Energy in the Ukraine: the implications of energy efficiency

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INTRODUCTION

Any meaningful debate on the opportunity for construction of the Khmelnitski 2 and Rovno 4 nuclear units (K2 - R4) in the Ukraine, and on support for this operation by a loan from the European Bank for Reconstruction and Development, can only take place within the framework of an analysis of the general energy situation in the Ukraine and an examination of the most appropriate solutions likely to improve that situation in a sustainable manner.

This short note presents the strategic importance and urgency of an energy-efficiency programme for the Ukraine. This objective is a priority action in the Ukrainian energy sector, both for the Ukrainians themselves and for international bodies supporting cooperation.

1. ENERGY AND ELECTRICITY IN THE UKRAINE

1.1. Energy consumption and energy intensity

a) *High energy intensity*

The Ukraine's per capita gross domestic product (GDP)[1] dropped from US$7,160 to US$3,338 in the 1991-1999 period, with a population which remained at around 50 million. By way of comparison, the GDP of the European Union was around US$20,000 in 1999.

In this same period, per capita consumption of primary energy in the Ukraine fell from 4.84 toe in 1991 to 2.86 toe in 1999. In comparison, per capita consumption of primary energy in the European Union was 3.9 toe in 1999. [2]
This means that the energy intensity of the Ukraine – the ratio of energy consumption to GDP – was:

- 0.68 toe per US$1,000 in 1991;
- 0.86 toe per US$1,000 in 1999.

The energy intensity of the European Union was 0.19 toe/US$1,000 in 1999.

Therefore:

i) In 1999, the energy intensity of the Ukraine was 4.5 times greater than that of the European Union (which means energy consumption 4.5 times greater for a given level of GDP).

[1] The statistical data used in this note are from the ENERDATA database (Grenoble, France). The GDPs are with "purchasing power parity" and are given in 1995 US dollars, at 1995 prices.
[2] Data on current energy consumption in the Ukraine are given in appendix 1.

ii) The situation worsened between 1991 and 1999: energy intensity in the Ukraine has increased (by a factor of 1.25), whereas the economic level has dropped.

b) *Very low energy efficiency*

Thus – even allowing for the uncertainties associated with calculation of energy intensities, their evolution and comparison (although this is the only comparison which can be made between countries on the basis of a simple and global indicator) – it can be seen that the most salient feature of the Ukraine where energy is concerned is the very low efficiency of its energy system and a very bad use of energy.
This observation, based on the global indicator provided by energy intensity, is confirmed by all of the studies and sectoral energy audits carried out in industry, buildings and for heating systems.
The increase in energy intensity between 1991 and 1999 was caused by the collapse of the industrial system (many plants operate at very low capacity), ageing of installations and the low level of maintenance.
In particular, losses in heating systems are considerable at all levels (production, transport, distribution and use of heat).

1.2. Electricity in Ukraine

a) Electricity consumption

The total final consumption of electricity dropped from 201 TWh (billion kWh) in 1991 to 118 TWh in 1999, i.e. a final per capita consumption of 2,400 kWh in 1999 (to be compared with 5,600 TWh for the European Union).

Electrical intensity, the ratio of final electricity consumption to GDP, was 0.54 kWh/US$ in 1991 and 0.71 kWh/US$ in 1999 (to be compared with 0.27 kWh/US$ for the European Union).

The same characteristics are observed for consumption of electricity as for consumption of energy in general:

- the Ukraine's electrical intensity is three times higher than that of the European Union at present;

- this intensity increased (by a factor of 1.3) between 1991 and 1999.

Observation

Consumption of electricity per sector in 1999:

Industry	54 per cent
Domestic	19 per cent
Tertiary	13 per cent

b) Electricity generation

The total amount of electricity generated in the Ukraine went from 279 TWh in 1991 to 174 TWh in 1999.

This breaks down as follows:

	1991		1999	
	TWh	**%**	**TWh**	**%**
Hydro	12	4	12	7
Nuclear	75	27	67	39
Thermal	192	69	95	54
of which:				
- oil	36	13	7	4
- gas	81	29	40	23
- coal	76	27	48	27

Generating from hydro and nuclear sources was stable during the 1991-1999 period (drop of 10 per cent from nuclear), whereas generating from fossil fuels dropped considerably (by a factor of 3.6), especially where coal and natural gas are concerned.

In parallel with this reduction in generating from fossil fuels, the installed capacity of fossil fuel plants remained at the same level (37,000 MW out of a total of 54,000 MW, of which 4,700 MW from hydro and 12,000 MW from nuclear).

There is therefore a significant over-capacity of fossil fuel plants (the level of use of fossil fuel plants in 1999 being around 50 per cent of its 1991 level).

There is therefore no necessity for investment in additional capacity, but:

- a need for rehabilitation of the existing fossil fuel plants (or decommissioning for the oldest ones);

- a need for fuel supplies to the fossil fuel plants: the major constraint on additional production of electricity being lack of fuel (or inability to buy it).

2. THE IMPLICATIONS OF ENERGY EFFICIENCY

2.1. Today

The Ukraine's total primary energy consumption was 138 mtoe in 1998, of which the Ukraine produces 69 mtoe itself and imports 69 mtoe.

If the Ukraine had an energy intensity comparable with that of the European Union, say around 0.3 toe/US$1 000, its primary energy consumption for a GDP of US$167 billion would be 50 mtoe, thus less than its annual production.

Of course such an assessment is not realistic, but it has the merit of highlighting the importance of the global potential for energy efficiency in the Ukraine.

Realising such a potential implies restructuring and modernisation of the industrial sector (still representing 40 per cent of final energy consumption) and a major political effort on efficiency in energy consumption (heat systems, domestic, tertiary sector, transport, etc.).

2.2. Tomorrow

A future projection will help to better evaluate the importance of an energy efficiency policy.

Let us assume an economic upturn in the Ukraine from 2000, allowing it to reach a level of GDP twice the 1999 value by 2010, i.e. US$334 billion.

If energy intensity remains at the 1999 level, i.e. 0.86 toe/US$1,000, total primary energy consumption would reach 287 mtoe; if energy intensity dropped to its 1991 value (0.68 toe/US$1,000) primary energy consumption would be 227 mtoe; if energy intensity was 0.3 toe/US$1,000, its primary energy consumption would be 100 mtoe.

(Note that in 2010, energy intensity in the European Union will certainly be less than 0.2 toe/US$1,000).

2.3. Conclusion

➘ Energy efficiency is uncontrovertibly the Ukraine's prime energy resource.

➘ The urgent introduction of a programme of energy efficiency in all sectors, for all uses of energy and energy products, must be a first priority for the Ukraine's energy policy and for policies of international cooperation in the area of energy.

➘ By lightening the burden which an inefficient energy system represents, energy efficiency is a vital element for economic recovery in the Ukraine.

3. IMPLEMENTATION OF AN ENERGY EFFICIENCY POLICY

3.1. The logic of actions

a) Electricity savings

The high level of electrical intensity should lead to the development of a programme of savings in electricity consumption, where its has been seen that the largest consumer is industry.

However, it must be noted that needs are emerging in the domestic and tertiary sectors and that a return to economic growth should lead to an increase in consumption of electricity even if, in parallel, electrical intensity is lowered.

The country must be able to meet this increased demand. This could be done at least cost by using the fuels, especially the natural gas saved under energy-saving programmes in the industrial sector, and that from heat systems where the potential for savings is considerable.

b) Energy savings

Energy intensity in the Ukraine is, we have seen, around four times higher than that of the European Union. There is a considerable potential for energy savings in all sectors of industry, heat systems, and in both private and public buildings, etc.

In 1996, after the creation of the Ukrainian State Committee for Energy Efficiency, the Ukrainian government adopted a detailed energy-efficiency plan featuring the importance of the potential for savings, a potential confirmed by all energy studies and audits carried out, especially under the TACIS programme.

To provide an example, two project sheets are presented in appendix 2 of this note which illustrate this dual electricity saving and fuel saving approach.

Appendix 1 : Data on current energy consumption in the Ukraine

For the year 1999, the energy balance of Ukraine could be summarised as follows[3].

Primary energy consumption: **143 Mtoe** (million tons of oil equivalent).

The distribution of this consumption by energy sources was :

	Mtoe	**%**
Coal	**42**	**29.4**
Oil	**20**	**13.9**
Nat. Gas	**62**	**43.5**
Prim. Elec.*	**19**	**13.3**
TOTAL	**143**	**100**

* primary electricity : hydro plus nuclear

Final energy consumption : **98 Mtoe** .

The distribution of this consumption by energy carriers was :

	Mtoe	**%**
Coal	**15.6**	**15.9**
Oil	**16.1**	**16.4**
Gas	**46**	**47.0**
Electricity	**10.2**	**10.4**
Heat*	**10**	**10.3**
TOTAL	**98**	**100**

*Heat : it refers to heat produced by HOB (heat only boilers) or co-generation plants and supplied through a public distribution network. From this definition we can conclude that the final consumption of heat is under-estimated in the present energy balance as a significant part of heat consumed in industry is not supplied through a public network but produced on site.

Comments:

1. Heat and electricity have the same contribution to the final energy balance (10 and 10.2 Mtoe respectively).

[3] Source : ENERDATA s.a.

2. Gas consumption is predominant in the final energy balance (47% of the final energy consumption and 46 Mtoe). In value, the final consumption of gas in 1999 is equivalent to that of the year 1991, whereas the level of electricity consumption fell from 17,3 Mtoe in 1991 to 10,2 Mtoe in 1999 and the level of heat consumption from 32,5 to 10 Mtoe.

Whereas the decrease in electricity consumption was due to the collapse of the industrial sector, the decrease in heat consumption was mainly imputable to the Residential and Tertiary sectors where the low quality of supply (resulting from the bad quality of heat production and distribution infrastructures) resulted in a substitution by natural gas. However this substitution is made using low efficiency equipment (e.g. using gas cookers for heat purposes).

3. This situation should be considered in the light of the balance trade for energy products.

Energy imports Y.1999

	Net imports Mtoe)	**%**
Crude oil	**+11.5**	**+18,0**
Oil products	**+4.78**	**+ 7,5**
Gas	**+47**	**+ 73,4**
Coal	**+0.92**	**+ 1,4**
electricity	**-0.17**	**- 0,3**

73,4% of energy imports are gas.

By improving district heating network infrastructures and heat supply quality one can expect that district heating (which on the principle is an efficient way of supplying and consuming energy) will recover part of its historical market share in the residential and tertiary sectors. This trend will reduce the pressure of energy (mainly gas) on the country's trade balance and therefore have a very positive impact on the overall economy.

Appendix 2: two examples of energy efficiency programmes

The first programme deals with direct electricity savings through the promotion of efficient lighting in the residential and the communal/administrative sectors. This programme is to be launched directly by the utility, and will lead to **annual savings up to 2.4 TWh of electricity. As a consequence, 55 to 96 million US** *$(1)* **of imported gas will be saved each year.**

The second programme is focused on district heating systems, and includes a number of **first priority investments** (pay-back period < 4 years) designed to improve the distribution of heat. More capital intensive investments, though profitable, are not contemplated here.
On the basis of three case-studies, **the programme covers the 10 main cities of Ukraine and will lead to 5.2 TWh of heat savings, i.e. an economy of 48 to 83 million US $ of imported gas per year.**

These two programmes can be implemented in a period of two years.

Programme 1 :

Efficient lighting in the residential and commercial / administrative sectors

Efficient lighting
Commercial and administrative sector

Investment	55 million US $
Annual electricity savings	1.3 TWh (41.5 million US $)
Investment per kWh saved (2)	1.6 cents/ kWh
Actual value (2) for 3.1 years life period	38 millions US $

(1) for an average price of gas of 97 S/tcm (2) discount rate of 10 %
Actual value = discounted savings - investment

Efficient lighting in the Residential sector

Investment	102 to 110 million US $
Annual electricity savings	1.1 TWh (35 million US $)
Investment per kWh saved (2)	2.3 cents / kWh
Actual value (2) for 5.5 years life period	33 to 43 millions US $

(1) for an average price of gas of 97 $/tcm (2) discount rate of 10 %
Actual value = discounted savings - investment

Programme 2 :

District heating programme

Investment		216 million US $
Annual heat savings	5.5 TWh	(65 million US $ (1))
Investment per toe gas saved (2)		51 US$/ toe
Actual value (2) for 15 years life period		360 millions US $

(1) for an average price of gas of 97 $/tcm
Actual value = discounted savings - investment
(2) discount rate of 10 %

The programme proposed is based on various district heating audits carried on in Ukraine with the support of TACIS, Thermie, USAID, danish cooperation, etc. Audits covered parts of Kiev, and other smaller cities

The main component of the programme is the district heating system of Kiev.

The proposed programme for the city of Kiev includes :

- measurement and temperature/flow control in sub-stations (400)	12 M$
- measurement and electronic control of 6 major boilers, plus manual for 10	30 M$
- building/flat heat control (25 to 30 % of the buildings)	12 M$

	dwellings (thousand)	square meters (thousand)
UKRAINE	17660	922000
KIEV	87000	43600
	sq meter/ dwelling	sq meter / inhab
UKRAINE	52.2	17.8
KIEV	54	16.6

The programme has been expanded to the main cities of Ukraine, on the basis of the**.** population and the square meters of dwelling registered.
The ten cities contemplated in the programme are : (populations *in thousand of inhabitants) :*

	population		*population*
Kiev	2646	ZaporizhzIiia	900
Kharkiv	1615	Lviv	810
Dnipropetrovsk	1186	Kr yi Rik	737
Donetsk	1121	Mariopol	524
Odessa	1087	Mykolaiv	519