Gas-chemical Complexes as a major factor in Innovation Development of Chemical Industry in the East of Russia

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Abstract: There are favorable preconditions for construction of gas-chemical complexes in the East of Russia. The paper presents the data on demand for chemical products in the internal and external markets. The economic feasibility of creating modern gas-chemical industry in the East of Russia is substantiated in terms of prices of gas feedstock and final product transportation.

Key words: gas-chemical production, demand and competitiveness of chemical products, eastern regions.

Gas-chemical sector has fitted well into the structure of the world's major oil and gas companies. Introduction of technologies for comprehensive processing of natural gas provides a colossal benefit.

The world's gas companies have been transformed into vertically-integrated holdings which started to control the entire process flow from natural gas production to processing which implies extraction of ethane and propane, pyrolysis of light hydrocarbons, production of chemicals and synthetic polymers on the basis of gas resources.

Since the 1970-80s the chemical industry of developed gas producing countries has shifted to technologically- and environmentally-friendly productions on the basis of light hydrocarbons (ethane, propane, butane).

The economic parameters of olefin production are mostly affected by the following factors: feedstock quality, plant capacity and extent to which it is loaded. For example, capital investment required to construct the plant for ethane pyrolysis are lower by 20% than those necessary to construct the plant for benzene (naphtha) pyrolysis and by 40-45% than those for a gas oil pyrolysis plant of the same capacity. Specific capital investment decreases as the capacity of the plant rises. With a three-fold capacity increase the specific capital investment decreases by 30-35%. The operating costs decline almost in the same range.

Today the plants with a unit capacity of 800 -1000 thousand t/year are operating and constructed in the world, whereas the capacity of most plants in Russia does not exceed 300 thousand t/ year [1].

It is considered efficient to process natural gas containing no less than 3% of ethane.

Unfortunately, in Russia this experience has been neglected and even now refined oil products remain the major hydrocarbon feedstock for chemical industry (Fig.1 [2]).

Despite considerable hydrocarbon resources available in Russia it is far behind developed countries in specific production and consumption of chemical products, and as a result, a great amount of chemical products is imported from other countries.

Unit capacity and technical state of almost all domestic facilities do not satisfy modern standards. Besides, high specific costs make them uncompetitive as compared to the modern large-capacity production facilities in other countries (Table 1).

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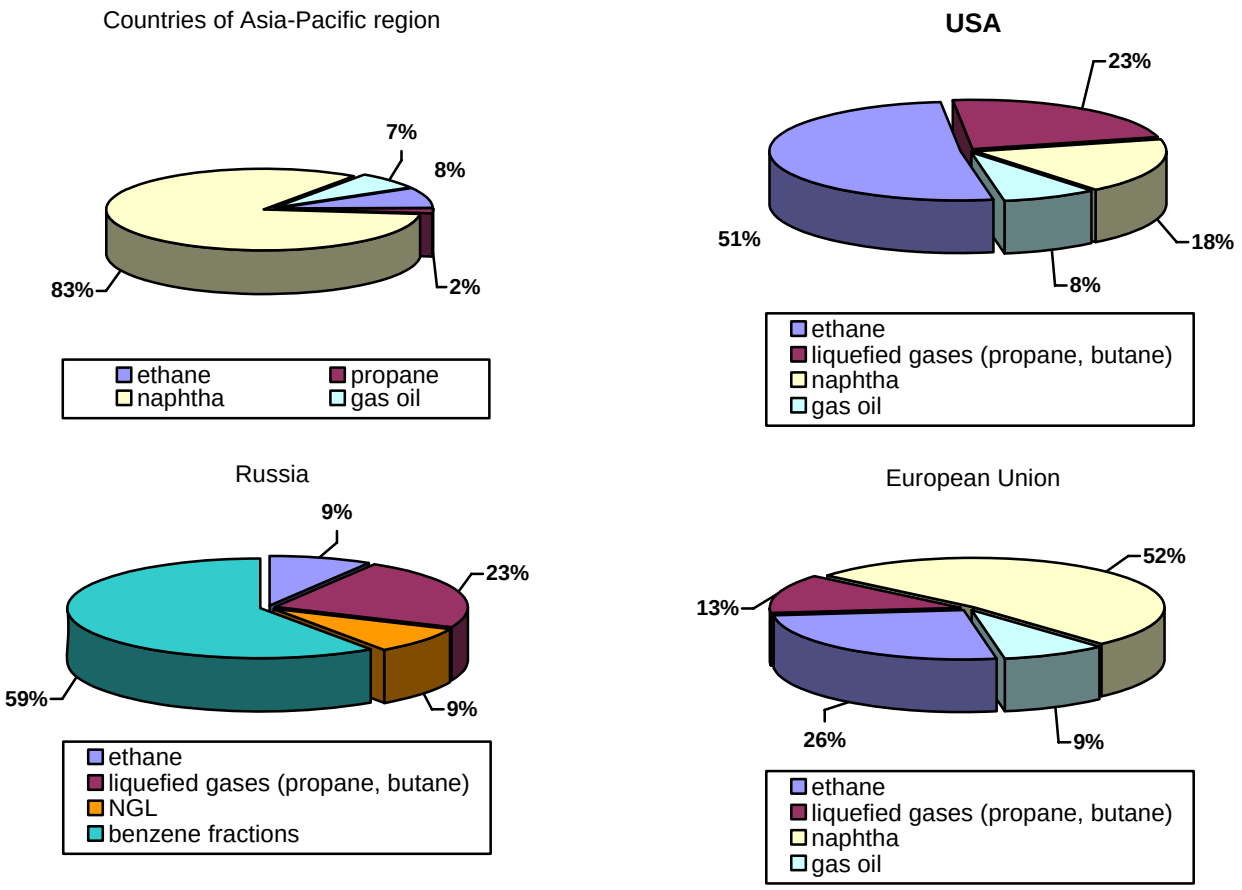

Fig.1. Structure of feedstock for ethylene production

TABLE 1. COMPARISON OF TECHNICAL STATE OF RUSSIAN AND FOREIGN PYROLYSIS PLANTS

Indicator	Domestic plants	Foreign analogues
Consumption of raw material per 1 t of ethylene, propylene, t Operation on ethane liquefied gases benzene	 1.56 2.0 2.49	 1.18 1.6 2.0
Consumption of energy resources, tce	1.3	0.5
Content of ethylene (propylene) in products, %	99.99	99.99
Unit capacity, thousand t/year for ethylene	300-450	800
Pyrolysis feedstock	Benzene and some gases	Any feedstock from ethane to gas oils

Specific feedstock costs at large-capacity facilities in Russia are higher by 20% than those at their foreign analogues, electricity costs – by 60% and salary – by almost 40% [2].

The current status and forecast of demand for primary types of chemicals in the Russian market indicate favorable prospects of its growth by 2015 (Table 2) [3]. The demand for primary types of products will increase in the external market as well (Table 3).

TABLE 2. THE CURRENT STATUS AND FORECAST OF DEMAND FOR PRIMARY TYPES OF PRODUCTS IN THE DOMESTIC MARKET, THOUSAND T

Product	Year			2015 to 2006, in %
	2006	2010	2015	
Mineral fertilizers (in terms of 100% of nutrients)	3833	7790	10290	268
Chemical fibers and filaments	274	418	540	197
Polyethylene	1206	1670	2470	205
Polypropylene	423	670	960	227
Polystyrene and styrene copolymers	325	465	670	206
Polyvinylchloride and vinyl chloride copolymers	742	905	1470	198
Polyethylene terephthalate	449	695	935	208
Polycarbonate	22	50	60	273

TABLE 3. THE CURRENT STATUS AND FORECAST OF DEMAND FOR POLYMERS IN THE INTERNATIONAL MARKET, MILLION T

Product	Year		Rate of growth,%
	2007	2030	
Polyethylene	70.3	167.3	238
Polypropylene	45.6	122.8	269
Polystyrene	15.7	24.8	156
Polyvinylchloride	35.6	65.8	185
Polyethylene terephthalate	47.4	109.0	230
Monoethylene glycol	18.3	36.1	197

However, the current changes in the world market of chemicals and petrochemicals, emergence of new large-scale producers in the traditional markets for Russian product sale complicate the role of domestic companies in struggle for markets. In the nearest time suppliers from the countries of the Persian Gulf (Saudi Arabia, Qatar, Oman) will be the main competitors for Russian producers of plastics, ammonia, methanol. In 2007-2011 there countries project to put into operation 9 ethylene production plants of the total capacity 9.5 million t/year [4].

Emergence of such large-capacity production plants provided with cheap feedstock, as a rule, gas, has led to price fall in the world markets for petrochemical products.

Thus, in the nearest future practically all industries of the Russian chemical complex will have to struggle for survival.

The Strategy for development of chemical and petrochemical industry of Russia till 2015 states that the specific production and consumption of chemicals per capita in Russia is far behind developed countries. For example, in 2005 plastic and synthetic resin production per capita in the RF accounted for 25.9 kg, in the USA – 276.4 kg, in a group of EU countries - on average 200 kg, in Japan – 104.5 kg. Russia is also behind in such important indicators as a fraction of plastics in the structure of construction materials and synthetic fibers in the balance of textile raw material [3].

Currently production of some types of polymer materials (polyamides, polycarbonates, polyurethanes), special rubbers, glues, sealants, etc. have been stopped. Production of carbon materials that are used in the modern aviation and rocket-and- space technology, and nuclear industry are under threat of closure. Above 42% of small-capacity production facilities are in a critical state.

The major products of domestic chemical complex are the products with low degree of feedstock processing. Therefore, demand for high-tech products (construction plastics, chemical fibers and threads, synthetic dyes, chemicals for protection of plants, etc.) is satisfied by their import.

At the same time Russia's capacities producing key types of chemicals are operating at an 80-90 percent load, i.e. increase in their loading is not expected.

The Strategy states that in the event that the urgent measures related to an expected rise in tariffs for products of natural monopolies are not taken only 15 of 45 most important petrochemical products will retain competitiveness

in the domestic market in 2010 and only 8 – in 2011.

Profitability of production will decrease from 11.9% in 2006 to 8.8% in 2011, and by 2015 the chemical complex will become unprofitable.

Thus, the need to create new large-capacity facilities for production of polymers and other chemicals in Russia and particularly in the Eastern regions is obvious. Favorable preconditions for creating gas processing and gas-chemical industry in the east of the country are related, the majority of gas and gas-condensate fields in Krasnoyarsk krai, Irkutsk region and most of the fields in Sakha republic (Yakutia) include from 4 to 6% of ethane, many of them contain helium in commercial concentrations which is a strategic commodity (Table 4). Development of the fields without helium extraction and utilization is inadmissible. However, helium extraction is economically justified only at comprehensive processing of natural gas at large gas chemical complexes in the regions with reliable transport infrastructure. The technology for extraction of natural gas components, including helium, is the technology of low-temperature separation. It allows helium extraction at a minimum temperature, i.e. at the end of the production process. This fact is indicative of the possibility of extracting all components of natural gas within one production process. Selling the obtained helium at its current prices will not allow recovery of production costs. However, extraction of all components and their subsequent utilization in gas-chemical production makes it possible to gain a considerable economic benefit [5].

TABLE 4. COMPOSITION OF NATURAL GAS IN THE MAIN FIELDS OF EAST SIBERIA AND THE FAR EAST

Field	Reserves, billion m^3		Gas composition, %				
	C_1	C_2	Methane	Ethane	Propane	Butane	Helium
Kovykta GC	1406.6	572.0	90.3	4.5	1.1	0.5	0.24
Verkhnechonskoye OGC	11.7	83.8	83.1	5.8	2.1	1.0	0.5
Yurubcheno-Tokhomskoye OGC	93.7	321.2	79.8	7.2	2.3	1.3	0.09
Omorinskoye GC	4.8	4.0	77.1	7.5	3.3	1.4	0.09
Chayandinskoye OGC	379.7	861.2	85.1	4.7	2.0	0.7	0.5
Talakanskoye OGC	35.5	18.6	85.9	5.6	2.0	1.0	0.5
Srednebotuobinskoye OGC	151.9	18.6	87.0	3.7	1.3	0.4	0.5
Dulisminskoye OG	50.3	18.1	78.3	7.8	4.0	2.2	0.3
Sakhalin shelf (on the average)	875.6	321.2	91.8	4.3	1.4	0.3	

Natural gas from the Sakhalin island and offshore fields does not contain helium, however, most of it is supplied in liquefied form which also enables ethane, propane and butane to be extracted from it at minimum cost.

The complexes should be created in Krasnoyarsk krai (the area of the Boguchany settlement) with a capacity of 12.0 billion m^3/year; in Irkutsk region (in the towns of Angarsk, Sayansk and Ust-Kut) with the total capacity of 39 billion m^3/year; in Sakha republic (Yakutia) near the town of Talakan with a capacity of 30.0 billion m^3/year and in the Sakhalin region (the Iliinskoye settlement) with the total capacity of 40 billion m^3/year [5].

The most convenient and economically efficient areas are Irkutsk region and the Sakhalin Island.

For example, Irkutsk region is characterized by a relatively short distance to Kovyktinskoye gas-condensate field (500 km), at which the system of directed drilling is successfully applied. This guarantees a gas cost of no higher than 70 US doll./1000 m^3 at an inflow valve of the gas separation plant (at an IRR of 15% at

the field and gas transportation tariff of 5 doll./1000 m^3 per 100 km).

Currently despite high economic efficiency of using ethane as a feedstock for polymers and petrochemical products the straight-run gasoline (naphtha) and natural gas liquids (NGL) are still planned as feedstock when designing and constructing new production facilities and reconstructing operating ones.

In the reports of the JSC "Angarsk petrochemical company" and JSC "Angarsk plant of polymers" on their sustainable development the companies pointed out that NGL will be used as a feedstock at the plant ЭП-300 to be upgraded to increase its capacity. The JSC "Rosneft" is planning to put into operation the Primorsky oil refinery with a capacity of 10 m t in 2017 with subsequent construction of a petrochemical complex at the refinery. The petrochemical complex will use 2 m t of naphtha as a feedstock including supplies from Komsomolsk oil refinery [6]. Besides, there are plans to construct West-Siberian oil refinery to supply feedstock (straight-run benzene) to "Tomskneftekhim" Ltd with a capacity of 1.5 m t/year, with its subsequent expansion to 3 m t/ year [7]. At the same time ethane from the fields of West and East Siberia and Sakhalin Island will still remain nondemanded. This situation is at least puzzling.

The authors have made an estimation of economic efficiency of petrochemical complexes intended for production of polymers on the basis of ethane (the town of Sayansk in Irkutsk Region, Sakhalin Island) and naphtha (Primorie Territory). The efficiency indicators were determined for large-capacity plants meeting modern requirements. Output of products is presented in Table 5. The prices were assumed on the basis of data from the "Report on results of a preliminary study on the ways to utilize natural gas from Sobinskoye gas-condensate field" which was made by the Japanese companies «ITOCHU» and «TOYO» on request of the JSC "Gazprom" (Table 6) [8] and the data on upgrading of Komsomolsk oil refinery (2006) [9]. The calculation was made in 2008 prices.

TABLE 5. OUTPUT OF PRODUCTS AT ETHANE AND NAPHTHA PYROLYSIS, %

Product	Feedstock for pyrolysis	
	ethane	naphtha
Ethylene	80.0	35.0
Propylene	1.5	15.0
Fraction C_4	4.8	9.5
Pyrolysis condensate	0.2	4.5
Benzol	-	9.5
Methane-hydrogen fraction	13.3	21.0
Pyrolysis resin	-	4.0

TABLE 6. PIRCES FOB NAKHODKA (VOSTOCHNY), US$/T

Product	Price
Polyethylene	1300
Naphtha	640
Kerosene	700
Diesel fuel	660
Methanol	300
Oil	640
LPG	580
LNG	300
Fraction C_4	270
Pyrolysis condensate	325
Benzol	500
Methane-hydrogen fraction	35
Pyrolysis resin	110

It was assumed in the calculations that the owners of the petrochemical complexes are independent companies purchasing feedstock (ethane and naphtha) at the LNG plants, gas processing plants and oil refineries.

In order to efficiently compete, the company should take advantage of the growing global market. For this purpose it should:

- continuously improve organizational methods of control,
- use the economy of scale,
- develop internal and international contacts,
- continuously improve professional skills of personnel,
- have an access to advanced technologies,
- use modern marketing strategies.

These problems can not be solved separately. Their solving requires various forms of cooperation: strategic alliances, financial and industrial groups, consortiums

The calculations performed show (Table 7) that at the current level of feedstock and polymer product prices construction of petrochemical complex on naphtha is economically inefficient, since at the enterprise operation at a full load its net profit is negative: - 4.5 bn rub./year. On the contrary, the enterprises operating on ethane both on Sakhalin Island and in the town of Sayansk in Irkutsk region have the profit of 18.7 and 17.6 bn rub./year respectively. IRR is 16.4%.

TABLE 7. OPERATING PARAMETERS OF THE ENTERPRISES

Parameter	Units	Area		
		Sakhalin	Primorie Territory	Sayansk
Volume of processing				
Ethane	thousand t	1290		1347.9
Naphtha	thousand t		2000	
Product output				
- polyethylene	thousand t/year	1027.0	696.5	1075.3
- polypropylene	thousand t/year	25.0	298.5	26.0
- pyrolysis condensate	thousand t/year	2.8	90.0	2.9
- fraction C_4	thousand t/year	62.0	190.0	64.7
- methane-hydrogen fraction	thousand t/year	171.6	420.0	179.3
- benzol	thousand t/year		190.0	
- resin	thousand t/year		80.0	
Capital investment	billion rub	74.3	89.2	70.6
Production costs	billion rub	-16.7	-41.0	-19.4
- semi-fixed costs	billion rub	-6.7	-8.0	-6.4
- feedstock	billion rub	-10.0	-33.0	-10.4
- railway tariff	billion rub			-2.6
Revenue	billion rub	35.3	38.5	37.0
Profit	billion rub	18.7	-2.5	17.6
Property tax	billion rub	1.6	2.0	1.6
Profit tax	billion rub	4.1	0.0	3.9
Net profit	billion rub	12.9	-4.5	12.2
NPV	billion rub	62.8	-61.3	59.1
Ordinary payback period	years	7.3	-	7.4
Discounted payback period	years	9.5	-	9.5
IRR	%	16.4	-	16.4

According to the authors' estimations the production cost of polyethylene at the current prices will not exceed 25 thousand rub./t. Railway tariff from Angarsk to Moscow is 2.8 thousand rub./t, railway tariff from Angarsk to Nakhodka is 2.4 thousand rub./t

The selling price of polyethylene in the domestic market as of 01.05.2010 is about 40 thousand rub./t. Export price of polyethylene in Nakhodka port is 1300 US doll./t.

Thus, the products of these enterprises can be sold both in the domestic and in the external market.

CONCLUSION

Creation of large-scale gas-chemical industry in Russia, particularly in the East of the country will become a pivotal factor in the innovation development of the national economy. Russia is interested in fast progress in this direction. This will make it possible to enter the market for high technologies in the nearest future. Moreover, the products on the basis of gas resources from the eastern fields are competitive and have a high economic potential for penetration into the internal and external markets.

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