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Critical Analysis of Main Provisions of the Energy Strategy of Ukraine up to 2030

In March 2006, the Cabinet of Ministers of Ukraine approved the Energy Strategy of Ukraine up to 2030 (referred hereinafter to as the Energy Strategy or the Strategy). The Strategy generated a rather mixed response of specialists and members of the general public, due to its clearly visible "nuclear" focus. The Strategy stipulates construction of 11 new nuclear reactor units with total capacity of 16.5 GW, 9 replacement reactor units with total capacity of 10.5 GW and two additional reactor units at Khmelnitskiy NPP (1 GW each). A detailed analysis of main parameters of the Strategy shows that they all are interrelated and serve the main idea of the document - i.e. development of the power industry of Ukraine at the base of priority development of nuclear power. To substantiate these conclusions, let us review key provision of the Energy Strategy in connection with plans to develop nuclear power industry.

1. How Much Fuel and Energy Is Ukraine Expected to Consume in 2030?

Forecasts of consumption of fuel and energy resources (FERs) in 2030 are based on anticipated growth of GDP of Ukraine in 3.1 times, from UAH 413.9 billion in 2005 to UAH 1,286.2 billion in 2030 (see Fig. 1 at page 10 of the Energy Strategy). These figures mean that the annual average GDP growth in the whole period is expected to reach 4.9%. We think that the rate seems rather optimistic, in its turn, such an assumption may result in overestimated assessment of FERs consumption in 2030. Anyway, let us assume that the GDP will really increase by 2030 in 3.1 times.

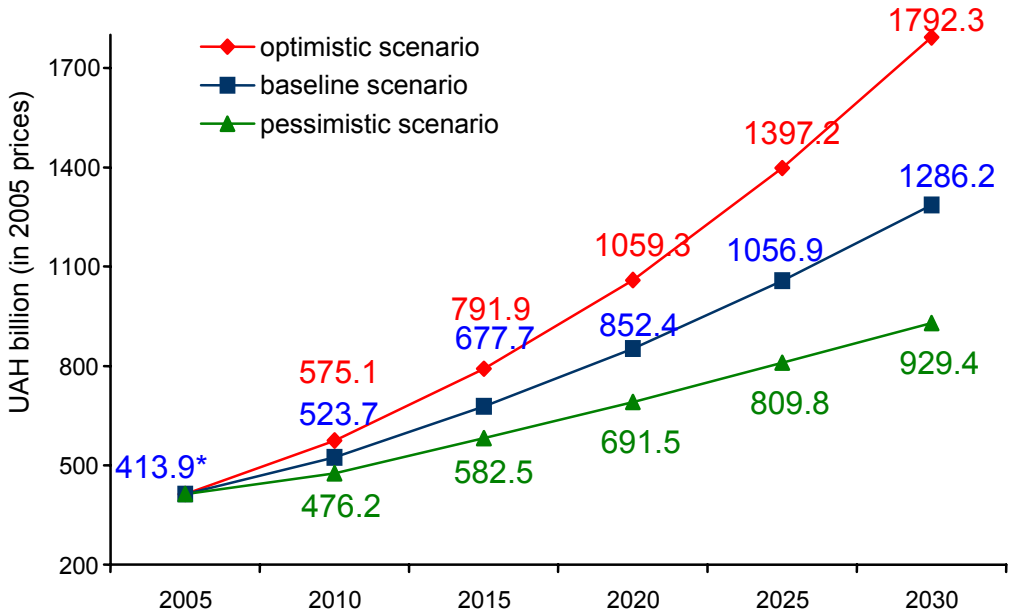

Figure 1. The Energy Strategy of Ukraine up to 2030: GDP growth forecast, UAH billion, in 2005 prices
* In all sections of the Energy Strategy, data for 2005 represent preliminary data, that were available as at 08.02.2006.

According to the baseline scenario of development of the fuel and energy complex of Ukraine up to 2030, consumption of primary energy resources will reach 302.7 million ton of equivalent fuel in 2030 (see Fig. 2 at page 10 of the Energy Strategy). In other words, PERs consumption is expected to increase in 1.51 times, that corresponds to reduction of GDP energy intensity by 2030 in 3.1/1.51 = 2.05 times. According to figures of the Strategy itself (see Fig. 3 at page 8 of the Energy Strategy), GDP energy intensity of Ukraine reaches 0.89 kg EF/$1 (purchasing power parity). Correspondingly, in 2030, GDP energy intensity is expected to reach 0.89/2.05 = 0.43 kg EF/$1 (PPP). EF = equivalent fuel = coal equivalent, LHV = 29.3 MJ/kg. For comparison: in 2005, the relevant figure for Poland reached 0.34 kg EF/$1 (PPP). Therefore, the Strategy sets the target for GDP energy intensity of Ukraine by 2030 much higher than the level Poland had already reached in 2005!

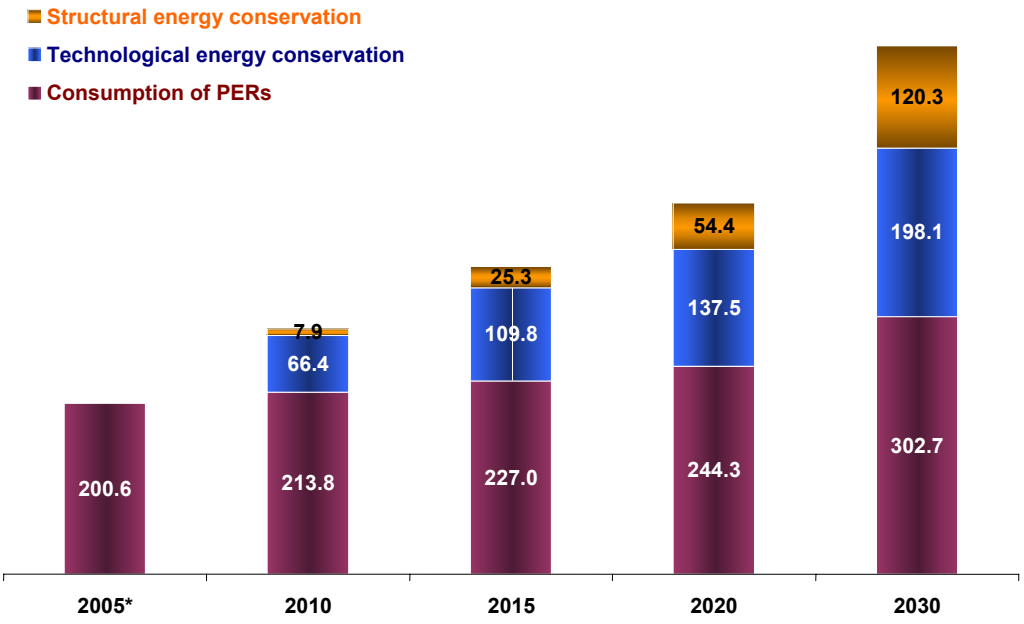

Figure 2. The Energy Strategy of Ukraine up to 2030: Expected dynamics of consumption of primary energy resources, levels of structural and technological energy conservation by 2030 (million tons EF, the baseline scenario).
* In all sections of the Energy Strategy, data for 2005 represent preliminary data, that were available as at 08.02.2006.

One can hardly assess such targets as something other than perpetuation of Ukraine's lagging in the sphere of energy efficiency. Why did not they attempt to set the Polish figure of 2005 (0.34 kg EF/$1 PPP) as the target for Ukraine by 2030? We consider such a target fairly realistic. In the next 25 years Poland may well reduce its GDP energy intensity to the level of Western European countries, but Ukraine at least would reduce its lag. In this case, expected FERs consumption of Ukraine by 2030 would reach: 200.6*3.1*0.34/0.89=**237.5 million tons EF** (instead of 302.7 million, as in the Strategy). The estimate is lower than the Strategy's one by 65.2 million tons EF! By the way, almost the same amount (64.78 million tons EF) is allocated to nuclear power generation in the overall balance of fuel and energy sources in 2030 (by that time, 24 reactor units are expected to operate). In other words, should we succeed to reach the level of GDP energy efficiency of 0.34 kg EF/$1 (PPP), there would be no need to construct 22 new reactor units, that are planned for commissioning in Ukraine by 2030 in the Strategy.

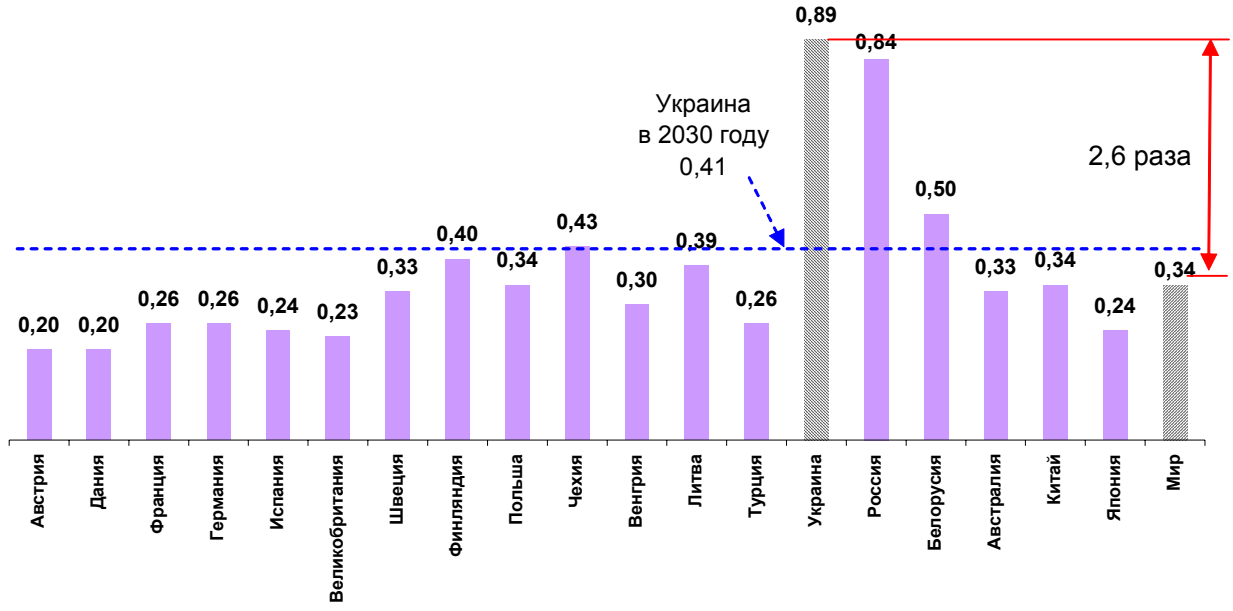

Figure 3. The Energy Strategy of Ukraine up to 2030: GDP energy intensity of different countries, kg EF/$1 (PPP) (*Key World Energy Statistics, 2003, 2004)

We believe, that the Strategy is based on the assumption of an inadmissibly high level of GDP energy intensity, that perpetuates lagging of Ukraine in the sphere of energy efficiency for the nearest decades. The GDP energy intensity figures of the Strategy make us to assume that no realistic assessments of energy conservation capacity in different industries were made. Besides that, forecasts of the GDP growth (and relevant energy needs) were made accounting for the contemporary structure of the Ukrainian economy, dominated now by energy intensive and resource intensive industries. The Strategy seems to ignore a fairly logical possibilities of radical changes in the structure in 25 nearest years, including even relocation of heavy industries from the country, priority development of ITs, nanotechnologies and other components of the innovative capacity of the Ukrainian economy.

2. What Types of Energy Will We Produce?

The Strategy stipulates priority growth of generation and consumption of electric energy, comparatively to consumption of other types of energy. For example, planned consumption of FERs is expected to increase in 1.51 times (see Fig. 2), while generation and consumption of electric energy are expected to increase in 2.22 times. Besides that, generation of electric energy by NPPs is expected to increase in 2.47 times (from 88.8 to 219.0 billion kWh/year) (see Fig. 4 at page 43 of the Energy Strategy).

If we assume that generation of electric energy should increase proportionally to the growth of FERs consumption (i.e. in 1.51 times), planned electricity generation figure for 2030 would reach 285.70 billion kWh/year (instead of 420.1 billion kWh), or lower by 134.4 billion kWh. The latter figure is equivalent of generation capacity of 12 new nuclear reactor units (with generating capacity of 1500 MW each):

12×1500 MW×8700 h/year×0.85 = 133.1 billion kWh/year. In other words, should growth of electric energy generation be proportional to growth of FERs consumption, Ukraine could avoid construction of 12 new reactor units!

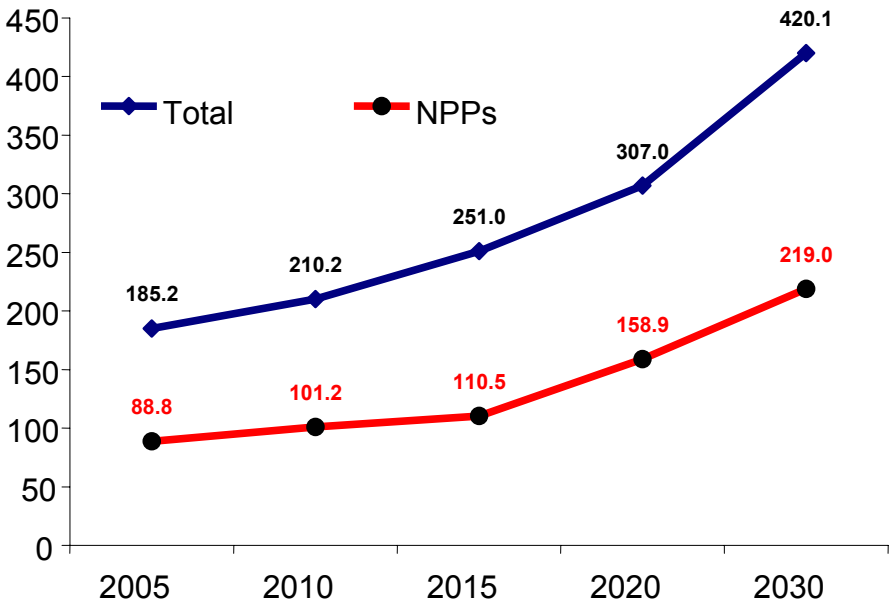

Figure 4. The Energy Strategy of Ukraine up to 2030: Annual electric energy generation in Ukraine in 2005 - 2030, billion kWh

3. How Would We Ensure the Substantial Increase of Electric Energy Generation?

According to the Energy Strategy, by 2030, 24 nuclear reactor units are expected to operate in Ukraine (including 14 new reactor units, 8 units with extended service life and 2 already operational ones). Overall, construction of 22 new reactor units is planned: 2 additional reactor units at the site of Khmelnitskiy NPP (2000 MW), 9 reactor units to replace already operational ones (10500 MW) and 11 reactor units at new sites (16500 MW). In addition, the share of coal in the national energy balance is expected to increase more than twice (from 43.5 million tons EF in 2005 to 101.0 million tons EF in 2030). Coal is expected to be used predominantly for generation of electric energy.

4. Who Would Consume the Substantial Increase of Electric Energy Generation?

The Strategy stipulates export of 25 billion kWh/year of electric energy in 2030 (see page 25 of the Strategy) and use of about 100 billion kWh/year for electric heating (the authors' estimate at the base of data of the Energy Strategy). As we have already noted, the amount is equivalent to generating capacity of more than 11 new reactor units (with generating capacity of 1500 MW each). In other words, the Strategy stipulates that 2 new reactor units would serve export supply only, while 9 new reactor units would serve electric heating! If we assume that the Strategy overestimates energy needs of the national economy (see above), a real export-oriented capacity of new reactor units might be higher in 2 or more times.

5. How Much Would the Strategy Implementation Cost?

In order to compare efficiency of investments to different options of development of the power industry of Ukraine by 2030, we will use data of the Strategy itself. For example, planned development of nuclear power up to 2030 would require the following capital investments:

- nuclear power industry UAH 208.2 billion.
- the nuclear fuel cycle UAH 21.7 billion.

  Total: UAH **229.9 billion.**

The nuclear power is expected to contribute 64.78 million tons EF to the energy balance of 2030. In such a case, unit investments per 1 ton EF of the balance would reach: 229.9/64.78= UAH 3.55 thousand/ton EF.

If we analyse data of the Energy Conservation section of the Strategy, we can see that planned "economically appropriate industrial technological energy conservation" at the level of 175.93 million tons EF in 2030 is expected to be reached due to capital investments of UAH 98.8 billion. In such a case, unit investments per 1 ton EF of reduction would reach: 98.8/175.93= UAH 0.56 thousand/ton EF (or 6.3 times lower than in the case of nuclear power). Moreover, 1 ton EF of "reduction" in the energy balance would not entail any additional operational costs, unlike NPPs that need substantial expenses for fuel, O&M and final disposal of irradiated nuclear fuel.

It is worth to note here that costs of introduction of boilers for burning of solid biomass fuel reach UAH 2.34 billion (see Table 1, data of the authors). These boilers could replace 5 billion m^3/year of natural gas (5.97 million tons EF/year). In the latter case, unit investment costs per 1 ton EF in the energy balance would reach: 2.4/5.97= UAH 0.4 thousand/ton EF (or 8.9 times lower comparatively to nuclear power). Therefore, the nuclear option of development of the power industry of Ukraine is economically inefficient comparatively to energy conservation and development of renewables.

Table 1. Capacity of the Ukrainian market of biomass and peat-fuelled boilers for priority introduction (may be realistically introduced by 2015).

Installation types	App. capacity of the Ukrainian market	Installed capacity MW_{th}	Operation period, h/year	Replacement of natural gas, billion m^3/year	Reduction of CO_2 *) emissions (million tons/year)	Investment costs (UAH million)
Wood fired heating boilers, 1...10 MW	500	500	4400	0.26	0.51	100
Industrial wood fired boilers, 0.1...5 MW	360	360	6000	0.24	0.46	72
Domestic wood fired boilers, 10...50 kW	53000	1590	4400	0.84	1.65	318
Farm straw fired boilers, 0.1...1 MW	15900	3180	4400	1.67	3.27	954
Straw fired heating boilers, 1...10 MW	1400	2800	4400	1.47	2.88	840
Peat fired heating boilers, 0.5...1 MW	1000	750	4400	0.52	1.03	150
TOTAL	**72160**	**9180**		**5.00**	**9.81**	**2434**

*) comparatively to burning of natural gas

The overall thermal capacity of the above installations reaches more than 9000 MW, allowing to replace up to 5.0 billion m^3/year of natural gas and reduce CO_2 emissions by almost 10 million t/year. We believe, that the above biomass-fuelled boilers may be realistically introduced by 2015. At the level of unit investment costs of UAH 200/kW for wood and peat-fuelled boilers and UAH 300/kW for straw-fuelled boilers, the overall investment costs, necessary for implementation of the proposed concept would reach UAH 2.4 billion. If we compare the latter investment costs with cost reductions, associated with lower consumption of natural gas (UAH 550/1000 m^3 × 5.0 billion m^3/year = UAH 2.75 billion/year), we can see that the annual effect of lower gas consumption exceeds the overall costs of the boilers proposed. It is worth to note that these cost savings will be generated every consecutive year.

6. What Kind of Energy Balance Do They Offer?

The structure of consumption of primary energy resources in Ukraine (according to the baseline scenario) is shown in Table 2. Let us focus on the issue of shares of alternative and renewable energy sources (A&Rs) in the energy balance of Ukraine. The share is expected to reach: 16.8 + 22.7 = 39.5 million tons EF (i.e. 13% of the overall consumption of FERs) in 2030. Section 7.3. of the Strategy "Development Capacity of Alternative and Renewable Energy Sources" provides a different assessment of A&Rs. According to the section, the share of A&Rs in the overall energy balance of the country might increase up to **57.73** million tons EF (19% of the overall FERs consumption) at the level of 2030 (see Table 3). In such a case, it is unclear, where these 57.73 million tons EF/year are "hidden" in the structure of FERs consumption (see Table 2) - one can find only 39.5 million tons EF/year there. It seems, that 18.23 million tons EF/year of A&Rs simply were not accounted for in the overall energy balance. However, if we account for their contribution, we could reduce the contribution of NPPs correspondingly (the figure is equivalent to the same 12 new reactor units, that could not be constructed).

Table 2. Structure of consumption of primary energy resources in Ukraine, according to the baseline scenario (data of the Energy Strategy)

Resources	2005		2030	
	million tons EF	%	**million tons EF**	%
Natural gas	**87.9**	43.8	**56.9**	18.8
Coal	**43.5**	21.7	**101.0**	33.4
Oil	**25.7**	12.8	**34.0**	11.2
Other types of fuel (coalbed methane, biomass, biogas, peat, etc.)	**11**	5.5	**16.8**	5.6
Ambient energy	**0.2**	-	**22.7**	7.5
Electric energy generation without fossil fuel burning, total	**32.0**	15.9	**70.9**	23.4
Inc.: HEPs and HESPs	**3.89**	1.9	**5.5**	1.8
NPPs	**28.11**	14.0	**64.78**	21.4
Thermal energy generation by NPPs	**0.3**	0.2	**0.4**	0.1
Total	**200.6**	100	**302.7**	100

Table 3. The Energy Strategy of Ukraine up to 2030: Development of main A&Rs (the baseline scenario), million tons EF/year

Alternative and renewable energy sources	A&Rs contribution			
	2005	2010	2020	2030
Alternative energy sources, total	**13.85**	**15.96**	**18.5**	**22.2**
inc. coalbed methane	0.05	0.96	2.8	5.8
Renewable energy sources, total, inc.	**1.661**	**3.842**	**12.054**	**35.53**
Biomass energy	1.3	2.7	6.3	9.2
Solar energy	0.003	0.032	0.284	1.1
Small hydro power	0.12	0.52	0.85	1.13
Geothermal energy	0.02	0.08	0.19	0.7
Wind energy	0.018	0.21	0.53	0.7
Ambient energy	0.2	0.3	3.9	22.7
Total	**15.51**	**19.83**	**30.55**	**57.73**

The planned growth of utilisation of "ambient energy" up to 22.7 million tons EF/year is particularly questionable, as the option stipulates a broad application of heat pumps. It is clear, that electric energy, necessary to operate these heat pumps, is expected to be covered by expanded capacity of NPPs. In this connection, two questions emerge: 1) Is it possible to consider ambient energy as a renewable source of energy? We think that it should not. 2) Is it possible to utilise such a large amount of ambient energy in the energy balance of 2030? In order to get a base for comparison, let us review official statistics and plans of application of heat pumps in EU-15. For comparison - according to the White Paper on development of renewables in the EU countries, in 1995, geothermal facilities of the EU (including heat pumps) generated 0.4 million tons of oil equivalent (0.57 million tons EF), or 0.028% of the overall consumption of FERs. By 2010, they plan to reach the target of 1.0 million tons of oil equivalent (1.43 million tons EF). In other words, Ukraine plans to use heat pumps to generate 15.9 times more energy in 2030 than 15 "old" European countries plant to generate in 2010. We believe that these forecasts of the Strategy are overestimated by one order of magnitude (at least).

Let us attempt to estimate the contribution of genuine renewables (see Table 4). The share of renewables is expected to reach 18.33 million tons FE (or 6% of the overall FERs consumption) in 2030. We believe, that the target is too pessimistic. For comparison, EU member-states in general set the target figure for contribution of renewables at the level of 12% by 2010. Some countries already reached the following shares of renewables by 2001: Norway - 45%, Sweden - 29.1%, New Zealand - 25.8%, Finland - 23%, Austria - 21.5%, Canada - 15.6%, Denmark - 10.4%. Almost all countries seek to ensure a substantial growth of renewables in the nearest decades. We believe, that, similarly to the case of energy conservation targets, the Strategy perpetuates disastrous lagging of Ukraine behind developed countries in the sphere of development of renewables.

Table 4. Development of renewables (data of the Energy Strategy), million tons EF/year

Renewable energy sources	Development of renewables, by years	
	2005	2030
Biomass energy	1.3	9.2
Solar energy	0.003	1.1
Small hydro power	0.12	1.13
Large hydro power	3.89	5.5
Geothermal energy	0.02	0.7
Wind energy	0.018	0.7
Total	**5.35**	**18.33**

Our estimates suggest that much higher targets for development of A&Rs may be set (see Table 5). In this case, in 2030, the share of renewables may reach 33.7 million tons EF, or 11% of the overall consumption of FERs (in the case of the overall energy demand of 302.7 million tons EF), or 14.2% (in the case of the overall energy demand of 237.5 million tons EF, if Ukraine will opt to rely on energy conservation more intensively). Such parameters would not bring Ukraine to the group of leaders in the sphere of development of renewable energy sources, but we would take a rather decent position among European countries.

Table 5. Utilisation of A&Rs in 2030, million tons EF/year

Off-balance energy sources, total	**22.20**
inc. coalbed methane	0.93
Renewable energy sources, total, inc.	**33.7**
Bioenergy	20.0
Solar thermal collectors	2.0
Photovoltaics	0.7
Small hydro power	1.3
Geothermal energy	1.1
Wind energy	8.6
Total	**55.9**

7. What Risks Should We Expect?

There are several political and technological risks of the "nuclear" scenario of development of the power industry, that forms the backbone of the approved Strategy. The political risk of the nuclear scenario of development of the power industry of Ukraine is associated with the fact of potential threat of almost complete dependence on Russia as a supplier of nuclear fuel and equipment for NPPs, similarly to the situation with natural gas. Ukraine has only one raw material (uranium), but now Ukrainian uranium allows to meet only 30% of the nuclear power industry demand.

The rest is supplied by Russia. Ukraine does not have a complete nuclear fuel cycle. Ukraine does not have technologies and capacity for processing and final disposal of irradiated nuclear fuel and radioactive waste. Nuclear fuel elements are also supplied by Russia. All operational nuclear reactors in Ukraine were manufactured in Russia. It is fairly possible that the orientation on Russian equipment will continue. In such a way, there seems to be a clear threat of the new "nuclear needle" of Ukraine's dependence on the neighbouring country, with all associated opportunities to influence other economic and political processes in Ukraine. We believe, that replacement of the "gas needle" by the nuclear one does not meet interests of Ukraine.

There is a major technological obstacle for implementation of the scenario of electric heating, based on supply of electric energy, generated by NPPs, as it is necessary to modernise existing power supply networks radically. In the majority of cases, existing power supply networks cannot operate at higher currents, that would be necessary in the case of a broad application of electric heaters. A large-scale application of electric heating would necessitate increase of operating currents in more than 3 times. The Energy strategy should objectively account for associated costs.

The idea of application of heat pumps and heat accumulators is not duly detailed in the Strategy. It is absolutely clear, that their introduction would also require major capital investments that should be accounted for as costs of "thermal energy" generated by NPPs. Unit costs of installed capacity of heat pumps reach about $200 - $300/kW. Even if heat pumps would consume a half of electric energy, generated by new reactor units, associated capital investments into heat pumps only would reach more than $ 2 billion. We failed to find relevant cost allocations in the Strategy.

8. Is There an Alternative to the Approved Energy Strategy?

We are convinced that such alternative really exists! Our vision of the alternative is shown in Table 6. As one can see, the alternative is based on several concepts that were discussed above:

- To develop the Ukrainian economy at the base of more intensive energy conservation, seeking to reach the target of GDP energy efficiency at the level of 0.34 kg EF/1$ (PPP) by 2030 (i.e. the level of Poland in 2005). In this case, the overall FERs consumption of Ukraine would reach 237.5 million tons EF in 2030.
- To increase the level of A&Rs consumption up to 55.9 million tons EF/year.
- To decommission nuclear reactor units as they will reach the end of their planned service life without planning construction of new reactor units.
- To increase coal consumption in Ukraine up to 83.1 million tons EF/year (instead of 101.0 million tons EF, as stipulated in the approved Energy Strategy). It seems to be more realistic, comparatively to the approved Strategy and if implemented, the option would result in a lower environmental pressure.

Table 6. Structure of consumption of primary energy resources in Ukraine (the baseline scenario of the approved Energy Strategy vs. the alternative scenario proposed)

Resources	2005		2030 the approved Energy Strategy		2030 the alternative strategy	
	million tons EF	%	**million tons EF**	%	**million tons EF**	%
Natural gas	**87.9**	43.8	**56.9**	18.8	**56.9**	24.0
Coal	**43.5**	21.7	**101.0**	33.4	**83.1**	35.0
Oil	**25.7**	12.8	**34.0**	11.2	**34.0**	14.3
Other types of fuel (coalbed methane, biomass, biogas, peat, etc.)	**11**	5.48	**16.8**	5.55	**55.9**	23.5
Ambient energy	**0.2**	0.0	**22.7**	7.5	**-**	-
Generation of electric energy without burning of fossil fuel, total	**32.0**	15.9	**70.9**	23.4	**7.6**	3.1
inc.: HEPs and HESPs	**3.89**	1.9	**5.5**	1.8	**5.5***	2.3*
NPPs	**28.11**	14.0	**64.78**	21.4	**2.1**	0.9
Thermal energy generation by NPPs	**0.3**	0.15	**0.4**	0.13	**-**	-
Total	**200.6**	100	**302.7**	100	**237.5**	100

9. What Should We Do?

We believe, that the following steps are urgently needed:

- To develop an alternative to the approved Energy Strategy of Ukraine, that should prioritise development of energy efficient technologies, alternative and renewable energy sources.
- To develop an energy conservation program of Ukraine, that should specify, in detail, sectors and technologies allowing to reach the target of reduction of the GDP energy intensity to the level of 0.34 kg EF/$1 (PPP) by 2030. A particular attention should be paid to the housing and utilities sector. To estimate economically appropriate capacity of such technologies, necessary investments for their introduction, operation costs and payback periods.
- To develop a program of utilisation of A&Rs, that should specify, in detail, sectors and technologies allowing to replace 55.9 million tons EF/year due to application of A&Rs. To estimate economically appropriate capacity of relevant technologies, necessary investments for their introduction, operation costs and payback periods.
- To develop and submit to the Government for review, an alternative version of the strategy, that should prioritise development of energy efficient technologies, alternative and renewable energy sources. We believe, that the existing Strategy was approved without consideration of other alternatives and the Government has the right to choose from more than one option.
- To authorise the National Agency of Ukraine for Energy Efficiency to co-ordinate development of the alterative strategy. We believe, that if the working group of the Ministry of Fuel and Energy will be authorised to develop the alternative strategy, the result would be largely the same. The agency is interested in the maximal generation capacity, as a result, it will never prioritise energy conservation and development of A&Rs in any energy strategy it develops.
- To remember that secretive methods of development of the Energy Strategy up to 2030 resulted in growing social tensions. In the course of decision-making on the alternative strategy, a particular attention should be paid to due arrangements for public participation from early stages and at all levels. Provision of timely information, transparency, openness, respectful attitudes to representatives of all public stakeholders and NGOs, including environmental ones (according to principles of the Aarhus Convention, that was signed and ratified by Ukraine), provision of all opportunities for public participation - all these factors would allow to improve quality of the alternative strategy substantially, moreover, they would allow to generate public consensus and support of the most active part of the civil society.
- To submit the alternative energy strategy for approval of the Verkhovna Rada of Ukraine after its review and approval by the Government. An agreed political decision on these matters should be made. We believe that the issue of the Energy Strategy of Ukraine up to 2030 is a priority and its should be reviewed and decided upon without delay.