

## CEREAL STRAW SUPPLY AND ITS DEPLOYMENT FOR INDUSTRY-USE CO-GENERATION IN NORTHEASTERN KHARKOV OBLAST

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**Abstract.** In view of continuing political and economic uncertainties between Ukraine and Russia, there is an underlying national imperative to reduce the reliance on imported natural gas. The economy of using cereal straw to substitute imported natural gas for district heating uses as a stand-alone project appear to be attractive. For the Kharkov oblast, using all available cereal straw would displace less than 2 % of natural gas imported from Russia in 2011. Preliminary analysis suggests the economics of burning of cereal straw solely for energy generation to be substantially less attractive than that of using straw to co-manufacture agri-paperboard for export and energy for in-plant uses, with the delivery of surplus low-quality heat for district heating in nearby towns.

**Keywords:** co-generation, economics, natural gas, straw.

### Introduction

Ukraine is one of the largest countries in Europe. Its total land area is 603,700 km<sup>2</sup>. The late- 2011 estimate of population was 45.8 million. The 9.96 million hectares of forest land (16.5 % of total land base) are located mainly in the extreme northern and western regions of Ukraine. Arable land of 32.48 million hectares (53.8 % of land base) covers most of Ukraine. The arable land of Ukraine is composed of very rich black soil which is ideally suited for the growing of field crops. Ukraine has about 25 % of the world's black top soil. For example, in the Kharkiv-Kirovohrad-Dnipropetrovsk oblasts, the humic content of the soil is in the range of 4.5 to 4.9 % [1; 2]. In 2011, Ukraine is among the top 10 producers of wheat in the world [3]. The present study was undertaken to assess the relative economic merits of a community-based enterprise to utilize surplus cereal straw in northeastern Kharkov oblast.

### Fossil fuel energy supply

Ukraine has insufficient indigenous gas, oil and coal supplies to meet the entire energy demand of its industries and households. In 2011, Ukraine had purchased about 38.5 billion m<sup>3</sup> of natural gas (valued at 12 billion USD) from Russia [4]. The pricing has been in dispute repeatedly between Ukraine and Russia during the past few years [5; 6]. Both parties have recently agreed that the pricing formula would be matching the price paid by Russia's EU customers, adjusted to delivery at the Ukraine border. Figure 1 shows the EU gas price tracking the Brent crude oil price. Ukraine has contemplated the importation of "lower price" gas from other sources such as Azerbaijan and Iran [10]. With few exceptions, international trade of natural gas business is based on a free market model. Thus, there is no market-driven logic as to why Azerbaijan (or Iran) would sell natural gas below the benchmark EU price to Ukraine. The pricing principle of Russian natural gas appears to be largely transparent in the free-market context. Like every other country possessing strategic resources, Russia will, of course, maximize all economic and geopolitical benefits for itself. In essence, Ukraine has no practical escape from the international natural gas pricing environment.

As given in Figure 2, with the recent price of Brent crude oil being in the range of 120 USD per barrel, the price of Russian gas at the German border could be re-set at ~450 USD per 1,000 m<sup>3</sup>. The reported 2011 transit pricing through Ukraine was 2.81 USD per 1,000 m<sup>3</sup> per 100 km [8, 9]. By deducting the cost of transiting Russian natural gas through Ukraine (~26 USD per 1000 m<sup>3</sup>) and Poland (~4 USD per 1,000 m<sup>3</sup>) to the German border, the price of natural gas at the Ukraine-Russia border was estimated to be about 420 USD per 1,000 m<sup>3</sup>. For 2012, Ukraine has already made a plan for the import price to be at 416 USD per 1,000 m<sup>3</sup> [4]. The price of imported natural gas could increase much further in its indexing to the escalating price of Brent crude oil. It is interesting to note that the total upstream cost of petroleum oil production (including exploration and extraction) was only about 30 USD per barrel on a global average basis in 2009 [7].

For strategic business reasons, Ukraine could and should aim for greater energy-supply diversification. The national path forward might best be made by a) lowering the natural-gas demand

through intensified improvement in energy-use efficiency and b) enhancing the development of alternative energy supply from biomass.

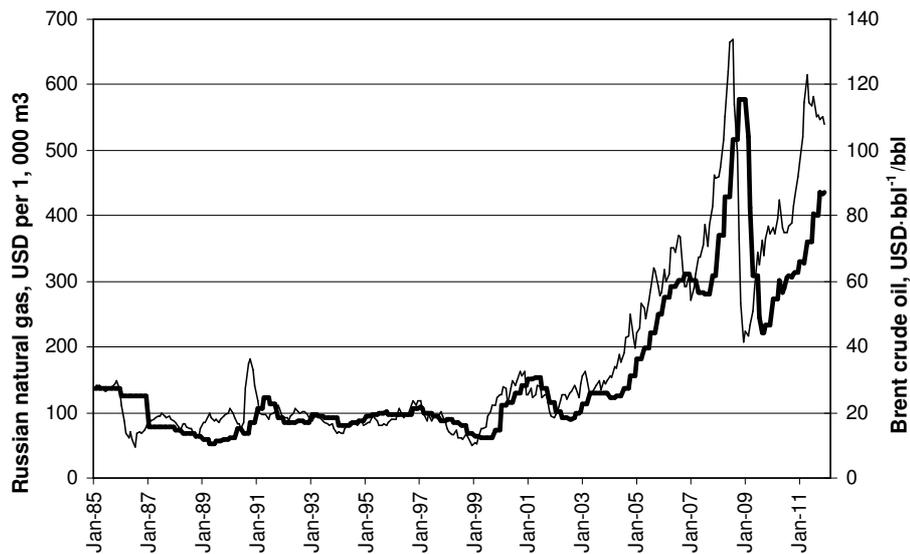


Fig. 1. Russian natural gas price tracking Brent crude oil price (based on data published by www.indexmundi.com)

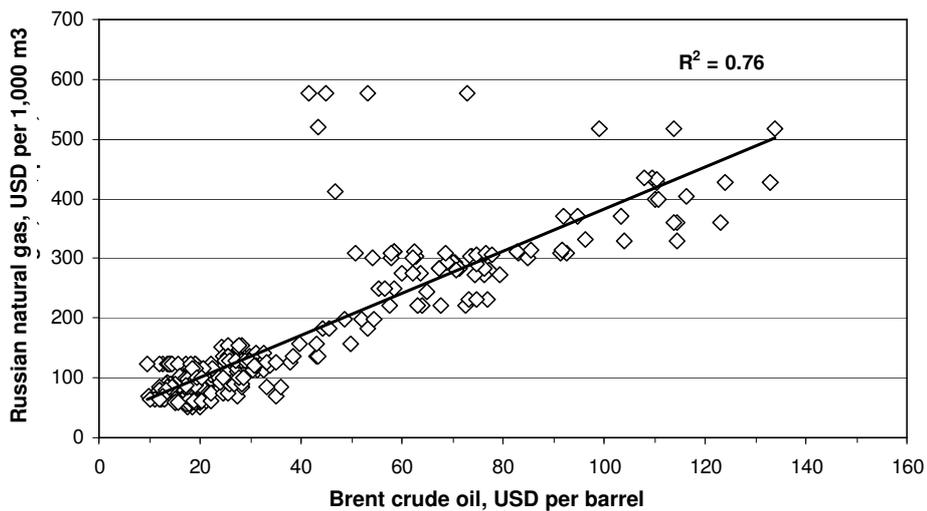


Fig. 2. Correlation between Russian natural gas price at German border and Brent crude oil price, 1985-2011

**Biomass availability**

Because of its substantially lower content of ash, wood residue is generally preferred over straw for bioenergy production. But the availability of this raw material for fuel uses is limited as the national forest land is relatively small. Cereal straw and other crop residues are essentially the principal means available for Ukraine to diversity its basic fuel needs. Figure 3 shows the 2001-2010 production of major grains in Ukraine. The USDA [11] has estimated an average above-ground straw yield of 1.7 tonnes straw per tonne of grain for winter wheat and a harvestable yield of 50 %. The harvestable yield takes into account of straw required for soil conservation and other uses. The net yield is thus calculated to be 0.85 tonne of wheat straw per tonne of grain. In comparison, yield of wheat straw at 1.9 tonnes per hectare (equivalent to 0.63 tonne of wheat straw per tonne of grain), was used by the Institute for Economic Research and Policy Consulting in its analysis of bioenergy production in Ukraine [12]. Using the 10-year average production of winter wheat and the average wheat-straw yield (viz., 0.74 tonnes per tonne grain), the calculated annual availability of wheat straw for off-field uses would be about 13 million tonnes. The availability of barley straw was estimated

similarly to be about 7 million tonnes annually. In 2010, Ukraine also produced about 6.8 million tonnes of sunflower seeds. At a minimal 20 % of hull in sunflower seeds processed, the biomass supply would be about 1.35 million tonnes. It may be noted that sunflower process residues, i.e., mainly hulls, are already converted commercially into briquettes for sale as household solid fuel.

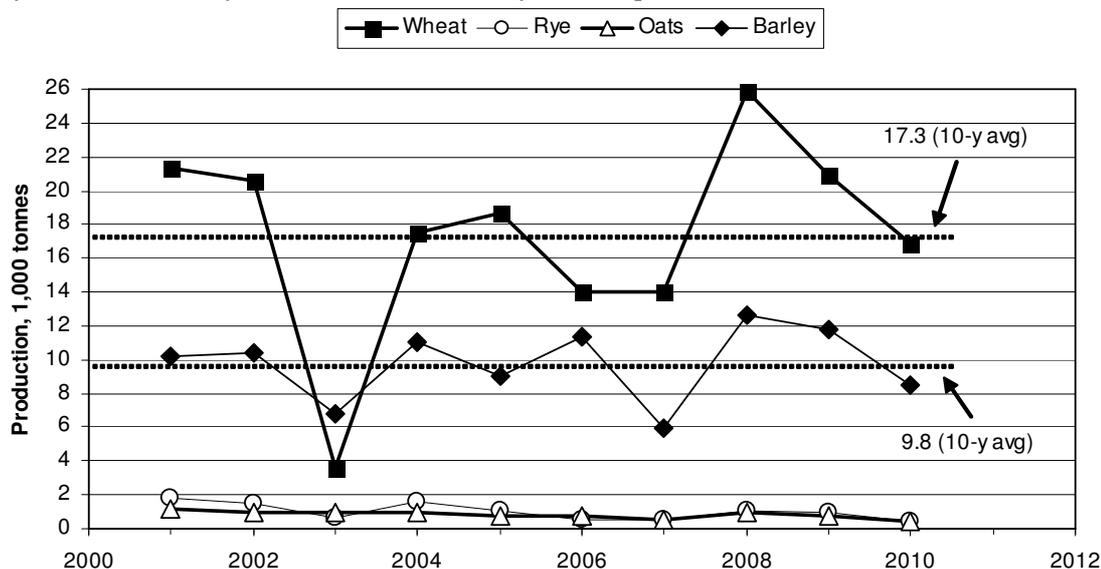


Fig. 3. Ukraine cereal grain production 2001-2010 [3]

### Kharkov oblast

Kharkov oblast with about 6 % of the total arable land in Ukraine was approximated to have about 1.2 million tonnes of surplus cereal straw annually. Gorbunov and Verbitskaya [13] had previously estimated the availability of cereal straw (i.e., wheat + barley) to be about 1.5 million tonnes in the Kharkov oblast.

The economics of burning cereal straw instead imported natural gas solely for district heating purposes appears to be favourable, in view of the prevailing high cost of imported Russian natural gas. On a simple energy content basis, if all 1.5 million tonnes of cereal straw in Kharkov oblast were deployed for energy production, there would be a displacement of about 0.63 billion m<sup>3</sup> of imported natural gas, equivalent to about 1.6 % of the national 2011 import volume. Table 1 illustrates that the valuation of cereal straw could be much higher still if it was used for the manufacture of novel agri-paperboard, with surplus heat used for district heating. In this fashion, high value export and enduring local employment would be created concomitantly.

Table 1

Comparative unit value of cereal straw		
End use	Bioenergy production	Agri-paperboard production
Nominal heating value	~14 GJ per green tonne (at 15 % moisture)	----
Conversion rate of straw	----	0.63 tonne product per green tonne
Unit price (2011)	8.25 USD per GJ (price at replacement value of imported Russian natural gas <sup>a</sup> )	Product valued at representative pricing of 554 USD (~747 USD <sup>b</sup> ) per tonne for commodity brown kraft linerboard in the EU market.
Calculated straw value	~115 USD per green tonne	~469 USD per green tonne

<sup>a</sup> Russian natural gas imported at 312 USD per 1,000 m<sup>3</sup> average in 2011 [4]. Gross heating value: 37.83 GJ per 1,000 m<sup>3</sup> [15]

<sup>b</sup> Paperboard price (4<sup>th</sup> Quarter, 2011) data published by PaperAge [16]; ECB [17] reference exchange rate for 4<sup>th</sup> Quarter, 2011 at 1.3482 USD = 1.00 EUR

Although the calculated economic value of cereal straw on the basis of its energy content is 115 USD per green tonne, the present market value of cereal straw is substantially less. At present, only a small amount of the straw is used off-field commercially for animal bedding. Because the off-field use of cereal straw is currently limited, the cereal straw is either burned in open fields or ploughed into the soil, after the grain harvest each year. It may be noted that in the “agri-paperboard” processing plan, the minerals present in the straw feedstock would be returned routinely to the soil, i.e., essentially no large export of soil mineral nutrients from the farm land.

Sokolovo (located about 45 km south of Kharkov) was provisionally selected to be the candidate site for the establishment of a new agri-paperboard factory. The nominal capacity agri-paperboard production would be 40,000 tonnes annually, of which 100 % of the output would be exported to the EU. The gross value of new agri-paperboard export from the proposed Sokolovo factory could be in the range of 30 USD million annually. It may be noted that, in practice, the novel agri-paperboard would be priced well above the commodity brown kraft linerboard which was used for the present calculation. There are several notable marketable attributes of the agri-paperboard, viz., zero-pollution manufacturing process; 100 % renewable energy supply, and no use of wood fibres [14], to support premium pricing in the EU market place.

As shown in Table 2, the four contiguous Zmiivskiyi, Novovodolazkiyi, Kharkivskiyi, and Chuhuiivskiyi regions could safely supply 163,000 tonnes of straw annually, on the basis of 1998-2007 grain production data. If the total straw supply area of Sokolovo was considered to be circular, then the longest procurement distance would be only about 40 km. The apparent “straw-supply intensity” was calculated to be about 0.29 tonne per hectare) of land surface.

The straw (wheat) demand for the planned full-capacity production of agri-paperboard would be about 64,000 green tonnes annually. In the provision of co-generated steam and power for factory operation, another 72,000 green tonnes of straw (wheat and barley) would be required. The total demand would still be below the safe supply limit of 163,000 tonnes.

There will be surplus low-quality heat produced at the proposed factory. The disposal of waste heat would be an economic problem for the proposed agri-paperboard factory in Sokolovo. If there was no host for the surplus hot water, then this waste heat would need to be discharged to the atmosphere using air-cooled heat exchangers at the planned factory site.

Table 2

**Straw supply in regions near the candidate Sokolovo site**

Region No.	Regions of Kharkivska Oblast (Харківська область)	Area, km <sup>2</sup>	Winter wheat, tonnes <sup>a</sup>	Spring barley, tonnes <sup>a</sup>
12	Zmiivskiyi (Зміївський)	1,365	34,000	25,000
21	Novovodolazkiyi (Нововодолазький)	1,183	33,000	24,000
25	Kharkivskiyi (Харківський)	1,403	21,000	36,000
26	Chuhuiivskiyi (Чугуївський)	1,149	27,000	20,000
Total		5,100	115,000	105,000
Est. total straw available, tonnes <sup>b</sup>			85,100	77,700

<sup>a</sup> Based on 10-year average (1998-2007) production

<sup>b</sup> Assumed 0.74 tonne of straw per tonne of grain (wheat or barley)

Figure 4 shows that Sokolovo is an attractive location for the delivery of surplus hot water for district heating in nearby Merefa (Мерефа; about 15 km northwest of Sokolovo; population: ~25,000). Zmiev (Зміїв; about 13 km southeast of Sokolovo; population: ~17,000) is less favourable because it already has a substantial amount of waste heat available from the local operation of a large coal-fired power generation facility. The pricing of delivered heat for district heating could be set favourably for all parties concerned to reflect the cost of a new hot-water pipeline from the Sokolovo site to Merefa, and the potential CO<sub>2</sub> emission reduction credit that could be recovered from fossil fuel-substitution by the present district heating system. In this approach, the capital and operating costs of bioenergy for district heating would be cross-subsidized by the industrial enterprise’s own need for steam and power.

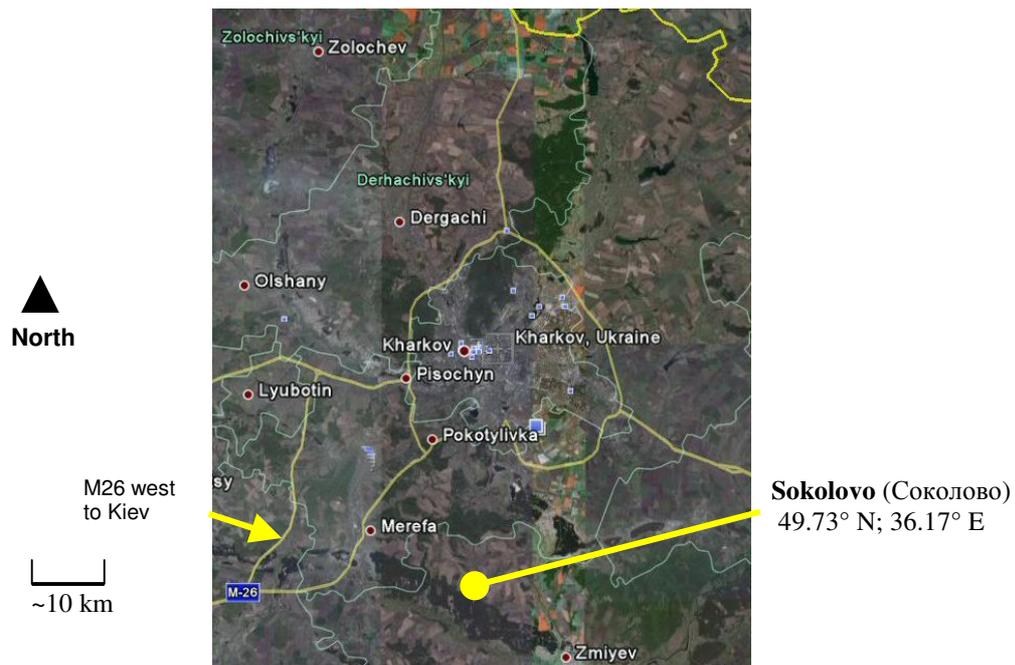


Fig. 4. Relative geographical location of Sokolovo

### Concluding remarks

In view of continuing uncertainties in the pricing of imported natural gas, Ukraine has a strategic imperative to reduce its substantial reliance on this source of energy. The economy of burning of cereal straw to substitute imported natural gas for district heating as a stand-alone project would appear to be significantly less favourable than that of other end-use options. The production of export-oriented agri-paperboard from surplus cereal straw would serve dual purpose of generating new export income and providing essential hot water for district heating.

### Acknowledgements

The local agricultural cropping data for Kharkov oblast were kindly provided by OAO Ranok Publishing House, Kharkov, Ukraine (AK38634W3).

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