COMPARATIVE ECONOMICS OF USING BIOMASS AND NATURAL GAS FOR CO-GENERATION OF STEAM AND POWER FOR PROSPECTIVE INDUSTRIAL ENTERPRISE IN BELARUS

Alfred Wong
Arbokem Inc., Canada
arbokem@arbokem.com

Abstract. Belarus relies now almost entirely on imported natural gas because it has no indigenous supply of natural gas or petroleum. Any adverse changes in external economics and/or politics could affect the pricing of industrial steam and power substantially. In 2007, expected rapid convergence of the price of Belarus-purchased natural gas price with that of the European Union and devaluation of the Belarusian ruble were causing substantial national economic concern. Although the longer-term pricing of natural gas imported from Russia has now been largely resolved, there is no certainty that government subsidization of energy prices in special Free Economic Zones (FEZ) could be and would be available continually. Reliable economical supply of steam and power is required for successful operation of the prospective industrial enterprise to manufacture agri-paperboard in Grodno FEZ. An analysis of the historical and forecast pricing trends of imported natural gas for generation of steam and power for industrial uses has shown the superior economy of using indigenous biomass over imported natural gas.

Keywords: bioenergy, co-generation, natural gas, wood wastes.

Introduction

Belarus (population: 9.5 million; total area: 207,600 km^2) is a land-locked country located in the northeastern region of Europe. It is characterized by forested plains, with considerable marshland. The forest cover in Belarus is about 1/3 of the total land [1]. The total stock timber has been estimated to be ~1.3 billion m^3. Cropping accounts for about 27 % of the land use.

A new enterprise is being developed in the Free Economic Zone (FEZ) of Grodno (Гродно) oblast to manufacture food-grade paperboard for export to the EU. The fibrous raw material would be locally-available surplus wheat straw and flax straw. At full production, the output is projected to be 60,000 tonnes of agri-pulp™ paperboard (syn. agri-paperboard) annually. The net demand of energy of the proposed factory would be 865,000 GJ steam and 53,000 MWh electric power. The manufacturing technology to be deployed would be based on a novel proprietary zero-pollution concept [2; 3].

One of the critical issues in the project realization is the supply of energy. Although the new enterprise would be offered concessionary pricing for natural gas and electric power in the Grodno FEZ, there remains considerable uncertainties about the stability of energy pricing for the economic viability of the agri-paperboard manufacturing operation. This study was undertaken to investigate the relative merits of co-generating energy based on imported Russian natural gas and surplus indigenous biomass.

Energy supply

Belarus has little or no domestic sources of fossil fuels [4]. As shown in Figure 1, the usage of coal for the operation of its heat and power generation facilities has largely been discontinued during the past two decades. The generation of electricity has steadily become more dependent on natural gas imported from Russia since the early 1990s. In 2006, natural gas constitutes more than 75 % of the total fuel balance in Belarus [5].

Sednin and Bogdanovich [5] have reported that Belarus electric power generation consists mainly of regional condensing power plants (~47 % of installed capacity) and combined heat and power plants (>50 % installed capacity). A certain amount of electricity is also imported from Ukraine from time to time. Thus, the price of steam and power purchased from the Grodno FEZ energy provider can be expected to be directly dependent on the future pricing stability of natural gas imported from Russia. In late 2008, the Belarusian government announced that a new nuclear power generation facility would be built in Ostrovets region (Grodno oblast) for planned start up is 2016 [7]. The power output would be 2,000 MW, equivalent to ~25 % of the Belarus power demand in 2006. The projected pricing of electricity delivered from the nuclear power plant has not yet been disclosed.

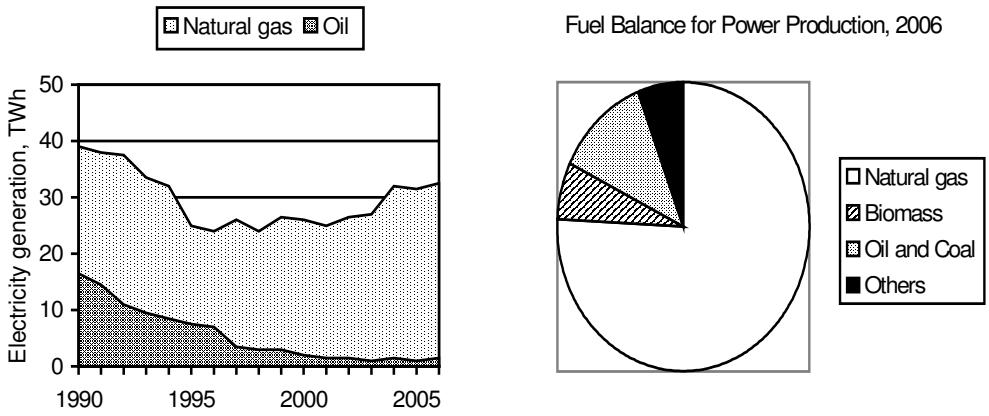

Fig. 1. **Electricity generation by fuel in Belarus** (data adapted from [5; 6])

The price of imported natural gas has been a contentious political and economic issue between Belarus and Russia since 2006, when Gazprom (the dominant Russian natural gas supplier) decided to terminate price subsidies to all CIS importers [8; 9]. The new Gazprom pricing for CIS customers would thus become identical to that for EU importers. It was widely recognized that any abrupt transition of Belarus gas price to EU gas price would have bankrupted the national economy of Belarus almost immediately.

The pricing trend of Russian natural gas delivered to the border in Germany and in Belarus is given in Figure 2. Contrary to the views of many vocal critics in the EU, the Gazprom gas pricing policy is actually quite "transparent" as the price at the German border has been tied closely to that of Brent crude oil for more than a decade. See Figure 3.

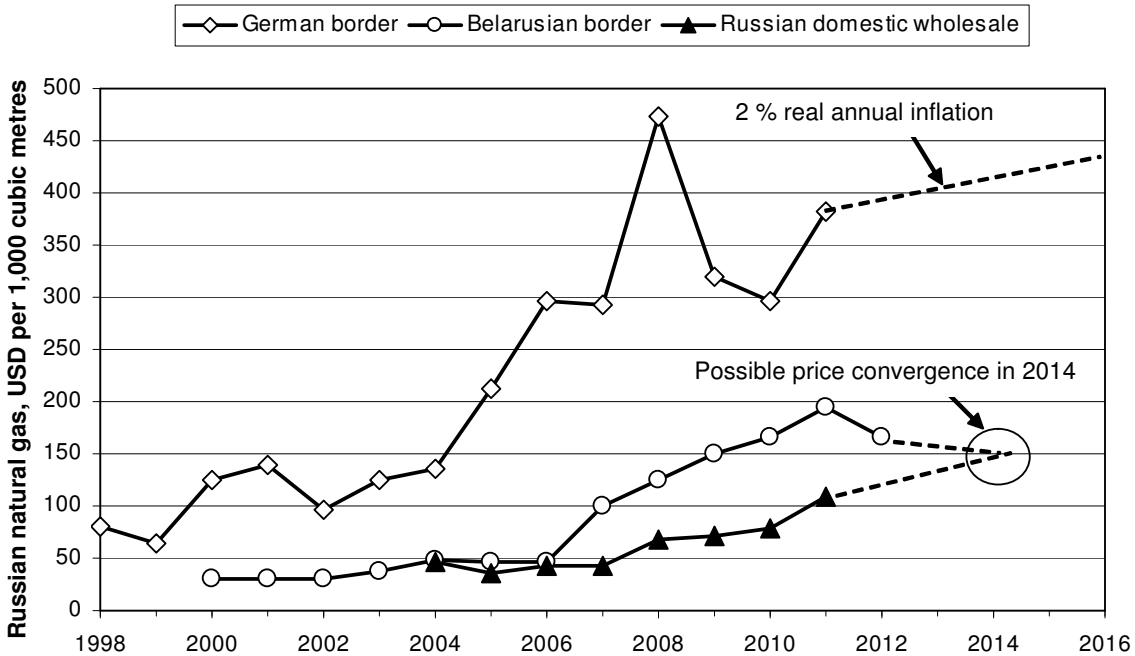

Fig. 2. **Pricing of Russian natural gas and Brent crude oil** (data from various sources)

In the ensuing price negotiations, threats of Russian curtailment of gas supply to Belarus, and corresponding Belarusian disruption of transit of Russian gas to the EU were made frequently during the past few years. In 2007, Belarus has reached an agreement with Russia to allow the imported natural gas price to rise steadily to the EU market price by 2011 [9]. Because of the severe global economic downturn in 2008 – 2009, the Energy Ministry of Belarus undertook to re-negotiate with Gazprom to delay the price convergence in 2011 [10 – 13]. The outcome of the negotiation with Gazprom in late 2011 was a) a fixed pricing of 165.60 USD per 1,000 m^3 for 2012, b) convergence with domestic Russian pricing (wholesale; adjusted for delivery to Belarusian border) in 2014 under the aegis of the Union State framework, and c) the sale of Beltransgaz (ОАО «Белтрансгаз») to

Gazprom for 2.6 billion USD [14 – 16]. The trajectory given in Figure 2 suggests that the average industrial-user pricing in Russia could reach about 150 USD per 1,000 m^3 by 2014. It is interesting to contrast the different paths taken by Belarus and by Ukraine [17] in resolving the price of imported Russian natural gas.

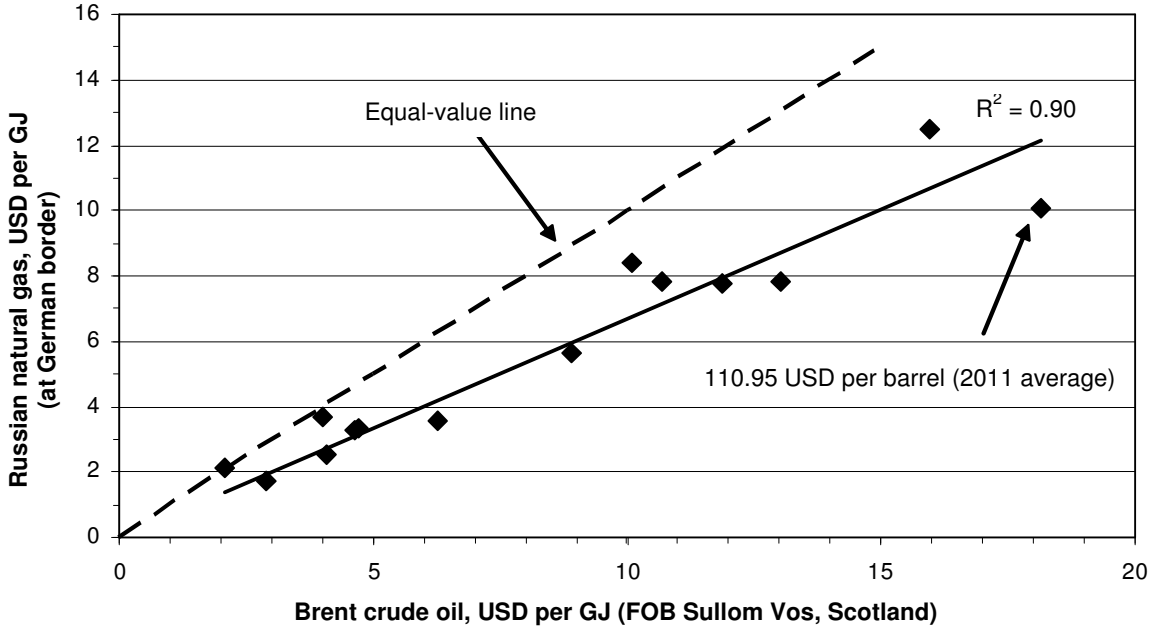

Fig. 3. **Relative pricing of Russian natural gas and Brent Crude oil on energy content basis, 1998-2011** (Russian natural gas: 37.83 GJ per m^3; Brent crude oil: 6.12 GJ per barrel; yearly average data adapted from http://indexmundi.com/commodities/)

Wood waste is already used in Belarus for (co-) generation of steam and power [18]. The wood waste production in Belarus has been estimated to be about 1 million m^3 annually [19], or about 420,000 oven-dried tonnes, at a nominal coniferous wood density of 420 kg dry per green m^3. The use of cereal straw for co-generation is less preferable than that of wood residues as the high mineral content of straw (especially K, Si and Cl) would cause severe operational problems in the combustion process [20].

In view of continuing the unsatisfactory energy supply situation, the President Lukashenko has announced additionally a new national goal of resolving the energy independence issue within 5 years [21].

Co-generation at the proposed manufacturing enterprise

In view of the evolving political and economic situation inside and outside of both Belarus and Russia, there is an ever-present economic risk for the proposed enterprise to buy steam and power, or natural gas from the Grodno FEZ authority at the "offered concessionary low prices" which is subsidized additionally by the Belarus State. Thus, the proposed manufacturing enterprise needs to consider a practicable alternative supply of energy.

Table 1 shows the comparative annual expenditure for fuel purchase (2011 basis) by the proposed manufacturing facility. Even at a higher capital cost, the co-generation approach using locally-available biomass would certainly be a more secure energy alternative. Because the agri-paperboard would be sold as "super-green" products in the crucial markets in Germany and the UK, the value of "100 % green energy" used in product manufacturing is of significant importance for marketing. As the "purchase energy" is produced from fossil fuel, i.e., natural gas, this energy supply option would not qualify under this marketing regime.

During the past decade, there has been an upsurge in the use of wood pellets for fuelling of industrial and district-heating boilers in the EU [26; 27]. The driving force has been the reduction of the emission of greenhouse gases, as the burning of wood-pellet fuel is considered to provide essentially net zero CO_2 emission. It is interesting to note that the average 2011 price of wood-pellet

fuel [27], on the basis of energy content, was nearly the same as that of Russian natural gas at the German border.

Table 1

Estimation of energy costs for proposed Belarus industrial enterprise

Fuel	Russian natural gas	Indigenous wood wastes
Gross calorific value of fuel	37.83 GJ per 1,000 m^3 [a]	18 GJ per dry tonne [23] or 9 GJ per green tonne (at 50 % moisture content)
Unit fuel cost (2011 year end estimate)	165 USD per 1,000 m^3 = 4.36 USD per GJ	18.54 USD per green tonne [b] = 2.06 USD per GJ
Total fuel cost (based on total 1.44 million GJ demand annually)	~6.3 million USD	~3 million USD

[a] Higher heating value [22].

[b] Belarusian Rubles (BYR) 85,700 per green tonne wood wastes, as estimated from i) BYR 50,000 per green tonne wood wastes (nominal quotation from Public Company Ivatsevichi «Ивацевичи» in Slonim, Grodno oblast, Belarus, April, 2010), ii) 2011 average exchange rate: 4,623 BYR = 1.00 USD [24], and iii) Industrial Producer Price Index = 171.4 %, from December, 2010 to December, 2011 [25]

In accordance with the EN 14961-2 specifications, the raw material for the manufacture of wood pellets for the EU market would effectively need to be high-quality "white wood", i.e., completely free of bark. In principle, the use of higher-quality wood wastes for wood pellet production could compete against the use of same material for co-generation in support of agri-paperboard manufacture. Table 2 illustrates that the "agri-paperboard" option would afford substantially higher national benefits than the "wood pellet" option. In both instances, the final product would be exported entirely to the EU.

Table 2

Comparative annual benefits for deployment of Belarusian wood wastes

Raw material (wood wastes)	Wood wastes use in export manufacturing business	Business benefits	National benefits
• "White wood" or equivalent grade for wood pellet production (in practice, lower bark-containing grades may be used for co-generation). • Supply: 160,000 green tonnes at 50 % moisture content. • Calorific value: 9 GJ per green tonne. • Nominal value: 2.1 EUR million (at 13.32 EUR per green tonne; See Table 1; 6,432 BYR = 1.00 EUR [24]).	1. Wood pellet. • Primary product: 89,000 tonnes wood pellets at 10 % moisture content. • Representative 2011 CIF Sweden pricing at 140 EUR per tonne [23]. • Estimated number of full-time jobs <10.	Annual revenue: ~13 million EUR.	• Incremental export revenue provided by the "agri-paperboard" business option: ~ 19 million EUR (or about 27 million USD). • Incremental full-time jobs created by the "agri-paperboard" business option: ~90.
	2. Agri-paperboard. • Wood wastes for co-generation to supply 1.44 million GJ of energy (including 15 % losses), for in-factory uses. • Primary product: 60,000 tonnes agri-paperboard. • Product valuation at representative 2011 pricing of 535 EUR per tonne for brown kraft linerboard pricing in the EU market [28]. • Estimated number of full-time jobs ~105.	Annual revenue: ~32 million EUR.	

The accruable national benefits of the "agri-paperboard" option could be increased by at least 27 million USD annually. It may be noted that the pricing of specialty agri-paperboard was set to be equivalent to that of commodity brown kraft linerboard. In practice, the value for agri-paperboard could be expected to be much higher in the EU market place because of its superior marketable attributes, viz., zero-pollution pulp and paperboard manufacturing process, 100 % usage of "green" energy, and zero usage of wood pulp fibres. The actual marginal economic benefits could thus be substantially higher.

Concluding Remarks

The installation of own biomass-based on-site co-generation facility is projected to afford longer-term satisfactory pricing stability of required energy. The capital investment of a biomass-fired co-generation system is recognized to be somewhat higher than that of a natural gas-fired co-generation system. In the Grodno oblast, the extensive forest industry is particularly well positioned to supply surplus woodworking waste materials for any regional biomass co-generating operations. On the basis of fuel cost alone, the economy of biomass-based co-generation would be superior to that of natural-gas fired co-generation. In comparison to the use of wood wastes for the export production of wood pellets, the use of similar-quality wood wastes for co-generation in support of agri-paperboard manufacturing would afford substantially greater benefits in terms of export revenue and job creation, from a national perspective (AK38628W3).

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