

Energy

The fuel and energy complex (**fuel extraction and power generation**) is one of the most dynamic sectors of the national economy and, in spite of the economic difficulties of late combined with a recent decline in output, it continues to play a very important role in the Ukrainian economy. The main feature of the Ukrainian energy sector is the large dependency on foreign sources for its energy supplies. With the exception of coal reserves in the Donets'k basin (with an annual output of 80 million tons, and domestic consumption of 66 million tons), nearly 90% of fuel (namely, natural gas and crude oil) is imported from Russia. Due to this high dependency on imports, the stability of the energy supply and the ensuing energy consumption of the country are far from the desired level. Prior to its independence, Ukraine received energy supplies in exchange for agricultural and industrial products. These days the country has to cope with prices set by the international markets, instead of the previously abundant Soviet supply. Ukraine's energy network forms a unified system directly connected to Russia's sizeable network, as a by-product of the country's Soviet past. Consequently, Ukraine has been closely integrated with Russia in terms of both gas and oil.

Within the sphere of fuel extraction, it is **coal** mining which is of greatest significance in Ukraine, where workable reserves exceed 117 billion tons. Today, annual coal output is ca. 90 million tons, which is matched to the current demands of the national economy. The coal industry is presently in a painstaking stage in its transformation. The sector is predominantly run by state-owned enterprises and incorporates mining, the processing of output and trade in coal. Small and medium-sized private companies have also formed local ventures involved in extracting coal, its separation and processing. At the same time, a number of inefficient collieries, or those mining fields whose reserves are dwindling, are to be closed down and there are more than 100 such collieries in Ukraine. In early 1990s there operated 280 collieries and 7 opencast sections in Ukraine where coal was extracted; 91.5% of coal production came from the Donets' basin

(e.g. Donets'k, Makiivka, Horlivka and Krasnyi Luch) and ca. 6% from the L'viv-Volhynian basin (e.g. Chervonohrad). Reconstruction of separator plants is under way; they were among the technologically most progressive plants in the world during the 1970s. Special mention should be made of lignite mining, which for the time being is completely neglected and supported neither by investment, nor innovation.

Demand for oil and gas in Ukraine can be only partially met by domestic extraction (crude oil: 6–7% of demand, natural gas: up to 20%) and the country relies on hydrocarbon imports, mostly from the Russian Federation and Turkmenistan. Hydrocarbon resources are currently mostly extracted on the Black Sea shelf and in the Sea of Azov, in Crimea, and in the Dnipro–Donets' depression in the northeast of the country.

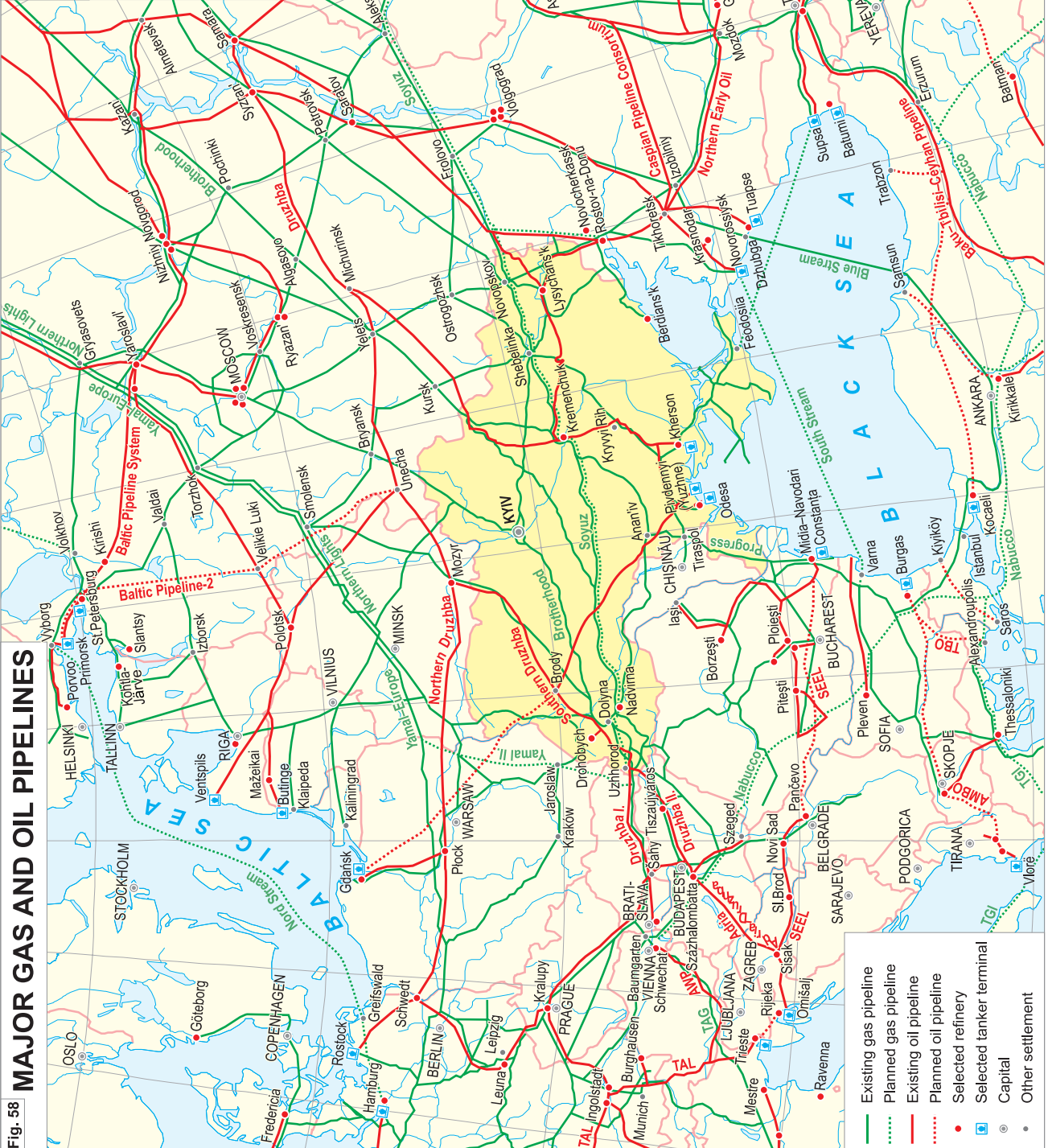
Ukraine's production of **crude oil** is small (nearly 4 million tons in 2005) and the country imports most of its supplies from Russia. 32% of oil products are destined to be consumed by the transport sector and the same amount by industry. Oil products account for about 13% of final energy consumption. Ukraine has 8 refineries (e.g. Lysychans'k, Kremenchuk, Drohobych, Nadvirna and Kherson) and the majority (e.g. at Lysychans'k) have been privatised by Russian capital. The total capacity of these plants amounts to 60 million tons annually, but barely one third of this is utilised. The perspectives of modernisation of refineries are associated with the expansion of the raw material basis and the establishment of specialized machinery engineering. With a highly developed **oil pipeline system**, Ukraine plays an important role as a transit country for Russian oil exports to Europe (*Figure 58*). The oil trunk-line system has a total length of 4,520 km and is operated by 31 pumping stations. The annual input capacity of the system is 120 million tons, and the output capacity is around 76 million tons. Crude oil is delivered from Russia and Kazakhstan to Ukrainian refineries, and also exported to Central European countries. Within the country, crude oil is transported by Ukrtransnafta, a joint-stock corporation, which has two subsidiaries af-

Fig. 58 MAJOR GAS AND OIL PIPELINES

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AMBO: Albania–Macedonia–Bulgaria Oil Pipeline
AWP: Adria–Wien Pipeline
SEEL: South East European Line
TAG: Trans–Austria Gasleitung
TAL: Trans–Alpine Pipeline
TBO: Trans–Balkan Oil Pipeline
TCGP: Trans–Caspian Gas Pipeline
TGI: Turkey–Greece–Italy Pipeline

Main sources: www.eia.doe.gov, www.inogate.org, http://mcootec.imce.ru, http://isn.rsu.ru/ru/mc



- Existing gas pipeline
- Planned gas pipeline
- Existing oil pipeline
- Planned oil pipeline
- Selected refinery
- Selected tanker terminal
- Capital
- Other settlement

20° East of Greenwich



filiated to the company, *Pridniprovskiy Oil-Trunk Pipelines* (Ukraine's southeastern region) and *Druzhba* (Friendship) Oil-Trunk Pipelines (with 740 km of domestic pipeline in the northwest: "*Southern Druzhba*"). During the last ten years, crude oil volumes transported by the pipeline system have ranged from 64 to 78 million tons, including the cross-country transit of 53 to 60 million tons. As a result, the Ukraine of today is not only an important country for the transit of gas, but is also a crude oil transport crossroads in Europe.

As is well known, the Caspian region these days appears to have the best prospects for growth in oil production. Currently there are multiple options for the delivery of Caspian crude oil to the world markets. The current route, via the Black Sea to the Mediterranean using the Bosphorus and Dardanelles is limited due to the traffic capacity of the straits and environmental concerns. The *Odesa–Brody pipeline* is the only route for transporting Caspian oil to Central Europe – bypassing Russia and the Turkish straits – via the GUAM states: Azerbaijan, Georgia, Ukraine (through the Baku–Batumi–Odesa/Pivdennyi terminals). A plan was adopted in December 2002, regarding the extension of the Odesa–Brody pipeline to the Polish port of Gdańsk. The project's success would enable the sources of crude oil supply to be diversified, and enhance the reliability of the European oil transportation system. Northwestern Ukraine hosts part of the 'Southern Druzhba' oil pipeline, Russia's main overland crude oil export route. Ukraine also has the 'Pridniprovskiy' trunk pipeline which transports oil to southern Russia, as well as to several Ukrainian refineries. Ukraine's oil transit capacity now exceeds 2 million barrels per day.

In spite of copious domestic **natural gas** reserves, production in Ukraine is only 18–19 billion cubic meters (bcm) per year, which accounts for a quarter of the country's needs (77 bcm in 2005), and it is for this reason that approximately 75% of the gas consumed in Ukraine is imported from Russia and Turkmenistan. Gas accounts for about 43% of the overall national energy consumption. Ukraine is the main transit route for Russian natural gas exports to Europe (some 90%) and it has an extensive gas transmission system, which consists of 37,100 km of pipelines (designed in the Soviet era) and 72 compressor stations (112 compressor shops with a total capacity of 5,600 MW.

The oldest **gas transit pipelines**, built during the Soviet period, are the Brotherhood, Soyuz (Union) and Progress, which continue to supply the former allied Socialist (Comecon) countries of the USSR in Central and Southeastern Europe. The input capacity of the system is 290 billion cubic metres (bcm) a year, and the output stands at 175 bcm a year. Gas transit levels have been growing over the years, reaching 142 bcm in 2005. 13 underground gas storage facilities with a working capacity of over 34 bcm represent an important technological resource in Ukraine's gas transmission system. The *underground gas storage network* comprises of four systems: the West Ukrainian (Pre-Carpathian), Kyiv, Donets' and South Ukrainian. Connected by a network of pipelines, the facilities (particularly those in the western regions) ensure the reliable operation of the gas transmission system as a whole, and contribute to a stable gas supply to domestic consumers and for the transit of Russian gas to Europe.

The Ukrainian gas market is dominated by the state-owned holding company 'Naftohaz Ukrainy' responsible for the production, import, transport and distribution of natural gas. Along with subsidiaries dealing in oil products, other subsidiaries of Naftohaz are Ukrhazprom (production and transmission of gas) and Ukrhaz (sales). RosUkrEnergo (since 2004) as a subsidiary of Russian Gazprom (the state-controlled gas monopoly) supplies all gas imports from Russia and Central Asia to Ukraine.

Since the second half of the 1990s, the USA has pushed for the construction of several pipelines (e.g. TCGP: Trans Caspian Gas Pipeline, since 1996) that would carry Caspian energy westwards without have to transit Russia, and therefore break Russia's monopoly on the region's energy transportation system. Moscow moved fast to construct its own, 1,213 km long *Blue Stream* submarine gas pipeline (2001–2003) from Russia to Turkey, which killed the USA and EU-backed TCGP project (*Figure 58*). At the same time, in concert with strong support from the USA, the *Southern Caucasus Pipeline* project (between Baku and Erzerum) was realised in 2006, allowing Azerbaijan and Georgia to resist Russian political and economic pressure. It was on this pipeline, together with the Baku–Supsa and Tbilisi–Yerevan–Tabriz gas pipelines that the Ukrainian *Supsa–Feodosiia* submarine pipeline was based, running between Georgia and

Ukraine (bypassing Russia), which can supply Caspian and Iranian gas to Ukraine and other European countries.

Since the “Orange Revolution” of 2005, the realigned, pro-Western (EU and NATO) attitudes of Ukrainian foreign policy have resulted in Russia increasing natural gas and crude oil prices to international market levels, for supplies destined for Ukraine. In January 2006 a gas-related crisis erupted between the two countries, following unsuccessful talks over gas prices, after which Naftohaz siphoned-off supplies from the main transit pipelines running via Ukraine, from Russia to Central and Western Europe. This resulted in the Russians shutting-down gas supplies. Indeed, this was not a unique reaction as Russia often closes off its supply to pipelines during times of political dispute (e.g. 2003 Latvia; 2006 Ukraine, Lithuania, Georgia and 2007 Azerbaijan), owing to the extremely close relationship between the Russian energy industry and the Kremlin.

Following the gas crisis, the EU has expressly endeavoured to decrease its strategic dependence on Russian (Gazprom’s) gas (43% in 2005) and to diversify its energy supply (Hafner 2006). The first step in this direction is to realise alternative, non-Russian controlled gas corridors to the EU: the Nabucco and Turkey–Greece–Italy (TGI) pipelines, further diversifying export possibilities to European markets, bypassing Russia and Ukraine entirely. Construction of the 3,300 km long *Nabucco* pipeline is expected to begin in 2009 and completion is planned for 2012. It would connect Baumgarten an der March, the largest natural gas hub in Austria with Erzerum in Turkey, the end of South Caucasus Pipeline. Once completed, it will allow transportation of natural gas from producers in the Caspian region such as Azerbaijan, Turkmenistan and Iran to the EU and other countries along its path. The recently announced *TGI* pipeline would transfer Caspian gas from Turkey, through Greece to Italy, with an annual capacity of 11.5 bcm and a completion date of 2012 (*Figure 58*).

These “southern corridors”, together with the planned Supsa–Feodosiia pipeline are an example of strengthening Euro-Atlantic cooperation and could reduce the increasing Russian economic and political influence in given countries, of which Ukraine is one. As a result of the existing and planned “pro-Russian” and “pro-Western” energy corridors, Turkey has

become a natural hub for Caspian and Iranian gas destined for Europe. But this strategic transit country, similarly to Ukraine, is increasingly dependent on Russian energy supplies (60% of natural gas and 20% of oil imports). Due to the Russian influence, Turkey has already demonstrated a cool attitude towards Ukraine’s and Georgia’s NATO aspirations and has openly opposed NATO’s naval deployments in the Black Sea area (Tsereteli 2005).

Again, Russia is evidently trying to preempt these two pipelines (Nabucco and TGI) in order to preserve its European market dominance. Following Western opposition to Gazprom’s involvement in Nabucco, in June 2007 Russia announced the *South Stream* project (a submarine pipeline running from Novorossiysk, Russia to Varna, Bulgaria), bypassing both the Caucasian countries and Ukraine.

Besides the above, in the frame of its anti-Nabucco campaign, in May-June 2007 Russia signed agreements with Kazakhstan, Turkmenistan and Uzbekistan (the main gas suppliers to the planned Nabucco), in order to construct new Russia-bound gas export pipelines, seriously damaging EU efforts for non-Russian controlled pipelines from the Caspian region. These plans, considered to be vital for Gazprom and Russia (among others) would establish a gas pipeline from Aleksandrov Gai, Russia (crossing Soyuz and the Central Asia – Centre Pipelines) to Novopskov, Ukraine in the same corridor as used by the Soyuz (1983) pipeline. With an annual 28 bcm capacity, this pipeline could serve as a link in the system through which gas is transported from Central Asia to Europe. The pipeline expansion between Uzhhorod and Novopskov would strengthen the role of Ukraine as a transit country for natural gas to Central and Western Europe.

Electricity. The second most significant actor in the energy sector is electricity generation. From the start of its development, electricity generation in Ukraine was focused on the consumption of indigenous organic fuels; later the emphasis was on nuclear power. As a result, these two branches have become the leading sectors. At the same time, potential reserves of alternative and renewable sources have the equivalent energy of 78 million tons of oil. In the field of alternative sources, wind power, biomass energy, the burning of gas (as a derivative of industrial waste) and pit gas (methane)

are the most important. As things stand today there is an urgent need to reconstruct the plants and their equipment, to replace obsolete technology used in the generation of electricity, and to facilitate the introduction of alternative and renewable energy sources.

More than 11,000 *power plants* operate in Ukraine with a total capacity of 51,900 MW (2006), of which thermal power plants are responsible for the majority (64.3%), followed by nuclear power plants (26.6%) and finally hydroelectric power plants (9.1%). Ukraine's power generation output exceeded 185 billion kWh in 2005. Nearly 48% of this energy volume was produced by thermal power stations, an additional 45% by nuclear ones and the rest by hydroelectric plants. The country has 35 major thermal power stations with differing capacities, ranging from 0.3 to 5 million kW, 4 nuclear power plants with a total capacity of 14,000 MW and 5 hydroelectric power plants operating on the Dnister and Dnipro rivers. The larger power plants are concentrated in the industrial region of the Donetsk Basin and in the vicinity of Kyiv. Ukraine's energy consumption is around 176–182 billion kWh per year, which enables the country to export its surplus energy.

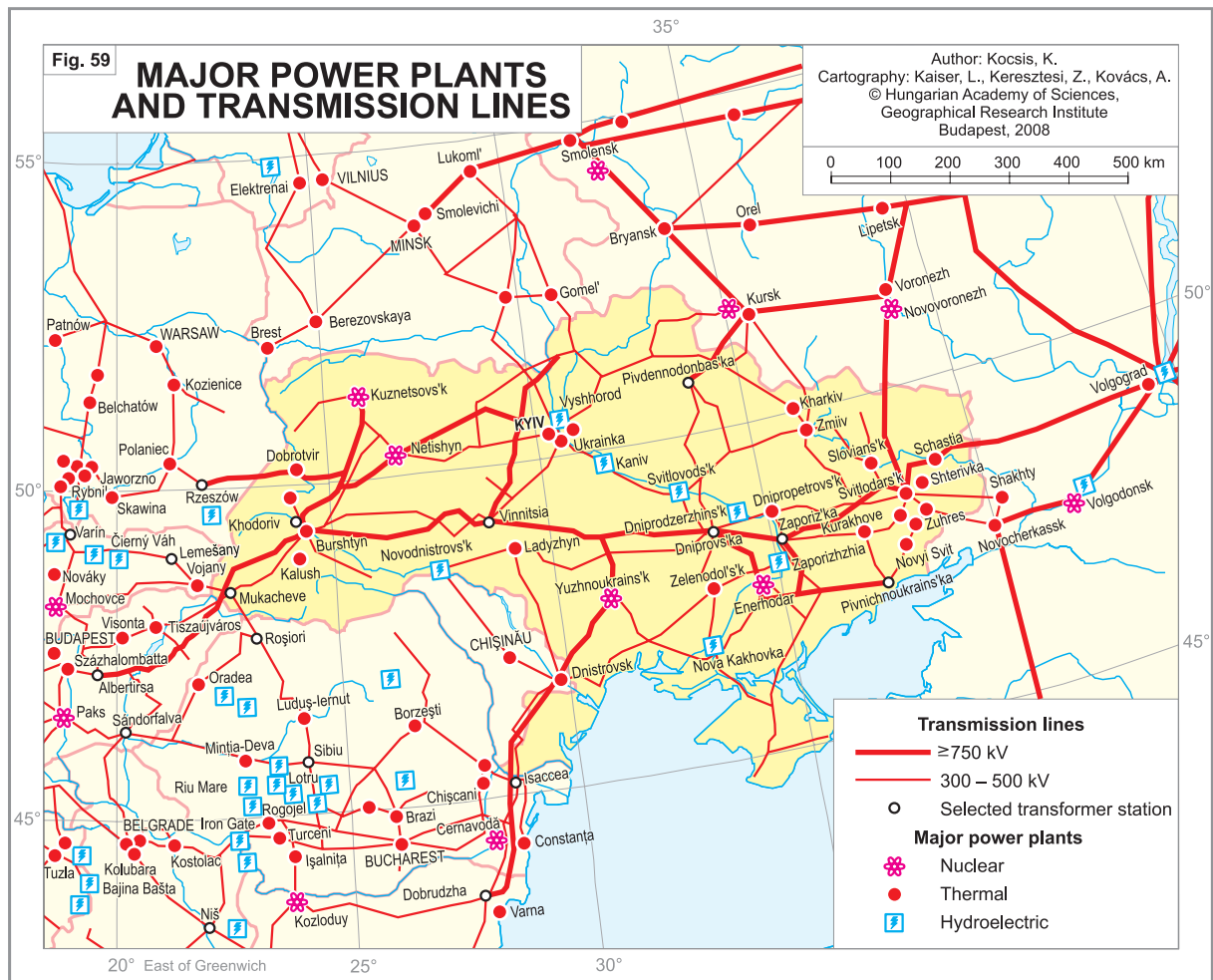
Ukrainian *transmission lines* (amounting to some 4,000 km with a capacity of over 750 KV) represented the most significant part of the "Yuzhny" (Southern) energy network of the former USSR. The first line was established in 1926 in the Donetsk Basin (between the power plants Shterivka and Kadiivka/Stakhanov). In 1940, the energy networks of Donbas and Dnipro were united, followed by those of Kyiv, Dnipro, Kharkiv and Donbas in 1960. These Ukrainian power systems were connected to the Soviet "Volga" energy network in 1962, through the world's first 800 kV DC transmission line, between Donbas and Volgograd (Figure 59). The launch of the Mukachevo transformer station (400 kV) in 1963 served to facilitate the export of electricity to Czechoslovakia and Romania. From the second half of the 1970s, the installation of 750 kV lines towards Kursk and Novonoronezh served as the link to the Soviet "Central" (Moscow) energy network. After 750kV transmission lines were built between Donbas and Vinnytsia, during the 1970s and 1980s lines bearing the same capacity were constructed towards the nearby Comecon countries, which were grappling with energy insufficiency at the

time. Namely, these countries were Hungary (to Albertirsa), Poland (to Rzeszów), Romania and Bulgaria (to Isaccea and Dobrudzha), and the export of electricity to these end-users was facilitated by the construction of numerous western Ukrainian large-capacity power plants (e.g. in Burshtyn, Kuznetsovs'k, Netishyn and Yuzhnoukrains'k).

The Ministry of Fuel and Energy is the top tier in the system regulating Ukraine's electrical energy networks. There are six power generation companies – 4 thermal ones and 2 state-owned hydropower companies – operating under its legislative control. State-owned Energoatom is responsible for the nuclear industry (including the 4 nuclear power stations) and the supply of nuclear fuel, security and nuclear waste disposal. State-run Energorynok is the operator of the Wholesale Electricity Market (WEM), based on the single-buyer model where prices for nuclear and hydropower generation are fixed by the government. UkrInterEnergo, also a state-owned company, exports electricity to Belarus, Hungary, Moldova, Poland, Romania and Slovakia. Ukrenergo is the company in control of the national grid, and is also the owner of cross-border lines. 27 local electricity companies are in control of distribution, under a TPA (Third Party Access) regime. The sector has been partially privatised with US-based AES and Slovakia's VEZ as foreign investors. Other independent electricity suppliers hold licenses to supply electricity at non-regulated tariffs. Large industrial consumers can acquire delivery licenses and purchase their own supply of electricity at non-regulated prices.

The network used for the transmission and distribution of electricity, which consists of 17,000 km of high-voltage transmission lines inherited from the Soviet Union, is inefficient and antiquated, resulting in significant wastage due to line losses. In 2000, Russia and Ukraine struck a deal to reconnect their energy grids, providing Ukraine with a more stable electricity frequency and enabling Russia to export its own electricity to other countries, including Moldova, Bulgaria, Romania and other Balkan states, via Ukraine.

The fact that many *thermal power plants* in Ukraine are old with antiquated equipment is a serious challenge. Obsolete technology and the lack of modern equipment (e.g. filters on smokestacks) have led to increasing pollution. There are efforts to raise efficiency and safety



of old thermal power plants, but these plans have been delayed due to financial difficulties and legislation gaps. Thermal power stations are to be found all over the country, but they reach a particularly high density in the traditionally industrial regions, such as Donbas, the belt along the Dnipro river, Ciscarpathia, and hubs like Kyiv, Kharkiv and L'viv. Thermal power plants in Burshtyn, Zelenodol's'k (Kryvoriz'ka), Dnipropetrovs'k (Pridniprovs'ka), Novyi Svit (Starobeshivs'ka), Schastia (Luhans'ka) and Zmiiv are in need of capital injections for their refurbishment.

Hydroelectric power – as a renewable energy source – only plays a modest role in Ukraine's total energy output. The average annual output of hydroelectric power in Ukraine amounts to 10.1 TWh, which meets 7% of consumption demand on electricity. The total installed capacity is 4.4 GW. Of the existing hydroelectric power plants (65) there are 8 large ones (between 350 and 1450 MW of installed capacity), e.g., Dniprohes-2 (Zaporizhzhia),

Kremenchuks'ka (Svitlovod's'k), Kyivs'ka HES, HAES (Vyshhorod) and Dnistrovs'ka (Novodnistrovs'k). Dniprohes in Zaporizhzhia, the largest Ukrainian hydroelectric power plant (built 1927–1932 and rebuilt 1944–1949) was one of the first significant achievements of Soviet industrialisation.

The economically feasible hydropower capacity of Ukraine is estimated to be 17 TW per annum for large and 3.7 TW for smaller hydroelectric power plants. According to the EBRD (European Bank for Reconstruction and Development) around 26% of resources have been exploited up until now. The majority of resources are concentrated in Central and Western Ukraine on the Dnipro, Dniester, Southern Buh and Tisa rivers.

Nuclear power has a great significance in the energy management of Ukraine since it is responsible for over 45% of electricity generated. It is produced by 15 nuclear reactors, all of the VVER type in 4 nuclear power plants: Zaporiz'ka in Enerhodar (6 reactors with

6,000 MW gross capacity), South Ukrainian in Yuzhnoukrains'k (3 reactors with 3,000 MW gross capacity), Rivnens'ka in Kuznetsovs'k (4 reactors with total 2,840 MW gross capacity) and Khmel'nyts'ka in Netishyn (2 reactors with 2,000 MW gross capacity, and an additional 2 under construction). There are plans to build new nuclear power plants in a few years time, to compensate for those reactors that were damaged and shut down in Chernobyl, in 1986 and 2000 respectively. Zaporiz'ka (built 1985–1995) is the largest nuclear power plant in Europe and the third largest in the world. It generates about half the Ukrainian electricity derived from nu-

clear power. For the time being Ukraine does not produce nuclear fuel of its own, though the country has resources of radioactive raw materials. Thus, uranium ore is being extracted in Central Ukraine at sites in Zhovti Vody, Vatutine, Michurins'k and Novokostiantynivs'k. There are some prospects for the establishment of a nuclear fuel production facility in Ukraine.

The exploitation of *alternative resources* for power generation is expanding. In the Autonomous Republic of Crimea and some southern oblasts (Odesa, Mykolaiv) *wind farms* are operating. These regions are also suitable for the development of solar power generation.

