

15. It is important to note that this paper is not about what factors realistically determine the framework of price negotiations, nor the eventual outcome. Political and specific economic variables interact in these negotiations in ways that yield outcomes which are difficult to predict analytically. This paper aims just to provide a reasonable sensitivity analysis of a range of outcomes of those discussions. It does not envelop the full range of potential outcomes, but rather provides a simple model that interested parties can use to test their own views on what outcome may take place, and a few scenario results to illustrate the potential impact. Further, we are not attempting to imply anything positive (about what would be the outcome) or normative (about what should be the outcome) of these discussions.

#### 4. VULNERABILITY INDICATORS

16. Ukraine's energy vulnerability<sup>10</sup> can be broken down into three complimentary indicators, derived from the ratio of net oil and gas imports to GDP:<sup>11</sup>

$$\text{Oil vulnerability} = \frac{\text{net oil imports}}{\text{GDP}} = \frac{\text{net oil imports}}{\text{total oil use}} * \frac{\text{total oil use}}{\text{total energy use}} * \frac{\text{total energy use}}{\text{GDP}}$$

Equivalently,

$$\text{Gas vulnerability} = \frac{\text{net gas imports}}{\text{GDP}} = \frac{\text{net gas imports}}{\text{total gas use}} * \frac{\text{total gas use}}{\text{total energy use}} * \frac{\text{total energy use}}{\text{GDP}}$$

By component, we then have,

$$1 - \text{self sufficiency in oil/gas production} = \frac{\text{net oil/gas imports}}{\text{total oil/gas use}}$$

$$\text{Dependence on oil/gas as energy source} = \frac{\text{total oil/gas use}}{\text{total energy use}}$$

$$\text{Energy intensity} = \frac{\text{total energy use}}{\text{GDP}}$$

17. Using data for Ukraine and comparator countries yields the following results for Ukraine's relative vulnerability (see Table 3):

- Ukraine is the most energy-intensive in the region.
- Ukraine is less oil dependent and more oil self sufficient compared to other countries in the region, but the country's high energy intensity makes it much more oil vulnerable than the EU countries.

<sup>10</sup> Energy vulnerability is measured here in ioe per US\$ GDP.

<sup>11</sup> The vulnerability analysis is based on "The Impact of Higher Oil Prices on Low-Income Countries and on the Poor", March 2005 UNDP/ESMAP.

- Ukraine is more gas self sufficient than all the countries in the table apart from Poland and obviously Russia. The country is less gas dependent than Belarus and Moldova, but more gas dependent than Poland and Germany. High energy intensity makes the country the second by gas vulnerability in the table.

Table 3: Oil and Gas Dependency and Vulnerability

	Oil vulnerability, ioe per 2001 US\$ GDP	Oil vulnerability , index, Germany=1	1- self sufficiency in oil production, ratio	Oil dependency, ratio	Gas vulnerability index, Germany=1	1- self sufficiency in gas production, ratio	Gas dependency, ratio	Energy intensity, ioe per 2001 US\$ GDP	Energy intensity, index, Germany=1	Energy intensity, ioe per 2001 US\$ GDP in PPP	Energy intensity (GDP in PPP), index, Germany=1	
Russian Federation	-0.99	-15.4	-1.95	0.21	-0.57	-18.3	-0.44	0.53	2.4	13.6	0.56	3.5
Moldova	0.42	6.6	0.98	0.19	1.57	50.9	1.00	0.69	2.3	12.8	0.51	3.2
<b>Ukraine</b>	<b>0.35</b>	<b>5.5</b>	<b>0.76</b>	<b>0.12</b>	<b>1.36</b>	<b>44.1</b>	<b>0.75</b>	<b>0.47</b>	<b>3.9</b>	<b>21.8</b>	<b>0.58</b>	<b>3.6</b>
Belarus	0.48	7.4	0.76	0.31	1.17	38.0	0.99	0.59	2.0	11.2	0.48	3.0
Poland	0.12	1.8	0.99	0.23	0.04	1.3	0.66	0.11	0.5	2.9	0.21	1.3
Germany	0.06	1	0.97	0.37	0.03	1	0.79	0.22	0.2	1	0.16	1

Source: World Bank and IEA Energy Statistics; calculations by authors

18. The challenges for policy are to understand what factors determine oil and gas dependency and energy intensity. As Table 4 shows, apart from gas and oil, Ukraine uses more coal and nuclear as measured by their shares in PES comparing with other countries (it is outperformed in use of coal only by Poland). It is the relative abundance of coal and nuclear that allows Ukraine to be less oil and gas dependent than its comparators. Ukraine's industry for the most part uses inefficient, highly energy intensive technologies, which brings about high level of energy intensity of the country. It is clear that the transition to less energy intensive technologies has been hindered by understated energy prices.

Table 4: Shares of energy resources in Primary Energy Supply, %

Shares in PES	Coal	Crude oil	Petroleum products	Gas	Nuclear	Hydro	Combustibles, renewables and waste	Electricity	Total
Russian Federation	17.3	31.6	-10.8	52.7	6.0	2.3	1.1	-0.2	100.0
Moldova	2.4	0.0	18.9	68.9	0.0	0.3	2.0	7.5	100.0
<b>Ukraine</b>	<b>24.9</b>	<b>17.3</b>	<b>-5.5</b>	<b>47.0</b>	<b>15.5</b>	<b>0.6</b>	<b>0.2</b>	<b>-0.2</b>	<b>100.0</b>
Belarus	2.5	61.9	-30.5	59.4	0.0	0.0	4.4	2.3	100.0
Poland	61.6	20.5	2.0	11.3	0.0	0.2	5.0	-0.7	100.0
Germany	24.6	31.7	5.5	21.8	12.4	0.6	2.6	0.2	100.0

Source: World Bank and IEA Energy Statistics; calculations by authors