice for new power generation throughout the EU. Renewables other than hydro provide a modest contribution, but wind energy, presently slightly above 2% at EU level, has shown impressive increase in recent years.

When looking at the system as a whole (all EU Member States are part of UCTE), the combined result of power generation expansion over the last three decades is a well diversified electricity structure at EU level. However, insufficient interconnections between regional markets make the national or regional markets less diversified.

Annual growth rates in electricity consumption (and production) have moved downwards over a long period. The present decade is expected to see around 2% annual growth. The baseline scenario shows a continued growth in electricity consumption towards 2030, to roughly 50% above 2000 levels, in spite of further decline in the annual growth rate to 1% after 2020.

Electricity demand by sector in EU-25, 2000-2030[viii]
TWh

	2000	2010	2020	2030
Total	2900.8	3483.2	4005.8	4366.6
Industry	1042.2	1199.9	1318.5	1396.5
Residential	694.6	880.5	1097.5	1272.3
Tertiary	651.9	856.2	1032.4	1144.4
Transport	68.8	78.7	73.9	71
Energy sector	267.9	298.8	312.2	317.2
Losses	200.3	195.1	195.9	190.7
	Annual Growth Rate			
	00/10	**10/20**	**20/30**	**00/30**
Total	1.8%	1.4%	0.9%	1.4%
Industry	1.4%	0.9%	0.6%	1.0%
Residential	2.4%	2.2%	1.5%	2.0%
Tertiary	2.8%	1.9%	1.0%	1.9%
Transport	1.4%	-0.6%	-0.4%	0.1%
Energy sector	1.1%	0.4%	0.2%	0.6%

The baseline scenario foresees a continuation of a healthy diversification at EU level with gas, solid fuels, nuclear and renewables all well above 20% each in the medium term (2015 to 2020), but nuclear falling to 19% by 2030, down from present 30%. With a fossil fuel share roughly constant at 55% through 2030 and some replacement of solid fuels by gas since 1990, CO_2 emissions from power generation stay close to the 1990 level from 2010 to 2020, but increase thereafter as a result of the marked fall in nuclear, which, under baseline conditions, would be predominantly replaced by solid fuels.

Ukraine

Ukraine electricity production in 2004 stood at 182 TWh. The country is a net electricity exporter with some 5 TWh sold abroad (Moldova, Hungary, Poland and Russia at the time). Inland consumption therefore reached 149 TWh, plus transmission and distribution losses (around 15%).

The mix of energy sources in 2004 concentrated on nuclear (48%) and conventional thermal power plants (46%), the latter being split between coal and natural gas. Hydropower (excluding pumped storage) covers another 6% of generation.

Annual growth rates in electricity consumption in Ukraine are showing a healthy upward trend. The present decade is expected to see almost 2% annual growth. The baseline scenario set out in Ukraine's Energy Strategy (see table below) shows an even more steep growth towards 2030 (3.7% annual growth during 2010-20 and 3.3% in the period 2020-2030). As a result, electricity demand is set to grow by 124% in the period 2004-2030. This takes place in a scenario where transportation and distribution losses are to be halved between 2004 and 2030 (from about 15% to 8%).

Electricity requirements by sector in Ukraine, 2004-2030[ix]
TWh

	2004	2010	2020	2030
Total	176.7	198.9	287.0	395.1
Industry	98.0	113.9	154.3	185.7
Transport	9.8	9.8	11.2	12.9
Services	17.5	22.8	43.2	71.4
Residential	24.2	29.0	54.3	93.2
Losses	27.3	23.3	24.1	31.9
	Annual Growth Rate			
	04/10	**10/20**	**20/30**	**04/30**
Total	2.0%	3.7%	3.2%	3.1%
Industry	2.6%	3.1%	1.9%	2.5%
Transport	0.1%	1.3%	1.4%	1.1%
Services	4.5%	6.6%	5.2%	5.6%
Residential	3.0%	6.5%	5.6%	5.3%

In terms of energy mix, Ukraine's long-term forecast for electricity generation focuses on four aspects: 1) increasing the role of nuclear generation from 48% to 52% by extending the lifetime of existing units and commissioning new ones, 2) lowering the contribution of thermal power plants to 42% while switching gradually to coal as the primary fossil fuel, 3) increasing the contribution of hydropower in absolute terms, and 4) extending the use of pumped storage from 0.1% to one percent[2].

Cost

This chapter deals with the genuine cost of electricity production. The relevant cost numbers to address must include external cost and costs of long term waste management and decommissioning.

Electricity production on the basis of different energy sources has a very different cost profile. Hydro and wind both have overwhelmingly capital cost but little daily operating cost. Nuclear and solid fuels have somewhat higher operating costs but still cheap fuel. Natural gas, at the other end of the spectrum, has relatively low capital cost, but considerable fuel cost. The high capital costs make nuclear and solid fuels unsuitable candidates for any production with an expected utilization of less than at least 50% of the time, in many cases more.

Another factor complicating any cost calculation is the fact that the "real" capital cost (based on the life expectancy of the plant) and the return on investment required by the stock market can be very different. An example demonstrates thus: Capital cost for nuclear electricity amounts to close to 50€ (~UAH 307) per MWh if based on 6000 hours operation per year and 15% return on investment the benchmark rate of return applied in the power sector. However, if the cost is based on 8000 hours per year and 6.5% capital cost (reflecting present interest levels but not necessarily the uncertainty for power generators on electricity sales and the prices these fetch in a competitive market) and a 50-year lifetime, capital cost will be 16€ (~UAH 98) per MWh, highly competitive.

Currently, in the EU, production cost for electricity is low. This largely reflects much lower capital cost on most of the production capacity (hydro, nuclear, solid fuels) than what would result from producing in plants built today. In particular, some existing plants may well be already fully amortised. The introduction of specific targets for power generated from renewables has been a warning signal on electricity prices. In the two years between 2004 and 2006, the introduction of

[2] Neither the International Energy Agency, nor the European Commission take pumped storage into account when looking at energy mix and generation capacities for electricity generation.

feed-in tariffs for power generated from renewables has been crucial in the 24 and 8 percent increases in industrial and household prices on average throughout the EU. The second factor has been the increased contribution in gas-generated electricity fed by fuel price increases.

We found a similar situation in Ukraine, where most of the fossil fuel (solids and gas) capacities have been in operation for 30 years. Many fossil-fuel units, or 10% of thermal power plants, in particular those using gas and fuel oil, have been mothballed during the last years due to rising fuel costs and low efficiency. However, in a scenario of steady demand growth where use of indigenous coal is promoted, there is a clear cost advantage in the extensive refurbishment of thermal generating capacities, since Ukraine can offset the price of lower CO_2 emissions.

Capacities

Increasing energy requirements for electricity and steam lead to a large expansion of installed capacity in the EU energy system, which is projected to increase by 66% in 2030 from 2000 levels. The rise in capacity is higher than the electricity production increase because more pronounced penetration of renewables with lower load factors compared to fossil fuel plants means higher capacity requirements.

Power generation capacity by type of plant in EU-25, 2004-2030
% share

	2004	**2010**	**2020**	**2030**
Nuclear energy	19.8	16.8	12.4	9.2
Renewable energy (excl. biomass-waste)	19.6	22.7	25.6	27.9
Hydro	14.6	12.8	11.5	10.2
Wind power	5.0	9.7	13.5	16.7
Solar	0.0	0.2	0.5	0.9
Thermal power	60.5	60.4	62.0	62.9
Solids fired	28.5	19.3	16.6	19.3
Oil fired	11.2	8.1	5.1	3.2
Gas fired	19.9	30.3	34.1	32.8
Biomass-waste	2.2	2.6	6.1	7.4
Fuel cells	0.0	0.0	0.0	0.0
Geothermal heat	0.1	0.2	0.2	0.1

Technological advances and the progressive deregulation of electricity markets – with smaller companies entering the market preferring plants with shorter lead times, lower capital costs and higher efficiency - are projected to cause significant growth in the use of gas for electricity generation. This is mainly through the extensive use of gas turbine combined cycle units. Thus installed capacity of gas fired plants is projected to increase dramatically, especially in the period to 2020, reaching 360 GW by 2030 from 132 GW in 2000. Gas accounts for close to 33% of total EU-25 generating capacity in 2030 compared to 20% in 2000.

The growth of gas-fired power plants occurs mainly at the expense of conventional solid and oil fired power plants, as well as nuclear power plants. The nuclear sector faces four major issues: 1) the closure of unsafe nuclear plants in NMS, 2) substantial decommissioning of existing nuclear plants beyond 2015, 3) the nuclear phase-out policies in certain EU-15 Member States and, 4) the likely decisions of economic actors not to replace all decommissioned nuclear with new nuclear plants on economic grounds. These factors result in a continuous decline of nuclear capacity, which by 2030 accounts for no more than 9.2% of total installed capacity in EU-25 (from 21.3% in 2000).

Installed capacity of solids fired power plants is projected to decline very rapidly both in absolute terms and as a share of total installed capacity in the horizon to 2010 (from 189 GW in 2000 down to 156.5 GW in 2010 with a market share of 19.3% - a decline of 9.2 percentage point from 2000 levels). In the horizon to 2020 installed capacity of solid fuel fired power plants is projected to remain rather stable whereas their market share exhibits a further decline to 16.6%. However, under Baseline assumptions, a predominant role in the replacement of retired nuclear plants will be played by advanced coal technologies (supercritical units and other clean coal technologies, e.g. IGCC and PFBC) as they are projected to become a cost-effective option in the long run, on the basis of the currently prevailing technology forecasts for power generation and the assumed evolution of international fuel prices. Thus solids fired capacity is projected to exhibit a significant growth in 2020-2030 with installed capacity exceeding 211 GW in 2030 (19.3% of total installed capacity). As regards oil fired power plants their capacity is projected to continuously decline over the projection period accounting by 2030 for just 3.2% of total installed capacity compared to 11.2% in 2000.

Renewable energy forms are also expected to have an important role in power generation in future. However, capacity expansion in hydropower plants is projected to be rather limited over the outlook period as a result of the already high exploitation of suitable sites in the EU-25 energy system and environmental restrictions especially in Nordic countries. This results in a decreasing share for hydro plants (from 14.7% in 2000 to 10.2% in 2030). In contrast, given supportive policies for renewable energy forms in the EU, wind turbine capacity increases substantially, reaching by 2030 up to 183 GW (16.7% of total installed capacity) compared to less than 13 GW in 2000. Solar photovoltaic energy starts emerging mainly beyond 2020 (accounting for 0.9% of total installed capacity by 2030).

Power generation capacity by type of plant in Ukraine, 2004-2030
% share

	2004	2010	2020	2030
Nuclear energy	26.4	28.0	30.9	33.3
Renewable energy	9.2	15.2	15.9	14.3
Hydro*	9.2	15.0	13.6	11.9
Other	0.0	0.2	2.3	2.4
Thermal power	64.4	56.7	53.3	52.4
Solids fired	0.0	0.0	0.0	0.0
Oil fired	0.0	0.0	0.0	0.0
Gas fired	0.0	0.0	0.0	0.0
Biomass-waste	0.0	0.0	0.0	0.0

(*) includes pumped storage

Under the conditions prevailing in the baseline scenario, investment in power plants including expenditure for replacing capacities amounts to around €625 billion. About half of this expenditure is needed for the replacement of existing power plants that will be decommissioned up to 2025. The investment in additional generating capacity relates mostly to renewables, which account for an investment expenditure of around €215 billion (~ 70% of the expenditure for increasing generation capacity).

Investment in the transmission grid is estimated at 3 to 4 billion euro per year, so that over 20 years the total investment need for transmission is around 70 billion. The total investment required will ultimately depend on the penetration of off-shore wind parks, which require higher levels of expenditure for connection to the grid. Therefore, the total electricity related investment over the next 20 years is projected at around €700 billion.

Increasing electricity demand calls for substantial expansion of generation capacities in Ukraine, set to grow by almost 70% from to 2030. Unlike in the EU, this rise in generation capacity is closely related to demand growth given the lower penetration of renewables, hence the load factor remains high due to the contribution of nuclear and thermal power.

This high load factor, in particular the forecasted contribution of nuclear energy, has to be balanced with capacities able to cover periods of peak electricity demand, such as hydro pumped storage.

With over 90% of installed capacity of fossil-fired plants in Ukraine having operated for over 100,000 hours (design cycle as defined by Ukrainian technical standards), and 63% having operated in excess of 170,000 hours, the planned development of these capacities is as follows:

The commissioning or refurbishment of 3,700 MW ought to be completed by 2010. 16,000 MW will be commissioned and refurbished between 2010 and 2020. Finally, another 17,000 MW will have to be made available by 2030. These developments should result in fossil-fired power achieving a load factor of 55% by 2030, in line with international industry standards.

Under the conditions prevailing in the basic scenario, the assumed cost for developing capacity, both replacement and new plants, in Ukraine stands at 418 billion hryvnya (€61 billion). The Energy Strategy does not differentiate between replacement and new investments, but rather breaks costs down by sector. Decommissioning, life extension and new capacities in nuclear generation are estimated at UAH 208 (€30.3) billion, or 50 percent of total investment in capacity. Fossil-fired plants will require UAH 183 (€26.7) billion or 44 percent of investment. The remainder is split between hydropower (including pumping storage), UAH 19.7 (€2.9) billion, and other renewables for power generation UAH 7.1 (€1.0) billion.

The electricity transportation network will require approximately UAH 82.9 (€12.0) billion during the next 25 years. This takes account of the costs related to the integration of Ukraine and UCTE transmission grids. Therefore, over the next 25 years, electricity related investment in Ukraine amounts to UAH 501 (€73) billion.

Competitiveness

Electricity prices are an important factor in a limited number of industrial sectors (chemical industry, metallurgical industry, pulp and paper). Because of the very different variable cost between different production systems and because of different demand during the day and during the year, electricity prices show strong fluctuations with time.

Long term price perspectives, based on marginal cost, i.e. production with the highest variable cost, are crucial for decisions to build new generation capacity, whether to replace outdated capacity or to meet increasing demand.

Most of the EU and Ukraine have had overcapacity over the last decade. This kept electricity prices low relative to the cost of new generation. However, some Member States, due to rapid demand growth, are coping with wholesale market electricity prices well above the EU average. This is now spreading to other Member States as demand has continued to increase, leading to the deterioration of the supply/demand position. Such deterioration is set to take place in Ukraine before the end of this decade.

This analysis suggests that two factors are of overriding importance for future EU electricity prices (apart from regulatory and physical requirements to generate a real open market):

1) The market framework must provide sufficient capacity to avoid inflated and or volatile prices because of a tight supply situation;
2) Reasonable gas prices are essential in order to prevent that excessive gas prices lead to generally high electricity prices reflecting the marginal cost of a minor part of overall electricity generation.

The above-mentioned factors are relevant to Ukraine’s electricity sector. In addition, the sector ought to take into account the following:

1) The development of new/refurbished capacities has to be already priced in electricity prices;
2) An energy efficiency policy that might abate demand over the next 25 years would greatly enhance the chances of moderate rather than excessive electricity prices, thus allowing for realising least-cost investment options.

- ***Nuclear generation***

Assuming a plant life of 40 years and 85% percent capacity utilization factor, nuclear generation remains competitive compared with coal or gas power plants[x]. On the other hand, construction times for nuclear plants can take seven to nine years, while the commissioning of gas and coal power plants is done in half that time.

For many years, the EU has been mired in debate about the role of the nuclear industry in power generation. While respecting the each Member State sovereignty, the current trend in the EU is poised to steadily reduce the capacity of nuclear plants as the ones in operation reach the end of their cycles. Nonetheless, some Member States have planned for commissioning new capacities or extending the life of operating plants. Others are still analysing the role of their nuclear industries.

As a whole, the EU nuclear power can be considered as indigenous production. While uranium mineral is predominantly imported, the EU carries out domestically all other processes of the nuclear fuel cycle, from fuel production to storage of spent fuel and other waste.

Ukraine has significant uranium reserves, although it purchases its nuclear fuel from a single source[3], which also takes care of the spent fuel.

- ***Efficiency improvements***

Assuming a production cost of 60 €/MWh in the EU, reducing electricity consumption by 20% towards 2020 would thus imply savings of electricity worth nearly 50 billion € in 2020. This would be 0.35 percent of the forecasted GDP in 2020.

Assuming that the cost in Ukraine will be 48 €/MWh (a 20% reduction given the large contribution from nuclear generation), the same reduction of electricity consumption would bring about savings of about 2.7 billion euro or 2.2 (!) percent of the forecasted GDP.

Clearly, investing in more energy efficient equipment for achieving such savings in the electricity bill will involve considerable costs itself leading to a lower net saving. While it goes beyond the scope and the possibilities of this document to attempt a quantification of the net effect, it is worth noting that many potential improvements in “electricity efficiency” would pay at much lower levels than 48€/MWh and reduced growth in electricity consumption would save investments in transmission lines and distribution system.

Renewable energy sources in electricity generation

Non-hydroelectric renewable energy refers to electricity supplied from the following renewable sources of power: solar, geothermal, biomass, landfill gas, wind. Installation of these renewable energy resources is growing.

Solar energy is a renewable resource because it is continuously supplied to the earth by the sun. There are two common ways to convert solar energy into electricity: photovoltaic and solar-thermal technologies. Photovoltaic systems consist of wafers made of silicon or other conductive materials. When sunlight hits the wafers, a chemical reaction occurs, resulting in the release of electricity. Solar-thermal technologies concentrate the sun's rays with mirrors or other reflective devices to heat a liquid to create steam, which is then used to turn a generator and create electricity.

Geothermal energy is continuously created beneath the Earth's surface from the extreme heat contained in liquid rock (called magma) within the Earth's core. When this heat naturally creates

[3] Ukraine is carrying out trials for the utilization of US-manufactured nuclear fuel.

hot water or steam, it can be piped to the surface and then used to turn a steam turbine to generate electricity. Geothermal energy can also be obtained by piping water underground to extract heat from hot, dry rocks. Heat is then returned to the surface to turn a steam turbine and generate electricity.

Biomass obtains its energy from the sun while plants are growing. Plants convert solar energy into chemical energy during the process of photosynthesis. This energy is released as heat energy when the plant material is burned. Biomass power plants burn biomass fuel in boilers. The heat released from this process is used to heat water into steam to turn a steam turbine to create electricity. Biomass is sometimes burned in combination with coal in boilers at power plants. This process, called co-firing, is typically used to reduce air emissions and other environmental impacts from burning coal. Co-firing biomass with coal may require a coal boiler to be modified somewhat so it can combust coal. When co-fired with coal, only a small amount of biomass is typically added (no more than 15 % of the total amount of fuel going into the boiler) to maintain the boiler's efficiency.

Electricity generation from renewable energy sources, 2004
GWh

	EU25	Ukraine
Municipal Waste*	19 690	0
Industrial Waste	19 533	0
Primary Solid Biomass**	37 896	0
Biogas	12 362	0
Liquid Biofuels	112	0
Geothermal	5 523	0
Solar Thermal	510	0
Hydro	336 677	11 888
Solar Photovoltaics	716	0
Tide, Wave, Ocean	518	0
Wind	58 804	25
Total:	**492 341**	**11 913**

** Municipal Waste: the split for renewable and non-renewable waste is also available.*
*** Primary Solid Biomass: data are also available for charcoal.*

Landfill gas is created when microorganisms cause organic waste, such as food wastes and paper, to decompose in landfills. Landfill gas is composed of about fifty percent methane. Carbon dioxide and volatile organic compounds make up the remainder. Landfill gas escapes into the air unless it is collected and burned. In landfill gas energy projects, landfill gas is burned in boilers, reciprocating engines, and combustion turbines to produce electricity. The landfill size and age, quantity of organic waste, and the local climate help determine how much gas a landfill can produce.

Wind turbines use long blades to collect the energy in the wind and convert it to electricity. The blades spin when the wind blows over them. The energy of motion contained in the wind is then converted into electricity as the spinning turbine blades turn a generator. To create enough electricity for a town or city, several wind turbine towers need to be placed together in groups or rows to create a “wind farm”.

GHG emissions associated with generating electricity from solar, geothermal, and wind technologies are negligible because no fuels are combusted in these processes.

CO_2 emissions

Summary of CO_2 emissions from electricity generation, 2003[xi]

CO_2 emissions per kWh from electricity and heat generation
grammes CO_2/kWh

	EU 25	Ukraine
Total*	386	341
using coal	821	560
using oil	600	626
using gas	353	364

** Emissions divided by total electricity output*

The evolution of the EU-25 energy system in the last decade has been characterized by a strong decoupling of energy demand from economic growth and, in addition, by a decoupling between energy demand and CO_2 emissions growth. While primary energy needs increased by 6.3% in 1990-2000, CO_2 emissions declined in the same period by 2.7%.

Increase of electricity consumption will be increase trend in EU and Ukraine to CO_2 emissions.

CO_2 emissions by sector, EU-25
Million tons

	1990	2000	2010	2020	2030
Power generation	1 264.3	1 250.0	1 328.0	1 303.7	1 392.5
District heating	98.3	44.9	33.9	29.6	31.5
New fuels (hydrogen etc.) prod.	0.0	0.0	0.2	1.2	2.2
Energy branch	141.5	144.9	123.7	112.7	97.5
Industry	698.9	567.7	577.0	595.2	569.8
Residential	506.1	452.1	482.7	494.9	486.7
Tertiary	274.2	244.6	261.8	275.8	281.9
Transport	792.7	969.9	1 074.6	1 115.5	1 092.9
Total	**3 776.1**	**3 674.1**	**3 881.9**	**3 928.6**	**3 955.0**
Annual growth rate (%)					
	90/00	**00/10**	**10/20**	**20/30**	**00/30**
Power generation	-0.1	0.6	-0.2	0.7	0.4
District heating	-7.5	-2.8	-1.3	0.6	-1.2
New fuels (hydrogen etc.) prod.	-	-	20.4	5.8	-
Energy branch	0.2	-1.6	-0.9	-1.4	-1.3
Industry	-2.1	0.2	0.3	-0.4	0.0
Residential	-1.1	0.7	0.3	-0.2	0.2
Tertiary	-1.1	0.7	0.5	0.2	0.5
Transport	2.0	1.0	0.4	-0.2	0.4
Total	**-0.3**	**0.6**	**0.1**	**0.1**	**0.2**

In Ukraine, CO_2 emissions forecast for energy sector show increase, but in 2012 will be not amount to level 1990.[xii]

There are basically three options to redress this situation:

- Efficiency improvements in electricity generation, distribution and consumption.
- Increasing the share of CO_2 free electricity (renewables or nuclear).
- Reducing solid fuels consumption or reducing CO_2 emission from solid fuels consumption through carbon sequestration.

Security of supply

The security of supply for electricity depends on three factors: 1) sufficient generation capacity, 2) sufficient transmission network and improved interconnection and, 3) diversification of energy sources in electricity generation.

European Union

It goes without saying that the specific security of supply situation for the main energy sources is part of the equation. In electricity, this is particularly relevant for natural gas. Whereas the baseline scenario offers an overall diversified electricity sector through 2030, gas remains a key contributor to power generation.

The high share of solid fuels is another problem, in the context of the EU climate policy and its commitments of reduction of emissions. If solid fuels were to decline significantly, alongside nuclear, the EU might see itself faced with an unacceptable over dependence on natural gas in the electricity sector, even if the share of renewables would grow more than reflected in the baseline scenario. A strong dependence on natural gas is particularly critical as long as natural gas is the only energy source for electricity for which there is an external security of supply concern.

Any development consistent with present EU Climate policy will need either to force solid fuels consumption in electricity much down compared to the baseline scenario or to ensure fuels consumption could still be seen as compatible with a high level of security of supply if "replaced" by nuclear.

Ukraine

Ukraine is now in the process of matching its enlarged generation capacity with an improved transmission network. In the near future, it will need to closely tackle these two issues in order to maximise the dispatching and allocation of newly commissioned capacity.

In terms of fuel mix for power generation, Ukraine will be well positioned by achieving its aims of increasing the shares of nuclear and indigenous coal power. Incidentally, this will also provide for keeping CO_2 emissions in check (against benchmark 1990 emissions) provided that coal power is based on clean coal technologies.

It can be argued that Ukraine needs to look at the long-term impact of its stated 50% contribution to power generation against security of supply. As of today, there are no instruments in place to widen the number of nuclear fuel suppliers beyond the one which currently supplies all its needs and which is not indigenous.

Potential for demand-side management

Pricing signals built into electricity purchase tariffs and prices are the existing mechanisms for rationalizing electricity demand. There are two aims sought by managing demand.

The first one is to reduce the marginal cost for electricity brought upon by the need to keep more expensive generation capacities available to the network. This generally means either higher investment costs for such generating plants or higher costs related to the procurement of more expensive fuels. The latter can also imply altering the import share of a given fuel thus reducing security of supply.

The second aim is to minimize the investment costs in the transmission network, specifically seeking to reduce congestion and bottlenecks.

The most efficient mechanisms available to manage demand are:

1) Time-zoning of electricity prices for consumers;
2) Pricing of the load patterns of consumers, both existing and new.

RENEWABLE ENERGY SOURCES (RES)

Overview of balance and forecast demand

Renewable sources of energy – wind power, solar power (thermal and photovoltaic), hydro-electric power, tidal power, geothermal energy and biomass – are an essential alternative to fossil fuels. Using these sources helps not only to reduce greenhouse gas emissions from energy generation and consumption but also to reduce the EU25 and Ukraine dependence on imports of fossil fuels (in particular oil and gas).

In 2004, the breakdown of renewable energy produced in the EU25 (6.52% in total energy balance) by source was as follows: 1.47% from hydropower, 4.4% from combustibles renewables and waste, 0.64% from solar and geothermal power.

In order to reach the target of a 20% share of energy from renewable sources in the overall energy mix, the EU25 plans to focus efforts on the electricity, heating and cooling sectors and on biofuels. In transport, which is almost exclusively dependent on oil, the EU25 hopes to increase the current target of a 5.75% share of biofuels in overall fuel consumption by 2010 to a 10% share by 2020.

In 2004, the breakdown of renewable energy produced in Ukraine (0.91% in total energy balance) by source was as follows (according to Energy Strategy): 0.72% from hydropower, 0.19% from combustibles renewables and waste, 0.0014% from solar and geothermal power.

For Ukraine, her Energy Strategy foresees an increase of 7.26 times (9.5 Mtoe) in renewables in the period 2004-2020 and 173% in the period 2020-2030 – to 26.1 Mtoe. By 2030, the share of renewables in Ukraine's primary energy needs shall amount to 12 percent. That will be the same share of renewables as in the EU25. It is a very optimistic forecast for Ukraine when taking into account that the government policy and regulation is only being drafted and investment needs for achieving this goal are estimated at about 60 billion UAH (~€8.2 billion).

The difficulties encountered in meeting this target can partly be explained by:

- the high cost of renewable energy owing to the investment required and the fact that externalities (the "external" cost of the different energy sources, particularly their long-term impact on health or the environment) have not been taken into account, which gives fossil fuels an artificial advantage;
- administrative problems resulting from installation procedures and the decentralised nature of most renewable energy applications;
- the opaque and/or discriminatory rules governing grid access.

Demand of Renewable Energy Sources in Ukraine, 2004-2030

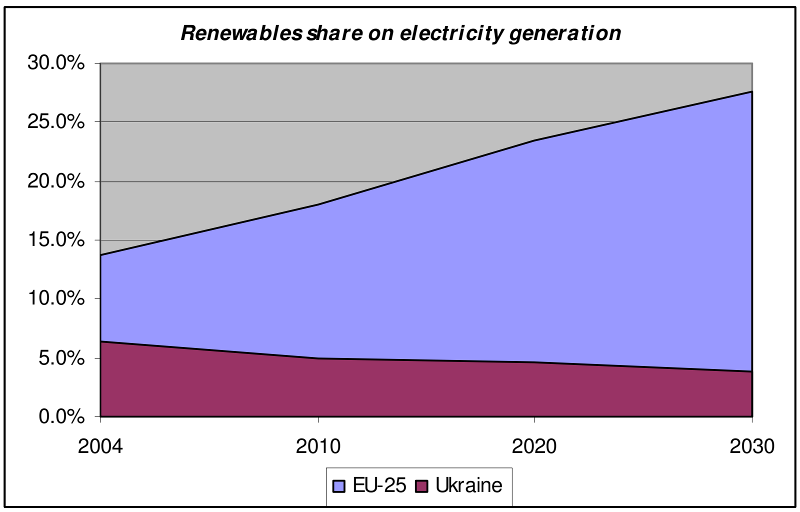
in Mtoe

	2004	2010	2020	2030
Total	2.2	3.6	9.5	26.1
Bioenergy	0.9	1.9	4.4	6.4
Solar energy	0.0	0.0	0.2	0.8
Large hydro	1.0	0.9	1.1	1.2
Small hydropower	0.1	0.4	0.6	0.8
Geothermal power	0.0	0.1	0.1	0.5
Wind energy	0.0	0.1	0.4	0.5
Low level heat sources (e.g. binary-cycle heat pump)	0.1	0.2	2.7	15.9

Cost/Competitiveness

The cost of renewable energy has been falling steadily for the last 20 years, but remains higher than that of conventional energy sources. This is above all because the external costs of fossil fuels have not been internalised. The average additional cost of meeting the 20% target in EU25 is estimated at between 10 billion and 18 billion euro per year, depending on energy prices and the research efforts made.

The cost of renewable energy ranges from the lowest (existing large hydropower) – 34.7-124.10 EUR/MWh to the most expensive ones: wind – 27.1-82.43 EUR/MWh, solar – 104.8-1 328.7 EUR/MWh. It depends in many cases on the state of technological development of the specific source[xiii]. However, compared to the total turnover in the energy sector, or the cost implications of other policy developments, the potential cost of presently adopted renewable policies (overall, biofuels, electricity) is relatively low.



Furthermore, developing the technologies used in the renewable energy sector will create new business opportunities, particularly for exporting these technologies. It is also expected to have a positive impact on employment and GDP growth.

The impact on competitiveness of renewables has so far been modest, primarily because the way they have been promoted in electricity generation (mainly through feed-in tariffs) has only had a small impact on electricity prices. The reduction in cost of wind generated electricity and increase in cost of other electricity sources (particularly gas) give reason to believe that future impact on competitiveness of renewable energy will remain at moderate level.

CO_2 emissions

Renewable energy sources produce negligible or zero greenhouse gas emissions. Increasing renewable energy's share of the total produced by all available fuels will therefore significantly reduce the EU25 and Ukrainians greenhouse gas emissions. In fact, this is a major reason for promoting them.

The most important potential deviation from this general rule is biomass, where – although the amount of carbon released to the atmosphere through biomass combustion corresponds to the amount of CO2 taken from the atmosphere during the period of plant growth – the cultivation of the crops and subsequent conversion and use may entail significant greenhouse gas emissions and other negative environmental impact. These aspects will have to be an integrated component of policies to further develop the use of biomass/biofuels.

Considerations on security of supply

Renewable energy contributes to security of supply by increasing the share of domestically produced energy, diversifying the fuel mix, diversifying the sources of energy imports and increasing the proportion of energy obtained from politically stable regions.

As a main rule, renewable energy is considered as indigenous but import of biofuels and other biomass occurs. More important, however, is the security of supply situation for the energy source replaced. Using renewable energy to substitute oil products (biofuels or biomass for heating instead of oil) offers the highest security of supply value of renewables, whereas substitution of coal (for Ukraine), abundantly available, is less valuable.

The EU will strengthen its position on all these measures of security of supply if it achieves the proposed share of renewable energy. Benefits are seen in all sectors and are particularly marked in transport. One way to sum up the benefits is to look at the quantity of fossil fuels displaced by renewable energies. Assuming the EU achieved 20% deployment of renewables, the annual reduction in fossil fuel demand can be calculated to be 252 Mtoe from 2020 onwards.

Ukraine also will strengthen its position on all these measures of security of supply if it achieves the proposed share of renewable energy. According to Energy Strategy foresees, the share of renewable energy sources in 2030 must be 19% in total energy balance.

Potential for demand-side management

Demand side management can be a solution for the balancing problem of distributed generation with high penetration of renewable energy sources.

As countries implement energy policies that promote energy efficiency, distributed generation and renewable energy resources, the share of distributed energy increases, particularly the intermittent type such as small hydro and combined heat and power (small and micro-CHP). Due to the fact that intermittent types of electricity generation are difficult to predict, electrical networks - both local and transmission— are turning to integrated distributed energy resource. By combining distributed generation with energy storage and demand response, countries can decrease problems caused by distributed generation and increase the value of intermittent energy in the market.

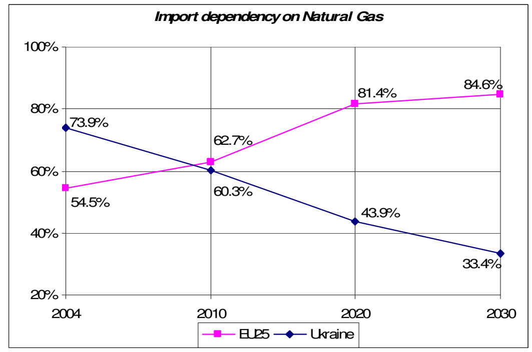
FINDINGS

There is no commonly agreed definition of security of energy supply. The simplest one equals it to dependency on energy imports. For the purposes of this paper, security of energy supplies is to be defined as the range of measures that provide for stable and sufficient access to primary energy resources. Stability and sufficiency of energy resources for a country or region shall be such that they have a negligible impact on restraining maximum use of the output capacity of the country/region economy.

Therefore, this report will look at energy security as a function of three variables: 1) import dependency, 2) energy intensity and 3) interconnection capacity.

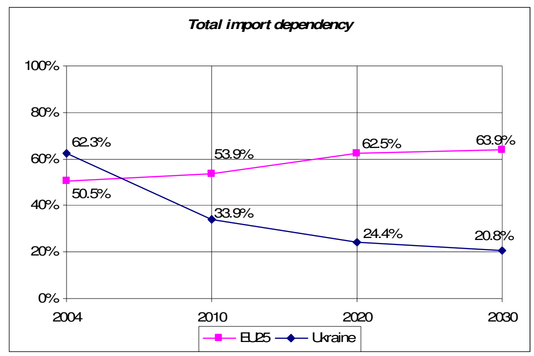
Import dependency

Taking 2004 as the baseline year for the scenarios in Ukraine and the EU, import dependency is at similar levels (50% in the EU and 62% in Ukraine). However, forecasted trends for the period until 2030 show diverging trends. As a result of increasing demand for oil, coal and particularly, natural gas imports, together with the lack of replacement for nuclear power, the EU dependency on imports increases by over 13% during the period 2004-2030. On the contrary, Ukraine stated policy of reducing gas consumption, together with the increased use of indigenous coal and nuclear, would reduce her dependency on imports threefold, down to 20% of primary energy needs.



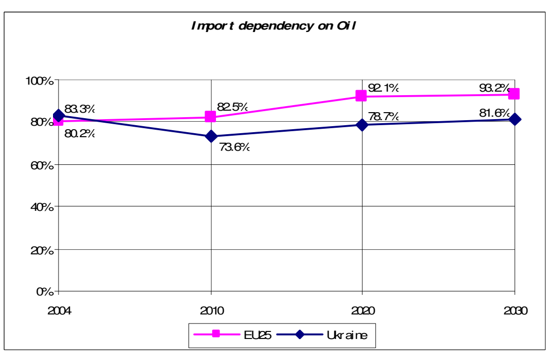
The most sensitive areas as regards import dependency are as follows:

- Oil and oil products: Assuming that oil products consumed in Ukraine are mostly the result of domestic processing and refining, forecasted demand requires close monitoring. When referring to actual patterns of oil products consumption in the new EU Member States, their growth in the period 1990-2000 was the highest amongst all primary energy sources, mostly due to soaring demand from the transport sector. In this respect, a yearly growth of 1.3% in Ukraine for the period 2004-2010 may seem conservative.



In the EU, estimates are to achieve at least zero growth in oil consumption by 2030. While ambitious, it can be argued that the transport sector in the region is fully developed, hence the target can be achieved by demand-side measures *(see oil chapter)* and higher efficiency in the car industry.

- Natural gas: Demand in the EU is led by increased electricity needs, while diminishing reserves in the North Sea drive the need for gas imports up to almost 85% of primary gas needs. Therefore, by 2030 the EU will be importing in excess of 400 Mtoe (~440 billion cm) of natural gas, or the volume of its gas consumption in 2004.



Power generation and energy-intensive industries (e.g. steel manufacturing) are leading natural gas demand in Ukraine. Strong demand and the absence of commercial extraction of indigenous gas, forced Ukraine to rely on the import of almost 74% of its gas needs in 2004. As mentioned in the relevant chapter, Ukraine's Energy Strategy sets an ambitious target of reducing gas consumption and, consequently, dependency on its import. By 2030, Ukraine gas demand should be 60% of 2004 levels with only 33% imported.

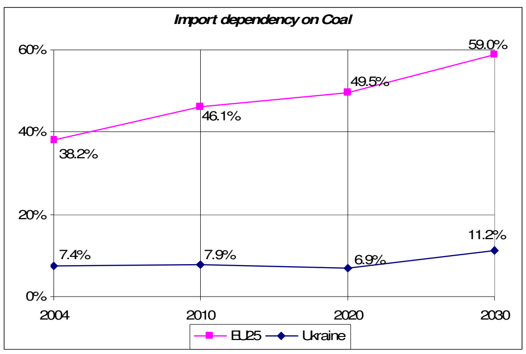
The switching of power generation from gas to nuclear as set out in the Energy Strategy can provide for a certain reduction in the demand for natural gas. It is not clear, however, that a substantial change as proposed in the Energy Strategy can be achieved unless there sectoral contribution to the GDP of Ukraine shifts from a heavy-industry base towards a higher contribution from services and high-value added economic activities.

- <u>Coal:</u> In terms of maximising indigenous production of primary energy sources, coal is an attractive option given Ukraine's substantial reserves. This option is particularly interesting as long as environmental costs are not quantified or offset against Ukraine's baseline of 1990.

In the EU, indigenous reserves for commercial extraction are dwindling, and coal-firing technologies designed in the 1970s are targeted for closure given the commitments towards emissions reduction. Nevertheless, the phasing out of nuclear energy will open a niche for coal-based power generation, which ought to be particularly felt after 2020, will open new opportunities for the use clean-coal in power generation, thus increasing demand for imported coal.

- <u>Nuclear:</u> Ukraine is set to meet the growth in electricity demand through the expansion of its nuclear industry. Assuming that building and commissioning costs, as well as the lengthier construction process are built within the development scenario, the country ought to be in a position to double the contribution of nuclear energy through the commissioning of safe and proven technologies.

In the EU, the development of nuclear energy remains a controversial issue with diametrically opposed views. Therefore, the current scenario is based on a decreasing share of nuclear energy as the existing plants reach the end of the planned lifetimes.



- <u>Renewable energy sources (RES):</u> These are indigenous primary energy sources with no "hidden" environmental costs. Their use is becoming increasingly attractive, although still require political support for a wider implementation. The latter has been in place in the EU for some years thus acting as a catalyst in the penetration of certain RES. Similar stimulus ought to be put in place in Ukraine, which seeks to increase RES almost tenfold in the period 2004-2030.

An important caveat in fostering the development of renewable energy sources calls for the countries concerned to ensure that their development does not draw on resources which are essential to other economic activities (*e.g. agriculture)*.

Energy intensity

Reducing energy intensity in a given economy is only possible to the extent permitted by the sectoral economic structure.

Reduction of energy use has proved to provide additional benefits to the economy, through the development of new relevant technologies and their implementation.

Given current energy intensity levels in the EU (gross energy intensity in 2004 was 160 toe per million USD of GDP at 2000 prices)[xiv], further reductions in energy use, which are foreseen to achieve another 50% reduction by 2030, will be mostly the result of investments specifically targeting efficiency improvements in energy use. As mentioned above, it is expected that lower GDPs due to these investments will be offset by the economic impact of technologies in energy efficiency.

Ukraine's current energy intensity stands at 500 toe per million USD of gross domestic product. The target set out in the Energy Strategy for 2030 is to achieve a 50 percent reduction which would still leave it above current EU levels. In practical terms, such a significant reduction in energy use can be met without recourse to targeted-investment, rather as a result of the refurbishment and/or expansion of outdated facilities and infrastructure.

Interconnection and storage capacities

- European Union: the EU has currently a 120-day obligation on storage of oil & oil products. Similar requirement for natural gas are being finalized as a follow-up on the green paper “A European Strategy for Sustainable, Competitive and Secure Energy”.

Given the trends on natural gas imports, in keeping with their diversification, the commissioning of downloading facilities for liquefied natural gas (LNG) has to increase further. Similarly, it is necessary to ensure steady current and future oil & gas supplies through reliable pipeline systems.

The interconnection level of electricity networks has also to be improved. Growth for electricity demand in the EU has focused on the supply side, while investments in transnational grid interconnections have given rise to bottlenecks in the single electricity market.

- Ukraine: The country has no oil or gas obligations on strategic stocks, although her technical infrastructure would facilitate the establishment of such systems. Ukraine’s significant transit role for hydrocarbons is set to be diminished by the absence of new oil deposits from Russia and the building of new pipelines for oil and gas around the Black and Baltic seas. In the absence of long-term gas supply contracts, Ukraine does not have any detailed plans for tapping the LNG market.

Ukraine electricity network is synchronously interconnected to the Russian Federation, which provides additional stability to the system and, in the medium- to long-term could become a stable market for Ukrainian electricity surplus. In the short- to medium-term, Central Europe is the obvious export market, although export capacity is currently limited because it operates as part of the UCTE systems, with which only a small part of Ukraine’s network is interconnected.

References

[i] “Energy indicators for Ukraine, 2004”, International Energy Agency, http://www.iea.org/Textbase/stats/indicators.asp?COUNTRY_CODE=UA

[ii] “Energy balances for Ukraine, 2004”, International Energy Agency, http://www.iea.org/Textbase/stats/balancetable.asp?COUNTRY_CODE=UA

[iii] “Energy balances for EU-25, 2004”, International Energy Agency, http://www.iea.org/Textbase/stats/balancetable.asp?COUNTRY_CODE=37

[iv] “CO_2 emissions from fuel combustion 1971-2003”, International Energy Agency, 2005.

[v] “CO_2 emissions from fuel combustion 1971-2003”, International Energy Agency, 2005.

[vi] Ukraine: Energy Policy Review 2006 - Ukrainian Version. 2006. – P. – 209.

[vii] “CO_2 emissions from fuel combustion 1971-2003”, International Energy Agency, 2005.

[viii] “European Energy and Transport, Trends to 2030 – update 2005”, European Communities, 2006.

[ix] “Ukraine Energy Strategy 2030”, IEA Energy Statistics.

[x] “Projected Costs of Generating Electricity, 2005 Update”, NUCLEAR ENERGY AGENCY, INTERNATIONAL ENERGY AGENCY ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, 2005

[xi] “CO_2 emissions from fuel combustion 1971-2003”, International Energy Agency, 2005.

[xii] Ukraine: Energy Policy Review 2006 - Ukrainian version, International Energy Agency, 2006.

[xiii] “Projected Costs of Generating Electricity - 2005 Update”, Nuclear Energy Agency. International Energy Agency. Organisation for Economic Co-operation and Development.

[xiv] “Energy indicators for EU-25, 2004”, International Energy Agency, http://www.iea.org/Textbase/stats/indicators.asp?COUNTRY_CODE=UA