On the strategy for power sector development in the Kaliningrad Region

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ON THE STRATEGY FOR POWER SECTOR DEVELOPMENT IN THE KALININGRAD REGION

The balanced power sector development in the Kaliningrad region requires an accurate estimation of the parameters of the main generation complex, the formation of a backup generation complex, and the efficient management of power sector.

***Key words*:** Kaliningrad regional power sector, main generation complex, backup generation complex, regional electrotechnical complex, optimal power consumption management, rank analysis, technocenosis.

The administrations of the RF regions recognise the problem of power supply as a priority and aim to incorporate it into the general development strategy as well as into the ongoing restructuring of power industry. Being home to 30% of proven world's natural gas reserves and 23% of coal reserves and producing 11% of the world's primary energy, Russia expends 7% of the planet's energy in the production of only 3% of world gross product. The energy intensity per product unit, which is four times as high as in developed countries, the expected growth in power consumption (in terms of primary energy, this parameter achieved 3-5% per year in Russia in 1995-2008 as opposed to the world's average 2%), and the inevitable increase in oil and gas prices require a strategy for the development of regional power industry, which would rely on stable power supply, energy efficiency, the employment of local energy sources and self-sufficiency pertaining to power generation in emergency situations.

In the framework of designing individual strategies for a number of Russian regions, it is necessary to take into account the globalisation processes. This is exceptionally important for the Kaliningrad region, where integration is declared a primary target both for Russia and the European Union. However, today it is already evident that thus multivariate integration process should be accompanied by a comprehensive analysis of its consequences for all spheres of economy, especially, the all-important sphere of energy.

The content of the energy strategy requires a radical revision. First of all, one should determine the object of the strategy which can be understood as a regional electrical energy complex (fig. 1).

A regional power complex is an aggregate of power sources and consumers possessing technocenotic properties, limited in space and time as well as an aggregate of logistic and resource and technical support systems, which aims at stable power supply in the framework of an integrated management system and overall provision, either individually or with the external power system [1-3].Thus, already at the level of definition, one can claim that the strategy for the development of the Kaliningrad regional power complex should encompass the balanced development of all its systems: the main generating complex, the backup generating complex and the electrotechnical complex, as well as the resource and technical support system. Without underestimating the importance of logistic support system and resource and technical support system, we should mention that, in the framework of a long-term investment strategy, the key role is played by an accurate definition of the structure and parameters of regional generating complex, while, as to universal requirements for sustainable development, the crucial element is a careful choice and introduction of the methodology of optimal management of regional electrotechnical complex. Thus, we will further focus on these aspects.

As early as the 1980s, it became obvious that the Kaliningrad regional power system (OAO Yantarenergo) was 90% energy deficient, while its electricity balance was unacceptable. Over the last years, the leaders of the region, the state and the former RAO UES of Russia have been seeking the ways to resolve the energy problem of the region. Numerous variants were considered, but to date, it has boiled down to the construction of one large power plant, which is expected to solve all problems. It is the project of the construction of the large CHPP-2 in the environs of Kaliningrad.

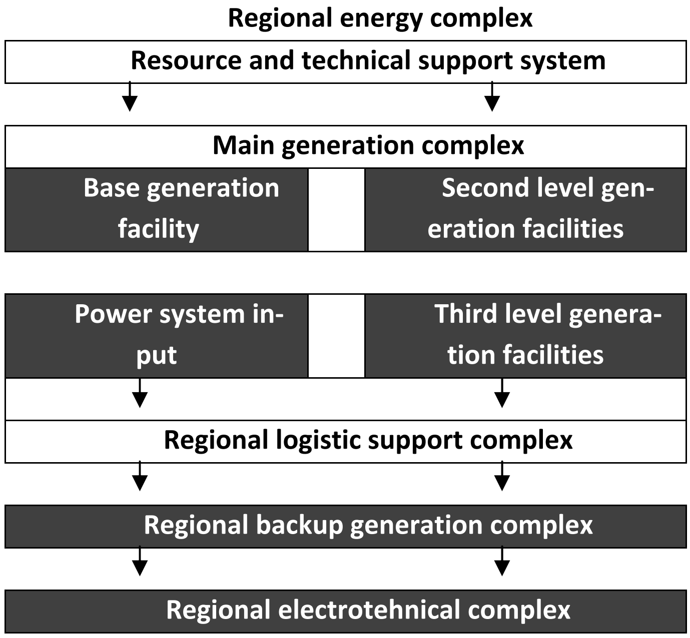

Fig. 1. The basic configuration and structure of regional power complex

Despite the fact that as the CHPP comes online the formal shortage of locally generated electricity will be eliminated, the issue of regional power supply remains due to the debatable decision of the RAO UES management. Regardless of the construction of the CHPP-2, numerous external factors diversely influencing the development of the Kaliningrad regional generating complex are coming to the foreground. Let us formulate the crucial ones:

1. A special geopolitical and economic position of the Kaliningrad region required special approaches to the planning of the development of the main regional generating complex.
2. The standard of living in the region should approximate the European one, which also concerns the regional power complex.
3. The prospective accession of Russia to the WTO may radically and unpredictably affect the power consumption market both in the Kaliningrad and the neighbouring regions.
4. The feasible ratification of the Kyoto Protocol by the Russian Federation will inevitably require a significant increase in the efficiency of regional electrotechnical complex.
5. The drawing up of the programme of regional power complex development should include operational and strategic aspects alongside technical and economic ones.
6. Any forecasts for the energy balance of regional energy sector should take into account the inevitable two-threefold increase in gas prices in the near future.

The analysis of the mentioned factors shows that all of them are difficult to predict and are almost impossible to manage at the level of either regional or federal governments. In such cases, the determination of the generation complex parameters should employ special methods that take into account the inaccuracy and ambiguity of the initial data [3]. It is not the realm of traditional methods of power plant design, which boil down to minimising the cost of a unit of generated power.

It is external aspects; now let us focus on the other side of the problem pertaining to the main regional generation complex. The region is home to the following power source: the Kaliningrad CHPP-2 (Kaliningrad, OAO Yantarenergo, 450 MW installed capacity); the Kaliningrad Sate District Power Plant-2 or SDPP-2 (Svetly, OAO Yantarenergo, 114.8 MW); the Gusev CHPP-5 (Gusev, OAO Yantarenergo, 15.5 MW), the Sovetsk CHPP-10 (Sovetsk, AOOT Sovetsky Paper Mill, 36 MW); the Kaliningrad CHPP-9 (Kaliningrad, JV ZAO Tsepruss, 18 MW); the Kaliningrad CHPP-8 (Kaliningrad, Darita municipal enterprise, 12 MW); the Pravdinsk HPP-3 (Pravdinsk, OAO Yantarenergo, 1.14 MW), the Ozyorsk HPP (Ozyorsk, OAO Yantarenergo, 0.5 MW), the Kulikovo wind power complex (Kulikovo, OAO Yantarenergo, 5.2 MW); the Kaliningrad CHPP-1 (Kaliningrad, OAO Yantarenergo, the generating units were removed from service).

The total capacity of generating facilities (excluding CHPP-2) exceeds 200 MW. Due to various reasons, at the moment, these power sources are far from operating in the design condition, which leads to power shortage tackled by means of a 330 kW transmission line running through the territory of Lithuania from the North-western ring of the united Russian energy system. If the attempts of the Baltic States to separate from the united energy system of Russia succeed, the situation can be significantly exacerbated. It brings us to the conclusion that there are two possible variants of the functioning of the Kaliningrad regional electrical energy complex: 1) the relatively normal operation of the complex retaining the mentioned electricity balance; 2) the operation in the conditions of the absence of power supply through the territory of Lithuania.

According to the calculations of OAO Yantarenergo, in winter period, the consumer capacity that require an uninterrupted power supply can reach 500 MW. It is, first of all, water and heat supply facilities and sewage systems, hospitals, bakery plants, busy cultural institutions and shopping malls, communication facilities, administration buildings, pump stations, and enterprises with uninterrupted technological cycle. The expected 50-100 MW power deficit, unless corresponding measures are taken, may bring the regional infrastructure into decay within a few days.

One cannot say that this aspect was totally neglected earlier and nothing has been done to alleviate the energy problem. The CHPP-2 is being constructed, OAO Yatarenergo is aiming either to connect the power system on the territory of Poland, which is a 'cul-de-sac' today, to the "Russia-West" transmission line, or to power the south-western part of the region from the Polish power system (such projects were considered in the mid-1990s). The SDPP and the operating CHPPs were planned to be reconstructed alongside the integration of smaller module gas-fuelled heat and power plants of a 25-30 MW capacity into the regional infrastructure. However, each project taken alone had certain disadvantages (the lack of financing, insufficient capacity, etc.) and, taken together, the projects were neither coordinated nor tested according to technocenotic criteria [ibid]. And, what is more important, none has been fully implemented.

Let us return to the power strategy for the Kaliningrad region. Theory prescribes: a plan to construct one 500-1000 MW power plant requires additional plans for ten 50-100 MW power plants, one hundred 10 MW power plants, one thousand 1,000 kW plants, etc [ibid]. And this 'pyramid' usually begins with the development of the 'natural environment' – small and medium facilities (power plants, in this case) – rather than with the creation of an 'elephant' (CHPP-2). So, as we talk about stable generation in different operating modes, provided high probability of alterations in external environment, and at minimal costs for overall provision, we keep in mind the mentioned distribution of power plants in the regional power system.

It is evident that today the optimal distribution is not the case in the Kaliningrad region, which stems from the fact that the CHPP-2 (as the first point) does not belong to the curve of the parameter-based rank distribution showing the actual power demand in the region. It is located significantly above the optimal first point and its capacity is much higher than theory prescribes (fig. 2) [ibid].

One can certainly say that Kaliningrad follows the path of Vladivostok, where the Primorskaya CHPP has been 'haunting' the city for many years. Of course, the situation would change, if the maximum capacity were assumed 200-400 MW (50-100 MW generators); the actual hyperbolic curve of parameter-based distribution could approximate the theoretical one and be used in the strategy for the development of regional power sector. In December 2000, TACIS experts (Project ERUS 9804 — Support to Regional Energy Organisations) independently recommended to the Kaliningrad region the construction of a 300 MW power plant with two 125.7 MW gas and one 66 MW steam turbines (a gross capacity of 317.4 MW provided a 310 MW output, which, for short periods, can be increased by 10%). It is important that a 300 MW capacity precisely fits the curve of parameter-based distribution, which we have repeatedly claimed in the media and at different forums.

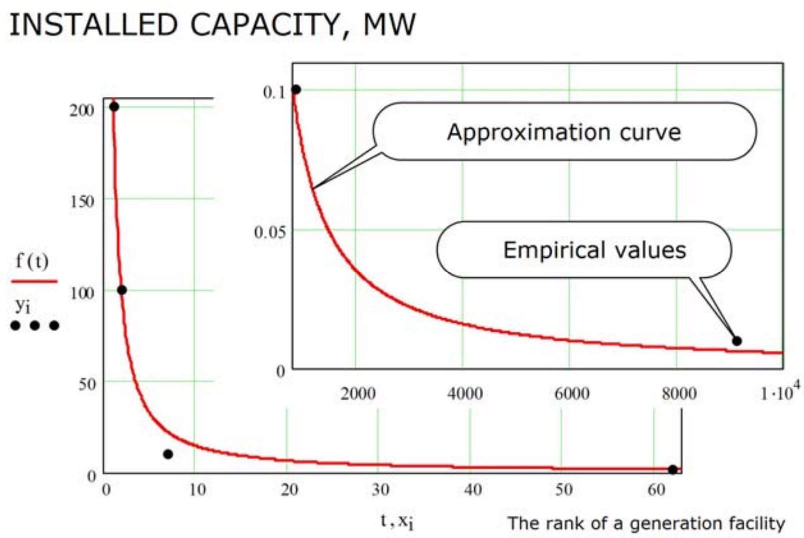

Fig. 2. The optimised parameter-based rank distribution of generation facilities in the power system of the Kaliningrad region (modelling results)

If we assume the capacity of the base facility (the first point in fig. 2) as 300 MW, the following optimal variant of the distribution curve will be quite feasible: the second level of generation includes the Svetly SDPP, the Gusev CHPP, the Sovetsk CHPP-7 and five-seven newly built smaller CHPPs of a capacity of 30-60 MW per plant (the second and third points); the third level of generation will be represented by the Pravdisnk hydroelectric complex and the Kulikovo wind power complex as well as 40-50 smaller power plants of a capacity of 1-3 MW (first of all, wind and hydropower plants, etc.); finally, the following points are all backup mini- and micro power plants of a capacity ranging from 0.5 to 5000 kW. As we know, the Svetly, Gusev, and Sovetsk power plants require modernisation, while the Pravdinsk hydroelectric complex is in need of further restoration. However, it will give us a stable three-tier generation system.

On April 16, 2008, Rosatom and the regional government signed the agreement on the construction of a nuclear power plant in the Kaliningrad region (the Baltic NPP). The launch of the NPP is scheduled for 2016. The order authorising construction was signed on August 13, 2008 by Sergey Kiriyenko. OAO Energoatom Concern was appointed the construction manager. OAO Saint Petersburg Research and Design Institute ATOMENERGOPROEKT (OAO SPAEP) was recommended as the general design engineering institution. The project was expected to be completed by the end of 2009. The Baltic NPP will be constructed in the Neman district of the Kaliningrad region 15 kilometres South-East of the town of Neman (30 kilometres from the Lithuanian border). The basic technical and economic parameters of the NPP are as follows: reactor type – VVER-1200; installed capacity of a power unit – 1150 MW, number of power units – 2; generating capacity – 2400 MW; project financing – 134.3 billion roubles.

Obviously, talking about a regional generating complex, one cannot neglect the construction of an NPP in the region. However, here one encounters a number of unresolved issues. The problem lies in the difficulty to predict how the NPP will fit into the regional power complex, how it will influence the regional infrastructure, and how it will integrate into the power systems of neighbouring states in view of the new parameters of the Kaliningrad generation complex, rather than in the mere fact that the power plant is nuclear.

Let us formulate the pertinent questions. Firstly, what is the plan to increase power consumption (in terms of peak capacity) in the Kaliningrad region, in the next 6-8 years, from 738 MW (the 2009 maximum) to 1.8 GW, which is necessary to meet the generation schedule of the NPP, based on? At the same time, one should take into account that the Kaliningrad regional electrotechnical complex in its current condition is characterised by a much lower maximum capacity increase rate (4-5% average annual rate over the last decade and a zero increase in the last 4 years: 2004 — 640 MW, 2006 — 711 MW, 2007 — 670 MW, 2008 — 667 MW). Consequently, the normal operation of the Baltic NPP will be impossible unless new energy-intensive enterprises are created in the Kaliningrad region. Secondly, how will the power generated by the Baltic NPP and Kaliningrad CHPP-2 compete within the common market? One should not forget that since the mid-1980s, there has been no power plant in the Kaliningrad region operating in the condition remotely resembling the design one. In certain circumstances, the CHPP-2, which has been being constructed for 15 years, is at risk to join the ranks of the mentioned power plants. Thirdly, how will the regional system, seriously preparing to operate in isolation, ensure the base mode power output for the new NPP through two independent transmission lines? Even today it is evident that in the isolated mode, which can result from the secession of the power system of the Baltic State from the UES of Russia, the NPP will not be able to operate due to solely technical reasons. It seems that the normal operation of the NPP and stable power export will require the integration of the Kaliningrad power system into the regional Central European power system association (UCTE-CENTREL). Fourthly, what geoecological, demographic, and socieocnomic consequences will ensue from the establishment of a 30 km zone for the new power plant on the small territory of the Kaliningrad region? Fifthly, what is the opinion of the EU countries as to the construction of the NPP, which is to be taken into account in the framework of prospective integration projects?

Let us recall that in a few years (after the secession of the power systems of the Baltic States from the UES of Russia) the Kaliningrad system will find itself in the isolated operation mode, in which one large power plant cannot ensure the required stability of power supply to regional consumers. Any power plant experiences, with some regularity, scheduled, unscheduled or emergency outages, some of which lead to a total 'blackout'. Thus, stable operation in the isolated mode requires local autonomous backup alongside the second and third level power plants (see fig. 1).

Actually, the backup generation complex should be restored in the Kaliningrad region. In our opinion, the priority measures to be taken in this connection are as follows:

1. The classification of regional organisations according to power supply stability, which will enable us to compile the list of special organisations requiring the backup from autonomous power plants.
2. The estimation of the backup coefficient for special organisations, which will allow us to calculate the number and types of power facilities for each organisation.
3. The development of a complex of administrative and technical measures as to the backup of special organisations, which would take into account the specific conditions of operation and logistics in the special period.
4. The development of a complex of electrical safety measures to be taken during the operation in the backup mode and safety-related training of the staff.
5. The establishment of an optimal nomenclature of the regional backup generation complex aimed to optimise the main subsystems of resource and technical support.
6. The creation of a system of the support to decision-making in the field of backup generation complex management, resulting in the optimisation of the whole spectrum of costs.

One should specifically focus on the system of the support to the process of the formation of a backup generation complex. Here we should apply the methodology of parametric synthesis based on the law of optimal technocenosis construction (fig. 3) [1-3].

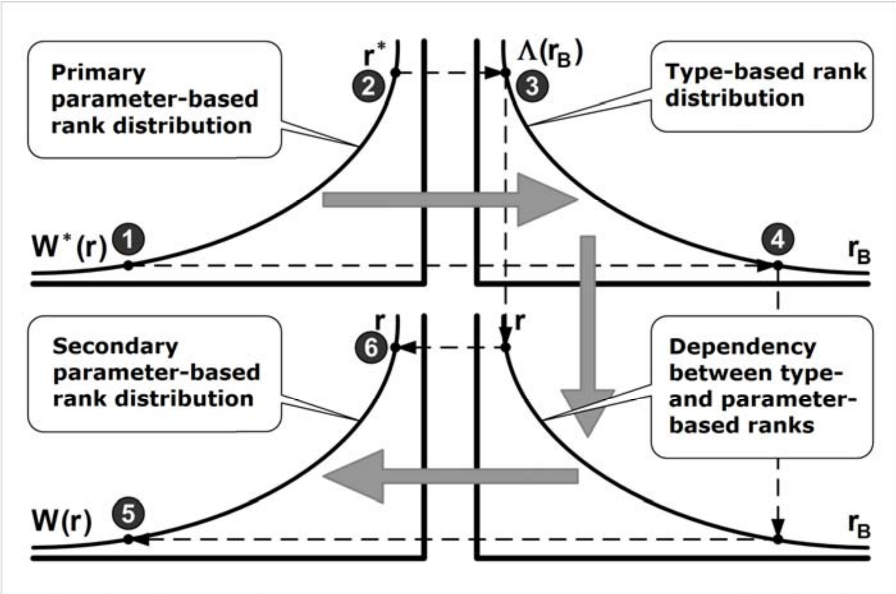

Fig. 3. The scheme of the implementation of parametric synthesis methodology

A variant of parametric standardisation in a technocenosis is parametric synthesis, by which we understand the procedure of the optimal nomenclature in the technocenosis, i.e. the establishment of connection between parameter- and type-based rank distributions, which leads to the optimal typological diversity of technical equipment. The essence of parametric synthesis is encapsulated in the fact that one produces a type- and parameter-based rank distribution in a combined coordinate system as well as a graph linking the type- and parameter-based ranks. Unlike the procedure of parametric standardisation, where rank distribution is based on the processing of statistical data on actual technocenosis, the parametric synthesis procedure involves rank distribution generated by the computational implementation of the equations of the law of optimal technocenosis construction in view of parametric limitations. These limitations initially help produce the primary parameter-based rank distribution conforming to the power supply requirements of regional organisations. Then, one draws the type-based rank distribution, which corresponds to the primary parameter-based one. Here, the correspondence between the distributions is achieved on the basis of the feedback principle between the parameter value and the number, which follows from the law of optimal technocenosis construction. Then, one establishes the connection between type- and parameter based ranks of the technocenosis. Finally, the iterative method is used to implement the multidimensional optimisation process, in the course of which, by means of fitting, the backup power plants (of the existing nomenclature) form the type diversity of backup generation complex conforming to the law of optimal technocenosis construction [3].

Thus, the possibility of operation in the isolated mode and the strategic aspect (crucial for the formulation of the public approach to the problem) impose an equally important requirement on the generating complex, i.e. stability in all operation modes. What are the proposals as to the development of the Kaliningrad regional generation complex in view of both the theoretical variant and the actual situation? It is crucial, having modernised and restored the existing facilities, to construct several smaller 30-60 MW CHPPs in the regional centres of heat and power demand (as mentioned before, such power plants are extensively used in Europe). Moreover, it is essential to construct 40-50 smaller power plants of a capacity of 1-3 MW (first of all, mini-hydro power plants, wind power plants and other environmentally friendly energy sources). As to 0.4 kW backup power plants, they should be purchased by the consumers (nowadays, these are predominantly the facilities of municipalities, border authorities, the Ministry for Internal Affairs, public enterprises and organisations, private companies, etc.). The number of such power plants will also determine the demand for individual backup. Despite the fact that this process is spontaneous, it should be managed either directly or indirectly (by monetary methods: laws, taxes, budget, etc.).

Let us consider the regional electrotechnical complex (see fig. 1). The energy intensity of Russian production is three-four times as high as in developed European countries and the USA and seven times as high as in Japan. Situation in the field of housing utilities is even worse. Over the last decade, this indicator has been getting worse every year. The corresponding data suggest that, in terms of housing utilities, the North-West of Russia in general and the Kaliningrad region in particular do not perform well in comparison other Russian regions. It seems, the situation will not change, unless we take the path, which the USA, Germany, Japan, and other countries have been following since the energy crises of the 1970, when the methods of research and optimisation of large power and electrotechnical complexes and system started to be employed in practice.

It is essential to understand that the uncontrolled growth in power consumption, which results from, first of all, the extremely low energy efficiency of Russian manufacturing industries and utility services, is a major destabilising factor in the development of a regional generation complex (including the Kaliningrad one). The problem lies in the fact that the efficiency of capital investment in the development of generation complex decreases over time, while newly generated electricity demand, in the absence of energy efficiency factors, inevitably increases with almost linear dependence (fig. 4).

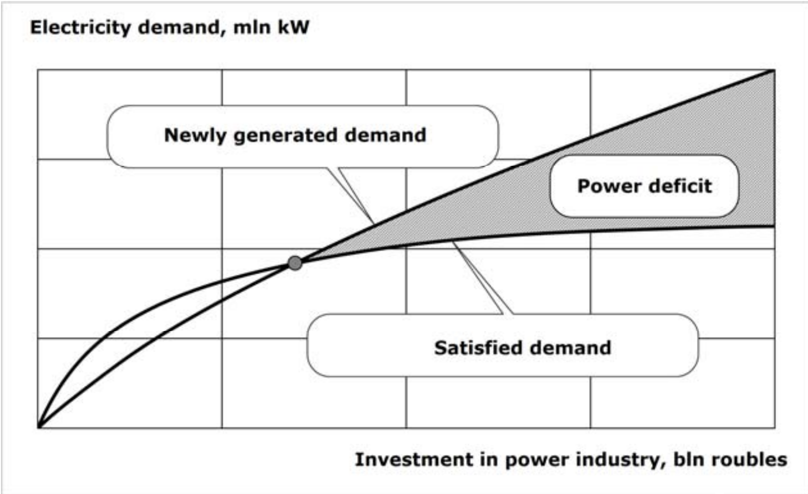

Fig. 4. The shortage in installed generation capacity in the absence of energy efficiency factors

One can see that, over time, it reaches the point (fig. 4, the point of the intersection of the curves), when even significant investment in the generation complex cannot create continuous uncontrolled demand for newly generated electricity. It seems that we are starting to face this situation in Kaliningrad, where it became almost impossible to connect to the power system in the centres of industrial growth and rapid housing development. Manufacturers and developers always blame OAO Yantarenergo for everything, though sometimes it is them who are at fault. The optimal management of the Kaliningrad regional electrotechnical complex should be performed by the regional government at the system level in the framework of a corresponding methodology and be divided in four stages (fig. 5) [1-3].

The statistical model of power consumption, the backbone of which is the determinate data processing by means of rank, interval and cluster analysis is supplemented with the dynamic adaptive model anticipating the power consumption process in the next 5-7 years (fig. 6). At the same time, the feedback is essential; it adjusts the initial power consumption database on the basis of current modelling results. The dynamic character of the model is a result of the developed system of input parameters reflecting the properties and external conditions of organisations' operation as well as of the stochastic analytical mechanism [2, 3].

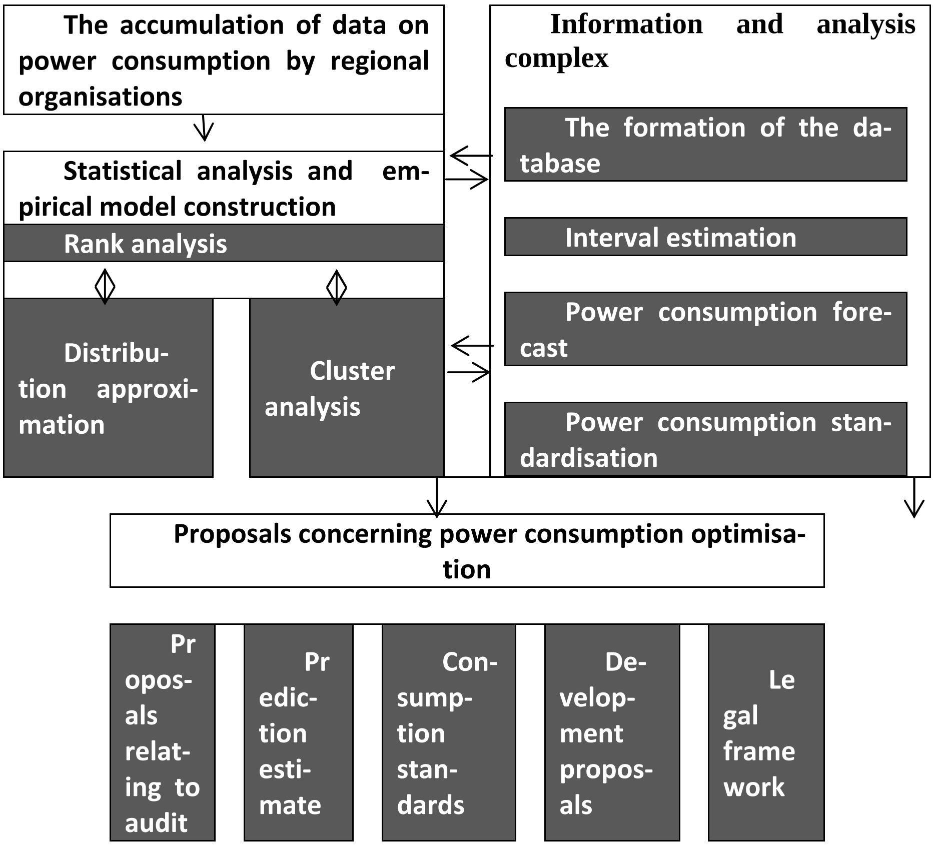

Fig. 5. The methodology of regional electrotechnical complex management

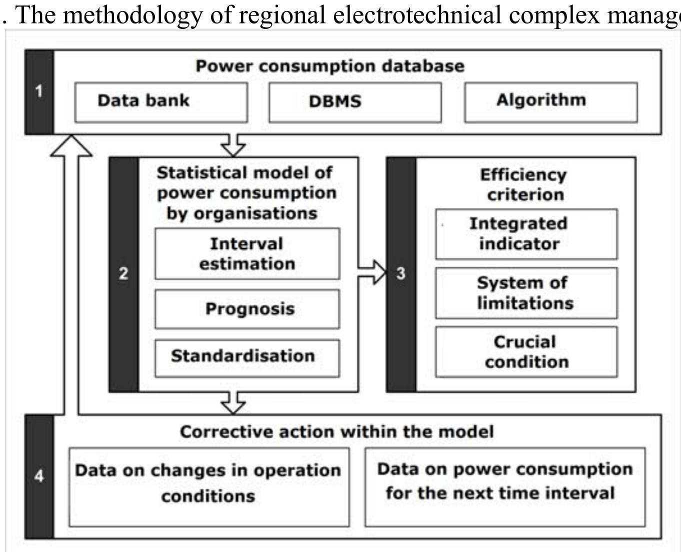

Fig. 6. The structure of the dynamic adaptive model

Practical results and modelling suggest that even in the conditions of small regions, it is possible to save dozens of millions of dollars within a few years solely by the employment of the methodology of optimal power consumption management and without significant capital investment. The parallel introduction of technical solutions and energy efficient technologies leads to the increase in the saving rate [1-3].

Conclusion. There is a set of specific and complicated problems in the Kaliningrad power complex, which are to be solved by covering several aspects. Firstly, it is the improvement of the generation complex development programme based on technical and economic analysis and technocenotic ideas. Here, one should take into account the interests of the industry (first of all those of power generation entities and consumers), the multifactor prognoses of power consumption and all financing opportunities. Considering the regional generation complex, one should not overlook the construction of the nuclear power plant; however, there are still questions to be addressed. How will the NPP integrate into the regional power complex, how will it affect the regional infrastructure, how will it integrate into the power systems of neighbouring countries? The existent power plants are to be modernised and switched to widely available fuel (including coal). Moreover, it is crucial to construct five-seven smaller 30-60 MW and 40-50 smaller 1-3 MW CHPPs. A part of electricity demand can be still met by means of transit via the territory of Lithuania under either the current or a new scheme. It can be lucrative in the framework of the general energy balance and increase the stability of power supply. Finally, in order to ensure operation under special conditions, it is essential to create a backup regional generation complex. Secondly, there is a need for legislative support to the projects of development of wind and hydropower as well as other alternative energy sources, which conforms to the optimal variant and is advantageous in terms of environmental protection. One should keep in mind that, without legislative support, this sector of power generation does not develop in any country of the world. Thirdly, there is a need to introduce into the energy management system of the Kaliningrad region the methodology of optimal management of regional electrotechnical complex, which will eliminate the threat of power shortage, which emerges in the condition of uncontrolled power consumption growth. Fourthly, it is necessary to establish in the Kaliningrad region a research and consulting centre (possibly, a technology park) aimed to draw up a general concept and an improved programme of the development of regional power industry, including the formulation of and operation plan of supply to consumers during special periods, the coordination of operation and division of responsibilities.

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