INTELLECTUAL PROPERTY AS AN INDICATOR OF INNOVATIVE DEVELOPMENT OF THE NATIONAL ECONOMY

L.N. Perepechko, E.A. Rukhlinskaya

Introduction

There are a large number of methods developed to forecast the global economy evolution as well as economic advancement of certain countries [1]. Different indicators such as gross domestic product (GDP) and its growth rate, human capital development indices, the level of prices, consumption standard, etc are used to compare the economies of various countries. To compare the innovative development of the particular economy, one can use the inventive activity factors, intellectual property utilization rate and other indicators.

In this paper it is proposed to use the data on intellectual property (IP), owned by the country, its share in the global IP, as well as time history of the IP in a specific area of expertise, to determine the degree of economy development and forecasting the economy diversification in certain areas based on a comprehensive analysis.

Chapter 1. The importance of the indicator representing the availability and time history of national IP in a specific technical area. Problems in development of the Russian economy.

Currently human civilization is developing along the extensive way: the increase in energy consumption and natural resources, as well as production of consumer goods and food is disproportional in relation to population growth [2]. For example, from 2000 to 2010 the world population has grown from 6.1 to 7 billion people, whereas the gross world product (GWP) increased from 42.4 to 74.9 trillion US dollars. The cost and the service life of goods are reduced, vanishes such a thing as a repair. In this race of technology, GDP growth and living standards, the advantages pertain to the countries, which are the first to conquer the markets of the pioneer high-tech products.

The companies and the state protect their intellectual property for the following reasons:

1) scientists can get royalty fees on the sale of their rights to the invention to industrial enterprise;

2) companies protect their markets against the penetration of the competitors and profit maximization through mass production of high-tech innovative new products.

The intellectual property is protected both in the product manufacturing countries and the countries of product markets. At that, on the stage of the innovation life cycle, the number of inventions (IP) relating to a given innovation is maximal at the stage of design and development work, industrial engineering and production of pilot batches of the product.

Therefore, from the analysis of patents and patent applications filed in the patent offices we can get the following information:

1. what research direction is the most promising and relevant;
2. what kind of products and technologies are coming to market in the near future ;
3. which countries will be the suppliers of the equipment in certain areas;
4. which countries will be the leaders in terms of the GDP growth rate.

Intellectual property is an indicator showing the availability of high technology in the country possessing export potential.

At present, the development of innovative economy in Russia, as compared to developed countries and emergent nations, is encountered a problem of weak involvement of the scientific and technological results (R&D) in the national economic turnover (just a few percent of the created intellectual property is demanded in the market). This statement is supported by the following facts:

- low relative production of high-tech products as compared with developed countries;
- a small number of industrial enterprises engaged in technological innovation;
- small relative volume of investment into R&D of industrial enterprises and the private economy sector.

Over the last years, a discrepancy between the amount of expenditure on R&D and the return on scientific developments in the form of new products and employed advanced technologies is gradually increasing. The domestic public spending on R&D in monetary terms increased during the period from 2000 to 2008 more than 4 times (or 1.5 times if calculated at constant prices), the amount of research funding in monetary terms raised over the same period by factor of 5 (or twice if calculated at constant prices), whereas the impact of such costs decreased. By the end of 2007, the proportion of new products in the total amount of goods and services was just 5.5%, and the proportion of conceptually new products in the industrial production was 0.4%. [3, 4].

Low susceptibility of the real sector to innovations is related to the general status of fiscal and monetary policy of the state, the situation in the state's industry, the availability of high-tech manufacturing and its growth.

As an example, let us investigate the relationship between the growth rate of intellectual property (IP) in various countries and GDP growth rate.

Table 1 presents GDP data of the countries in the proportion of global GDP [5]. The selection of countries was made as follows: representative countries of the advanced (post-industrial) economy, the so-called G-7 countries (Group of Seven countries): USA, Germany, France, Great Britain, Japan, and Canada), the fast developing countries (BRICs: Brazil, Russia, India, and China) and Asian countries with no natural resources, developing through the use of imported high technology: South Korea and Malaysia.

Table 1. GDP of various countries presented in the proportion of global GDP on an annual basis (1992-2009).

Year	**USA**	**Russia**	**China**	**Japan**	**Germany**	**Malaysia**	**France**	**Brazil**	**India**	**UK**	**Canada**	**South Korea**
1992	22.75	4.19	4.31	9.22	5.85	0.40	4.00	3.30	3.04	3.61	2.04	1.48
1993	22.94	3.75	4.82	9.05	5.69	0.43	3.88	2.99	3.13	3.62	2.04	1.54
1994	23.15	3.18	5.29	8.85	5.66	0.45	3.85	3.07	3.22	3.66	2.08	1.63
1995	22.91	2.94	5.66	8.71	5.57	0.48	3.80	3.15	3.34	3.64	2.06	1.71
1996	22.93	2.74	6.01	8.62	5.43	0.51	3.70	3.18	3.46	3.61	2.02	1.71
1997	22.96	2.66	6.30	8.40	5.30	0.53	3.63	3.13	3.66	3.58	2.02	1.79
1998	23.39	2.46	6.62	8.03	5.28	0.48	3.67	3.10	3.76	3.62	2.05	1.65
1999	23.71	2.53	6.89	7.75	5.20	0.49	3.66	3.03	3.76	3.62	2.09	1.77
2000	23.56	2.65	7.13	7.61	5.13	0.51	3.63	2.93	3.75	3.59	2.10	1.84
2001	23.29	2.73	7.55	7.45	5.08	0.50	3.62	2.92	3.81	3.60	2.09	1.87
2002	23.07	2.78	8.01	7.27	4.94	0.51	3.56	2.90	3.87	3.57	2.10	1.95
2003	22.83	2.88	8.52	7.12	4.76	0.52	3.47	2.89	4.00	3.55	2.06	1.93
2004	22.54	2.94	8.92	6.96	4.59	0.53	3.37	2.82	4.11	3.49	2.02	1.93
2005	22.28	2.99	9.46	6.83	4.43	0.53	3.30	2.84	4.29	3.41	2.00	1.93
2006	21.76	3.08	10.14	6.63	4.36	0.54	3.21	2.79	4.48	3.33	1.95	1.94
2007	21.08	3.17	11.00	6.45	4.25	0.54	3.12	2.76	4.68	3.25	1.90	1.93
2008	20.52	3.25	11.74	6.20	4.18	0.55	3.04	2.79	4.84	3.16	1.86	1.92
2009	20.14	3.02	12.90	5.92	4.01	0.55	2.99	2.85	5.16	3.03	1.82	1.94

Over 20 years, the proportion of China's GDP grew by almost a factor of 3 (i.e. the growth rate of China's GDP overtake the world average growth rate of GDP). Besides China, the heightened rates of GDP growth have also India, South Korea and Malaysia. GDP growth rate in Russia, Brazil and Canada remain almost unchanged within a certain narrow range.

It is interesting to trace the relationship between GDP and intellectual property (IP) for different countries.

According to the World Intellectual Property Organization (WIPO) [6], the number of patent applications is growing every year, and from 1990 to 2009 has increased by almost a factor of 2. Moreover, the proportion of patent applications of non-residents in the total number of patent applications is also growing, as patents are increasingly being used to protect the IP rights on foreign markets.

Russia ranks 6th in the world in the number of patent applications received by the national patent office from the country residents, i.e. Russia is among the top ten countries of inventive activity. In 2007, Russian residents have filed with Russian Agency for Patents and Trademarks (Rospatent) 27.5 thousand applications (2.75%) of total 1 million patent applications filed worldwide. But, on the other hand, Russia ranks 21st in the number of international patent applications filed under the Paten Cooperation Treaty (PCT) (655 out of 163,600 applications in 2008, or 0.4% of the total). This discrepancy testifies that Russia does not protect national inventions in the international market, not exporting high-tech products and is not involved in high-tech manufacturing in other countries.

It is of interest to study the trend of filing international patent applications by Russian residents, as the situation has changed over the past 20 years since the emergence in Russia of a new economic order and new laws.

Illustrative is the number of applications for invention supplied by the residents of various countries to the US Patent Office - the richest country of the world, as well as its rate of growth (Table 1). According to the annual reports of the US Patent Office [7], a total number of patent applications supplied to US during the period from 1991 to 2009 has increased almost 3-fold (from 164 to 456 thousand). What means such a figure as the protection of inventions in the US? It means that the US market will be saturated with high-tech knowledge-intensive products, manufactured either in the country that holds technology right, or produced at the US enterprises owned by the right holder country. Thus, this indicator shows the high-tech development in a country, that protects its products in the US market.

Table 2 shows the percentage of applications from national residents, served in the US Patent Office by year.

Table 2. The relative number of applications from national residents, served in the US Patent Office during the period from 1992 to 2009.

Year	USA	Russia	China	Japan	Germany	Malaysia	France	Brazil	India	UK	Canada	South Korea
1992	53.40	0.11	0.07	22.32	6.73	0.01	2.79	0.06	0.04	2.65	2.13	0.85
1993	57.20	0.09	0.08	19.92	6.01	0.01	2.47	0.06	0.03	2.53	2.22	0.93
1994	56.48	0.11	0.05	19.89	5.96	0.02	2.38	0.08	0.04	2.56	2.17	1.24
1995	58.37	0.10	0.07	17.78	5.58	0.01	2.35	0.05	0.04	2.45	2.24	1.33
1996	54.76	0.13	0.07	20.24	5.89	0.02	2.30	0.07	0.06	2.45	2.24	2.18
1997	55.95	0.12	0.05	19.40	5.73	0.03	2.21	0.06	0.06	2.39	2.23	2.29
1998	55.74	0.11	0.07	18.62	5.71	0.02	2.16	0.07	0.07	2.51	2.28	2.24
1999	55.45	0.14	0.10	17.70	6.28	0.03	2.30	0.07	0.10	2.57	2.18	1.86
2000	55.69	0.13	0.16	17.87	5.99	0.04	2.24	0.07	0.15	2.54	2.34	1.93
2001	54.37	0.13	0.19	18.76	6.09	0.04	2.10	0.07	0.20	2.56	2.28	2.06
2002	55.09	0.11	0.27	17.56	6.11	0.04	2.04	0.07	0.27	2.51	2.30	2.37
2003	55.17	0.10	0.30	17.62	5.52	0.07	1.93	0.08	0.34	2.25	2.21	3.04
2004	53.10	0.09	0.46	18.16	5.55	0.09	1.91	0.08	0.37	2.18	2.21	3.82
2005	53.20	0.09	0.54	18.43	5.29	0.08	1.78	0.08	0.37	2.04	2.26	4.41
2006	52.07	0.10	0.88	18.04	5.25	0.09	1.68	0.08	0.45	1.96	2.30	5.09
2007	52.91	0.10	0.86	17.27	5.18	0.07	1.76	0.08	0.52	2.01	2.21	5.04
2008	50.75	0.12	0.98	18.06	5.52	0.07	1.88	0.10	0.63	2.14	2.27	5.17
2009	49.31	0.11	1.51	17.97	5.52	0.07	2.05	0.10	0.68	2.32	2.28	5.25

A comparison of two tables clearly shows the relationship between GDP growth rate and the rate of growth (decrease) in the number of patent applications.

In China, India, Malaysia and South Korea the growth rate in number of applications is above mean value. The growth rate of applications filed by the residents of Russia, Brazil, and Canada remain almost unchanged.

For nearly 20 years residents of Russia file in the US just 0.1% of the total number of applications filed by the US Patent Office, while China has increased the relative number of applications during this time more than 20 times. In other words, China is expanding its share in the US market of high-tech products, whereas Russia – does not.

This analysis leads to several conclusions: for particular country, GDP is associated with the protection of intellectual property abroad, because it is determined by the growth of high-tech production and export of high-tech products or their manufacturing abroad. Compared to other countries, Russia does not increase its presence in foreign markets, therefore it is too early to talk about the availability of the conditions for the transition of the country to the innovation stage of economy development.

Chapter 2. Intellectual property and the progress in the field of municipal solid wastes processing and disposal

Waste disposal problem is not only technical but also a social problem. Municipal solid waste (MSW), which is continuously mass-produced by urban population, consists mostly of crude hydrocarbons that allow one to consider waste as a kind of renewable fuel resource. Every year Russia produces about 35-40 million tons of solid waste, or 200 million cubic meters of MSW [8, 9].

On the other hand, in Russia there is a need of continuous heat supply. Historically, in Russia the large cities are dominated by district heating. It would seem logical to realize in Russia large-scale construction of environmentally sound waste-to-energy plants using MSW as a fuel, as well as availability of a significant number of technologies and IP in the field of MSW processing and disposal.

To identify the countries which possess technologies for MSW processing and carry out R&D in this field as well as start production of the relevant equipment, the patent search was carried out through the databases of the European Patent Office (http://worldwide.espacenet.com/), national patent offices of the Russian Federation (http://www.fips.ru/), as well as China and the USA (http://www.chinatrademarkoffice.com/, http://www.uspto.gov/). First, studies were conducted on all of the MSW disposal technologies. The data obtained is presented in Figure 1.

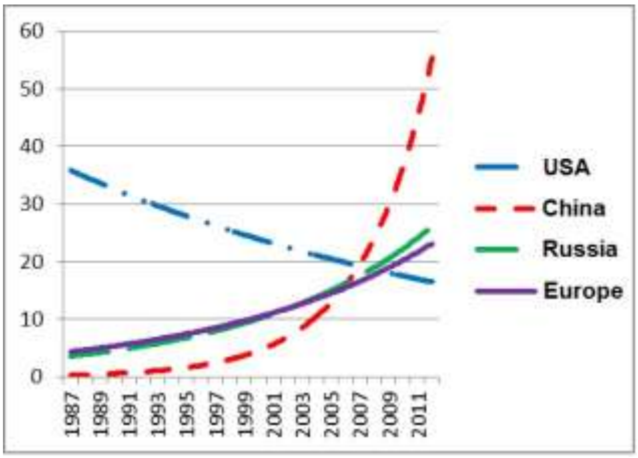

Fig. 1. The number of patents on MSW disposal technologies obtained by year and country: USA, China, Russia, and European countries.

Analysis of data in Fig 1 results in conclusion that in total the most MSW processing technologies are available in the US, though R&D in this area is gradually reduced. China has only recently begun to develop and apply the MSW disposal technologies, though started to do so with maximum activity as compared with other countries.

Russia and European countries are carrying out development studies as well, though according to the time history of patent filing, the equipment for solid waste processing and disposal in the future will be mainly produced in China.

Different methods of solid waste disposal such as recycling after sorting, dumping, thermal processing, etc. have been developed both in Russia and throughout the world [9, 10]. Solid waste disposal technologies are divided into the disposal, recycling and incineration technologies. Waste dumping does not solve the environmental problems, though only postpones the need for recycling of solid waste, as the natural decay periods of its components are up to 200 years [11]. Recycling of solid waste (sorting) is economically unviable, since the revenue from sorting mixed solid waste can not cover the cost of sorting under any circumstances, it requires tariff-cross subsidies on processing and further landfilling [12].

Incineration of unsorted waste involves the lowest processing costs when treating solid waste at its receiving (when just bulky waste is sorted out) and obtaining commercial products in the form of heat, ferrous and non-ferrous metals, and constructional raw materials. [13]

Solid waste incineration technologies are divided into the combustion on the grate (the most common in the world technology) [14], incineration in rotary drum furnaces, and incineration in low temperature plasma with advanced pyrolysis and production of synthesis gas. Today, there are more than 2 thousand plants operating in the world to combust solid waste on the mechanical grates, about 200 furnaces for thermal treatment of waste in a fluidized bed, about 20 rotary kilns to burn MSW, as well as single plants using pyrolysis and gasification [15]. Environmentally friendly technologies for solid waste combustion have been developed and patented in Russia. In 2012, Federal Service for Supervision of Natural Recourses (RPN) admitted combustion of solid waste for the best technology for waste disposal in Russia [16].

Therefore, when working with above mentioned databases, we also searched for patents on incineration technologies applicable for MSW combustion. Based on the data obtained, we have drawn the graphs providing the exponential trend lines to show the time history of patenting by year since 1987 (Fig. 2).

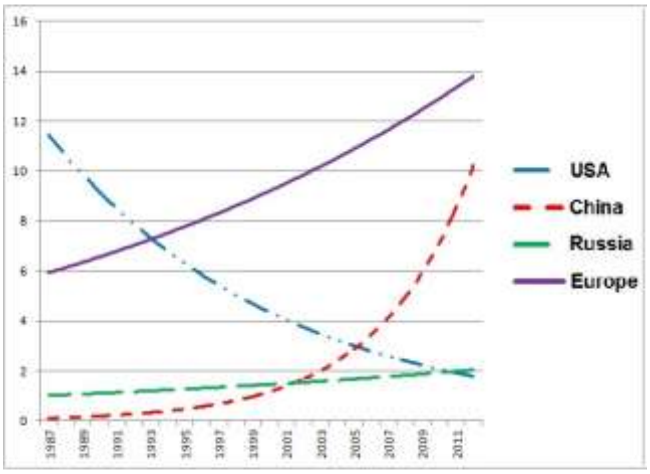

Fig. 2. The number of patents on the MSW incineration technologies obtained by year and country: USA, China, Russia, Europe.

Analysis of the results presented in Fig. 2 shows that the combustion of solid waste is the fastest growing technology in Europe and China. In Russia this trend is almost not developed. The US already have acquired a significant number of technologies and thus reduce R&D in this area. Based upon time history of patenting, one can conclude that in the future the equipment for incineration of solid waste will be mainly manufactured in Europe.

When comparing the conclusions made with the today's situation in the field of solid waste disposal, it becomes obvious, that our findings are strongly supported by tangible evidence that the production of modern equipment and the construction of numerous plants for the thermal disposal of solid waste is mainly concentrated in the USA, China and European countries. In Russia the successful examples of such plant constructions are quite rare, moreover they are built based on the use of foreign technologies and imported (European) equipment.

In 2000, Germany, Austria, and Switzerland have passed laws that prohibit the storage of untreated waste in landfills due to the damage caused by dumping of air, soil, ground water, and also because of the high greenhouse effect. Japan employs about 1,900 units for thermal processing of solid waste that utilize 75% of MSW disposed in the country. In the US in 2007, 12.5 % of MSW has been subjected to thermal processing with the production of 48 TWh of usable energy. In China, over the period of 7 years from 2001 to 2007, the proportion of thermal processing of waste has grown from 2 to 14 million tons per year. In 2007, the country had worked 66 waste incineration plants (WIP). It is expected that this number will increase to 100 by 2012. At present, there are more than 2,500 WIPs operating worldwide and utilizing about 200 million tons of solid waste per year and generating 130 TWh of electricity. The total number of WIPs in Europe is more than 400 [16]. WIPs have long ceased to be just for waste treatment plants, their main purpose is the production of electricity and thermal energy. In Europe, the total amount of waste sent for incineration with and without energy cogeneration is gradually increased. In the period from 1995 to 2010 the production of energy based on the solid waste combustion has doubled [17].

In Europe, China and the US there are state-run programs to support combustion and disposal of solid waste. In China, the heat and electricity produced from biomass or MSW is bought by the state at prices almost 2 times higher than the prices of energy produced using conventional fossil fuels. The country adopted a number of regulations that encourage investment of funds exactly in the area of MSW incineration, that is considered as a promising development in the field of sanitary cleaning of large cities; state has established benefits such as compensation of value-added tax in the case of purchasing the equipment for WIP, priority commercial loans, compensation of 2% of the fixed borrowing rate, and guaranteed subsidy on electricity sold by such a company.

Russia, having large territory, undeveloped private land ownership, weak environmental legislation, and poor control of environmental pollution is an outsider in the construction of WIPs, continuing to contaminate large areas of land, making a significant contribution to the increase in greenhouse gases and pollution of ground water [18].

Experience in incinerators construction in Russia

According to the Federal Service for Supervision of Natural Recourses (RPN), in Russia only 4-5% of MSW is involved in the processing by waste receiving and processing plants. In Russia there are about 400 such plants, including 243 MSW processing complexes, 53 sorting complexes, and at least 10 waste incineration plants. The number of specially equipped sites for waste disposal namely landfills is made up of about one and a half thousand countrywide, number of authorized landfills is a little more than 7 thousand, while the number of unauthorized landfill sites, which are to be regarded as environmental damage already accumulated over the past decades, in 2012 was 17,5 thousand. All of these MSW disposal sites occupy an area of more than 150 thousand hectares [16].

Meanwhile, Russia has acquired half a century experience in the construction and operation of waste incineration plants. First incinerator, not only in Moscow but also in Russia, named State Unitary Enterprise (SUE) "Special Plant #2", was put into operation in 1975. The plant was designed by All-Union Thermal Engineering Institute (named later JSC "VTI") based on domestic technology, using partly the Czechoslovak equipment (mechanical grate produced by CKD-Dukla company of Czech Republic). SUE "Special Plant #3", located in the Southern Administrative District of Moscow, went into operation in 1983. Main processing equipment was manufactured by "Volund" company (Denmark). In 1989 both active plants were closed by the decision of the USSR State Nature Management Committee for environmental reasons.

The first attempt to build a waste incineration plant in the post-Soviet times in Russia was undertaken in Chelyabinsk, where construction of a plant with capacity of 150 thousand tons began in 1996 to incinerate MSW and produce process steam using domestic technology [19]. Nevertheless for a number of reasons, primarily financial ones, construction of this plant was suspended.

The construction of WIP #4 for the disposal and recycling of MSW and biological waste started in 1996 in Moscow at the site of "Rudnevo" (Moscow Eastern Administrative District) under a contract with the Helter company (Germany).

A project of pilot waste incineration plant in Berdsk was designed in 1998 based on domestic technology jointly developed by the Institute of Thermophysics, Siberian Branch of the Russian Academy of Sciences (IT SB RAS), JSC "Tekhenergokhimprom", and VNIPIET, (Novosibirsk). Although the construction of the plant was started, it was suspended and then terminated. From then on, the construction of new facilities for the thermal utilization of MSW to produce heat and electricity, i.e. waste-to-energy plants was carried out only in Moscow.

In 2001, WIP #2 was commissioned after the reconstruction. Plant capacity has been brought up to 150 tons of solid waste per year with generation of about 4 MW of electricity for municipal needs. The main equipment for the reconstruction of the plant was delivered by French company CNIM. Cleaning system operates on domestic equipment. At present the plant is completing the construction of workshop for processing of slag waste using domestic technology. After completing this workshop, solid waste disposal technology will become waste-free. In fact this is the first thermal power plant in Russia, fueled by MSW as a basic fuel [18]. WIP #3 (with installed capacity of 11 MW) and WIP #4 (12 MW) were reequipped later. WIP #3 was commissioned in 2007 after renovation that was carried out by the Austrian company "EVN AG". The design capacity was attained to 360 tons of solid waste per year with generation of 11 MW of electricity. WIP #4 was redesigned in 2003 using Hirschmann’s technology and equipment. The design capacity of the waste receiving plant is 250 thousand tons per year.

Moscow Government Decree #313-PP dated 22.04.2008 "On the development of the technical basis of the urban system for municipal waste management in the city of Moscow" envisaged the construction in the capital city of six new plants for the solid waste disposal with production of heat and electricity, but currently the practical implementation of this decree is suspended. In 2013 Moscow administration has refused to guide the construction of new incinerators.

The reasons why the thermal processing plants for MSW are not built in Russia

1. Polluting emissions

One of the reasons why the thermal processing plants for MSW are not built in Russia is caused by the protests of environmentalists and people opposed to the polluting emissions from these plants. In fact, emissions and harm to the environment due to landfills and garbage dumps is not less though most often is greater than the damage that may cause the plant, because of absence of control and lack of waste treatment systems at landfills and dumps. Second, the technologies of cleaning the air and water developed in the 21st century that are used in modern incinerators, make it possible to decrease concentrations of the toxic contaminants several times lower than the MAC (maximum allowable concentration). The results of measurements made by the All-Russian Thermal Engineering Institute (VTI) at the plants operating in Moscow also show compliance with the standards adopted by the EU on all regulated values which, incidentally, are much stricter than those laid down in Russia for conventional thermal power plants [20].

2. The lack of domestic environmentally sound technologies

Back in the 2000s, All-Russian Thermal Engineering Institute (JSC “VTI”), one of the leading institutions in the development and implementation of various fossil fuel heat power plants, has developed detailed project report for domestic production of standard waste-to-energy disposal systems. In these project report incineration of MSW is carried out on combustion grates. Since 1998, IT SB RAS, together with VNIPIET and JSC "Tekhenergo-khimprom" develops waste-free ecologically friendly technology for MSW incineration in rotary kilns with a system of plasma afterburning of ash and slag. Scientific and technical solutions of JSC "VTI" and IT SB RAS are protected by numerous patents.

Technology of the JSC "VTI"

JSC “VTI” has developed a basic fundamental technical solutions that enable one to create a full-scale commercial prototype of modern domestic waste-to-energy power plant with the installed capacity of 12 MW and 24 MW (respectively 120-180 and 360-420 thousand tons of MSW per year).

Heat power plant combusting MSW is a modern enterprise with a complete industrial process for thermal processing of waste and conventional steam cycle to generate electricity. Heat power plant includes one or two processing lines (PL) each having the capacity of approximately 180 tons of MSW per year.

Implementation of full-scale commercial prototype of modern domestic power plant fueled by solid waste will allow us to duplicate broadly such facilities both in Russia and the CIS countries. According to today's estimates, Russia has a potential to build at least 34 such plants in 22 cities. Table 4 presents the specifications of the standard waste-to-energy heat power plants with installed capacity of 12 and 24 MW, designed by JSC "VTI".

Table 4. General specifications of the proposed standard waste-to-energy heat power plants with installed capacity of 12 and 24 MW.

Name	Quantity value	
The installed capacity for power generation, MW	12	24
The amount of MSW to be incinerated, thousand t/year	120-180	360
Combustion efficiency, t/h	18-24	42
Superheated steam production output, t/h	30-50	70-100
Installed capacity on the heat generation for balance-of-plant needs (BOP needs), MW	< 8	< 8
Heat consumption for BOP needs, MW	< 3,5	< 4,5
Annual electric energy output, MWh/year	74500	150000
Electricity consumption for BOP needs, MWh/year	25000	30000
Electric energy delivered into urban networks, MWh/year	49500	120000
Additional fuel consumption, thousand nm^3/year	450	800

Table 5 shows the maximum concentration of harmful substances in the treated flue gases.

Table 5. The maximum concentration of harmful substances in the treated flue gases by technology of JSC "VTI" [21].

Substances	Values, mg/nm^3 (in terms of the oxygen content in the dry flue gases equal to 11%)	
	The average daily	The average half-hour
Fly ash	10	30
Hydrogen chloride (HCl)	10	60
Fluorine hydrogen (HF)	1	4
Nitrogen oxides (NOx)	120-130	
Sulphur dioxide (SO2)	50	200
Carbon Monoxide (CO)	50	100
Organic substances (C_{org})	10	

Dioxins and furans (PCDD / PCDF)	$0,1X10^{-6*}$
Cadmium and thallium	$0,05^{*}$
Mercury	$0,05^{*}$
The total content of lead, cobalt, chromium, manganese, nickel, arsenic, antimony, copper, and vanadium	$0,5^{*}$

Technology of the IT SB RAS

IT SB RAS, together with JSC "Fire technology" and VNIPIET has developed the concept of coordinated solutions to environmental and the thermal engineering problems for recycling of MSW, in which the creation of integrated district heating plants (IDHP) is justified [22, 23]. In contrast to VTI technology, here the solution to the problem of MSW disposal is proposed to medium-sized cities. The main purpose of IDHP is production of heat and hot water for district heating rather than generation of electric power. The basic technology principle of new thermal power plant is the use of two basic types of fuel: MSW together with combustible industrial waste, supplied daily, and conventional fossil fuels.

Fully developed engineering flow diagram provides for the application of domestic equipment for waste incineration, waste-heat boilers, and heat pumps that use the heat of exhaust gases in order to improve the overall efficiency of the IDHP. The application of high-efficiency gas cleaning devices is provided as well. The foundation of integrated district heating stations is laid on new principles, engineering flow diagrams, and equipment designs that can be implemented at Russian plants. The exact equipment type and configuration for IDHP depend on the location of the plant, the amount of waste treated, type of fossil fuel and the urban and regional energy supply policy.

IDHP is intended for processing and disposal of industrial and domestic wastes of the city (or city district) with a population of about 100 thousand people. Its efficiency is not less than 40 thousand tones per year, including 30 thousand tons of solid MSW and 10 thousand tons of industrial waste.

IDHP can be used for treatment of all kinds of recyclable municipal solid wastes: garbage from residential and public buildings, waste from street cleaning, trash from the trimming of trees and shrubs, etc., as well as all kinds of industrial non-toxic and toxic wastes of all hazard classes, with the exception of radioactive wastes and the wastes containing mercury, lead, arsenic, and selenium. Heat recovery system of the plant makes it possible to use both high-grade flue gas heat and low-grade heat generated due to the condensation of moisture in the flue gas, as well as the heat recovered by means of coolant from gas treatment and processing equipment.

The advantage of IDHP is that it provides the environmentally friendly ash recycling technology, since IDHP is complemented by ash melting unit with plasma reactor to produce inert slag and non-toxic gas emissions.

Thus, even today there is a practical opportunity to create domestic environmentally friendly facilities for thermal disposal of solid waste.

3. Construction of plants for thermal processing of solid waste lacks money

The cost of waste dumping in landfills depends on disposal technologies, the availability of water-, air-, and soil-protection systems, as well as landfill monitoring and maintenance systems. In some countries, where landfills (dumps) must meet strict environmental standards, or disposal of untreated waste is prohibited by law, the capital and operating specific costs for disposal exceed those for MSW incineration.

Prospects for the MSW use in the Russian Federation as a secondary energy resources are associated with the adoption of legislation aimed at substantial reduction in landfill dumping, at least for large and medium-sized cities, as well as the concernment of energy producing companies in the development of renewable energy sources. Only in this case thermal treatment of MSW will be cost effective and will not face the problems with financing.

Conclusions

The existing waste management system in Russia, focused primarily on disposal of MSW, is imperfect, providing air and ground water pollution, and as a result, reducing quality of life. It is not consistent with the principles of sustainable development of the economy and requires a fundamental modernization.

Service experience of numerous foreign MSW thermal processing plants shows that modern thermal power plant fueled by solid waste is an environmentally friendly enterprise. This is confirmed by the test results on domestic special plants in Moscow that were conducted during their start-up and subsequent operation. The concentration of controlled chemicals in combustion products of MSW does not exceed the regulatory values accepted in the EU that provides an environmentally safe operation of such plants. The resulting ash and slag residues can be processed into inert product for subsequent use, for example, in road construction at the plant premises.

Waste-to-energy heat power plant is the most accessible and one of the most cost-effective renewable energy sources. According to international data, the average cost of electricity generated by such power station is almost ten times lower than that of solar energy and more than two times cheaper than wind energy.

Despite the fact that Russia still considers itself one of the leaders in the field of electrical power engineering, currently only three waste-to-energy thermal power plants with total installed capacity of just 26.6 MW are in operation in the Russian Federation (for comparison - the total capacity of such thermal power plants in the USA is 2.7 GW). At that, the main equipment for Russian plants is imported from abroad. The plants are owned by housing and public services (SUE "Ekotekhprom"). It should be noted that construction and operation of waste thermal treatment plants oversees is dealt by energy companies, at that the interest of power engineers to this source of energy continues growing. For example, the total electric power of all companies owned by just one energy company namely E.ON, exceeds that of Russia by almost 10 times.

The problem of solid waste disposal is both technical and social. MSW is one of the renewable energy sources, especially significant in the colder regions of Russia. In contrast to the situation in 20th century, today Russia is lagging behind in matters of construction the facilities for clean MSW combustion technology. Nevertheless in Russia there are domestic solid waste incineration technologies which are at the level of world standard. These technologies are patented mostly only in Russia. In order to increase the country's foreign markets representation, it is important to obtain international patents on domestic technologies.

The conducted analysis shows that intellectual property is a good indicator when comparing the economies of individual countries. It serves as a criterion for the availability of high technologies in the country and indicates the stage of high-tech involvement in the country’s economy.

One can expect that the countries with positive trend in patenting of inventions will have in the near future a high level of innovation-driven economy development and dominate in the global market of high-tech products.

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